One of the lessons learnt from emergencies or disasters in the South-East Asia Region is that information and knowledge management is a weak area. The Indian Ocean tsunami of 26 December 2004 was no exception. In any emergency, no matter how difficult, information needs to be collected, stored, and retrieved systematically for analysis. This should be done before, during and after any event. By having a disciplined structure and practice around these activities, we can be more effective in turning information into knowledge and knowledge into action.

This was one of the goals of this book: the other was to take up the challenge of documenting a mega-event. This way one can review what happened on 26 December 2004 by correlating diverse information from various sources and how this impacted health. This book, in two volumes, serves as a reference textbook for the event itself as it happened in each country of study and provides a method for documenting emergencies in the larger discipline of emergency risk management in health. Populations will always live with risks and managing them better can only come with well-informed, evidence-based action, especially those that have a bearing on health. The book contributes to this practice—the information is relevant for future events and contributes to better public health practice in emergencies.
Tsunami 2004: A Comprehensive Analysis

Volume-I
# Acknowledgements

This publication is an initiative of the Emergency and Humanitarian Action unit, a huge endeavor that would not be possible without the support of the Regional Director and Deputy Regional Director; the collective efforts of various people are gratefully acknowledged. This work was developed in conjunction with the World Association for Disaster and Emergency Medicine.

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<tr>
<th>Name</th>
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Research in emergencies has always been a debatable issue. How can one engage in research when the priorities are basic needs for living and survival? Even with resources available and with capacities in place, research and even basic information management always takes a backseat.

Indeed, the earthquakes and tsunami of 26 December 2004 were too huge an event to even think of undertaking some form of research, information collection in real time. But within six months of the disaster, WHO-SEARO started thinking of this and developed several publications. As some of the early documents were being completed and disseminated, it was clear that a more comprehensive technical review was needed. Efforts in planning for a publication such as this were initiated and, in the end, a comprehensive, multi-sectoral retrospective study was conducted. This book is the output of that work.

The challenge was and remains that a lot of the evidence available for emergencies are in different places: peer reviewed journals, unpublished reports; and media coverage. All this raises two fundamental issues 1) information is not available in one source and 2) information is not analyzed through a particular methodology. This book tries to do both. In essence it includes the valuable inputs of peer reviewed, published materials and those that are unpublished or non-peer reviewed in order to get a better picture of the events and the actions taken for it. In simpler words, the book is a documentation of evidence behind the events, the actions and their impact.

This pioneering initiative has been done to the efforts of those who worked during the tsunami and, more importantly, those who suffered its impact.

With the thought that many would not have suffered in vain or those who have worked tirelessly may have planted seed for better practice in the future, it is hoped that this book will, not be just an academic exercise but knowledge that will be used to benefit people. As it contains evidence for better preparedness and risk reduction, it is hoped that it will help to strengthen national capacities, through resilient and better informed communities.

Dr Samlee Plianbangchang
Regional Director
The earthquake and tsunami of 26 December 2004 was an unprecedented emergency of great magnitude affecting several countries simultaneously and which required an extraordinary response. National governments of the affected countries worked jointly with national and international humanitarian partners like UN agencies, the International Federation of Red Crescent and Red Cross societies, national and international NGOs, during post-tsunami emergency, relief, recovery and development phases. It was also one of the rare occasions when massive financial assistance was provided through generous donations from not only the donor countries, agencies and international funding institutions like the World Bank, IMF, ADB etc, but also from individuals, groups and private agencies globally.

The post-tsunami public health impact on the affected population was of immediate concern to national governments and international partners. The World Health Organization (WHO) being the nodal UN agency for the health sector was responsible for coordinating the public health humanitarian assistance to support the national governments through its Regional and country offices.

Since most of the affected countries are located in WHO’s South-East Asia Region, the WHO Regional Office for South-East Asia was in the forefront, coordinating the public health humanitarian assistance to support national governments through its country offices. The limited emergency preparedness capacity in the affected countries was strengthened through massive mobilization of national and international solidarity, which, in turn, provided timely and coordinated assistance to the affected communities.

There were several lessons learnt during the post-tsunami emergency operations and later during the post-tsunami recovery and development phases. These have been covered in a number of publications prepared by WHO-SEARO and include the following:

- Moving Beyond the Tsunami: The WHO Story: a narrative of the event and the work done by WHO and its various offices for response and early recovery.

- A series on the work of various technical and operational areas with regard to the tsunami.

- Voices from the Field: a multimedia production which puts together the guidelines, accounts from staff and partners in the field.

- From Relief to Recovery: a documentation of the recovery efforts in the affected countries.
Being a technical organization, WHO realized the need to publish a scientific document based on the repository of public health-related information collected in the aftermath of the Tsunami of 2004. In this endeavour, WHO-SEARO coordinated and took the lead. It involved selected public health practitioners, academicians as well as citizens and staff of ministries of health and WHO engaged in the emergency operations to cover various post-tsunami perspectives. Moreover, a systematic framework and approach was defined and agreed upon to make the documentation and process scientific.

The key issues regarding documentation of the relief and recovery responses of the tsunami of 2004 are as follows:

- Available information was in different places and not easily accessible.
- Key accounts of the tsunami are not generally available in peer reviewed journals but more in unpublished reports.
- No analysis of the post-tsunami recovery and response phases has been done and therefore how health relates to other sectoral responses and how other sectors relate to health has not been looked at closely.

This publication attempts to fill these gaps by collating all relevant information and analyses to see how the parts fit together. It covers an analysis of health before, during and after the emergency closely reviewing these in the context of all the players, socio-political factors, and various systems that determine how a society/community functions.

The book has three main parts: An introduction to the methodology and the analytical framework; a description of the event in general and a description of the event per-country with a pre-event and post-event comparison according to various societal functions and systems and lastly, an analysis that puts together the various findings in every chapter.

It is hoped that the book will:

1) Serve as useful reference on this unprecedented event;
2) Provide evidence, not just experience for some of the lessons drawn;
3) Provide a model on how to approach research in emergencies; and
4) Help all humanitarian players in monitoring more effective response mechanisms in future.

Although several researchers initially said that a mega-earthquake and tsunami were rare events and may not happen again in a century, we witnessed the Fukushima earthquake and tsunami in 2011. Moreover, there was the threat of a repeat of the events of December 2004 on 11 April 2012, when an 8.7 magnitude (Richter Scale) earthquake occurred in the same fault line. Fortunately, there was no tsunami. However, what was heartening was that the actions taken for early warning and evacuation and public information by governments, communities and health facilities were on the basis of lessons drawn from the 2004 disaster.

We need to live with risks and we need to manage them. This can only be done with evidence. The book provides proof that gathering evidence will always be relevant for future events and is well worth the effort for better public health practice and, more importantly, for saving lives in emergencies.

Dr Poonam Khetrapal Singh
Deputy Regional Director
<table>
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<tr>
<th>Acronyms</th>
<th>Description</th>
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<tbody>
<tr>
<td>ADPC</td>
<td>Asian Disaster Preparedness Centre</td>
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<tr>
<td>AusAID</td>
<td>Australian Agency for International Development</td>
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<tr>
<td>BAKORNAS</td>
<td>National Disaster Management Board (Indonesia)</td>
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<td>BPS</td>
<td>Badan Pusat Statistik-Statistics (Indonesia)</td>
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<td>BRR</td>
<td>Rehabilitation and Reconstruction Agency (Indonesia)</td>
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<td>CDC</td>
<td>US Centers for Disease Control and Prevention</td>
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<td>CRED</td>
<td>Centre for Research on the Epidemiology of Disasters</td>
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<td>CSOs</td>
<td>Community Support Officers (Sri Lanka)</td>
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<td>DKP</td>
<td>Dinas Kebersihan dan Pertamanan was the government sanitary department in Banda Aceh</td>
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<td>DOTS</td>
<td>Directly Observed Treatment, Short course</td>
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<td>DRP</td>
<td>Disaster Response Plan</td>
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<td>DVI</td>
<td>Disaster Victim Identification</td>
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<td>EHA</td>
<td>Emergency and Humanitarian Action Unit</td>
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<td>EMS</td>
<td>Emergency Medical Services</td>
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<td>ERP</td>
<td>Emergency Response Plan</td>
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<td>EWARN</td>
<td>Early Warning and Response Network</td>
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<td>FAO</td>
<td>Food and Agriculture Organization</td>
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<td>GAM</td>
<td>Free Aceh Movement (Gerakan Aceh Merdeka (Indonesia))</td>
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<td>GAM</td>
<td>global acute malnutrition</td>
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<td>GDP</td>
<td>gross domestic product</td>
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<td>GOARN</td>
<td>Global Outbreak Alert and Response Network</td>
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<td>HAF</td>
<td>Humanitarian Action Forum</td>
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<td>HIC</td>
<td>Humanitarian Information Centre</td>
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<td>ICRC</td>
<td>International Committee of Red Cross</td>
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<td>ICU</td>
<td>intensive care units</td>
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<td>IDP</td>
<td>internally displaced persons</td>
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<tr>
<td>IFRC</td>
<td>International Federation of Red Cross and Red Crescent Societies</td>
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<tr>
<td>IMC</td>
<td>International Medical Corps</td>
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<td>INGO</td>
<td>International NGO</td>
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<td>International Organization for Migration</td>
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IRC  International Rescue Committee
LTTE  Liberation Tigers of Tamil Eelam (Sri Lanka)
MoH   Ministry of Health
MSF   Medécins Sans Frontieres
MUDWS Ministry of Urban Development and Water Supply (Sri Lanka)
NDMC  National Disaster Management Center (Maldives)
NDRCU National Disaster Relief Coordination Unit (Maldives)
NERRP National Economic Recovery and Reconstruction Programme (Maldives)
NGO   non-governmental organization
NICD  National Institute of Communicable Diseases (India)
NIMHANS National Institute of Mental Health and Neurosciences (India)
OFDA  US Office for Foreign Disaster Assistance
PDAM  Water Supply Service in Aceh Province
PHC   Primary Health Centers
SARS  Severe Acute Respiratory Syndrome
SCF   Save the Children Foundation
SEARHEF South-East Asia Regional Health Emergency Fund
SOP   standard operating procedure
SUMA  supply and management system
TB    tuberculosis
TEC   Tsunami Evaluation Coalition
TRIAMS Tsunami Recovery Impact Assessment and Monitoring System
TTG   Tsunami Technical Group
USMR  under-five year old mortality rate
USAID US Agency for International Development UK
USGS  US Geological Survey
VC    Voluntary Contributions
WATSAN water and sanitation
UN    United Nations (UN) Organizations
UNDAC United Nations Disaster Assessment and Coordination Team
UNDP  United Nations Development Programme
UNEP  United Nations Environment Programme
UNESCO United Nations Educational, Scientific and Cultural Organization
UNFPA United Nations Population Fund
UNHCR United Nations High Commissioner for Refugees
UNICEF United Nations Children’s Fund
WFP   World Food Programme
WHO   World Health Organization
Part I

Introduction and Methods

Chapter 1

Introduction
The disaster from natural hazards that occurred in the Indian Ocean on 26 December 2004 resulted in the greatest loss of human life from such events in the last 100 years. The magnitude 9.1–9.3 (reports vary) quake, the largest and longest duration earthquake of the last 40 years, elevated the floor of the ocean at least three meters causing the most powerful tsunami in the Indian Ocean since 1883.1 The combined forces of the earthquake and tsunami resulted in the deaths of more than 250,000 people, displaced more than 2 million from their homes, and destroyed/damaged huge areas of the natural environment and human-built structures along the coasts of 10 countries in South-East Asia and five countries in East Africa (Table 1.1). A total of 2277 people from outside the South-East Asia Region (SEAR) were killed, including citizens from other countries (27 countries) many of whom were tourists. The estimated economic loss was the greatest due to a natural hazard ever recorded and stimulated the largest-ever outpouring of human and economic assistance.2

In order to comprehensively review the health aspects associated with the earthquake and tsunami of 26 December 2004, the WHO Regional Office for South-East Asia decided to summarize this information in a book that would be useful in determining future preparedness measures.

There is little documented history of tsunamis in the Indian Ocean prior to the devastating event in 2004. Prior to 2004, a major Indian Ocean tsunami occurred in 1883. When compared to 2004, the Indian Ocean coastal population densities in 1883 were low and the potential for destruction was minor. While both the 1883 and 2004 tsunamis reached heights of at least 30 meters, the 1883 tsunami killed fewer (approximately 36,000 people) than did the 2004 tsunami. Unfortunately, the recent occurrence of a major Indian Ocean tsunami does not indicate that the ocean will not generate another major tsunami for another 100 years. Research indicates that a major earthquake with the potential to create another large tsunami in the Indian Ocean could occur within a few decades or less. Indeed, the occurrence of a magnitude 8.4 earthquake off the coast of Indonesia’s Sumatra Island in September 2007 renewed concerns that another earthquake with the potential to create a devastating tsunami could occur in the near future.3 This earthquake occurred in the Sunda Trench along a section of fault known as the Mentawai fault, and could signal the end of a long period of calm. The Mentawai fault has a history of following a cycle in which it produces no earthquakes for about a century, and then, generates moderate earthquakes over several decades before culminating in a major earthquake. The September 2007 earthquake may mark the beginning of a period punctuated...
INTRODUCTION

by moderate earthquakes that is likely to culminate in a major earthquake and possibly devastating tsunami. Fortunately, the 2007 earthquake did not generate another destructive tsunami.4

Moreover, the number of South-East Asians exposed to potentially disastrous events continues to rise as the South-East Asian population densities are growing along the coasts, flood plains, and earthquake faults. Without strong preparedness measures and effective disaster management in place, fatalities, as well as decreased quality of life due to disasters, will increase in South-East Asia.

Although much has been written about the damages and the related losses suffered by societies impacted by the earthquake/tsunami, the recorded information has been widely dispersed, and there has been no concerted effort to synthesize the available material. This is true particularly regarding the effects on the health systems of the countries affected by the 2004 earthquake and tsunami. But the health aspects of the tsunami disaster cannot be fully understood without at least a basic understanding of other aspects of the disaster. For example, the delays in the delivery of medical care services to some injured tsunami survivors can be explained, at least in part, by the state of the transportation system in the impacted regions following the tsunami. And, the disproportionately high number of women among the fatalities may be explained in part, by cultural influences. Such a synthesis and analysis of what occurred during and following these catastrophic events are essential and had to be studied within the context of the disaster as a whole. Thus, it is cogent to define the pathophysiology of the disasters that followed the events of 26 December 2004, and determine the effectiveness of the relief and recovery responses that followed.

The occurrence of the same events that impacted multiple countries in South-East Asia within hours of the earthquake provided a unique opportunity to study the differences in the abilities of those countries to cope with the events. In the chapters that follow, a synthesis and analysis of available information are provided for the five countries most severely affected by the events of 26 December 2004: India, Indonesia, the Maldives, Sri Lanka, and Thailand (Table 1.1). Particular emphasis has been placed on the health aspects of these disasters. Two of the countries (Indonesia and Sri Lanka) studied were experiencing ongoing civil strife at the time of the events.

The sources used for the abstraction of the information included: (1) peer-reviewed literature; (2) gray literature; (3) accessible reports generated by governmental, inter-governmental, and nongovernmental organizations; and, when needed; (4) personal, semi-structured interviews with notable persons who were involved in the disasters. Much of the information that had been documented was not available for this review and some had been lost.

The scope of the material accessed was quite broad and had no common structure or terminology. These factors combined to add confusion and complicated the efforts to synthesize the information. Therefore, a new guideline developed and promulgated by the World Association for Disaster and Emergency Medicine and by the Task Force on Quality Control of Disaster Management,5 was used as the basic structure for the information. Prior to this review, the utility of this structure had not been applied, and hence, its utility had not been tested. The use of this structure facilitated the analyses and understanding of the material abstracted. Use of the frameworks embedded in the structure provided heretofore unrecognized insights into the events, the damages created, the impact on the societies affected, and on the relief and recovery responses brought to bear in the five countries. Use of the frameworks facilitated the identification of not only what happened and what didn’t happen, but also helped to detect some major gaps in the available information. Furthermore, use of the structure demonstrated the complex dependence and interdependence...
of the societal functions upon one another. Hopefully, this structure will help readers achieve a better understanding of the tsunami disaster and will inspire others in the disaster medicine community to adopt the same approach when documenting disasters.

There are five major parts to the discussions that follow: (i) Introduction and description of the methodology; (ii) Events; (iii) Country reports using the basic functional components of the societies; (iv) Analyses by the societal components; and (v) Synthesis, critique, and conclusions and recommendations.

One of the goals of this book includes gaining a further understanding of the impacts such events have on the affected societies, the pathophysiology of disasters, the effects of interventions, and the impact of preparedness measures. Much is revealed that had not been appreciated previously; this will have a substantial impact on our ability to cope with the next disaster caused by such naturally occurring events.

References


Table 1.1: Countries directly impacted by the earthquake and tsunami of 26 December 2004. Countries in bold-italics are the subjects of this study.
Part I
Introduction and Methods

Chapter 2
Methods
As noted in the foregoing Chapter, the widely dispersed and unstructured information accessed for this analysis created difficulties in the amalgamation of the information. No framework had been used that would facilitate bringing the information together into a form necessary for the analyses. Furthermore, there was no commonly agreed upon glossary of terms, and the terminology used in the material accessed was inconsistent. These issues comprised major barriers to the synthesis required to make this project useful (See Chapter 24: Barriers).

The World Association of Disaster and Emergency Medicine and the Task Force for Quality Control of Disaster Management have created a structure that includes a set of frameworks for facilitating such analyses. Conceptual framework provided in Health Disaster Management: Guidelines for Evaluation and Research that was published in 2003 provides a Conceptual Framework that outlines the progression of a hazard to a disaster deconstructed further. The Conceptual Framework flowchart has been upgraded since first published in Volume 1 (Figure 2.1) and the definitions of each of the terms presented in the flowchart are in Table 2.1. These terms are used throughout this publication.

Many of the publications abstracted for this analysis have described a disaster in a chronological order using the terms of absolute number of hours, days, or weeks. In addition, these publications have addressed the longitudinal phases of the disaster as the event, damage, response, and development, as if they followed in a strict sequential chronological order. While these methods for describing a disaster have been widely used, they are flawed and limit the ability to compare events and disasters. For example, Day 2 of a disaster precipitated by an earthquake is not likely to provide useful information when comparing it to Day 2 of a disaster caused by a hurricane; thus, the information cannot be generalized for comparison between the two events. As defined by the Guidelines, the phases of the event, damage, response, recovery, and development often overlap rather than follow in strict sequential, chronological order. For example, during a hurricane, the relief response is likely to begin before the event has ended.

The structure for the information uses two additional inter-related frameworks: (1) the Longitudinal Framework; and (2) the Transectional Framework. The Longitudinal Framework provides a method for describing disasters using phases defined by properties rather than by absolute times (Figure 2.2). The phases identified in the Longitudinal Framework include the pre-event, event, damages, changes in functions, relief, and recovery (Figure 2.2).
The Longitudinal Framework is used throughout this review, and is the basis upon which the five country chapters (India, Indonesia, the Maldives, Sri Lanka, and Thailand) are structured (Part II).

In addition to describing each of these longitudinal phases, all changes following an event must be related to the status during the pre-event longitudinal phase. Although the pre-event status has been overlooked in disaster literature, its documentation is vital in order to understand a disaster. Without knowing the pre-event status of a stricken community, it is not possible to determine how much damage occurred as a result of the event and/or to determine the consequences of the damage on the functional state of a component of the society. For example, knowing that 50% of the wells in a tsunami-impacted area were contaminated following a tsunami tells little about damage without the knowledge of the number of wells that were contaminated before the event. Without pre-event data, it is not possible to determine how much well contamination occurred as a result of the tsunami.

The second Framework, central to the processes used in the development of this book is the Transectional Framework. This Transectional Framework offers a generic method for describing a society for purposes of disaster planning, evaluation, and research; it deconstructs a society into non-hierarchical systems identified as basic societal systems (BSSs) (Figures 2.3 and 2.4). These 13 basic societal functional systems include: (1) Medical Care; (2) Public Health; (3) Water and Sanitation; (4) Shelter and Clothing; (5) Food and Nutrition; (6) Energy Supplies; (7) Public Works and Engineering; (8) Social structures; (9) Transportation and logistics; (10) Security; (11) Communications; (12) Economy; and (13) Education. The principal functions and responsibilities of each of the basic societal systems are outlined in Table 2.2. Using these systems, it is possible to assess the levels of function of each or a combination of the systems at a particular time. These assessments transect the Longitudinal Framework at selected times (Figure 2.4) and are used to define the needs of one or more of the Basic Societal Systems (BSSs) based on the identified needs. The most appropriate responses (interventions) to meet these needs are selected and implemented. Thus, trends in the functional state of any one or a combination of the Basic Societal Systems may be followed over time. These assessments not only define the effects of the damages and the resultant changes in function of a particular BSS between assessments, they facilitate the identification of the outcomes/impacts of any intervention.

The 13 Basic Societal Functional Systems are dependent and/or interdependent on one another; impairment of one system can lead to problems in the functions of one or more systems. Impairment of a basic societal system may result from structural damage, inadequate supplies, and/or inadequate services required to meet the needs of the affected population.

The Transectional Framework also identifies a 14th function—Coordination and Control. Coordination and Control is the glue that binds all of the other 13 basic societal systems. Coordination and Control is the function that directs responses to a disaster (Figure 2.5). Its principal function during a disaster is to ensure that each system meets the needs identified by assessments.

The Longitudinal and Transectional Frameworks are central to the format of this book. The definitions and structure of these frameworks form the blueprint for the five country reports in the chapters that follow and are used in each of the sections that follow.
This work is the first documentation of the utility and value of the use of these frameworks in disaster research and evaluation. One of the goals of this book is to serve as a model for the use of these frameworks in evaluations and research in disaster health. Ideally, this structure will be employed early in a disaster rather than years after the events responsible for the disaster, but this was not possible for this book. The comparisons between the countries form the basis for the conclusions and recommendations.

**Organization**

The following processes were used for the development of this book:

1. Identifying the objectives and goals of the book (see Chapter 1);
2. Gathering all relevant, accessible information for each of the five countries being studied;
3. Using the same format for each country report;
4. Abstracting relevant, available data by Basic Societal Systems from each of the country chapters;
5. Performing an analysis of each of the Basic Societal Systems using the longitudinal framework;
6. Identifying and discussing barriers to the process utilized;
7. Synthesizing the information from the Basic Societal Systems analysis from the five countries; and
8. Developing conclusions and recommendations from the synthesis.

**Goals**

As noted in the preceding chapter, the goals of this book include gaining a further understanding of the impacts such forces have on the affected societies, the pathophysiology of disasters, and the effects of the interventions used on the respective societal burdens, as well as the impact of preparedness measures that were in place prior to the occurrence of the precipitating event.

**Access of the Data and Information**

Information was gathered from all accessible sites. Extensive use was made of MEDLINE, PUBMED, CINHALS, and of the available search engines available on the Web. In an attempt to fill some of the apparent gaps in the information gathered, semi-structured interviews were conducted with persons who were involved in the disasters. Nevertheless, as one peruses the country chapters, some of the remaining gaps become obvious. Generally, these gaps were the result of information that had been retained by the agencies involved; had been removed from the Internet; or had never been published. Also, extensive efforts were made to access the relevant gray literature as well as the relevant peer-reviewed literature. Most of the gray resources were annotated, as was the peer-reviewed literature. Every effort was made to triangulate all of the information abstracted. The information used in this project is referenced as to sources. Note must be taken that many of the sources were UN (especially WHO and its Regional Offices) documents downloaded from the Internet. Care was taken to avoid the use of opinions in the information accessed from the Internet.

**Organization**

All the country report chapters are organized according to individual Basic Societal Systems; within each Basic Societal Systems, the material has been organized with respect to its timing within the Longitudinal Framework. Principal attention was directed to the Medical Care and Public Health Basic Societal Systems, and those Basic Societal Systems upon which the Medical Care and Public Health systems are dependent or interdependent.

**Analyses**

Further analyses included integrating the information from the five country chapters according to Basic Societal Systems. For example, the pre-event status of the Public Health system noted in each of the chapters was synthesized to identify similarities and differences. Each of the Basic Societal Systems was analyzed particularly as it was related to the Medical Care and Public Health Systems. Finally, these comparisons by Basic Societal Systems were synthesized further into two “Putting It Together” chapters. This additional
synthesis led to the formation of conclusions and recommendations.

It should be noted that information referenced in each of the country chapters was not re-referenced in the analysis and synthesis sections as re-citing each reference for each country would have been duplicative and cumbersome to the reader. The reader is referred back to the country report chapters for such references. Material added in the synthesis chapters is referenced appropriately within the synthesis chapters.

Summary
The findings derived from this analysis were obtained using the structure and its component frameworks proposed by the World Association for Disaster Medicine and the Task Force for Quality Control of Disaster Medicine and confirm the utility and validity of this methodology.

References
Figure 2.1: Revised Conceptual Framework

Figure 2.2: Longitudinal phases of a disaster

**Longitudinal Phases for Definition of Pathophysiology**
**Transectional “Snapshots”**

- Pre-event
- Event
- Damage
- Change in Function
- Relief
- Recovery

**Transectional Structure of Society**

- Public Health
- Medical Care
- Economy
- Communications
- Security
- Logistics & Transport
- Social Structure
- Public Works & Engineering
- Education
- Water & Sanitation
- Shelter & Clothing
- Food & Nutrition
- Energy Supply

**Figure 2.3**: Longitudinal phases transected by points of assessment of an individual Basic Societal System

**Figure 2.4**: Transectional structure of a society—the Basic Societal Systems
Figure 2.5: Basic Societal System with the central Coordination and Control function
### Table 2.1: Terminology used to describe the progression of a hazard to a disaster

<table>
<thead>
<tr>
<th>Term</th>
<th>Explanation</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hazard</td>
<td>A hazard is a phenomenon that is human-made, naturally occurring, or both, and poses a danger to society. The danger posed by a hazard can adversely effect human health, property, activity, and/or the environment.</td>
<td>A fault line that runs through town of 150,000 people</td>
</tr>
<tr>
<td>Event</td>
<td>An event is the realization of a hazard and also has the potential to adversely affect society. The guidelines describe an event by its duration, character of onset and scope, and the hazard responsible for the event. Additionally, an event has the potential to trigger secondary events. The Andaman-Sumatra earthquake of 26 December 2004, for example, triggered the Indian Ocean tsunami.</td>
<td>An 8.9 earthquake shakes an entire town for three minutes</td>
</tr>
<tr>
<td>Damage</td>
<td>Damage refers to the harm or injury that results due to an event, and can occur to both humans and the living and non-living things they depend on.</td>
<td>The town’s only two hospitals collapsed</td>
</tr>
<tr>
<td>Absorbing capacity</td>
<td>The ability of a structure to prevent or mitigate the damage from the event.</td>
<td>Building(s) that remained standing while others around them collapsed</td>
</tr>
<tr>
<td>Change in function</td>
<td>Change in function refers to the change in the ability of a major functional component of a society to operate due to damages caused by an event. For example, a society’s water and sanitation functional component may undergo a change in function if an event results in waterline damages.*</td>
<td>The hospitals no longer can provide services</td>
</tr>
<tr>
<td>Buffering capacity</td>
<td>The ability to continue to function despite the structural damage sustained</td>
<td>Ability to use alternate sources of electrical power such as generators when the electrical grid is damaged</td>
</tr>
<tr>
<td>Needs</td>
<td>The differences between requirements and available supplies.</td>
<td>Amount of water required to supply a minimum of 15 liters of water/person/day</td>
</tr>
<tr>
<td>Response capacity</td>
<td>The ability to meet the needs to minimize further losses, or restore or preserve the functions of the affected society.</td>
<td>Disaster response teams Disaster response exercises Surge capacity</td>
</tr>
<tr>
<td>Local responses</td>
<td>Interventions provided by the affected community to meet the needs of the affected society.</td>
<td>Use of the local disaster response capacity</td>
</tr>
<tr>
<td>Outside responses</td>
<td>Interventions provided using outside resources when the local responses cannot meet the needs of the affected society.</td>
<td>Medical teams from outside the affected area</td>
</tr>
<tr>
<td>Disaster</td>
<td>A disaster has occurred when the changes in function are so severe that the society impacted requires outside resources to cope with the changes in function due to the damage created by the event.</td>
<td>National resources are required to provide medical care for the injured in the community impacted</td>
</tr>
<tr>
<td>Resilience</td>
<td>The pliability, flexibility, or elasticity of the society to prevent an event from producing a disaster. It consists of the absorbing, buffering, and response capacities.</td>
<td>Earthquake-resistant construction</td>
</tr>
<tr>
<td>Risks</td>
<td>The probability that something negative will occur.</td>
<td>Probability that an earthquake will occur</td>
</tr>
<tr>
<td>Risk reduction</td>
<td>Decreasing the risk that something negative will occur.</td>
<td>Earthquake resistant construction</td>
</tr>
<tr>
<td>Preparedness</td>
<td>The aggregate of all measures and policies taken by humans before the event.</td>
<td>Stores of supplies e.g., antibiotics</td>
</tr>
</tbody>
</table>

## Table 2.2: Overall responsibilities of the Basic Societal Systems

<table>
<thead>
<tr>
<th>Basic Societal Functional Systems</th>
<th>Responsibilities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Public (preventive) Health</td>
<td>Health of groups of people or a population; the protection and improvement of the health status of a society.</td>
</tr>
<tr>
<td>Medical (curative) Care</td>
<td>Provision of medical care to individual patients. Includes primary, secondary, and tertiary care as well as psychosocial support and treatment.</td>
</tr>
<tr>
<td>Water and Sanitation</td>
<td>Provision of adequate supplies of water suitable for drinking and for the preparation of food, and application of measures and techniques aimed at ensuring and improving environmental health in a community through the collection, evacuation, and disposal of liquid and solid wastes with or without prior treatment.</td>
</tr>
<tr>
<td>Shelter and Clothing</td>
<td>Provision of protection against harmful environmental elements.</td>
</tr>
<tr>
<td>Food and Nutrition</td>
<td>Provision of any edible substance containing nutrients that, on ingestion, helps to maintain the vital functions of a person or other living organism.</td>
</tr>
<tr>
<td>Energy supply</td>
<td>Any property with the capability to transform or change a function or parts of the environment or the society; that which is needed to keep the technical aspects of society operational. It includes fuels (wood, gas, diesel, kerosene, etc.) and electricity used for the provision of heat, cooking, and light.</td>
</tr>
<tr>
<td>Public Works and Engineering</td>
<td>The application of technical knowledge and assistance to develop and maintain the infrastructure of the affected society.</td>
</tr>
<tr>
<td>Social structures</td>
<td>Relationships within a group of people and the key elements that influence and dictate such relationships, e.g., religion and its systems, hierarchical structure, population density, existing social and governmental systems, cultural practices, and living conditions as given by the environment.</td>
</tr>
<tr>
<td>Logistics and Transport</td>
<td>Any activities concerned with the supply, procurement, storage, transport, and evacuation of persons, equipment, supplies, wastes, etc.</td>
</tr>
<tr>
<td>Security</td>
<td>Provision of safety and security of a given (defined) population. (Security is the state of being protected from injury inflicted directly or indirectly by other living beings or events.</td>
</tr>
<tr>
<td>Communications</td>
<td>All forms for the interchange of information.</td>
</tr>
<tr>
<td>Economy</td>
<td>Provision of the resources essential for maintaining the basic functions and infrastructure of a society.</td>
</tr>
<tr>
<td>Education</td>
<td>Education and training of citizens, including all resources used in educating and training the population.</td>
</tr>
</tbody>
</table>

Part II

Events

Chapter 3

The Events
Like a scene in a science fiction story, the 2004 Indian Ocean tsunami demonstrated a level of destruction that seemed otherworldly. Whole communities were wiped off the map as the tsunami embarked on a nine-hour killing rampage that took the lives of people as far as 6000 kilometres from where it began. For days and weeks following the tsunami, many who witnessed its waves were bewildered and understood little about what had occurred. Rumours that a second tsunami would occur soon terrorized and haunted people living along Indian Ocean coastlines. In India’s Andaman and Nicobar Islands, some islanders, remembering that the tsunami occurred during a full moon, fled coasts when the next full moon appeared a month later.

Before the event occurred, there was little public awareness about tsunamis before the event occurred, because the occurrences of widely destructive tsunamis have been rare. Similarly, researchers have had few opportunities to observe tsunamis, and know little about them compared with other naturally occurring events. Unlike tornadoes, hurricanes, and volcanic eruptions, tsunamis occur with very little notice and lead time in which to react. And unlike other disastrous events that occur with little or no notice or advance warning, such as earthquakes, tsunamis occur rarely. While strong earthquakes—magnitude 7 or greater—occur about 18 times each year and “great” earthquakes—magnitude 8 or higher—occur about once per year, a widely destructive tsunami occurs only about once every 15 years. Consequently, researchers rarely observe more than the aftermath of a tsunami. Possibly the only disaster caused by a natural hazard that is more rare than a major tsunami, is a major asteroid impact. An asteroid impact equivalent to the impact of a hydrogen bomb occurs only about once every 200–300 years.

In a single day, 26 December 2004, not just one, but two extremely rare events occurred: an earthquake measuring more than 9 on the Richter scale, and a tsunami. Tsunamis only occur when some other major event displaces a massive quantity of seawater, which then ripples outward in tsunami waves. On 26 December 2004, the tsunami-generating event was an earthquake in the Indian Ocean with a magnitude of at least 9.1—the largest earthquake in the last 40 years. The tsunami that followed was the most destructive recorded in modern times.

On 26 December 2004, the Indian Ocean tsunami and earthquake that triggered it, killed more than 250,000 people (dead and missing) and displaced 2 million people. Had public awareness and preparedness for tsunamis been greater in the Indian Ocean region, the number of lives lost and damage caused by the tsunami possibly could have been less. Had a similar tsunami occurred in the Pacific Ocean, it is likely...
that more people would have been warned of the tsunami’s approach and escaped from its path. The Pacific Ocean contains six tsunami sensors—there were none in the Indian Ocean basin. The Pacific Ocean also contains nearly 150 other water-level instruments such as tide gauges that report real-time data via satellite. The Indian Ocean contained only four such devices: one near Australia’s Cocos Island and three in the Maldives. All four of the sensors were located more than 1700 kilometres from the epicentre of the earthquake. Additionally, a Pacific Tsunami Warning Centre with a tsunami alert system, monitors possible tsunami-generating earthquakes and tsunami using sensors. No such centre or alert system existed for the Indian Ocean.

The Pacific Tsunami Warning Centre, located in Hawaii, was established to protect coastal communities surrounding the Pacific Ocean, where tsunamis most commonly occur. But the Centre receives data on seismic activity from all over the world, and while the Sumatra-Andaman earthquake occurred in the Indian Ocean rather than the Pacific Ocean, it quickly caught the attention of the geophysicists staffing the Centre. At about 15:00 hours Hawaii time, geophysicists Stuart Weinstein and Barry Hirshorn received seismic data suggesting that a magnitude 8 earthquake had occurred along the seafloor just off the coast of Indonesia. And within 15 minutes of the earthquake, they issued a Pacific-wide tsunami information bulletin informing countries in and around the Pacific basin of the estimated size and location of the detected earthquake. Weinstein and Hirshorn, however, could not report on whether the earthquake had generated a tsunami. Had the earthquake occurred in the Pacific Ocean, they would have analyzed, in real time, satellite data transmitted from tsunami sensors and other water-level instruments in order to determine whether the earthquake had generated a tsunami. But, when Weinstein and Hirshorn looked for water-level data in the Indian Ocean, they found none, as no satellite-transmitted data on water-levels in the vicinity of the Sumatra-Andaman earthquake existed.

Because Indonesia and Thailand border both the Indian Ocean and Pacific Ocean, they would have received the Warning Centre’s tsunami bulletin reporting on the earthquake. But it is unclear what kind of response, if any, the bulletin triggered in either country. Neither Indonesia nor Thailand had a recent history of a major tsunami, and thus, the possibility of a tsunami occurring might not have raised serious concerns. Other countries surrounding the Indian Ocean, lay entirely outside the Pacific Ocean basin and did not receive the tsunami bulletin. At an estimated magnitude of 8, however, there was little reason to believe that the earthquake would produce a tsunami that would impact any region other than northern Indonesia, if it produced one at all.

Forty-five minutes after the earthquake, Weinstein and Hirshorn performed a slower, but more accurate method for calculating the size of the earthquake and realized the earthquake was much larger than they had previously estimated. The geophysicists revised the earthquake’s estimated magnitude upward to 8.5, which would have released approximately 16 times more energy than a magnitude 8 earthquake. They summoned advice from the Director of the Warning Centre, geophysicist Charles McCreery, and subsequently issued a second bulletin reporting that the earthquake was larger than first estimated, and that a tsunami may have been generated. At this point, the geophysicists believed a small, local tsunami had already affected Indonesia. What they did not know is that even the second calculation had seriously underestimated the earthquake’s magnitude. And although an earthquake-generated tsunami already had impacted Indonesia, it was neither small nor local. In Indonesia, the tsunami resulted in waves up to 30 metres high, and within 45 minutes of the earthquake, the tsunami had devastated coastal areas of the northern Indonesian province of Aceh. But the tsunami did not limit its course of destruction to Indonesia.

Approximately three hours after the earthquake, the geophysicists found an Internet news report indicating a tsunami had hit Thailand. They
were shocked to learn that the earthquake had triggered a tsunami large enough to cause casualties and destruction along a coast 600 kilometres from the earthquake’s epicentre. Soon after, an e-mail from Harvard University seismologists helped to explain the destruction. The e-mail indicated that the earthquake was at least a magnitude 9, an earthquake with the energy equivalent of about 32 magnitude 8 earthquakes.

Weinstein, Hirshorn, and McCreery realized that more countries still might be in danger and with the help of the U.S. State Department, frantically tried to reach anyone that could evacuate coastlines that had not yet been hit. Meanwhile, the tsunami moved quickly, radiating out from the earthquake epicentre at about the speed of a jet airplane. By this time, the tsunami had already impacted many countries, having reached Indonesia and India’s Andaman and Nicobar Islands within minutes of the earthquake, Sri Lanka, India’s mainland and Thailand in about two hours, and the Maldives in about three hours. Although it was too late to warn these countries, the geophysicists hoped to warn countries along the east African coast. Finally, they reached the U.S. embassies in Mauritius and Madagascar and the embassies promised to warn Somalia and Kenya, which had not yet been hit. Kenya received the warning with enough time to evacuate coasts before the tsunami arrived, and only one person was killed by the forces of the tsunami (Table 3.1, Figure 3.1).

**The Tsunami**

Had there been in the Indian Ocean basin a better system in place for detecting, warning, and evacuating coastlines, lives possibly could have been saved in many more countries. And greater public recognition of tsunami warning signs could have spared even more lives. For example, in countries close to the Sumatra-Andaman earthquake epicentre (such as Indonesia), the tsunami arrived within minutes of the earthquake, too soon for even the best of warning systems to have been effective. But, had more Indonesians known that earthquakes can trigger tsunamis or that an unusually large and sudden withdrawal of the sea from the shore can indicate that a tsunami is approaching, many more lives may have been spared. Few people, however, recognized these warning signs. In a few small communities where people did recognize warning signs, the people evacuated the coast, and thus, avoided large-scale fatalities due to the tsunami. In many cases, those who recognized tsunami warning signs belonged to small indigenous groups who had learned about tsunamis through stories passed down from generation to generation. There is some evidence that warnings learned from animal behaviours also may have been important in prompting evacuation from the sea shore.

In Thailand and Indonesia, tsunami stories are believed to have spared many lives in two indigenous, small-island communities familiar with the stories. In Thailand, the Moken story of the Laboon—or man-eating wave—and in Indonesia, the Simeuluen story of the smong—the coming of the ocean onto land—had taught islanders to recognize tsunami warning signs. In a village of about 200 Mokens familiar with the story of the Laboon, the 26 December 2004 tsunami devastated the village infrastructure, but killed only one Moken. And on Aceh Province’s Simeulue Island, just 40 kilometres south of the Sumatra-Andaman earthquake’s epicentre, and where the tsunami arrived just 10 minutes after the earthquake, only 44 of the island’s 78,389 people are believed to have died. And, of the 44 who died, local authorities say only seven died due to the tsunami and the rest due to the earthquake. On Simeulue, the story of the smong is said to refer to an earthquake and tsunami that occurred in 1907. The 1907 earthquake and tsunami were not well studied, but according to local legends, the events killed 70% of the island’s population. A similar story existed in the Andaman and Nicobar Islands, where the mortality in one location was very low because of the warnings perceived by the local community.

In Indonesia, earthquake shaking followed by the withdrawal of the sea from shore (Figure 3.2)
would have been the only advance warning
Indonesians close to the epicentre could have
relied on in the few minutes that passed between
the earthquake and the tsunami’s arrival. In
countries further from the earthquake epicentre,
however, a warning system could have spared
lives. In the roughly two hours between the
earthquake and the tsunami’s arrival in Sri Lanka,
Thailand, and mainland India, many people could
have escaped the coast in time had they been
given ample warning. Additionally, in countries
far from the epicentre, people were less likely to
have felt the earthquake that occurred prior to
the arrival of the tsunami. In Sri Lanka, very few
people reported having felt the earthquake, and
those who did generally felt only “very weak”
shaking.1,8

Along coasts, shaking provides by far the earliest
warning that a tsunami may occur and that the
coasts may not be safe. But along coastlines
where earthquake shaking is not felt, several
other tsunami warning signs may be observed.
Shortly before the arrival of a destructive tsunami
wave, for example, witnesses may see an
unusually large and sudden withdrawal of the sea
from shore (Figure 3.2). The large withdrawal
of the sea from shore during a tsunami, is
known as a negative wave or the trough that
occurs between wave crests. During a tsunami,
either a negative or a positive wave may arrive
first depending on a coast’s orientation to the
seismic fault that generated the tsunami.5–11 In
the case of the Indian Ocean tsunami, a negative
wave occurred before the first positive wave in
Indonesia, Thailand, and other countries located
east of the fault line. But in Sri Lanka, mainland
India, and other countries west of the ruptured
fault, a positive wave arrived first. Although the
first arriving negative wave in coasts east of the
fault should have prompted people to evacuate
beaches as it sucked seawater away from shores,
it generally had the opposite effect. Witnesses
who saw the sea withdraw, typically responded
by venturing out onto the exposed seafloor to
inspect stranded sea life, thus, putting themselves
at greater risk of being seriously injured or killed
Figure 3.2. The need for community awareness
of the events that unfold and the action to be
taken is emphasized, but difficult for the programs
to put it into practice for events that are as rare as
are tsunamis.

Countries far from the epicentre of the Sumatra-
Andaman earthquake and west of the fault would
have had few natural warnings before the first
positive tsunami wave arrived. But three or four
large positive waves typically occur during a
tsunami with the first wave not always being the
largest wave. In some cases, a less destructive
positive tsunami wave may serve as a warning
that more dangerous waves will follow. This
appears to have been the case in Sri Lanka,
where some reported that the first tsunami
wave they observed was unusually large, but not
seriously damaging. This wave was followed by
a large withdrawal of the sea from the shore and
a second much larger and destructive positive
wave. Unfortunately, instead of recognizing
this first positive wave as a possible sign of
impending danger, many people regarded it as a
spectacle and gathered along the coast instead of
evacuating.14,15

Given that of the few tsunamis that do occur,
only 4% occur in the Indian Ocean, it may
seem reasonable that few people living along
the ocean’s shores were aware of a hazard that
could produce a tsunami or how to recognize
tsunami warning signs.11 And it may not come as
a surprise that no country bordering the Indian
Ocean had placed tsunami sensors in the ocean
or had organized a tsunami warning system.
But, while Indian Ocean communities were
not prepared to face a tsunami, the possibility
of a major tsunami in the Indian Ocean was
not entirely unanticipated. Approximately one
year before the tsunami, a number of scientists
including an Australian seismologist named Phil
Cummins, began calling for a warning system in
the Indian Ocean. Less than one year before the
tsunami, Cummins had delivered a presentation
in Japan with a now eerily prophetic title,
“Tsunami in the Indian Ocean – Why Should
We Care?”16 Cummins had realized that a fault
line off the Sumatra coast of Indonesia had
the potential to create a tsunami large enough to bring destruction to communities along the Indian Ocean. But despite Cummins' and other scientists' efforts to draw attention to the issue, little was done to prepare Indian Ocean communities for a possible tsunami. Had the likelihood that the Indian Ocean fault could produce a tsunami been better recognized, education could have been provided to coastal communities so that they would have recognized tsunami warning signs and the governments could have installed water-level instruments reporting real-time information near to the known fault lines. Additionally, communities most at risk could have been identified and the risk of fatalities and other damages from a tsunami possibly could have been minimized.

As the Indian Ocean tsunami demonstrated, how a tsunami propagates through the ocean and interacts with natural and human-made coastal features determines how large and how destructive a tsunami wave will be when it arrives on shore. The tsunami’s impact on coasts surrounding the Indian Ocean varied considerably from one country to the next. When an earthquake generates a tsunami, most of the generated energy of the tsunami travels perpendicular to the ruptured fault line. In the case of the Indian Ocean tsunami, most of the tsunami energy traveled to the east and to the west of the Sumatra-Andaman fault, which ruptured roughly from the south to the north. Indonesia and Thailand, which lay east of the fault, and Sri Lanka, Maldives and India, which lay west of the fault, were the countries that were hardest hit. In Bangladesh, which lay to the north of the fault, no tsunami damages were reported (Figures 3.3 and 3.4).

Even along short lengths of coastline, tsunami wave heights and how far inland the tsunami waves travelled varied considerably. On the Thai island of Phuket, the tsunami devastated Kamala beach with waves as high as five metres, but hardly touched Surin beach, just a few kilometres to the north. In the case of Surin and Kamala beaches, Surin beach was spared the impacts of high tsunami waves due, in large part, to a steep incline of the seafloor leading up to it. On the other hand, along Kamala beach, a shallow, gently rising seafloor amplified the approaching tsunami waves, exposing the beach to some of the highest tsunami waves to strike Phuket island.

Several factors affect variations in wave height and inundation along coasts including the shape of the seafloor; land elevation near the shore, and the existence of natural barriers such as mangroves. As a tsunami approaches shore, its wave height, length, and speed change depending on the depth of the water and its interactions with the seafloor (Figure 3.5). Out at sea, tsunamis have short wave heights relative to their extraordinarily long wave lengths and they move very fast. In water more than 4 kilometres deep, a tsunami may move at 700 kilometres/hour and have a wave length of more than 150 kilometres while maintaining a wave height of only a few metres or less from crest to trough. By comparison, a typical wind generated-wave measures only 5 to 20 metres. When a tsunami travels through deep water, the long, gentle rise of its waves usually will pass beneath seafaring vessels unnoticed. But as a tsunami approaches shore, a rise in the seafloor slows it down and its enormous wave lengths convert into enormous wave heights, in a process called “shoaling” (Figure 3.5). Shoaling results in the largest tsunami waves along seafloors that rise gradually over long distances, as it did along the seafloor leading to Kamala Beach. On the other hand, along steeply rising seafloors, a tsunami has less distance over which it can convert wave length into wave height. And, as the wave runs up against a steep seafloor, some of its energy is reflected back into the sea rather than being converted into tall waves.

Water depth influences a tsunami wave’s speed not only near shore, but also out in the sea. Ocean waters between the Sumatra-Andaman earthquake epicentre and Thailand are shallow compared to the ocean waters between the epicentre and Sri Lanka—the Indian Ocean tsunami traveled much faster on its way to Sri Lanka than it did to Thailand. And, while the
Tsunami wave arrival times have been easier to determine than tsunami wave heights. None of the tsunami’s waves were measured directly as they arrived along coastlines. In the days and weeks following the tsunami, researchers used the best evidence they could find to estimate the heights that the waves had reached. But the evidence decayed quickly, and researchers often used different methods to measure and report what they found. Combined with what researchers know about the tsunami’s propagation through the ocean, however, wave height estimates help explain how the tsunami’s arrival varied from one region to the next and why. Due to the close proximity to the epicentre and the orientation to the fault and evidence found on shore, the earliest and tallest waves arrived in Indonesia.\(^{18}\)

In Indonesia, the tsunami arrived within minutes of the start of the earthquake and villages disappeared under waves reaching as high as a 10-storey building. Waves reaching between 10 and 30 metres high, devastated hundreds of kilometres of Indonesian coastline and, in some cases, reached as far as 5 kilometres inland. Many of Indonesia’s tsunami-impacted coasts were characterized by low land elevations that extended far inland. With few cliffs, hills, or other land barriers to stop the tsunami, its waves pushed seawater into Indonesian communities, that under normal circumstances, were too far from the coast to see or hear the ocean.\(^ {18}\)

No other country was hit by waves as high or as devastating as those that arrived in Indonesia. But even outside Indonesia, waves reached as high as 12 metres. Perhaps even more astonishing is the fact that waves reaching as high as 12 metres occurred along coasts as far as Sri Lanka—1,700 miles away from the epicentre.\(^{18}\) Thailand and India also were hit hard, with wave heights reaching as high as seven to 10 metres. In the Maldives, the tallest waves were four metres high, which may seem small when compared to the tsunami waves in Indonesia, Sri Lanka, India, and Thailand. But they were large when compared to the average land elevation of just 1.5 metres in the islands comprising the Maldives. In some cases, tsunami waves entirely engulfed some of the country’s islands, leaving the people inhabiting them with no way to escape.\(^ {10}\)

Tsunami wave heights, inundation levels, population densities, and local infrastructure can explain a great deal about differences in the number of injuries and deaths and the destruction that occurred in various Indian Ocean communities on 26 December. Understanding the injuries, deaths, and damages that occurred in regions close to the epicentre and fault line, however, is more complex.

**The Earthquake**

In those areas close to the epicentre, including Indonesia’s Aceh province and India’s Andaman and Nicobar Islands, the disaster that unfolded on 26 December began not with the tsunami, but with the earthquake that occurred before it. Aceh province and the Andaman and Nicobar Islands suffered not one, but two disastrous events—an earthquake greater than all of the earthquakes from the previous five years combined and the most destructive tsunami in recorded history. Although destructive earthquake shaking did not travel as far and wide as the destructive tsunami waves that followed, the earthquake seemingly took a heavy toll in Aceh province and the Andaman and Nicobar Islands. Unfortunately, few efforts have been made to distinguish earthquake damage from tsunami damage in Aceh province or the Andaman and Nicobar Islands—little is known about how much damage the earthquake caused.

The Sumatra-Andaman earthquake marked an unusual event in the earth’s natural history, but the attention gathered by the even more unusual and widely destructive Indian Ocean tsunami overshadowed the attention given to the impact of the earthquake. In the Andaman and Nicobar Islands, the disaster was deadly, and hundreds of thousands of people were left homeless, displaced, and in need of assistance.
Islands and Aceh province, the shift of the tectonic plates was so great that it reshaped some landmass. In some cases, the shifts dropped beaches below sea level and they disappeared into the sea. Other areas that had been below sea level were uplifted to above sea level, thus expanding coasts toward the sea.

The earthquake also was impressive in the length of fault that ruptured. An astounding 1200 to 1300 kilometres of curved plate boundary between the Indo-Australian plate and Eurasian plate ruptured (Figure 3.5), more than double the length seismologists initially had believed. The rupture began less than 200 kilometres off the northwest coast of Sumatra at 00:59 UTC. It then ruptured northward at a rate of about 2.8 kilometres/second for approximately eight minutes, the longest earthquake rupture ever recorded. The first 650 kilometres of the Sumatra-Andaman fault rupture is believed to have generated the tsunami. The remaining section of the rupture, which continued north and more slowly than the first 650 kilometres, is not believed to have generated tsunami waves.

Although the seismic waves that the earthquake generated were not as widely destructive as the tsunami waves it produced, the seismic waves traveled much faster. Seismic waves reached Indonesia almost instantaneously, Sri Lanka in four minutes, Europe and Antarctica in 12 minutes, and everywhere else on earth within 21 minutes. However, as the seismic waves traveled further from the earthquake epicentre, they became weaker. For the most part, seismic shaking detectable by humans only occurred in countries surrounding the Indian Ocean (Figure 3.7).

In communities in which people felt the earth shaking, the duration and intensity of the shaking they felt varied depending on many factors. Earthquake magnitude and distance from the epicentre are important measures determining how hard and for how long a given community will experience shaking. But many other factors also determine earthquake shaking, such as local geographic sediments, and the depth of the earthquake’s epicentre. Ground made of soft, wet sediments will shake like a bowl of jelly when an earthquake strikes, and shaking can last three times longer than it would if the ground were composed of hard granite. Also, the depth of an earthquake starting point below the surface of the earth’s crust, known as an earthquake’s focal depth affects the amount of shaking; greater shaking if the epicentre is shallow rather than deep.

No single method can determine the amount of shaking that has occurred in a community that has experienced an earthquake. Shaking can be directly measured by a strong-motion seismometer, but there were no strong-motion seismometers in the Indian Ocean basin to record the intensity, scale, and magnitude of the Sumatra-Andaman earthquake. Little is known about how hard or for how long shaking occurred in areas close to the epicentre of the earthquake other than what was gathered from witness reports, such as those obtained by an on-line survey conducted by the US Geological Survey (USGS). In the survey, 363 earthquake witnesses reported the intensity of the shaking that they felt using the Mercalli Intensity Scale, which ranks earthquake intensity on a scale of I to X, with “I” indicating the earthquake was not felt, and “X” indicating extreme shaking and damage. According to the survey, witnesses in the Indonesian cites of Banda Aceh and Meulaboh reported the greatest shaking (Figure 3.8). When averaged, the 15 reports obtained from persons in Banda Aceh and four reports received from Meulaboh rank the shaking that occurred in the two cities as a IX on the Mercalli Intensity Scale; witnesses reported the shaking was violent and heavily damaging. Banda Aceh and Meulaboh are the closest points to the epicentre from which the USGS received responses. The furthermost point from which a respondent reported having felt the earthquake, was in the Maldives, 2477 kilometres from the epicentre of the earthquake. Twenty-five Maldivian respondents reported that the earthquake averaged a score of IV.
The characteristics of the Sumatra-Andaman earthquake were ideal for the generation of a tsunami. To create a tsunami, an earthquake must have a large magnitude and abruptly deform the sea floor. Earthquakes with magnitudes of <6.5 rarely produce tsunamis, and earthquakes with magnitudes of <7.6 rarely produce destructive tsunamis. The stress released between colliding plates beneath the seafloor in the Indian Ocean on 26 December 2004 resulted in an earthquake magnitude rarely observed by seismologists. Calculations following the Sumatra-Andaman earthquake estimated it had a magnitude of at least 9.1 and possibly as high as a 9.3.23

The Making of the Tsunami

An earthquake most likely to abruptly deform the seafloor and trigger a tsunami, is created by a vertical slip between tectonic plates, occurs in deep water, and has a shallow focus relative to the seafloor surface (Figure 3.9). An earthquake created by a vertical slip between two tectonic plates, known as a thrust earthquake, is far more likely to create a tsunami than is an earthquake created by two plates slipping past one another horizontally, known as a strike-slip earthquake. In a thrust earthquake, two overlapping plates are thrust toward one another. As the fault between the two plates ruptures, the densest plate slips beneath the other, a process known as subduction, and can result in a sudden rise or fall in part of the seafloor. If a sudden and large vertical movement in the seafloor results, it will displace the column of water above it. Not only was the Sumatra-Andaman earthquake a thrust earthquake, it was a megathrust earthquake. Like a thrust earthquake, a megathrust earthquake is created by vertical slippage, but a fault that creates a megathrust earthquake remains locked for longer periods of time, allowing it to build up more stress.

The water displaced by an abrupt change in the seafloor is not unlike the water displaced by a rock thrown into a pond. This displaced water creates waves that disperse the energy of the displacement by radiating outward like ripples on the pond’s surface. An earthquake that occurs below deep ocean water can displace more water and is more likely to create a tsunami than is an earthquake that occurs below shallow water.

Finally, an earthquake’s focal depth, or point of stress release relative to the seafloor surface, also determines whether it will produce a tsunami. An earthquake with a shallow focus is more likely to abruptly change the contour of the seafloor and, therefore, produce a damaging tsunami. On the other hand, an earthquake with a deep focus, might not cause a change in the surface of the seafloor. The Sumatra-Andaman earthquake had a focal depth of less than 70 kilometres, shallow by earthquake standards and close enough to the seafloor surface to create a vertical displacement of the seafloor of up to five metres.

The section of fault that created the Indian Ocean tsunami has put centuries of built-up stress to rest and is unlikely to generate another major earthquake for some time. Unfortunately, it is not the only section of faults in the region capable of generating a tsunami. As mentioned, a section of fault located south of the fault that ruptured during the Sumatra-Andaman earthquake is believed to pose a hazard that may create a tsunami in the Indonesian coast south of Aceh. Should this fault rupture and produce a tsunami in the near future, Indonesians should be better prepared. Indonesia now is processing events in real time, has established a strong seismic network, and has installed new water-level instruments that report water-level data in real time. Perhaps even more importantly, tsunami awareness has grown, such that seemingly the next time an earthquake occurs and the sea withdraws from the coast, fewer Indonesians will wait along coasts to see what happens next.

Indonesia is not the only country in South-East Asia that faces a hazard (fault) likely to create a tsunami and many South-East Asia coastlines are not better prepared for another tsunami. The same seismologist (Phil Cummins) who anticipated the Indian Ocean tsunami, has warned that a second fault in the Bay of Bengal could produce another major tsunami.16 The
area Cummins suggests could be impacted by such a tsunami includes an area populated by 60 million people, including the cities of Kolkata and Dhaka. Large tsunami waves could be particularly damaging in the north of the bay where a huge, low lying, delta region would likely be heavily penetrated by a tsunami. Although such an earthquake may not occur for as long as 200 years, it could be much sooner.

Summary

The 2004 Indian Ocean tsunami was the result of the largest earthquake in more than 40 years. The megathrust earthquake displaced the water above it generating a massive, multi-wave tsunami with wave heights of more than 30 metres. In Indonesia and the Andaman and Nicobar Islands of India, even if there had been a tsunami warning system in place at the time of the earthquake, it would not have been possible to have achieved an evacuation in time to save the most lives. Different characteristics of the seafloor, in part, determined the differences in velocity of the tsunami as it reached the five countries most affected by the event(s).

People interviewed

Stuart Weinstein, Geophysicist and Assistant Director of the Pacific Tsunami Warning Center, Honolulu, Hawaii, United States

Seth Stein, Professor, Department of Earth and Planetary Sciences, Northwestern University, Evanston, Illinois USA

Robert Morton, Research geologist, US Geological Survey Center for Coastal and Watershed Studies, St. Petersburg, Florida, USA

Vasily Titov, Chief Scientist, National Oceanic and Atmospheric Administration Centre for Tsunami Research

References


11. NOAA National Geophysical Data Center. 


Figure 3.1: Areas hardest hit by the Indian Ocean tsunami. The earthquake’s epicentre—point on the Earth’s surface above the earthquake’s origin—occurred off the northwest coast of Indonesia.


Figure 3.2: Persons investigating the sea floor associated with the withdrawal of water from the shore prior to the impact of the first tsunami wave. (Photograph found in the camera of a photographer killed by the tsunami)

Figure 3.3: Tsunami wave energy propagated primarily to the east and the west of the Sumatra-Andaman fault which ruptured roughly south to north. This map indicates tsunami wave heights at sea.

Figure 3.5: As tsunami waves approach shore and a rise in the seafloor, their wave lengths shorten and wave heights grow in a process known as shoaling.


Figure 3.4: Indian Ocean model and tsunami simulation. Of the 1200 kilometres of seafloor ruptured by the earthquake, the first 650 kilometres ruptured the fastest and generated the tsunami. The strongest waves propagated east and west of the rupture. Waves traveling to the east of the rupture, however, traveled slower than did those that traveled to the west because shallower ocean waters to the east slowed the waves.


Figure 3.6: Sumatra subduction zone. The epicentre of the Sumatra-Andaman earthquake is marked by the yellow star. The Sumatra-Andaman earthquake ruptured 1200 to 1300 kilometres of seafloor from the northeast to the northwest with an epicentre located off the northwest coast of Sumatra island.

Figure 3.8: The amount of shaking in areas of interest using the Mercalli Intensity Scale. Circle size corresponds with the size of the city from which reports were made, with large circles representing big cities and small circles representing small cities. *USGS used the original Mercalli Intensity Scale as shown here rather than the Modified Mercalli Scale adopted in 1931.

<table>
<thead>
<tr>
<th>Intensity</th>
<th>I</th>
<th>II-III</th>
<th>IV</th>
<th>V</th>
<th>VI</th>
<th>VII</th>
<th>VIII</th>
<th>IX</th>
<th>X</th>
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<td>Moderate</td>
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<td>Very Strong</td>
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<td>Extreme</td>
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<td>None</td>
<td>Very light</td>
<td>Light</td>
<td>Moderate</td>
<td>Moderate/Heavy</td>
<td>Heavy</td>
<td>Very heavy</td>
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</tbody>
</table>


Figure 3.9: When the Sumatra-Andaman fault ruptured, it released centuries of built up stress between two colliding tectonic plates, creating a sudden and abrupt change in the seafloor that displaced the column of seawater above it, which generated the Indian Ocean tsunami.
Table 3.1: Earliest arriving tsunami wave times in the countries hardest hit by the tsunami. The earliest arriving wave was not necessarily the largest or most destructive. Kenya is the furthest country from the earthquake epicentre in which the tsunami resulted in a fatality. (A & N = Andaman and Nicobar; min = minutes; km = kilometres)

<table>
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<tr>
<th>Country</th>
<th>Earliest tsunami wave arrival time</th>
<th>Time elapsed between earthquake (00:59 UTC) and earliest wave arrival (min)</th>
<th>Approximate distance from tsunami epicentre (km)</th>
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<td>1:14</td>
<td>15</td>
</tr>
<tr>
<td>India A &amp; N Islands&lt;sup&gt;5&lt;/sup&gt;</td>
<td>06:19</td>
<td>1:19</td>
<td>20</td>
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<tr>
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<td>2:51</td>
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<tr>
<td>Sri Lanka</td>
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<td>2:55</td>
<td>116</td>
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<tr>
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<td>12:56</td>
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Part III
Country Reports
Chapter 4
India
India

Events

In the village of Tranquebar in the Nagapattinam district of the State of Tamil Nadu of India (Figure 4.1), villagers intimately understood the dangers of the ocean. More than three out of four of the village's families earned their living through fishing, and many had lost family members to the sea. But on the morning of 26 December 2004, when waves higher than 4 metres charged into Tranquebar, the ocean unleashed a level of destructive power that shocked even the village's most experienced fishing families.¹ In the neighbouring village of Porayar, disaster management specialist Samuel Manuel also was caught off guard. Samuel initially responded with disbelief when he first heard seawater had flooded the coast and threatened his church, located more than one km inland from the beach in Tranquebar.

At approximately 09:30 hours (h), Samuel had been sitting in his church listening to a sermon in the village of Porayar, when two boys rushed into the church and told him that “the sea was coming”. At first, Samuel thought the boys were pulling a prank. In the 45 years that he had been living in the area, he had never heard of seawater flooding as far inland as Porayar. Samuel sent a friend on his motorbike to look into the matter. His friend quickly returned yelling that “the water is coming”, but was so panicked that he couldn’t properly explain what he had seen. The church’s pastor ended his sermon and told members of the congregation to seek safety.

While the villagers from Tranquebar were fleeing inland, carrying luggage on their heads and bringing children in tow, Samuel rode his motorcycle towards the shore rather than away from it. At this point, the second of two large tsunami waves that had hit shore was receding, and Samuel saw that the water had reached inland to within just a few hundred metres of his church. As Samuel drove his motorcycle toward shore, fleeing villagers tried to turn him around. But, Samuel continued to head to the shore even as his motorcycle skidded dangerously in the mud and ankle-deep water. When he finally reached the shore at about 10:00 h, he was surrounded by dark water, debris, dead bodies, and cries for help. Able-bodied villagers all had fled, leaving seriously injured and trapped survivors stranded among the debris with no one to rescue them. Samuel rushed to the nearest main road to find help to evacuate injured survivors. Although two or three vehicles filled with anxious villagers sped by without stopping, one van with 12–15 young men stopped to help. Samuel and the young men found many badly injured survivors caught in the

¹Only the health (medical care and public health) literature was extensively searched. Findings relative to the other Basic Societal Systems were identified in the searches of Public Health and Medical Care Systems.
Drugs and medical supplies were donated from local drug stores to help fill some of the gaps, and thus, helped to ensure that some supplies were available to treat some of the victims.

Before the tsunami, a large proportion of Tranquebar’s population had been living in government housing built of unreinforced cement that collapsed when the tsunami waves struck. As he rescued survivors, Samuel lifted slabs of concrete four times heavier than what he could normally lift. Together, Samuel and the young men rescued more than 200 injured survivors and carried them to the road where they stopped vehicles to transport the injured to the government hospital in Porayar.

However, immediately following the tsunami, there was a severe shortage of medical personnel and no doctor was available at the Porayar hospital and no medical staff was available to care for the injured survivors at three of the other area hospitals. The tsunami had ruined a government hospital in Tranquebar, two private hospitals had been closed for the holidays, and Porayar hospital’s three doctors were all out of town.

Fortunately, one local doctor came to the injured survivors’ aid. Samuel’s wife, Priscilla, was a doctor who normally worked for a hospital 12 km outside Porayar. But on the morning of 26 December, Priscilla had been in Porayar attending church with her husband. After the pastor had abruptly ended the sermon, Priscilla returned home, just a short distance from the church. At about 10:30 h, some villagers arrived at her house seeking treatment for an unconscious boy. The villagers explained that there was no doctor at the Porayar hospital, and further told her that many injured victims were seeking treatment there. On hearing this, she rushed to Porayar hospital to offer her help, and found the hospital crowded with patients. The Porayar hospital had just 50 beds; these had filled quickly and injured survivors were lying all around the hospital. Many unskilled volunteers assisted at the hospital, but few skilled medical professionals were available. A staff nurse, two maternity assistants, and a pharmacist helped Priscilla treat some 300 victims, but no other doctor arrived for more than 24 hours following the tsunami. As a small hospital, Porayar did not have sufficient amounts of drugs and medical supplies to treat the sudden influx of patients. However, drugs and medical supplies were donated from local drug stores to help fill some of the gaps, and thus, helped to ensure that some supplies were available to treat some of the victims. Some of the victims were in critical condition, and needed higher levels of care than was available at the Porayar hospital. An unknown number of critically injured victims died after reaching the hospital; however, many also were stabilized, and then taken by volunteers to the district’s main hospital, Mayiladuthurai, approximately 30 km from the Porayar hospital. Transferred victims included those who had suffered severe head injuries, broken bones, spinal injuries, near drowning, and/or traumatic asphyxia from being buried under heavy objects. The Porayar hospital did not have any mechanical ventilators. All that could be done was to use suction to clear the airways of those survivors who had inhaled dirty seawater, and to provide some of the victims with supplemental oxygen using one of the four oxygen tanks available at the hospital.

Priscilla and her small medical support team worked tirelessly throughout the day. As the evening approached, fewer and fewer victims arrived at the hospital; by 11:00 h, only dead bodies were being brought to the hospital. By 01:00 h, Priscilla and her makeshift support team had tried to treat as many of the injured survivors that had arrived at the hospital that they could. On the day following the tsunami, the need for treatment of victims with injuries was minimal, but the need to deal with the dead was great. Of the 6991 residents of Tranquebar, 260 had died and their bodies had been brought to the Porayar hospital. On the day after the tsunami, a doctor who arrived to help treat the victims instead spent most of the day managing the dead.
Analysis
This case illustrates several important issues associated with the medical care of victims of the tsunami in Tranquebar: (1) only one local physician was available; (2) nurses, paramedical personnel, and untrained workers provided necessary first aid, and demonstrated the value of these first responders in providing life-supporting first aid; (3) almost all of the injured victims arrived at the hospital within the first 24 hours following the tsunami; (4) supplemental, essential supplies (life-saving support) were procured from local, private resources; (5) limited available resources may have prevented potentially salvageable lives from being preserved; (6) the need for adequate transportation capabilities and communications was great; and (7) the dead were brought to the hospital. These findings underscore the importance of the preparedness of local individuals; had they received life-supporting first-aid training and training in performing triage, possibly even better results could have been achieved. Additionally, it is possible to designate the longitudinal phases into which each of the occurrences fit: (1) the event; (2) the damage created by the event; (3) the inability of the hospital to manage the surge in the number and the severity of the injuries of the victims; and (4) the relief responses. This facilitates the comparison with what occurred in other areas.

Damage
Unfortunately, the devastating consequences of the tsunami in India did not begin or end in Tranquebar. Before the day’s end, the tsunami had devastated many coastal communities along the mainland of India and in the Andaman and Nicobar Islands. Along India’s coasts, the tallest tsunami waves reached as high as 15 metres and took 12,405 lives. In India, tsunami-impacted coasts were located both very near and very far from the Sumatra-Andaman earthquake epicentre (Figure 4.1). The closest impacted Indian coast was located in the Andaman and Nicobar Islands, just 470 km from the earthquake’s epicentre, and nearly as close to the epicentre as was Indonesia. The furthermost impacted Indian coast, located in the state of Kerala, was more than 2,000 km from the earthquake’s epicentre, and is part of India’s west coast that did not face the epicentre.1

The territory of the Andaman and Nicobar Islands experienced the largest and earliest arriving tsunami waves in India. The islands not only encountered tsunami waves as high as 15 metres, but also experienced destructive earthquake shaking before the tsunami arrived. While many communities surrounding the Indian Ocean felt weak or moderate earthquake shaking, only in the Andaman and Nicobar Islands and Indonesia did the earthquake result in destructive shaking and other earthquake-triggered events before tsunami waves arrived. In the Andaman and Nicobar Islands, three phenomena occurred just before the tsunami—heavy earthquake shaking, volcanic mud eruptions, and land elevation shifts.2

Precisely how much earth shaking occurred in the Andaman and Nicobar Islands is unclear. The only instrument available to record seismic data in the territory, a strong motion seismometre in its capital city of Port Blair, failed to record the earthquake.3 Thus, reporting on how much shaking occurred in the territory relies mostly on damage assessments and accounts of witnesses in Port Blair, about 500 km from the earthquake epicentre than is the territory’s southern-most island. In Port Blair, witnesses reported that the earthquake began to shake weakly at about 0635 h local time, and then intensified until people no longer could remain standing. Witness accounts report three to five minutes of shaking, with the strongest shaking lasting about 40 seconds. In Port Blair, the earthquake caused minor damage to many public buildings and severely damaged or even destroyed a few poorly built concrete buildings.3–5

How much earthquake shaking occurred in the islands south of Port Blair and closer to the epicentre is even more enigmatic. In the territory’s southern district of Nicobar, earthquake shaking accounts were poorly catalogued—the damage to the local infrastructure of mostly one-storey wooden
structures caused by the tsunami, generally erased evidence of earthquake damage. But due to their close proximity to the earthquake’s epicentre, it is likely that the southern-most Nicobar Islands experienced much greater shaking than in Port Blair and other in communities in the Andaman district.\(^3\)

Aside from the shaking, the rupture of the Sumatra-Andaman fault resulted in two additional phenomena before the arrival of the tsunami, one of which would irreparably damage many coastal communities and ecosystems. After the earth began to shake and before the arrival of the first tsunami wave, several mud volcanoes awakened from dormancy, and land elevations shifted. The eruptions spewed mud several metres into the air and could be heard as far as 3 km away. But, the eruptions occurred on the uninhabited side of the island of Baratang, and this did not result in fatalities or infrastructure damages. Land elevation shifts, however, created permanent changes to the island’s geography that would seriously disrupt the lives of islanders.\(^4\)

Earthquake-triggered subsidence and uplift, submerged coastal communities, destroyed valuable coastal ecosystems and, in some areas, compounded the devastating impact of the tsunami. Changes in land elevation were particularly devastating in the Nicobar Islands, where subsidence of up to four metres submerged mangrove forests and permanently swamped Nicobari villages with seawater. Also, land subsidence amplified the impact of the tsunami, by lowering inland areas to within easier reach of the destructive waves.

Evidence of subsidence in the Nicobars persists. On Great Nicobar island, ocean waves now surround a 100-metre red and white lighthouse that once towered over the white sandy beaches of Indira Point (Figure 4.2).\(^6\) While the earthquake rupture created subsidence in the Nicobar Islands, it caused mostly uplift in the Andaman islands, the northern portion of the territory. While overall, the earthquake triggered greater subsidence than uplift, uplifted islands also suffered coastal damages. Along some coasts, uplift of up to two metres destroyed coastal ecosystems, as coral reefs were lifted out of the ocean and mangroves drained.

Uplift and subsidence did not occur concurrently with earthquake shaking, but were delayed, phenomena that complicated later efforts to determine when the first tsunami waves arrived. In Port Blair, subsidence of about 1–1.5 m is believed to have occurred more than 30 minutes after the earthquake. Around the same time (07:14 h), a Port Blair tide gauge recorded an unusual rise in water levels, but not enough data are available to determine whether the rise resulted from subsidence or marked the arrival of the first tsunami wave.\(^3\) Within the 800 km north to south Andaman and Nicobar Island chain, tsunami wave arrival and height varied greatly from island-to-island, but little instrumentation data are available to sort out the differences. However, tsunami waves are believed to have arrived within minutes of the earthquake in the southern-most islands of the district of Nicobar, and sometime between 07:15 and 07:25 h in Port Blair.\(^5,6\)

When the tsunami arrived, it pummeled islands with 3–5 waves which were 1.5–15 metres high which in some areas, penetrated > 1 km inland.\(^7\) The largest tsunami waves and almost all of the tsunami destruction occurred in the Nicobar Islands, which were in close proximity to the tsunami-generating segment of the earthquake fault.\(^4\)

Many of the Nicobari Islands are flat and had low land elevations even before the earthquake-triggered subsidence. The combined impact of subsidence and the subsequent tsunami waves destroyed nearly the entire infrastructure on these islands and, in some places, rendered them almost unrecognizable. On the Nicobar island of Trinket, the combination of subsidence and powerful tsunami waves cut the island into three pieces and dramatically changed the island’s coastline (Figure 4.3).\(^6\) The combined effects of the earthquake and tsunami have permanently
changed the geography of the Andaman and Nicobar Islands.

By the time the last tsunami wave receded from the shores of the Andaman and Nicobar Islands, 35,133 lives had been lost, almost all of them in the Nicobar Islands. But even as the last tsunami wave receded from the shores of the Andaman and Nicobar Islands, many thousands of Indian lives remained in danger.

Two hours after the Sumatra-Andaman earthquake, and long after the tsunami waves had retreated from the Andaman and Nicobar Islands, the tsunami still had not yet reached the Indian mainland. Yet, as the tsunami continued to make its way across the ocean toward the mainland of India, residents along the mainland coasts remained unaware of the danger. Officials in Delhi had learned about the earthquake that occurred in the Andaman and Nicobar Islands, but not about the tsunami. In the midst of colossal devastation and disrupted communications due to the tsunami, local officials were not able to alert the rest of the country and lost the opportunity to spare the lives of mainland Indians.4

In the nearly two hours that separated the tsunami’s arrival in the Nicobar Islands from its arrival along the coast of the Indian mainland, the tsunami’s energy attenuated. In contrast to the Nicobar Islands, the mainland coasts impacted by the tsunami were heavily developed and densely populated. The earliest tsunami waves arrived along the shores of the mainland of India at about 09:05 h—approximately two hours and 40 minutes after the earthquake5—and had its greatest impact in the state of Tamil Nadu and the territory of Puducherry, a small Tamil Nadu enclave (Figure 4.4).6,7 Along the 1000 km of Tamil Nadu coast, the tsunami reached a height of nearly 6 m and was associated with the deaths of 8,009 people; along the 25 km of Puducherry coast, it reached a height of 6.5 metres and killed 599 people.8

Within Tamil Nadu, the greatest human toll occurred in the coastal district of Nagapattinam. Population density, high tsunami waves, low land elevation, and the presence of the Uppanar River and Vedaraniyam Canal allowed the tsunami to penetrate >2 km inland and took more than 6000 lives. In the Nagapattinam fishing harbour, the tsunami severely damaged hundreds of fishing boats, bulldozing many of them into piles that trapped fishermen inside (Figure 4.5).8,9

The tsunami also took lives in the state of Kerala, where 177 people died and in the state of Andhra Pradesh, where 107 people died. The extent of the tsunami’s impact in Kerala was somewhat unexpected, since Kerala was located in the “shadow zone” with respect to the propagation direction of the tsunami. Tsunami waves arrived in Kerala at 11:10 h, approximately four hours and 40 minutes after the earthquake.11,12 To reach Kerala’s west-facing coast, tsunami waves had to wrap around Sri Lanka and the southern tip of India and shift their propagation from west to east. Tsunami waves arriving in Kerala are likely to have received a boost from the coinciding high tide energy bouncing off of the Chagos Laccadive Ridge, a steep underwater ridge located southwest of India’s mainland. The greatest tsunami devastation in Kerala occurred in areas surrounding the Kanjiragad inlet in Kollam District where the coastal and seafloor features allowed the tsunami to reach a height of 5 metres; it killed 132 people who were within close proximity of the inlet.10–12

Whereas coastal and seafloor features amplified the impact of the tsunami in places like Kerala’s Kollam district, in a few instances, they reduced the tsunami’s impact along Indian coasts. Along some of the coasts, steep coastal topography blocked extensive inland inundation or dense vegetation and extensive sand dunes absorbed some of the tsunami’s energy. For example, south of Chennai, where the Vellar River empties into the ocean, dense vegetation acted as a bio-shield to reduce the destructive impact of the tsunami.13

With the withdrawal of the last tsunami wave from the Kerala coast, the ocean around India’s
coast resumed its normal rhythm. But it would be a long time before the lives of the people along India’s tsunami-impacted coasts resumed normalcy. With 150,000 homes damaged or destroyed, and many thousands of livelihoods lost, a long path to recovery lay ahead. And some losses were beyond recovery. The 12,405 lives lost represented family members and friends who would never return.

In summary, the events of the day wreaked havoc on the Andaman and Nicobar Islands where it is unlikely that enhanced communications systems and tsunami warning devices could have been effective in moving the population out of harm’s way before the arrival of the tsunami. However, tsunami warning systems between the Andaman and Nicobar Islands and the mainland of India could have facilitated evacuation of many people in the coastal regions.

**Population impacted**

Of all the countries impacted by the tsunami, India was the largest and had the greatest population; India has nearly 3,287,000 km² of land and a population of over 1.1 billion. India has an overall population density of about 125 people/km² and approximately 72% of its population live in rural areas. With the exception of the territory of the Andaman and Nicobar Islands, the tsunami-impacted areas tended to be more densely populated than the nation as a whole. For example, the southern states of Tamil Nadu and Kerala had an average of 495 people and 841 people/km² respectively. And in Tamil Nadu, the population had a greater tendency to live in urban areas than did the national population as a whole. With 42% of its population living in urban areas, Tamil Nadu is the country’s most urbanized state.

In contrast to other tsunami-impacted areas of India, the Andaman and Nicobar Islands were sparsely populated. The island territory’s population had a density of just 49 people/km², and inhabited only 36 of the territory’s 572 islands. The islands are separated into two districts, the Andaman district to the north and Nicobar district to the south. Of the approximately 395,000 people living in the Andaman and Nicobar Islands, almost 90% lived in the Andamans. Consequently, the population density of the Nicobar Islands was even lower than that of the territory as a whole—just 23 people/km². The low population density in the Nicobar Islands helps to explain why more deaths did not occur there than along the mainland, even though the Nicobar Islands faced considerably larger tsunami waves than did the mainland. The tsunami took the lives of nearly twice as many people in the Tamil Nadu district of Nagapattinam on India’s east coast than it did in the Nicobar Islands (Table 4.1) despite the fact that Nagapattinam had a population density 26 times greater than the Nicobar Islands. If the population density of the Nicobar Islands had been equivalent to that of Nagapattinam, the tsunami may have resulted in tens of thousands of fatalities. This fact offers little consolation, however, to the Nicobar Island community, which lost nearly 3,500 people out of a population of only 42,000 (8.3%).

**Public (population/preventive) Health and Disease Control in India**

**Pre-events**

In the years leading up to the tsunami, India had made economic strides that would soon lift the country from its low-income economic status to a lower-middle income status. During this period, India’s public health status also improved. But improvements in public health indicators advanced slowly, remaining closely in-line with what would be expected of a low-income country. As in other low-income countries, the burden of communicable diseases, reproductive health issues, and nutritional deficits weighed heavily on public health. Approximately 36% of all deaths in India were caused by maternal and perinatal health issues, nutritional deficiencies, and communicable diseases compared to 32.1% world-wide, and 13% in the neighbouring country of Sri Lanka (Figure 4.6).
In the years following India’s independence from the British in 1947, the country witnessed improvements in many population health indicators. From 1951 to 2003, India’s crude death rate decreased from 25 to 8/1000 population, and life expectancy increased from 36 years to 62.5 years. Additionally, infant mortality rates decreased by half from 1970 to 2004, and maternal mortality rates decreased by about one-quarter from 1997 to 2003. But these and other health achievements failed to meet India’s health goals; health in India was improving more slowly than in many neighbouring Asian countries including Sri Lanka, China, Thailand, Indonesia, and Malaysia.14,24

Even with improvements in the mortality rates, India’s maternal mortality rate remained grim (Table 4.2). With 301 maternal deaths/100,000 births in 2003, India had one of the highest maternal mortality rates in the world.21 And, a large proportion of maternal deaths were due to preventable causes, including the 41% related to anaemia and/or hemorrhaging.24,25

India’s infant mortality rate also was high with 58 deaths/1000 live births.14 Sixty-four percent of infant fatalities occurred during the neonatal period. One of the factors that contributed to high maternal and infant fatality rates was poor nutrition primarily among women and children. About one-third of India’s newborns had low birth weight (<2500 grams)—a condition that increases a child’s likelihood of dying at a young age. Additionally, India’s high malnutrition rates were believed to have contributed to 50% of all child deaths.21,28-30

In addition to poor reproductive health and high malnutrition rates, India also faced a number of persistent communicable diseases, of which tuberculosis (TB) and malaria were among the most serious (Table 4.3).24,27 Tuberculosis took more lives in India than any other communicable disease. Each year, India lost 327,000 lives to tuberculosis, and had a TB incidence rate of 16.8/10,000 population in 2004; it reported more new cases of TB annually than any other country.24,27 In 1962, India initiated a tuberculosis control programme that would eventually become one of the world’s largest public health programmes. The programme was largely ineffective until it was revised in 1993, after which the curative success rate increased. At the same time, however, the management of tuberculosis was complicated by the emergence of AIDS, which makes people infected with HIV more susceptible to tuberculosis. And, while curative rates increased, little progress was made in decreasing incidence.24-30

As with tuberculosis, India also had a long and difficult history with malaria. The disease had nearly been eradicated in the mid-1960s, but resurfaced in the 1970s. In the decade leading up to the tsunami, 2 to 3 million cases were reported annually. In 2004, India reported an incidence of 17.7 cases/10,000 population.28-32 Aside from tuberculosis and malaria, India also struggled with high rates of acute respiratory infections and diarrhoea.20-32 In 2004, India had a staggering acute respiratory infection rate of 235.7/10,000 population, and an acute diarrhoea rate of 95.4 cases/10,000 population. Diarrhoea and acute respiratory infections took a particularly heavy toll on children, accounting for 46% of under-five year old childhood deaths.28-34

Although some of India’s communicable disease problems improved following the introduction of the Universal Immunization Programme in 1985, population health did not reap the full benefits of this programme due to poor vaccination coverage. In 2004, vaccination rates ranged from a low of 56% for measles to a high of 79% for three doses of Hepatitis B (Table 4.4).32 By 2004, several neighbouring countries had achieved much higher coverage rates; Thailand, Sri Lanka, and the Maldives all had measles coverage rates of 96% or higher.20,31 Although the burden of measles declined following the introduction of the Universal Immunization Programme, India seemingly had not realized the full preventative potential of the measles vaccine. Between 1985 and 2004, the interval between measles outbreaks decreased from approximately one
every three years to one every five years. Yet, in 2004, measles was responsible for more childhood fatalities than any other viral infection, and although India reported a measles incidence of 0.48/10 000 population in 2004, this may be an underestimate of the true measles incidence.

In addition to poor vaccine coverage, poor surveillance also hampered efforts to reduce communicable disease problems. Accurate and timely disease surveillance is key to measuring disease burden, detecting outbreaks, and instituting effective control measures. In India, however, gaps in surveillance sometimes prevented quick detection of outbreaks and under-reporting of true incidence for many communicable diseases. For example, the true incidence of malaria and measles may have been much higher than the officially reported. Several problems plagued India’s surveillance system, including the failure to include a large portion of the medical system in case reporting. Although many patients visit private medical care facilities rather than public facilities, the government did not require private medical care facilities to report communicable disease cases. And although laboratory services were available, their quality was inconsistent. Also, the surveillance system was an aggregation of disease-specific initiatives, which fragmented efforts to collect data.

India has a good capacity to respond to outbreaks and launch intensive campaigns to combat them. Public health programmes compete with other development priorities. As such, some diseases remain uneradicated or controlled.

Failure to detect and effectively control several outbreaks during the 1990s highlighted weaknesses in India’s surveillance system, and prompted national efforts to revamp the system. As a result, India launched the Integrated Disease Surveillance Project. On 8 November 2004, just a little over a month before the tsunami occurred, the project aimed to better coordinate surveillance efforts and encourage greater participation in case reporting from the private sector, although private medical care facilities still were not required to report.

Although India’s average public health indicators were consistent with those of a low-income county, it is important to note that not all of India’s states and territories fit the national profile. Average national population health figures hide a great deal of variation in public (population) health found among India’s 28 states and seven union territories. While the national maternal mortality rate was believed to be 301 deaths/100 000 live births, it ranged from as high as 490 deaths per 100 000 live births in Assam to as low as 110 deaths/100 000 live births in Kerala. On the whole, health indicators were considerably better in the areas that were hardest hit by the tsunami than for the nation as a whole. This was particularly true with respect to the states of Tamil Nadu and Kerala. Compared with the national life expectancy rate of 62.5 years, life expectancy rates for Tamil Nadu and Kerala were 67.6 and 73.4 years, respectively. Additionally, the districts impacted by the tsunami also tended to have higher vaccination rates than the country as a whole. In Tamil Nadu, one-dose measles vaccination coverage exceeded 95%.

Although overall public health indicators pre-event in the region that later would be impacted by the tsunami compared favourably with national averages, these areas did have a number of key public health concerns. In the coastal region stretching from the southern-most region of Andhra Pradesh through the state of Tamil Nadu and extending into south-eastern Kerala, malaria incidence rates generally were low and did not present a major population health problem. But in the district of Nicobar, malaria trends were considerably more troubling. For the Territory as a whole, rates of malaria were only slightly higher than the national average, with 20.8 cases compared to 17.7/10 000 population for the nation as a whole in 2004. But the Territory’s malaria burden decreased substantially on the small population of the Nicobar district, which had a malaria incidence rate of 99.4/10 000 population.
**Damage to Public Health**

Injuries and deaths related to the injuries are human damage. India reported at total of 19,592 persons injured (reported to medical facilities and accounted) of which 12,405 (63.3%) died and 7,187 (36.7%) survived (Table 4.1). Almost all (84.1%) of the injuries caused by the earthquake and the tsunami occurred in the Andaman and Nicobar Islands (25.7%) and in Tamil Nadu (58.4%). Of the 13 tsunami-impacted districts in Tamil Nadu, Nagapattinam alone accounted for 75% of that state’s 8009 tsunami fatalities.36-39 Along its 188 km coast, Nagapattinam lost 6000 lives or about 32 fatalities/km of coast.37 Injuries and deaths also were particularly high in the Nicobar district. Of the 3513 fatalities that occurred in the Andaman and Nicobar Islands, almost all occurred in the Nicobar Islands. Lives were also lost in two additional states and one union territory. The tsunami took an additional 599 lives in Puducherry, 177 lives in Kerala, and 107 lives in Andhra Pradesh.

Overall, only 36.7% of the injured victims who presented to medical facilities survived (Table 4.1). The numbers of injured that presented to private facilities are not accounted. In three of the states, only 30% of those injured, survived. However, in the state of Puducherry, 48.3% of those injured survived, and in the state of Kerala, 90.1% of those injured survived. It is of note that the wave heights that impacted Puducherry were the lowest of the states impacted, and the tsunami did not reach Kerala for more than four hours after the first wave that impacted the mainland as it had to wrap around Sri Lanka and change direction from west to east to west. Although the overall numbers of injured in Puducherry were only 6.0% of the total number of injured reported for all of India, the burden on the affected population was second highest (12.8/10 000 population) among the impacted states. The Andaman and Nicobar Islands experienced the greatest burden with 55.5 persons injured/10 000 population (more than four times that of any of the other states) and 10 times the number of deaths/10 000 population of any of the other states. The reasons for the differences in the survival rates between the states are not clear, but should be explored.

As noted, the Andaman and Nicobar Islands experienced the highest wave heights and also experienced the effects of the earthquake.36-42 The types of injuries encountered in the Andaman and Nicobar Islands could not be identified.

There were no epidemics reported directly related to the tsunami. Shortly after the tsunami, however, epidemiologists became concerned when a rise in the number of measles cases was detected in Tamil Nadu. On 30 December, the emergency surveillance system detected a cluster of measles cases in an IDP camp in the district of Cuddalore. In the six weeks following the tsunami, 101 measles cases were reported in Cuddalore, with the number of reported cases peaking during the second week following the tsunami.41-48

**Relief Responses in Public Health**

In India, regular exchange of surveillance data between primary health centres and state and district headquarters helped to ensure the flow of surveillance data gathered during the disaster. But, because surveillance efforts had failed to include a large proportion of the Medical Care Basic Societal System, surveillance was less complete in India than in Thailand or Aceh province of Indonesia. In India, post-tsunami surveillance involved only the public sector, which represented only 20% of India’s healthcare services provided at the time.42

Following the tsunami, Indian health authorities identified a list of important communicable disease concerns including vector-borne diseases such as malaria, water-borne diseases such as cholera, and direct-contact diseases such as measles. To protect against vector-borne diseases such as malaria and dengue, relief responders took several measures to reduce breeding of potentially disease-carrying mosquitoes to prevent them from transmitting diseases to tsunami survivors. United Nations and national governmental agencies took the lead in distributing bed nets. Fogging of the camps and
the tsunami-impacted areas was conducted to prevent mosquitoes from breeding in pools of stagnant water. In Tamil Nadu, 10 entomological teams conducted vector control activities in 73 tsunami-impacted villages. In the Andaman and Nicobar Islands, UNICEF stocked local bodies of water with a species of fish with an appetite for mosquito larvae.

To protect against water-borne diseases such as cholera, governmental and UN agencies and various NGOs took several measures to provide survivors with access to sources of potable drinking water. In addition to addressing water quality, responders in the Public Health System also took precautionary measures to enable them to respond should an outbreak of water-borne diseases occur. For example, the UN provided the public health department with cholera kits that could be used to treat up to 2400 people should they become infected with the disease. The WHO “Cholera Kits” contain guidelines for diagnosis and treatment of cholera and shigella dysentery as well as supplies of intravenous fluids, antibiotics (doxycyclin and ciprofloxacin), oral rehydration salts, disinfectants, and culture swabs. Each kit provides enough supplies to treat 100 adults and 100 children.

To protect against measles, health authorities launched measles vaccination campaigns in the two hardest-hit areas of India, the union territory of the Andaman and Nicobar Islands and the state of Tamil Nadu. In Tamil Nadu, the measles vaccination campaign began on 29 December and lasted until 9 January. The campaign targeted children 6-60 months of age in all the tsunami-impacted villages. The campaign reportedly vaccinated 10 319 children—more than 100% of the estimated population of the target population in the state. In the Andaman and Nicobar Islands, the post-tsunami vaccination campaign reportedly boosted measles immunization coverage from 91.0% pre-event to 96.3%.

Post-tsunami vaccinations also included vaccinations for protection against tetanus. In Tamil Nadu, injured victims and sanitary workers received tetanus booster immunizations as part of their treatment. In some cases, however, tetanus immunizations were given to people who were not injured, but who besieged medical teams for the vaccination. Alarmed by media warnings that an epidemic could kill many more persons in the tsunami-impacted areas in the week following the tsunami, many people were anxious to receive some sort of protection. Consequently, in some cases, medical responders sometimes provided survivors with tetanus immunizations as a means of reducing survivors’ anxiety.

Health authorities also kept careful watch over and investigated cases presenting with disease/symptoms. When a cluster of measles cases was detected in Tamil Nadu, health authorities quickly sent a team of Field Epidemiology Training Programme researchers and other disease experts to Cuddalore district to investigate. The team concluded that the outbreak was not likely to have been the result of the tsunami. Although most of the measles cases had been reported in tsunami-affected areas of the district, the rate of reported measles cases actually was higher in the non-tsunami affected area of the district than in the impacted areas.

The National Institute of Communicable Diseases (NICD) and WHO established additional surveillance units in tsunami-impacted areas, including four in Tamil Nadu, four in Andhra Pradesh, one in Puducherry, and three in Kerala. The National Institute of Communicable Diseases (NICD) and WHO established additional surveillance units in tsunami-impacted areas, including four in Tamil Nadu, four in Andhra Pradesh, one in Puducherry, and three in Kerala.
diseases and disease vectors. For example, relief workers worried that bodies and mass graves could become a communicable disease hazard (a persistent disaster myth—there is no evidence that decaying bodies present a health risk), employed several chemicals in the management of fatalities. Consequently, graves commonly were treated with disinfectant chemicals, such as bleach and phenyl. Graves also were treated with lime and bioculum to prevent foul smells and speed decomposition. Bleach and phenyl were also used in areas cleared of dead bodies. In Tamil Nadu, the DDHS sent large quantities of these chemicals to the impacted areas to meet the demand (Figure 4.7).33

Initially, 644 relief camps were established on the mainland.61 Of these at least 96 were established in Tamil Nadu. Otherwise, it was not possible to track the number of IDPs or IDP camps in India post-tsunami.

Recovery Responses in Public Health

The public health burden of India decreased substantially with the relatively rapid attrition of IDPs from the camps. There are no reports as to where they migrated or whether they returned to their homes. Many were situated in temporary shelters away from the camps.

There were no epidemics or even major outbreaks of disease reported following the tsunami. Thus, there were no public health problems from which to recover. Damaged medical facilities gradually were repaired or rebuilt and laboratories were repaired.

Development of Public Health

The public health system was gradually improved above its functional status before the events of 26 December. The bolstered surveillance system has been sustained. In May 2005, WHO-SEARO convened a meeting to develop plans that, when implemented, should mitigate the damage and the changes in functions associated with future events.69 Twelve benchmarks for development were defined. Three of these benchmarks defined during the WHO-SEARO conference in Bangkok applied directly to the public health system: (1) the capacity to identify risks and assess vulnerability levels; (2) health facilities repaired/built are being modified to withstand expected hazards, and should be able to continue to provide the medical care required during events and disasters; and (3) early warning and surveillance systems are being developed. Follow-up meetings have indicated that substantial progress has been made by India in relation to these benchmarks.49

Medical (curative, individual) care in India

Pre-events

During the decade prior to the tsunami, India’s economy moved forward and high-quality, private medical care facilities staffed with highly skilled medical personnel mushroomed in some Indian cities. But for most Indians, the burden of reaching and paying for private medical care was very high, and public services provided an alternative. Most of India’s population was rural, poor, and uninsured, and did not have access to the medical care they needed to maintain healthy lives. In 2000, the World Health Organization ranked India’s overall healthcare system performance at 112 out of 191 countries.50 India had a government-funded, universal medical care system. But government funding of the public system was poor and public medical care facilities suffered from shortages of staff and supplies, high absenteeism, and poor accountability. The Indian government’s expenditure on health comprised only 1% of its national GDP.51 As a result, the quality of care provided by the public sector was compromised, and most Indians sought treatment from the public system only if they could not afford alternatives. Although only 1.5% to 2.0% of the population had health insurance, many Indians, even very poor Indians, paid for private services rather than public services which are perceived to be of lower quality. Consequently, delivery of medical care was mostly through out-of-pocket payments for 80% of medical care costs.52
Most medical care services were provided by the private sector—approximately 80% of outpatient services and 55% of inpatient services. The private sector also owned a great deal of the country’s medical care resources; the private sector is believed to have accounted for approximately 75% of India’s medical care specialists, 85% of its medical care technology, and 67% of the country’s hospitals. However, the public sector provided a large proportion of India’s hospital-bed capacity—63% of the country’s hospital beds. Moreover, since private medical care facilities were not required to register with the government, there only are scant data available regarding India’s private health sector. Consequently, many aspects of India’s Medical Care System can be discussed in detail only with respect to its public system. Furthermore, it seems that the medical personnel in the public system were less qualified than those in the private sector—better qualified staff sought work in the private sector. The impact of this factor is not clear. However, given the weaknesses in the public system, it may not have had adequate capabilities and/or capacities to respond to the medical care needs following major catastrophes such as the tsunami. Perhaps this is reflected by the outcome that only 30% of those injured by the earthquake/tsunami survived (Table 4.1).

Other weaknesses in India’s medical care system included poor availability of services in rural areas and for reproductive health needs (Table 4.5). Although approximately 75% of the population live in rural areas, 75% of India’s doctors live in urban areas. Reproductive services failed to provide skilled personnel for more than half of the country’s births. Skilled medical personnel attended only 42% of all births, while traditional midwives (traditional birth attendants) attended 35%, and a friend or relative attended 22% of births. Traditionally, most Indian births took place under unhygienic conditions. For women in rural communities, there often was no option for referral to an appropriate healthcare facility if needed. This may be responsible, in part, for the remarkably high maternal death rates of 301/100,000 live births (Table 4.2).

Although national medical care indicators provide an overall picture of the Indian medical care system, it is important to note that, as with the public (population) health indicators, national averages tended to hide major differences between different states and territories. One of the factors that contributed to the differences in the Medical Care System across the states was the fact that India’s Medical Care System was decentralized. Under India’s health policies, state governments were responsible for the provision of primary health care, while the central government’s role generally was limited to family welfare and disease control. States have jurisdiction over hospitals and management of the medical care system. Each state has its own Ministry of Health and Family Welfare. Within each district of a state, there was a district hospital headed by a District Health Officer.

Medical care in India was provided through two versions of the public medical care infrastructure: one for rural areas; and one for urban areas (Table 4.6). Before the tsunami, a three-tier public Medical Care System that consisted of about 137,311 sub-centres, 23,109 primary health centres, and 3,043 community health centres served rural areas. And, there was a two-tier public medical care system that consisted of 3,500 urban family welfare centres and 12,000 secondary and tertiary hospitals that served urban populations. Primary health centres formed the backbone of the healthcare system in rural areas, with the sub-centres serving as primary healthcare outreach posts. As noted, the capabilities and performance of the medical care system varied considerably between India’s many states and territories. For example, in Kerala, skilled medical personnel attended 88% and 96% of births in rural and urban areas respectively, compared to 11% and 44% respectively of rural and urban births in the Uttar Pradesh. Additionally, the public Medical Care System appeared to perform considerably better in some regions of the country than in others. For the most part, medical care services appeared to be stronger, and in some cases much stronger, in
the regions hardest hit by the tsunami than in the country as a whole: in the country as a whole, approximately 65% of the population did not use public health facilities, whereas only 47% and 50% of the population generally did not use the government health facilities in Tamil Nadu and Kerala, respectively. One of the exceptions was Andhra Pradesh, where Medical Care System indicators tended to be more closely in line with the country as a whole and in which 74.3% of the population generally did not use government facilities.56–61

The medical care systems in the two states in which the tsunami would take the greatest toll, Tamil Nadu and Kerala, were ahead of the nation in many respects, and the initiatives became models for other states. Shortly before the tsunami, the Tamil Nadu Medical Services Corporation implemented a logistical management system for coordinating the purchase, storage, and distribution of medicines with excellent results that other states soon would replicate. The system helped to ensure the ready availability and quality of drugs for more than 11 000 government medical institutions in the state.50

Additionally, Tamil Nadu and Kerala had more primary health centres (PHCs) relative to their population size than did the country as a whole. Prior to the tsunami, the ratio of PHCs/population was 1/46 940 people throughout India, even though PHCs were intended to serve just 30 000 people each, and were central to providing medical care services to India’s underserved rural populations. In Tamil Nadu, the ratio was slightly better, with about 1/45 000 people, but in Kerala, the ratio was 1/35 000 people. With respect to the number of overall medical care facilities available, 324 hospitals, 1411 PHCs, and 8 682 health sub-centres provided public medical care services in Tamil Nadu compared to 143 hospitals, 943 PHCs, and 5094 sub-centres in Kerala.48

The medical care systems were unique in the tsunami-impacted union territories of Puducherry and the Andaman and Nicobar Islands, due to their status as union territories and geography. In addition to the central government having a leading role, the Medical Care Systems in Puducherry and the Andaman and Nicobar Islands faced unique challenges due to their fragmented geography. Puducherry’s four districts are separated into four enclaves surrounded by three South Indian states. Two of these districts, Karaikal and Puducherry, are surrounded by Tamil Nadu, and like Tamil Nadu, were hit by the tsunami. Similarly, the Andaman and Nicobar Island population lived on more than 30 separate islands. In order to provide adequate resources, the government established more healthcare facilities in these two territories relative to their population sizes than for the other territories. In Puducherry, the population to PHC ratio was much better than in the country as a whole, and services, such as skilled birth attendance reached a high percentage of the population (26 384 people/PHC), and skilled personnel attended 93.4% of all births.60–62

The Andaman and Nicobar Islands are >1000 km from the mainland. To ensure access to medical care services to this isolated and fragmented island population, the government established 20 PHCs, each of which supported a population of just 13 000. With respect to other public medical care facilities in the Andaman and Nicobar Islands, each of the territory’s 107 sub-centres served 2400 people, and each of the territory’s community health centres served 64 000 people.59

In addition to the sub-centres, primary health centres, and community health centres, the Andaman and Nicobar Health Department also provided health services through three hospitals; one referral hospital and two district hospitals. The referral hospital, G.B. Pant, was located in Port Blair, and had 450 beds. The Andaman District Hospital, located in Mayabunder, had 42 beds, and the Nicobar District Hospital, located on the island of Car Nicobar, had 112 beds. Healthcare services provided by the Health Department had a combined bed capacity of 1015 beds for a ratio of one bed/355 people.63
The G.B. Pant Hospital was the largest medical care facility in the Andaman and Nicobar Islands. Other smaller medical care facilities were located on Car Nicobar island and in most other larger communities. Before the tsunami, there were 135 health facilities in the Andaman and Nicobar Islands, with 98 facilities in the Andamans, and 37 facilities in the Nicobars. Additionally, the navy had its own hospital based in Port Blair, which served the needs of armed forces personnel with basic specialties, such as surgery, ophthalmology, and radiology. The navy hospital had 107 beds and served a population of 13,455.

To further support medical care services in the Andaman and Nicobar Islands, the territory was linked to an international programme bringing greater specialized support to remote hospitals through telemedicine, established by the India Space Research Organization. Rural health facilities could video conference with specialists in large urban hospitals to help them provide patient care. Rural and remotely located hospitals connected to specialized hospitals using telemedicine included three hospitals in the Andaman and Nicobar Islands—the G.B. Pant Hospital, INHS Dhanavanthri Naval Hospital in Port Blair, and the Bishop Richardson Hospital on the island of Car Nicobar.

Medical care staffing levels in the islands were more in line with national averages, with slightly greater coverage in the Island’s southern Nicobar district than in its northern Andaman district. In absolute numbers, the healthcare facilities in the Andaman Islands were staffed with many more medical personnel than in the Nicobar Islands. In the district of Nicobar, there were only 20 physicians, 53 nurses, and 21 midwives. In the Andaman islands, there were 117 physicians, 298 nurses, and 140 midwives. However, per capita, the Nicobar Islands had more medical care personnel than did the Andamans. The Nicobar Islands had 4.8 physicians, 12.6 nurses, and 5 midwives and for every 10,000 people, while the Andaman islands had 3.7 physicians, 9.5 nurses, and 4.4 midwives/10,000 population.

Damage to medical care

On the day that the tsunami struck India, many medical care facilities were functioning at low operating levels. It was a Sunday of a holiday weekend and many medical care workers were at home or had traveled to other towns to visit with family and friends. Yet, on the day of the tsunami, some of the medical care facilities received unprecedented demands for medical attention. Under the worst circumstances, the Medical Care System had to meet this demand not only with a shortage of medical care workers, but also with diminished operational capacity and capabilities.

The earthquake and tsunami damaged 80 sub-centres, 13 primary health centres, and partially damaged seven district hospitals in India. Of all the impacted states and territories, the greatest medical care infrastructure damages occurred in the Andaman and Nicobar Islands, where 29 of 107 sub-centres (21.7%), four of 20 primary centres (20.0%), and two of three district hospitals (66.7%) were damaged. Thus, the earthquake and tsunami damages dealt a major blow to the territory’s overall Medical Care System. Also, the earthquake and tsunami killed many medical care workers in the Nicobar Islands, further crippling local healthcare services.

Damage to the medical care infrastructure along the coast of the mainland of India was less severe, as the inundation by the tsunami reached far into the shore in only a few focal points along the coast. For the most part, tsunami waves reached no more than 500 metres inland, and left most medical care facilities untouched. However, some medical care facilities did not escape the tsunami unscathed. The greatest damage along the mainland occurred among the hardest-hit districts of Tamil Nadu (Figure 4.9). The most crippling of these damages may have occurred at the Nagapattinam district hospital, which was heavily damaged by the tsunami, and the nearby Tharangambadi sub-district hospital which suffered major equipment loses. In Tamil Nadu, the tsunami also damaged six PHCs and 19 sub-centres.
Changes in Medical Care Functions
The damage inflicted by the tsunami impaired the functional state of the affected Medical Care systems. In the Andaman and Nicobar Islands, despite the damage, most of the islands still had access to at least one local doctor. Nonetheless, after the earthquake/tsunami, local medical care services were overwhelmed. On the Nicobari Island of Katchal, the island’s local doctor survived the earthquake and tsunami, but the island’s primary health centre, medical equipment, and medical supplies did not. With many injured victims, few medical resources, and no outside medical support for three days after the tsunami, the Island’s only doctor was overwhelmed, and many people may have died due to inability to meet their medical needs.

Although the tsunami had badly damaged the Nagapattinam General Hospital, quick action by the hospital’s staff helped to ensure that none of the hospital’s 350 patients died due to the tsunami. On learning about the first tsunami wave, the staff hurried to evacuate patients from the hospital before the largest and most damaging wave arrived.37

On the mainland, in the aftermath of the tsunami, hospital damages, the sudden increase in demand for medical services, crowding, and the accumulation of dead bodies at the hospitals all complicated efforts to deliver needed medical care services. For example, due to damages to the Nagapattinam district hospital, many seriously injured patients had to be transported 150 km to Tanjavore Medical College Hospital.37

Even where the tsunami did not flood healthcare facilities, the healthcare systems near the coasts were overwhelmed by a sudden influx of dead bodies and crowds of survivors. For example, at the Colachal General Hospital near Tamil Nadu’s southern-most region, staff initially was inundated by the deceased, injured, and onlookers that suddenly crowded onto the hospital’s grounds. The hospital’s staff lacked sufficient numbers of security personnel required to keep the crowd of anxious relatives and the curious at bay, while they tried to determine which of the incoming were dead or in need of treatment.37

Relief Responses in Medical Care
Following the earthquake and tsunami, critically injured survivors received treatment from village, town, and district medical care workers. Local doctors, nurses, pharmacists and others saved many critically injured survivors, often having available only minimal resources. By the time state, national, or international responders arrived, the life-saving period of the disaster was nearly over. This was true particularly in the Andaman and Nicobar Islands district of Nicobar, where it would take days before outside medical assistance could reach many of the hardest-hit areas. In the Nicobar district, the tsunami’s impact was so great that the district had few medical care resources to draw upon.65

With most of the territory’s tsunami-damaged medical care facilities having been in the Nicobar Islands, many of the local medical care workers had to set up makeshift facilities in buildings that had not been destroyed or out in the open. On the islands of Terressa and Katchal, local schools were turned into makeshift hospitals.64,65 And in the Car Nicobar village of Mus, which was cut off from the rest of the island for days because the tsunami had destroyed roads leading to the village, local medical care workers established a makeshift medical care facility for 1346 displaced villagers who were living on a football field (Figure 4.8).61,62

On the mainland, local medical care workers responding to the disaster generally were less debilitated by tsunami damage than were the workers in the Nicobar Islands. Unlike the hard-hit Nicobar Islands, the impacted communities that had lost hospitals were able to send critically injured survivors to undamaged hospitals further inland. And, although the mainland coastal districts on the first day, for the most part, were on their own when it came to providing medical care to tsunami survivors, most of the directly impacted areas received outside support by the second day. In Tamil Nadu, the state quickly
mobilized medical support into directly impacted areas, and by Days 2 and 3 of the disaster, healthcare providers in all of the impacted districts had received support from other districts.47

In contrast, outside medical support to the Nicobar Islands had a difficult and painfully slow journey before it could reach survivors. All supplemental medical personnel, equipment, and supplies had to be flown or shipped to the islands. And, since most of the Nicobar Islands did not have airports, and the earthquake and tsunami had destroyed many harbours and jetties, the islands often were not equipped to receive ships or planes. What outside medical support did arrive in the Nicobar Islands within the first week following the tsunami, was concentrated on the Island of Car Nicobar, the district’s most heavily populated and developed island. Of the hardest hit islands, Car Nicobar also received the earliest support. While responders arrived in Car Nicobar as early as the second day following the tsunami, some impacted islands could not be reached for several days. Thus, many of the islands had to manage injured survivors with their own crippled Medical Care Systems for much longer than tsunami-impacted coasts along mainland India.

The earliest medical support to the impacted islands came from the territory’s capital of Port Blair. Three naval ships were able to reach Car Nicobar from Port Blair on 27 December and began evacuating injured survivors to Port Blair for treatment; most were treated at the G.B. Pant Hospital, which had not been damaged by the tsunami. However, some victims also received treatment at the Indian Naval Health Service’s Dhanvantari Navy Hospital, which had opened its doors to survivors of the earthquake and tsunami. On 27 December, navy ships also departed for the island closest to the earthquake epicentre, Great Nicobar. Two coast guard ships carrying relief materials and a medical team arrived at Great Nicobar on 28 December.46 Also, on the second day following the tsunami, the telemedicine link with Car Nicobar was re-established, thus allowing doctors on the islands to consult with health specialists not available on the islands.63

Because the Andaman and Nicobar Islands were a Union Territory rather than a state, the central government of India directed the overall responses to the losses caused by the damage from the tsunami. Medical care support from the central government to the Andaman and Nicobar Islands was relatively greater than it was to many of the other areas impacted; local authorities did not wait for the central government to take action to save tsunami survivors. Eventually, the overall responses to the tsunami in the Andaman and Nicobar Islands, including the medical responses, would be managed from Delhi by central government authorities. On 27 December, India’s central government authorities also arranged for a team of healthcare specialists to travel to the Andaman and Nicobar Islands to assess damages and assist local healthcare authorities. The team first stopped in Port Blair, and then continued to Car Nicobar, where they arrived on the afternoon of 28 December. The central government continued to send medical teams from the mainland, including medical workers, who arrived on navy vessels some of which had been specially equipped to provide medical care. The Indian navy sent the INS Magar, which had been equipped to operate as a 120-bed hospital ship. The ship arrived off Car Nicobar about four days after the tsunami, and then traveled to other impacted islands to the south.64 The Ministry of Health and Family Welfare dispatched nurses, doctors, and paramedical personnel to areas hard hit by the tsunami, and later opened medical camps in remote islands in need of medical care.61 However, this support arrived too late to treat the severely injured.

Although the impacted states on the mainland also received medical support from the central government, the bulk of the medical responses was local and state supported; state authorities in Kerala deployed 224 doctors to the directly impacted areas and set up 40 medical camps.62 And, the state of Tamil Nadu sent a total of 278
medical teams to tsunami-impacted areas. Some of these mobile medical teams provided services to several camps or villages on a rotational basis. In addition to visits from mobile medical teams, each of Tamil Nadu’s 96 relief camps also had a full-time village health nurse and health inspector. In addition to the state responses, many medical schools and private hospitals in Tamil Nadu and other states sent medical relief teams.40,60

Recovery Responses in Medical Care
Gradually, the relief responses of the Medical Care System turned from augmenting medical services in tsunami-impacted areas, to restoring, and in some cases, developing local medical care services. But, the most difficult work lay ahead in the Nicobar Islands where the resources and skilled workforce had to restore damaged medical care infrastructure. Such personnel were extraordinarily difficult to acquire. However, despite the challenges, an Indian NGO, Bharatiya Jain Sanghatana, offered to rebuild all of the PHCs and sub-centres that were destroyed by the tsunami with no cost to the Andaman and Nicobar administration. Under the project’s plan, Direct Relief International provided US$ 1.7 million to Bharatiya Jain Sanghatana to rebuild the facilities designed to resist earthquakes. Within one year following the tsunami, 50% of the facilities had been completed.62

On the mainland of India, the task of rebuilding the damaged medical care infrastructure faced fewer logistical challenges, and thus, progressed quickly. In Tamil Nadu, the high priority given to restoring the Nagapattinam general hospital resulted in the quick resumption of services. Clean-up crews removed 2000 truck-loads of sludge from the hospital, and then, flushed it out using fire hoses. Equipment and other supplies were replaced by various donors, and within eight days, the hospital was fully functional.40

In some cases, the difficulties the Medical Care System faced following the tsunami resulted not from the earthquake or the tsunami, but from the relief efforts. Medical facilities already facing a host of logistical difficulties due to earthquake and tsunami damages, often were swamped by inappropriate donations. The handling, sorting, storing, and in some cases, disposing of these inappropriate donations cost local medical facilities time, money, and filled much of the needed space. As in other tsunami-impacted countries, India faced difficulties handling a flood of incoming donations of medications. Donors sent unsorted and sometimes expired medications that had to be screened before they could be used. The Tamil Nadu Medical Supplies Corporation made warehouse space available for the donated medications, but did not have sufficient staff to screen and sort all of the incoming medications.40,46-50,66

Aside from restoring the medical care infrastructure and handling donations, efforts also were made to ensure that for at least three years, cost would not be a limiting factor in the earthquake and tsunami survivors’ access to medical care. The central government established a programme to provide tsunami-affected families with health insurance coverage for up to five family members for three years following the tsunami. This programme was administered through the United India Insurance Company.63,66

Water and Sanitation
Pre-events
Potable water
In the five decades following independence, rapid development of water resources fueled a green revolution in agriculture, and brought the drinking water supply system to 85% of its inhabitants.67 But, while the water resource infrastructure grew, the natural water resources did not. In the years leading up to the tsunami, population growth, industrialization, reliance on irrigated agriculture, and rapidly expanding cities sharply increased demand for water. Meeting these demands strained water resources resulting in declining per capita availability. India had a per capita annual average of just 1719 cubic metres of renewable water available
for development\footnote{Based on FAO AQUASTAT estimates of Total Actual Renewable Water Resources, an index of the water resources theoretically available for development from all sources within a country.\cite{FAO2007}} compared to 12,739 and 6,382 cubic metres in Indonesia and Thailand, respectively.\cite{FAO2007}

Water resources in India are unevenly distributed geographically and seasonally. About 75% of India’s rainwater falls during an approximately four-month, southwest monsoon season lasting from June through September. Tamil Nadu, however, receives rain under the influence of two monsoons, the southwest monsoon and the northeast monsoon seasons in October and November; it receives more rain during the northeast monsoon. In general, water resources in India are greatest in the north and the east and scarcest in the north and the south.\cite{FAO2007, Singh2005}

While India faced declining per capita availability of water, it also faced declining water quality. Agriculture, industry, domestic waste, and high levels of groundwater extraction have resulted in high levels of contaminants in many of India’s freshwater sources, including pathogens, nitrates, fluorides, arsenic, and selenium. Untreated, domestic sewage was the primary source of water pollution. Sewage treatment facilities were inadequate in Indian cities, and were nearly absent in rural areas.\cite{FAO2007, Singh2005} Of the total wastewater generated in the metropolitan cities, only about 30% was treated before being discharged into the environment.\cite{FAO2007, Singh2005} Over-extraction of groundwater sources also was becoming an increasing problem. Not only did over-extraction launch India’s overall groundwater levels into a rapid decline, but declining groundwater levels allowed saline water to leach into aquifers that were near to the coasts or in areas in which hazardous contaminants, such as arsenic and fluoride, were accumulating.\cite{FAO2007}

As with average Indian public health indicators, average national water and sanitation indicators obscure a great deal of variation among the states. In some states, there are huge disparities in the states’ share of the national population and of their water resources. For example, the state of Rajasthan claims 8% of India’s population, but just 1% of the country’s freshwater resources.\cite{Singh2005}

The types of water sources used to support local populations also varied from one part of the country to another. In the tsunami-impacted area, the villages and hamlets in Kerala, Tamil Nadu, and Andhra Pradesh relied primarily on water pumped from shallow wells into overhead tanks. In the tsunami-impacted territory of Puducherry, the villages and hamlets relied primarily on water drawn from deep wells located 5–6 km inland.\cite{Singh2005} In the hardest tsunami-impacted state, Tamil Nadu, the water and sanitation situation was characterized by relatively high access to improved water sources among households, but also relatively high contamination problems and high reliance on declining groundwater sources. In Tamil Nadu, poor wastewater treatment had resulted in particularly high levels of chemical pollution in its water resources.\cite{FAO2007} Open-channel sewage systems that discharged untreated sewage into rivers, creeks, and the ocean were common. And, in the districts of Nagapattinam and Cuddalore, there were no wastewater treatment plants.\cite{FAO2007}

In Tamil Nadu, available surface water sources had been almost entirely harvested, and the state had become heavily reliant on groundwater. With this heavy reliance on groundwater, many of the state’s aquifer levels had dropped considerably, and tube wells were used to reach progressively deeper and deeper to reach water.\cite{FAO2007} An assessment of groundwater sources conducted during 2003 in 385 administrative blocks in Tamil Nadu, found that eight had become contaminated with saline, >138 had been over-exploited, 142 had been listed as critical or semi-critical, and only 97 were considered safe for groundwater development.\cite{FAO2007} The union territory district of Puducherry, which is surrounded by the state of Tamil Nadu, relied almost entirely on groundwater aquifers. Puducherry’s aquifers...
were being over-extracted, and in the coastal areas, the aquifer was beginning to become contaminated with saline.70

The earthquake and tsunami-impacted territory of the Andaman and Nicobar Islands had its own unique set of water issues. Water scarcity was a serious problem. Although rainfall in the islands was abundant—approximately 3m annually—runoff was high, and the Islands tended to have low groundwater storage capacities and few perennial streams.67,68 In the Andaman and Nicobar Islands, water resources become scarce during the dry season which begins in November and lasts until April. The islands’ dry season also corresponds with its tourist season, which increases the demand for and exacerbates the scarcity of water. In the Andaman and Nicobar Islands, groundwater provided islanders with one of their primary supplies of water.71–75 In the territory’s Nicobar district, which would suffer the greatest consequences due to the earthquake and tsunami, rainwater was not heavily utilized as a source of freshwater. This was due, in part, to the lack of infrastructure for gathering it; the traditional houses that Nicobari tribes lived in, had grass-thatched roofs and no pipes for draining water into a tank. In an effort to improve access to water in the Islands, the government had installed a water desalination plant on the Nicobar island of Chowra, on an experimental basis. But the plant was under-utilized as a source of drinking water, since local superstitions made tribal islanders wary of drinking water that had gone through a machine.75–79

Sanitation
Sanitation at the household level with respect to toilet facilities varied considerably. Indians living in urban communities were more likely to have access to toilets whereas access to toilets tended to be poor in rural communities. The combination of declining water availability and quality put India’s population at greater risk of suffering sanitation-related health problems. India’s population also faced increased health risks due to limited access to toilets. The number of households with toilets ranged anywhere from 18.7% in the state of Chhattisgarh to 96.1% in Kerala.54,55 In urban areas, 75% to 81% of all households had toilets, but in rural areas, where the majority of the Indian population lived, only 18% to 19% of households had a toilet.67–69 Consequently, hygiene and sanitation were major health concerns in India, with poor hygiene and sanitation accounting for 9% of all deaths in India.47–49

In many of the coastal fishing communities in tsunami-impacted areas on the mainland, and in many tsunami-impacted Nicobari tribal communities in the Andaman and Nicobar Islands, open-field defecation was common.

Damage to Water and Sanitation
In the aftermath of the earthquake and tsunami, water-related damages generally were greater than were the sanitation damages, because pre-events, there had been only limited sanitation infrastructure. Tsunami damages to the water system in India primarily were to wells, and were the most pronounced in the Andaman and Nicobar Islands and in Tamil Nadu.

Along the mainland, water damages did not lead to shortages to the same extent as they did in the Andaman and Nicobar Islands.
Along the mainland, tsunami damages to the water infrastructure is estimated to have cost...
approximately US$ 8.4 million with the greatest damage occurring in Tamil Nadu, US$ 4.4 million, and in Kerala, US$ 3 million. In Tamil Nadu, the tsunami contaminated >1500 wells within 300–800 m of the shore.\textsuperscript{80,81} Damages occurred in approximately 376 villages and hamlets, with the greatest damages concentrated in about 179 of them.\textsuperscript{80,81}

Following Tamil Nadu, the greatest water infrastructure damages on the mainland appear to have occurred in Kerala where tsunami damages to shallow wells and water distribution systems in 187 villages cost an estimated US$ 3.0 million. Finally, the tsunami also damaged water infrastructure in the mainland state of Andhra Pradesh where small wells along the state’s southern shores were inundated costing an estimated US$ 0.21 million in damages.\textsuperscript{79,80}

Interestingly, the hardest-hit regions did not always suffer the greatest water infrastructure damages.\textsuperscript{80} The union territory of Puducherry suffered some of the worst overall damage, but suffered comparably little water infrastructure damage. Since Puducherry draws most of its water from deep wells located several kilometres inland, there was no damage to its primary water sources. Damage was limited to a few small wells located near shore, hand pumps, and minor damages to the distribution system, costing an estimated US$ 0.8 million.\textsuperscript{79,80}

Since essentially there were no major sanitation systems in the impacted mainland areas prior to the tsunami, overall tsunami damages to the sanitation system were limited to public and private toilets. Damages to toilet facilities are estimated to have been US$ 0.8 million including US$ 108 000 in Andhra Pradesh, US$ 0.52 million in Tamil Nadu, US$ 57 500 in Kerala, and US$ 115 000 in Puducherry.\textsuperscript{79}

Changes in Water and Sanitation Functions
In the Andaman and Nicobar Islands, tsunami damages to the islands’ fragile supply of freshwater led to acute shortages just as the territory’s dry season had begun. In the territory’s isolated Nicobar Islands, the tsunami inundated wells and washed away stored water supplies, leaving survivors with limited resources for drinking water. On the most populated Nicobar Island of Car Nicobar, the tsunami salinated almost the island’s entire water supply network, including a system of wells of the Indian Air Force that supplied 1700 people with water. With the exception of a small area located near the island’s administrative headquarters, the water system was almost entirely disrupted.\textsuperscript{79} As a result, some Nicobari islanders had to rely on questionable water sources, and in at least one documented case, became ill.

On Car Nicobar, at least one outbreak of diarrhoea appears to have been linked to the use of contaminated water and poor sanitation following the tsunami. In a camp on Car Nicobar island, the island that lost the greatest number of lives, a number of survivors reported having diarrhoea. The camp had a population of 1346 survivors, the largest on the island, and had been cut off from outside assistance for several days following the tsunami. For water, the camp used six wells, which had not been commonly used before the tsunami. And because there were no toilets available, the survivors had to defecate in the open.

On 7 January, the number of survivors in the camp experiencing diarrhoea began to increase and by 29 January, a medical facility set up in the camp had treated 113 persons with diarrhoea, primarily children. When tested, five of the six wells being used for drinking water tested positive for coliforms. When these wells were chlorinated, the incidence of diarrhoea declined.\textsuperscript{79}

Although the isolated Nicobar Islands were in the region of the territory hardest hit by the tsunami, acute water shortages also became a serious problem in the Islands’ urban centre of Port Blair and the surrounding island. On the island, a gravity line delivering water from a dam to a treatment plant had been broken, resulting in
a reduced supply of drinking water. At the same time, many displaced tsunami survivors had been brought to the island, thus increasing the demand for potable water.

Although damages to sanitation generally were minor when compared to the damages to water supplies, sanitation needs became more acute than before the tsunami because survivors had been moved into crowded relief camps. But although open defecation may not have posed a serious health risk in the Nicobar tribal communities prior to the tsunami, new conditions following the tsunami made the practice an increased health risk.

Relief Responses in Water and Sanitation

The ways by which survivors met freshwater needs from the time the tsunami struck until outside assistance arrived has been poorly documented. While on the mainland, outside support reached impacted communities within 24-48 hours, in the Nicobar Island, many communities remained cut off from outside support for days. It seems that in most cases, communities found freshwater in wells located far enough inland which were not impacted by the tsunami.

On the India mainland, the drinking water relief responses to the needs for potable water either were quick or painfully delayed. Indian authorities were able to get a quick overview of impacted areas, and rapidly mobilized drinking water assistance along the mainland, but not in the Andaman and Nicobar Islands where logistical problems delayed the completion of a comprehensive assessment of the water and sanitation status by weeks. Reaching the Andaman and Nicobar territory’s many islands though the rough waters of the Indian Ocean always had been difficult, but after the tsunami had wrecked harbours and jetties, it had become a nightmare.

On the mainland, however, water transportation damages were considerably less debilitating; undamaged water resources were available in neighbouring communities, and after the tsunami had struck. Water and Sanitation System authorities were within close reach of the impacted areas, and helped to ensure fast and effective responses. Water authorities were available locally because India’s drinking water sector was decentralized—thus, ensuring that states such as Tamil Nadu had strong local agency support for responding to water system needs. On the other hand, because they were a territory rather than a state, the Andaman and Nicobar Islands were administered largely through the central government, and as a consequence, did not have the same capacity to engage quick local responses.

On the mainland, directly impacted populations generally did not suffer an immediate shortage of water. While many of the water sources and the infrastructure were damaged or destroyed in impacted areas, they remained intact in the inland areas into which survivors fled. Survivors congregating in inland areas not impacted by the tsunami drank water from local water sources. But, government agencies recognized the extra demand on these water sources might exhaust them, and quickly augmented them using water supplied by tanker trucks. Many NGOs and other responders also augmented supplies with water packaged in bottles or bags.

The armed forces were the first to assist and delivered small quantities of water in packages, dropped from aircraft. Meanwhile, water also was being delivered via ship, but the delivery of relief goods by ship was slow. The ships had to travel long distances to reach the many impacted Nicobar Islands, and many could not dock due to earthquake and tsunami damages to the harbours and jetties. Consequently, small boats were used to ferry goods from the ships to the islands. In Port Blair, where tsunami damages and the sudden influx of tsunami-survivors from the Nicobar Islands caused water shortages, local authorities asked people to carefully ration water resources until the water infrastructure could be restored.
After the tsunami, relief responders also had to be careful to ensure tsunami relief efforts did not contaminate water supplies. Relief workers burying large numbers of bodies in mass graves in Nagapattinam had to carefully consider where to dig the graves so as not to contaminate local groundwater sources. Because the land elevation was low and the water table high in Nagapattinam, responders had to dig shallower graves so as not to contaminate the aquifer.

**Recovery Responses in Water and Sanitation**

Meeting the medium- and long-term needs of India’s tsunami-impacted communities differed between the mainland and the Andaman and Nicobar Islands. On the mainland, piped water was restored quickly to communal water collection points from wells that had not been contaminated or from new wells that had been dug into clean aquifers; and tanker trucks continued to deliver water to relief camps. Water authorities also pumped salt and debris from, and chlorinated inundated wells in an attempt to restore the functions of the contaminated wells. But these efforts met with only limited success. In some cases, authorities replaced the damaged wells with new ones or other alternatives. In Tamil Nadu, the Tamil Nadu Water and Drainage Board established two electro-dialysis plants to treat 12,000 litres of groundwater/day in the villages of Ayyampettai and Rasapettai, where the tsunami had heavily contaminated freshwater supplies. Also in Tamil Nadu, the Central Ground Water Board constructed 10 new bore wells in the state’s Tirunelveli, Nagapattinam, and Cuddalore districts. Although early responses to water needs tended to focus more on the quantity of drinking water available in impacted areas as opposed to the quality, more attention was directed at water quality issues as attention shifted to the recovery efforts. Water tanks were tested for quality and households were given chlorine tablets or other decontaminants to help them keep their drinking water safe.

However, the distribution of chlorine and other decontaminants had to be supported with education. Drinking water that has been improperly treated with chemicals, can make people ill or discourage them from treating their water. As an example, in Tamil Nadu, some people reported having become sick after drinking over-chlorinated water. In many cases, people could smell and taste the chlorine and refused to drink the water. Even when chlorine levels in treated water were within prescribed levels, some refused to drink it due to its taste and smell. To help prevent people from drinking over-chlorinated water, Tamil Nadu dispatched health inspectors to test the treated water and instructed households on how to properly use chlorine tablets.

In the Andaman and Nicobar Islands, logistics, weather, and labor shortages made restoring and developing the water and sanitation infrastructure difficult. Because the Islands are isolated in the middle of the Indian Ocean, and often, are subject to unpredictable weather, importing the equipment and building supplies required for water and sanitation projects were prohibitively expensive. Additionally, water and sanitation projects had to compete for labor with many other major reconstruction projects, such as road and building projects. In the Andaman and Nicobar Islands, the India Department of Drinking Water Supply and Ministry of Water Resources assessed water supply damages and laid out a water supply recovery plan.

Efforts to ensure access met with more success earlier during the disaster on the mainland than they did in the Andaman and Nicobar Islands. Within 10 days of the tsunami, access to water among tsunami survivors on the mainland was reported to have returned to its pre-event state. But, while access had been improved in the Andaman and Nicobar Islands, shortages still presented a problem in many of the islands communities and water restoration on some of the islands was slow. Even as late as early February, many communities still faced lower than normal (pre-event) access to water. In the Nicobar Islands of Nancowry and Kamorta, the water supply had been 100% restored. But, on
some of the Islands, restoration of water supplies ranged from a high of 90% on South Andaman to a low of 40% on Teresa.79–83

In the months following, contaminated groundwater sources in both the Andaman and Nicobar Islands and along the mainland benefited from a particularly heavy monsoon season. Particularly heavy monsoon rains beginning in May helped to speed the recovery of groundwater.83–85

With respect to sanitation, both the mainland and the Andaman and Nicobar Islands also faced challenges to providing tsunami survivors adequate access to sanitation such as toilets. This was particularly difficult in the Andaman and Nicobar Islands, where few supplies were available in the Nicobars to build needed sanitation facilities, and thus, the government and NGOs dug open pit or open trench latrines near camps. The pit and trench latrines, however, served relief camp sanitation needs poorly.

**Development of Water and Sanitation**

In establishing local sources of freshwater, two of the more developed regions of the Nicobars were provided with reverse osmosis plants to desalinate water. The Central Salt and Marine Chemicals Research Institute installed a reverse osmosis unit in Car Nicobar and in Campbell Bay on Great Nicobar.75 In other regions of the Nicobars, greater exploitation of rainwater was encouraged and the UNICEF distributed more than 5300 water tanks and 300 rainwater-harvesting units to tsunami-impacted communities.55

**Shelter and Clothing in India Pre-events**

In the areas impacted by the Indian Ocean tsunami, warm temperatures prevail throughout the entire year, and locals do not require heavily insulated homes with indoor heating. In the coastal areas of southern India, temperatures generally ranged from 21 to 37°C with the coldest temperatures occurring in January and the hottest temperatures occurring in June and August. Temperatures are even more moderate in the Andaman and Nicobar Islands, where temperatures range from about 23 to 33°C, with the lowest temperatures occurring in February, and the hottest temperatures occurring in April. But, while people living in these areas may not have required shelter from freezing temperatures, they needed shelter to protect them from heavy rains and to provide a secure place to conduct their daily activities.

Unfortunately, many Indians had to make do with sub-optimal housing conditions. Prior to the tsunami, 4.1% of India’s population lived in slums; and, in the states and territories impacted by the tsunami, nearly 4.8% of the population lived in slums. The percentage of the population living in slums in the impacted area varied widely from just 0.2% in Kerala to 7.5% of the population in Puducherry. A large number of people (6.8% of the population) also lived in slums in Andhra Pradesh.78–80 In areas that would be impacted by the tsunami along the Indian mainland, the housing stock was largely informal and not engineered. A large number of homes were constructed of plastered masonry or reed walls, and with roofs of thatch, Mangaloor tiles, or reinforced concrete.78–80 This construction had a very low absorbing capacity for the forces of the tsunami.

Additionally, little care was taken to ensure that housing was built to withstand earthquakes. No major municipal authority had a system for ensuring that new construction projects adhered to seismic building code provisions. Most cities required an engineer to certify that new buildings complied with the prevailing building codes, but there was no mechanism in place to ensure that the certifications were genuine.78 Poor adherence to earthquake safety standards in building houses was prevalent even in the Andaman and Nicobar Islands, although the Islands are among India’s most seismically active areas.
was outside of the purview of building laws/ regulations; these laws were not operational in many rural areas and for housing near the sea shore.

The islands also were vulnerable to events involving inundation of sea water, such as occur with hurricanes, since as in the mainland, people living on the islands tended to live near the shore. The danger of flooding and other inundation was more likely in the southern Nicobar Islands than among the Andaman Islands. The Nicobar Islands tended to be smaller and have lower elevations did than the Andaman Islands. Yet, human settlements, particularly among the indigenous populations in the Nicobar Islands, also gravitated along coastal areas. Indigenous communities lived very close to shore, usually settling near mangroves or protective bays, and built their homes on stilts facing the sea.

**Changes in Shelter and Clothing Functions**

The housing damages combined with evacuations from affected coastal areas resulted in the immediate displacement of 627,119 people in India. The immediate aftermath of the tsunami, families from homes that had been damaged or who feared that their homes were dangerously close to the shore, fled their homes and needed temporary housing.

The displacement of populations of the affected coastal areas was particularly problematic in the Andaman and Nicobar Islands, where thousands of people were displaced not only from their homes, but also from their islands. Six islands were evacuated, which increased the separation between survivors and their homes, and augmented the societal burdens on the islands to which they were evacuated.

India was unprepared for the more than 600,000 people who suddenly needed shelter. Initially, the displaced crowded into public buildings, mosques, schools, or makeshift encampments. In the Nicobar Islands, nearly all of the infrastructure was destroyed, and almost all of the displaced islanders migrated into spontaneous camps that were away from shore. In the camps, they were exposed to the changing weather. In the largest camp, 1,346 Nicobari people erected their makeshift tents on one football field.

**Relief Responses in Shelter and Clothing**

In the days following the tsunami, government agencies, NGOs, and other responders brought relief supplies and services to the existing camps, and also helped to establish new camps for survivors who had been encamped in public buildings. By the end of December, the government had established 644 relief camps for tsunami victims. Within a few days after the tsunami, the number of people in camps declined quickly and fewer camps were needed. Many survivors, who had left their homes out of fear that they were too close to shore, returned...
home. And, some of the displaced left camps and moved in with families or friends (hosts).

In a little more than three weeks after the tsunami, the number of people in camps dropped from more than 500,000 to approximately 100,000 (20%); 256 camps (40%) remained.84-85 However, many of the people who found alternative places to stay continued to visit camps during the day in order to receive relief supplies.40

Recovery Responses in Shelter and Clothing

A little over three weeks after the tsunami, most of the remaining camps and the people living in them either were in the state of Tamil Nadu or the union territory of the Andaman and Nicobar Islands. There were 44,207 displaced people that remained in 58 camps in Tamil Nadu, and 43,332 displaced people in 169 camps in the Andaman and Nicobar Islands.81-84 Initially, camps housed displaced people primarily in tents. Eventually, tents were replaced with temporary shelters made of corrugated metal. But, in many cases, the temporary shelters turned out to be more than temporary.

Disputes about where homes for the displaced should be rebuilt slowed efforts to provide permanent housing. Two years after the tsunami, NGOs and state agencies had restored only about 30% of the tsunami-destroyed and damaged housing stock, and most of the tsunami-displaced population continued to live in temporary shelters.83 Some of the NGOs and state agencies made the greatest progress in restoring permanent housing in Tamil Nadu: 5000 permanent houses were provided by the end of the first year. But, more than half of the tsunami-destroyed housing stock in Tamil Nadu had yet to be replaced by the end of the first year.83 By the end of the second year 23,414 had been replaced,83 and 29,446 by the end of the third year after the tsunami.84

Rebuilding in Tamil Nadu was complicated by several factors, including concerns that some previously inhabited coastal areas were not safe for reconstruction. After the tsunami, Tamil Nadu tried to discourage survivors from rebuilding close to the sea on the grounds that homes close to the sea could be destroyed by a future tsunami. The Tamil Nadu government withheld US$ 3000 in government aid from survivors who rebuilt homes within 200 metres of the high tide mark.84

Outside of Tamil Nadu, progress in replacing tsunami-destroyed housing was even slower. Although the greatest tsunami housing destruction occurred in the Andaman and Nicobar Islands, two years after the tsunami, the NGOs and governmental agencies had completed only housing foundations—but no houses had been built on them.83,84 As in Tamil Nadu, there were conflicts over where new houses should be built. Rebuilding in the Andaman and Nicobar islands located far from the mainland, was slowed by logistical problems and also because the islands had few local resources; governmental agencies and NGOs struggled to get supplies to the islands in a timely and cost-effective manner. Consequently, planned housing project completion dates were delayed, and three years after the tsunami, many islanders continued to live in corrugated metal boxes, not knowing when they would be moved into a permanent home.83

In the Nicobar Islands, recovery responses aimed to protect tsunami survivors from another possible tsunami, slowed permanent shelter restoration by hampering survivor’s own efforts to rebuild. Indigenous Nicobar Island inhabitants, who always had lived near the coast and sometimes on very low-lying islands, wanted to rebuild where their homes had been before the tsunami.84,85

Developments in Shelter and Clothing

Government officials concerned that a second tsunami might wash away villages located near the shore or on very low-lying islands, evacuated survivors from coasts and low-lying islands and moved them to elevated areas away from coasts, where they planned new settlements. Nicobar survivors, however, disagreed with the need to
abandon their former villages and to settle so far away from the ocean upon which they relied for many of their needs.

Indigenous islanders, who were evacuated from their home islands were particularly frustrated with the government’s efforts to relocate them. In the Nicobars, the inhabitants of Bompooka and Chowra Islands were evacuated from their low-lying home islands to relief camps on Teressa island. Despite an exile lasting 18 months, the people of both Bompooka and Chowra continued to plan on resettling on their original home islands. In the case of the Chowrites, they did not wait for the government to allow them to resettle their original villages, but, instead, began making canoe voyages between Teressa and Chowra to begin resettlement before their exile had ended.83,84

Food and nutrition in India

Pre-events

Before the earthquake and tsunami, the nutritional status of children in India was among the worst in the world (Table 4.6). India’s children faced serious malnutrition problems with one of the highest prevalence rates for underweight children in the world. India accounted for one-sixth of the world’s population, but the country contained one-third of the world’s malnourished children <5 years of age. And, with approximately 60 million underweight children <5 years of age, India had a prevalence of underweight children that was nearly double that of Sub-Saharan Africa. Data for 1998–2000 indicate that 47% of children <5 years of age living in India were underweight, 45% were stunted, and 16% suffered from wasting. The primary causes of childhood malnutrition were high levels of exposure to infection and inappropriate infant and young child feeding and caring practices.86,87

The distribution of malnutrition among children in India was skewed, with poorer populations and lower castes suffering the greatest malnutrition burdens. Malnutrition also varied considerably from state to state. Children in the states impacted by the tsunami did not suffer the same level of malnutrition as did children in the country as a whole. Andhra Pradesh, Tamil Nadu, and Kerala all had prevalence rates of underweight children below the national average. Underweight prevalence rates were 38% in Andhra Pradesh, 37% in Tamil Nadu, and 27% in Kerala.87 The World Bank publication where these rates were reported did not report on underweight rates in the tsunami-impacted territories of Puducherry and the Andaman and Nicobar Islands.77,85

India’s primary tool for addressing childhood malnutrition was its Integrated Child Development Service, which operated thousands of outreach centres known as Anganwadis. When the tsunami occurred, more than 400 000 Anganwadi workers provided nutritional services to children <6 years of age and to pregnant and nursing mothers, including supplementary feeding, growth monitoring, and education on nutrition.37

In the Nicobar Islands, many of the approximately 26 000 indigenous people still relied heavily on hunting and gathering to meet their dietary needs, and on the sea life in nearby coral reefs and mangroves to meet their protein needs. To supplement what they hunted and gathered, they also reared pigs and tilled gardens where they planted yams, sugar cane, coconuts, and a wide variety of fruit including papaya, pineapple, and jackfruit.86,87

Damage to Food and Nutrition System

In the Nicobar Islands, both the earthquake and tsunami directly impacted the important food sources of the indigenous populations. First, the earthquake resulted in a drop in the land up to four metres in some islands and ruined several mangrove and coral ecosystems that supplied an important source of protein. As the islands sank further into the ocean, it took coral reefs and the mangroves with it. Additionally, the tsunami inundated the islands, washing away gardens and salinating the soil.88,89 It is reasonable to assume that some existing malnutrition could have compromised the strength of some and their ability to withstand the forces of the earthquake and tsunami. Damages resulting in compromised
access to food sources also included damages to distribution centres catering to the nutritional needs of the poor.

Changes in Food and Nutrition System Functions

Access to former food sources including wild boar, raised livestock, and coconut trees was limited due to environmental damages. Consequently, in the year following the tsunami, island residents became highly reliant on rice and vegetable rations delivered to the island by sea once each week.90 In impacted areas on the mainland and in the Andaman and Nicobar Islands, tsunami and earthquake damages rendered 40 Anganwadis inoperable.89 There were no reports of deaths due to starvation related to the earthquake or tsunami.

Relief Responses in Food and Nutrition System

Following the tsunami, relief workers faced several challenges in ensuring tsunami-impacted populations had access to safe and nutritional food sources. Generally, there was not an acute shortage of food immediately following the tsunami, and donations quickly filled any gaps in food supply that might have emerged without relief responses. But the quality of the donated food did not always meet the nutritional needs of survivors, and providing large quantities of fresh food that met nutritional needs sometimes was difficult. For example, some of the cooked food had spoiled before it reached the camps, and had to be thrown away. In response, early in the disaster, camp residents in Tamil Nadu requested that camps serve only freshly cooked meals. However, even with freshly cooked food in the camps, mishandling of food sometimes resulted in cases of diarrhoea.40,92

Recovery Responses and Development in Food and Nutrition System

In addition to sufficient calories and protein, disaster responders wanted to ensure that children also received sufficient quantities of micronutrients and offered nutritional supplements, most notably, vitamin A. Vitamin A was administered to large numbers of children in the tsunami-impacted areas, and often accompanied measles vaccination campaigns. In the Andaman and Nicobar Islands, post-tsunami vitamin A supplements were administered to more children than ever before. For the first time, the islands implemented a biannual vitamin A supplementation programme, reaching 89% of the islands’ population of two- to six-year-old children.92,93

Energy System

Pre-events

Pre-tsunami supplies of electricity were more robust on the mainland of India than they were in the Andaman and Nicobar Islands. In Tamil Nadu, residents relied on a large range of power sources including some produced in neighbouring states. Power sources included hydroelectric, nuclear, coal, wind, and gas. Additionally, power generation generally occurred in locations away from shore, therefore, reducing vulnerability to coastal hazards. Nonetheless, local authorities stockpiled spare parts in case damages were to occur due to tropical cyclones. In Tamil Nadu 53% of its electrical energy was produced from wind generators, 40% from bagasse and biofuels, and 4% from solar. All villages were electrified.92–94 At least 92% of the population on the Andaman and Nicobar Islands received electricity 24 hours x 7 days. Most of the power was provided by diesel generators and some by one hydroelectric plant.95 The diesel had to be imported.

Many communities in the Andaman and Nicobar Islands are separated by ocean and rely on independently operating electricity-generating systems. Before the tsunami, 34 diesel-generator power houses scattered throughout the islands supplied most of the territory’s electrical power. The largest power sources included a privately owned 20 MW diesel power plant near Port Blair.95

Although the islands primarily relied on diesel-generated electrical power supplies, a number of renewable energy sources also were in use, including a 5.25 MW hydroelectric plant in the
northern Andaman islands. In remote areas, some villages only had 5–6 hours of electrical power per day, and about 70 villages did not have any electrical power.95

The principal fuels for cooking consisted of firewood, twigs, dry leaves, crop residue, and even dried cow dung.

**Damage to Energy Supply System**

Damages to the electricity system on the mainland of India were limited mostly to the distribution system, and did not cause major disruptions for extended periods of time. But, in the Andaman and Nicobar Islands, substantial damage occurred to the generating systems that were within reach of the tsunami. In the Andaman and Nicobar Islands, most of the damage occurred in areas near shore that were flooded. Tsunami waves inundated generators, swept away diesel tanks, salinated fuel supplies, toppled distribution poles, and ruined tens of kilometres of distribution lines. On South Andaman island, the tsunami flooded the 20 MW diesel power plant just outside of Port Blair and forced the plant to shut down, and thus reduced the electrical power supplied by the Andaman and Nicobar Administrative Electricity Department by about 70%. Due to serious damages, some island electrical supplies remained almost entirely disrupted for as long as a month following the tsunami.95

In the Nicobars, the 2400 KVA capacity main power house at Malacca, Car Nicobar was destroyed, seriously disrupting electrical power supplies. The tsunami caused power infrastructure damage throughout the Nicobar Islands including, 85 km of destroyed power transmission lines and caused widespread disruption of power supplies. The tsunami also uprooted a 40-ton diesel fuel tank on the island of Car Nicobar.95

**Changes in Energy Supply System Functions**

All medical facilities are dependent on adequate supplies of electrical power in order to provide medical services. All medical facilities in the damaged areas suffered from the loss of electrical power. Few of the facilities had backup electricity generating capabilities. Most of the facilities directly impacted were not destroyed, but the medical facilities were unable to provide even the routine care they had provided pre-event. This severely compromised their ability to provide emergency services needed by the surge of injured victims.

Despite documented evidence that fuel storage facilities were damaged or swept away, no reports were found to indicate a shortage of fuel supplies in India. Only transient shortages occurred in the Andaman and Nicobar Islands.95

**Relief Responses in Energy Supply System**

While islanders waited for electricity to be restored, the use of existing, limited electricity supplies in the Andaman and Nicobar Islands had to be restricted to the most critical needs. On the island of Car Nicobar, communication systems, hospitals, dispensaries, and relief camp energy needs were prioritized above other energy needs until electrical supplies could be fully restored. Repairs of damaged generating equipment were accomplished by the military. Power lines on the mainland were repaired quickly. In some cases, power generation was disrupted not due to damages, but for safety precautions. A partially flooded, but not damaged, nuclear power plant near Chennai in Tamil Nadu that was temporarily shut down as a safety measure.94,98–100

**Recovery Responses in Energy Supply System**

On the Indian mainland, electricity distribution systems generally were restored within two to three days. Restoration was facilitated, in part, by the availability of spare parts. Electricity authorities had stockpiled spare parts in anticipation that damages might sometimes occur due to tropical cyclones. On the other hand, on the Andaman and Nicobar Islands repairs required more resources than what
were locally available. Additionally, delivering the resources and expertise to the areas that needed repairs was considerably more difficult than if the territory had been part of the mainland.

Developments in Energy Supply System
No information that impacted health was found.

Public Works and Engineering System

Pre-events
The Public Works and Engineering basic societal system is responsible for infrastructure needs of society. Therefore, it is responsible for the roads, bridges, railroads, the docks and jetties, the natural and built environment, and public services such as garbage and trash collection and disposal. India had a few train lines along the coastal areas impacted by the tsunami. However, there is an extensive road network including bridges serving these areas. Road transport accounts for 60% of freight and 80% of passenger movement in the areas impacted. There are multiple intermediate and minor shipping ports in the areas impacted.100,101

Damage to Public Works and Engineering System
The earthquake and tsunami left behind large quantities of debris and sludge. In some locations, the tsunami left behind layers of sludge that were one metre thick.40 Boats and vehicles obstructed the roads and the tsunami washed away several roads and damaged bridge supports. On the mainland, 162 km of national highways, 462 km of state/district highways, 14 bridges and 78 culverts were damaged.96 For example, 80 km of roads located within 800 m of the coastline in Tamil Nadu were seriously damaged. Some bridges and embankments were totally destroyed or washed away. In Tamil Nadu, the tsunami destroyed a bridge linking Nagapattinam and Karaikal, creating an obstacle for relief workers trying to reach the northern Nagapattinam district.40

The costs associated with the road damage were estimated at US$ 11.5 million. There was also substantial damage to the ports and fishing harbours; damages amounted to US$ 35.15 million. Although the rail lines were set back from the shore, one main line along the coast was damaged. At least eight rail cars were damaged.97,98

In the Nicobar Islands, the earthquake and tsunami resulted in large-scale environmental changes including the destruction of large tracks of mangrove forest. On the hardest-hit islands, subsidence due to the earthquake and tsunami inundation destroyed as much as 94% of island mangrove cover, ruining an important source of resources and protection for tribal populations.98,99

Following the tsunami, isolation in the territory’s southern islands was compounded by damages to roads, jetties, and harbours. In the Nicobar Islands, the islands hardest hit by the tsunami and with few airports, the earthquake and tsunami severely damaged 24 jetties, some of which were submerged below sea level because subsidence due to the earthquake had dropped land elevations. The Malacca jetty, located along the most populated Nicobar island—Car Nicobar, was destroyed, as was the jetty on the second most populated island. Additionally, jetties were destroyed on many other smaller islands, making access incredibly difficult. The road networks on Nicobar island also suffered. Coastal roads, such as the ring road on Car Nicobar, were seriously damaged isolating some of the villages connected by them.100,101

Changes in Public Works and Engineering System Function
Destroyed houses, blocked roads, smashed vehicles, and a thick layer of sludge and other debris blocked access to some areas. In addition, access to the medical facilities was blocked by debris or washed-out roads. This impaired access by the injured and the staff to the facilities as well as the delivery of essential supplies and replacements for damaged equipment. Thus, the availability of essential health services was compromised. This may have impacted on the ability to treat many victims with life-threatening injuries.
Damage to the ports led to substantial losses due to complete or partial suspension of imports, exports, and fishing activities. Additional costs were encountered due to the diversion of ships to other ports. Damage also required the transfer of cargo from ships to smaller vessels that could dock in the damaged ports. In addition, port-related services, such as fuel and water supply to the vessels were compromised. Furthermore, there was a loss of employment for many of the workers that serviced the damaged ports.98–100

Relief Responses in Public Works and Engineering System
Initially, alternate routes had to be established in order to bypass the damaged roads. Debris and sludge had to be removed in order to assure access to the medical facilities. Government authorities sometimes struggled to find enough workers to remove the sludge and debris. In Tamil Nadu, responsibility for the initial removal of debris and sludge often was delegated to municipal health officers. Finding sufficient workers for debris and sludge removal presented a challenge primarily in areas where tsunami destruction was widespread, such as in Nagapattinam.13,14,99,100

Recovery Responses and Developments in Public Works and Engineering System
For the most part, recovery (repair and reconstruction) was combined with development in terms of increasing the absorbing capacity of the rebuilt structures. In addition, resources were invested into the designation and improvement of evacuation routes, especially along the coastline. Removal of the debris had to be accomplished before rebuilding could begin and some degree of normalcy could be restored in devastated communities. Within six months, all routes were open, and trains were running on schedule. Some debris, including damaged fishing boats, could still be found. Roads were repaired quickly following the damage.13

Social Systems
Pre-events

India’s seven most common religions each had at least 4 million followers. Hinduism was the most popular religion and was practiced by approximately 80% of the population, Islam by 13%, and Christianity by 2%. In the south, a greater proportion of Indians identified themselves as Hindus or Christians. In Tamil Nadu, 88% of the population identified themselves as Hindus and 6% as being Christians.15,50,78,97

India had 15 national languages with >1600 dialects. Hindi was India’s most widely spoken language. Hindi is the designated national language, but the proportion of the population speaking Hindi is estimated from 20% to 41%! Of its most commonly spoken languages, 32 were spoken as a first language by at least 1 million Indians.101 English is the official business/legislative language, and often, was widely spoken as a second language. Although nationally, Hindi was India’s most commonly spoken language, it was less commonly spoken in the south. Along the coasts of the south, the most common languages used included Malayalam, spoken primarily in Kerala, Tamil, spoken primarily in Tamil Nadu, and Telugu, spoken primarily in Andhra Pradesh.103

The most delicate and unique social circumstances in the tsunami-impacted regions were found in the Andaman and Nicobar Islands. In the Nicobar Islands, the culture of its indigenous communities was so unique that India had passed a regulation to protect them from exposure to outside influences. Of the 42 068 people who lived in the Nicobar Islands, 26 565 (62.3%) were indigenous inhabitants and lived lives that were rich with rituals, involved little commercial activity, and relied heavily on the natural resources surrounding the islands. To enable these indigenous communities to sustain their way of living uninterrupted, the Andaman and Nicobar Protection of Aboriginal Tribes Regulation strictly limited travel by outsiders to the Nicobar Islands. Other than Indian government officials, very few people were allowed to travel to the Nicobar Islands.100
Even with strict regulations limiting travel to the Nicobar Islands, indigenous Nicobarese could not be entirely isolated from influences threatening to unravel their way of life. Before the tsunami, the population that made up Nicobar’s indigenous communities made collective decisions regarding their welfare through a group of village representatives who sat on a Tribal Council. The Tribal Council acted as an intermediary between external institutions and the indigenous population, and historically, had been comprised primarily of village elders. However, in 2003, villagers replaced many of the Tribal Council’s elders with younger members who could better understand the outside world, but who were less experienced with traditional rules regulating activities among indigenous inhabitants.

India’s effort to protect the Andaman and Nicobar Island’s unique communities indicated that India recognized the importance of social and cultural diversity and identification as important to the overall health and well-being of its citizens. Similarly, the country also had recognized the importance of mental health to its citizens’ overall well-being. Due, in part, to its experience with the Bhopal gas tragedy in 1984, recognition of mental health concerns gained considerable ground during the 20 years preceding the tsunami. In 1984, a toxic gas leak—the worst industrial accident the world had ever seen—killed thousands of people in the city of Bhopal and left many psychologically traumatized. The area was unprepared to address the resulting mental health issues—survivors did not receive psychological help for more than five weeks after the chemical leak. India’s experience with the Bhopal disaster and changes in its political climate resulted in greater support and expansion of the mental health services. But, while the recognition and support for the need for mental health support had improved during the 20 years preceding the tsunami, mental health services remained scarce and unevenly distributed.

As a country with a population of 1.1 billion, India had fewer than 3000 trained psychiatrists, or approximately 0.02 psychiatrists/10,000 people, and even fewer psychologists (0.002 psychologists per 10,000 population), fewer than in any of the countries examined other than Sri Lanka. And, since most of India’s mental health professionals were located in major cities, access to mental health services was particularly dire in rural areas. India had a National Mental Health Programme that formed the basis for public health initiatives in the field.

Damage to Social System

When the earthquake/tsunami toppled buildings and uprooted trees, it also left behind less visible but equally horrific damages to the social fabric of the communities impacted. The earthquake/tsunami brought deep grief to many survivors, disrupted demographic balances, and aggravated vulnerabilities. About one-third of those affected in the tsunami-impacted areas of India were believed to have come from socially marginalized and underprivileged groups including tribal people and Dalits. The earthquake/tsunami also killed a disproportionately large number of women and children. In the Karakai region of Puducherry, adult female fatalities outnumbered adult male fatalities nearly 2:1, and more than half of all of the deaths were children. Of the tsunami-related fatalities in Karakai, 33% were female and 51% were children.

Because the earthquake/tsunami killed a disproportionately large number of children, it left behind few orphans—the tsunami orphaned 480 Indian children, 289 (60%) of whom lived in the state of Tamil Nadu.

Changes in Social System Functions

The effects of the tsunami included the loss of loved ones, livelihoods, and homes, and left the survivors with immense grief and uncertainty. Losses were compounded by the scope of the disaster, which made it difficult for survivors to find bodies of loved ones and which brought their grief to the attention of the whole world. Because so many Indians had been killed at once, survivors had to search among mutilated bodies for missing loved ones—some never found them. And, media images turned traumatized survivors’ personal grief into a public spectacle.
To make things worse, some survivors turned to socially disruptive behaviours.

Older and sterilized women who were no longer fertile and lost children to the tsunami sometimes were left with no children, compounding the already traumatic experience of having lost a child. Additionally, as the primary caretakers of children, women were more likely to have been with their children when the tsunami swept them away, and consequently, often suffered insurmountable guilt over their children’s deaths. Women also were more likely to suffer harassment and abuse after the tsunami. The tsunami widowed 787 women, 562 (71%) of whom lived in Tamil Nadu. Women who had lost their homes or husbands often lost much of their security. In camps, poor sanitation facilities and cramped living conditions compromised women’s privacy and exposed them as targets for sexual abuse.

The disproportionately high number of female fatalities, however, resulted in a disproportionately high number of widowers and put pressure on unmarried women including underage women to marry. Families who had lost livelihoods and no longer could care for young women also contributed to this pressure. While the disaster undermined the lives of some women with regard to their marital futures, it also undermined the lives of women with regard to their future as mothers.

Although the men were less vulnerable to harassment and abuse than were the women and children, disaster-related hardships also took a psychological toll on men. Men were more likely to survive to mourn the deaths of their loved ones and to have to cope with fractured families. Widowers accustomed to having a wife care for them and their children while they earned for their families, in some cases, were unable to secure children’s upbringing and continue to support them monetarily.

Perhaps to drown their sorrows, because lost livelihoods left them idle or the availability of relief money resulted in increased alcohol consumption by some of the survivors, particularly men. A study tracking alcohol sales at four shops in impacted communities in Tamil Nadu between November 2004 and February 2005, found evidence that alcohol consumption had increased. Total sales for the four shops dipped slightly in December, but then climbed again in January and reached their highest level in February. And sales in January grew despite three of the four shops having been closed for four days. The three shops were closed on 31 December after survivors who had just received relief money mobbed several alcohol stores and initiated riots.

Many Indians were wrought with anxiety and fear that sometimes were a result of misunderstanding tsunamis. In the Andaman and Nicobar Islands, islanders worried that because the tsunami had occurred during the December full moon, the next month’s full moon might also bring a tsunami. Consequently, some islanders moved to higher ground before 26 January because of the concern that a full moon might trigger another tsunami.

A National Institute of Epidemiology survey of 314 adults in a tsunami-impacted village in the Cuddalore district found that 40 (12.7%) of the surveyed adults exhibited signs of the post-traumatic stress disorder. The survey also noted that survivors who had no livelihood, had lost a family member, or had a tsunami-related injury were more likely to show signs of the post-traumatic stress disorder.

Not all of the survivors responded to the disaster in the same way. Some were found to be more resilient to the traumas the disaster had thrust upon them than others and suffered fewer mental health disorders. In the Andaman and Nicobar Islands, the response to the tsunami may have been even more socially disruptive than the earthquake and tsunami damages. The response to the tsunami resulted in many shifts in cultural norms for the indigenous populations of the Nicobar Islands. The manner in which
the Nicobarese share resources and relate to one another was turned upside down as they changed their cultural rules in order to take greater advantage of relief and recovery programmes. In the Nicobar Islands, which were occupied by two contrasting communities—one resembling mainland communities and known as settlers, and a second community of indigenous tribes characterized by large family units and low reliance on modern amenities—the indigenous community was the more resilient. Nine Shompen are reported to have died due to the tsunami. The Schizophrenia Research Foundation (SCARF) conducted a rapid assessment in which tsunami-impacted individuals were surveyed and found that 53% felt that they needed some sort of psychosocial support.

**Relief Responses in Social System**

Following the tsunami, India’s central government immediately recognized the need for mental health support and designated the National Institute of Mental Health and Neurosciences (NIMHANS) to lead the national response. The NIMHANS sent mental health professionals to impacted areas within two days of the tsunami. State governments also mobilized quickly, and ultimately became the backbone of India’s mental health response with the exception of Puducherry and the Andaman and Nicobar Islands. As union territories, Puducherry and the Andaman and Nicobar Islands did not have their own government agencies to mobilize a mental health response, and instead, relied on NIMHANS to take the lead. Although central and state governments were quick to recognize and respond to the need for mental health support, it was WHO that proposed a programme that would provide community-based mental health responses, and ultimately, would reshape India’s approach to post-disaster mental health needs.

Although indigenous Nicobarese live in large extended families and do not recognize the small nuclear family unit, they were asked to break up large family units in order to take advantage of a government relief programme offering Rs.2000 (US$ 44)/affected family. The sudden emergence of relief and recovery programmes offering large amounts of cash and free goods undermined the tribal traditional rules guiding behaviour, political and family structures, and economic activities. Traditional knowledge alone could not meet the new challenges brought by the sudden demand for negotiating with outsiders; this demand
grew, young community members, who were more likely to be able to read and deal with outside institutions, increasingly replaced elders as community leaders. However, these younger leaders were less knowledgeable with respect to traditional rules guiding lives between indigenous people on the islands and the incidence of arbitrary decisions with respect to politics within indigenous communities began to undermine the Tribal Council and overall authoritative structure of the indigenous population.

For at least 10 days following the tsunami, survivors in the Andaman and Nicobar Islands received almost no formal mental health support. Few people in the islands were trained to provide mental health support and logistical challenges delayed the arrival of mental health professionals from the mainland. The first mental health professionals from the mainland, a NIMHANS multi-disciplinary team, reached the islands on 5 January. NIMHANS contacted the Health, Education, and Social Welfare Departments of the Andaman and Nicobar Islands to discuss the need to provide survivors with mental health care and to seek their cooperation. The NIMHANS also contacted and sought cooperation from community school principals, teachers, relief camp organizers, and volunteers from among the survivors to help build a mental health care network. With the cooperation of the contacted government departments and community members, NIMHANS convened classes to provide them with mental health support skills. The classes taught participants how to identify mental disorder symptoms, help normalize the daily lives of impacted children, and provide basic counseling.112,113

Recovery Responses in Social System

The post-tsunami shift to relying more on community support and more away from relying on medical treatment was greatest in Tamil Nadu, where the post-tsunami mental health response has since become the national model for post-disaster mental health responses. The community approach relies on community members such as teachers, social workers, and others with experience in working within the community to provide primary support. Following the tsunami, mental health professionals trained community members on providing basic psychosocial support to impacted families as a way of helping them to regain a sense of normalcy. Because the community-level workers already were intimately familiar with the communities in which they were providing support, they did not need to overcome the cultural and language barriers that outside mental health responders sometimes have had to overcome. When tsunami survivors needed more support than community-level psychosocial workers could provide, medical officers at the primary healthcare level stepped in to take care of their needs, and when this level of care was insufficient, patients were referred to psychiatrists at the district hospitals or medical colleges.

A WHO-SEARO assessment of the mental health response found that coordination problems appeared to have resulted in a considerable degree of overlap.101,102 Nonetheless, India, along with Thailand and Maldives, exhibited strong mental health response coordination compared to Sri Lanka and Indonesia. Coordination strengths within India’s mental health response were partially due to a strong civil administration in each district, with the power to control all of the agencies operating within the district. Additionally, India announced that outside assistance was not needed and was not reticent about telling unwanted agencies to leave and even enforced orders to leave with police help. Consequently, NGO presence and activities were more limited and controlled than in Indonesia or Sri Lanka.110–115

Lastly, in an effort to help reduce the psychological trauma that resulted from the loss of children among couples who had resorted to permanent methods of contraception, state officials in Tamil Nadu initiated a programme to offer free tubectomy and vasectomy reversal procedures to parents who had lost all of their children due to the tsunami.64
Developments in Social System
All of the tsunami-impacted areas in India adopted the community support approach at some level, but the community approach was most strongly adopted in Tamil Nadu where the state designated the Social Welfare Department as the leading mental health service provider. In other impacted areas, mental health institutions and medical colleges were the main service providers. Tamil Nadu gleaned several advantages in relying on the social welfare department rather than a medical institution. Medical institutions generally are limited to providing services through hospitals, clinics, and healthcare workers. The social welfare department, on the other hand, has a much greater reach throughout the community with an office, social welfare officer, and various support staff in each district. They have the capacity to respond according to the local needs.

Transportation and Logistics System
Pre-events
Mainland India had a vast transportation system consisting of roads, rail, air, and shipping ports. Means of transportation included horse carriages, cycle rickshaws, manually pedaled rickshaws, trains, buses, trucks, vans, auto-rickshaws, two-wheelers (scooters and motorcycles), cars, utility vehicles, and metro systems in the large cities. The population of India was expanding at an unprecedented rate. In the cities, traffic jams are frequent and travel is slow. The transportation and logistics system is publically owned and operated. In 2004, a crisis in public transportation was defined: the Transportation and Logistics System had overwhelming needs and limited resources with which to meet the needs. Most bus and train services were overwhelmed. Serious problems occurred relative to the safety of the transportation system. Boats and ships were essential for imports, exports, and fishing. Much of the economy was dependent on international shipping in the hundreds of ports that ringed India.

Ambulance transportation services were operated by multiple organizations including the government, police, fire brigades, hospitals, and private agencies. There was a wide discrepancy in available services between rural and urban areas, and one-third of the ambulance services did not have the equivalent of emergency medical technicians as staff; they did not provide emergency responses—and only served as transport. Pre-events, the Andaman and Nicobar Islands were isolated due to their distance from the mainland and vast rough seas that surrounded them. The tsunami damaged 160 km of national highway and 520 km of state roads. In Tamil Nadu, the tsunami destroyed a bridge linking Nagapattinam and Karaikal, creating an obstacle for relief workers trying to reach northern Nagapattinam district.

Transportation to, from, and within the Andaman and Nicobar Islands was challenging when compared to the other areas of India hit by the earthquake and tsunami. The Andaman and Nicobar Islands were far from the mainland and surrounded by rough ocean waters. Transportation of goods to the Andaman and Nicobar Islands always was slow, particularly to the Nicobar Islands. Generally, it required five days for a ship to travel from mainland India to Port Blair on South Andaman Island. Goods destined for the Nicobar Islands had to be transferred to other ships once they had reached Port Blair, and it could take up to two more days to reach their final destination in the Nicobars.

Damage to Transportation and Logistics System
As the tsunami only penetrated a maximum of 3 km inland, structural damage to India’s transportation and logistics system was confined to the coastline. Along with the widespread destruction of the public works infrastructure, extensive damage was suffered by the transportation system. The Asian Development Bank provided more than US$ 50 million to
assist in the reconstruction and rehabilitation of the transport system damaged by the tsunami, most of which was directed toward the repair of the damaged infrastructure. The costs of the damage were tightly intertwined with the damage to the public works and engineering system. Actual damage to the transportation system has not been culled out. It is known that boats, automobiles, buses, and trains were directly affected, but the costs have not been accounted.

No reports were found that defined damage to airports in India.

**Changes in Transportation and Logistics System Functions**

Transportation damages hampered delivery of aid to the tsunami-impacted areas along the coast of the mainland. Furthermore, ships could not dock and load/unload cargo. Airports remained functional. Due to losses of infrastructure, it was difficult for staff, equipment, and supplies to reach some of the medical facilities.

In the Andaman and Nicobar Islands, the lack of airstrips on which to land aircraft bringing needed supplies along with severely damaged harbours, created a logistical nightmare for those trying to deliver aid to the islands. At times, it was impossible to deliver large quantities of aid. The usual five-day voyage by ship from the mainland to the territory’s capital, Port Blair, followed by another voyage of up to two days to the Nicobar Islands, seriously slowed aid deliveries to the islanders who had been the hardest hit by both the earthquake and the tsunami. When ships finally arrived in the Nicobar Islands, they could not dock due to jetty damages and aid had to be ferried between the ships and the islands using small boats. Furthermore, when ships carrying rescuers, relief workers, and aid arrived on impacted islands, they found that many were not equipped to receive them.

**Relief Responses in Transportation and Logistics System**

Little literature regarding relief from the changes in function has related to the Transportation and Logistics System. Instead the work has focused on the repairs to the infrastructure as described in the above section on public works and engineering. It is known that India was able to mobilize resources from states and used its military. No specific interventions were identified regarding the transport and logistics system.

**Recovery Responses and Development in Transportation and Logistics System**

As in relief, little could be found relative to recovery and development of the transportation and logistics system. It is known that the rail system was restored within six months of the events and that the roads and docks were repaired. Further, it is clear that decisions were made to “build back better”. But, again, these projects were related to repair of the infrastructure and did not apply directly to the Transportation and Logistics System.

**Security systems**

**Pre-events**

Prior to the earthquake and tsunami, most security threats were related to internal conflicts and protection of the borders. Internal threats related to religion-oriented conflict sometimes resulted in violence and separatist movements. Authority and responsibility for security are spread throughout a host of agencies.

**Law enforcement**

There are > 1 million police officers in India (about 1/125 person. The police are dependent upon paramilitary forces for backup and gap filling. Police are under the control of the state governments. There exist state and local (municipal police units). The national government is able to supplement the paramilitary forces as deemed necessary, particularly with regard to guarding the coasts and borders.

**Military**

There are three military services in India: army, navy, and air force. They are supplemented by paramilitary and reserve forces that include law enforcement agencies. The army is dominant.
in terms of budget and number of personnel. In 2004, there were 1,325,000 active-duty personnel and 1,089,700 reserve and paramilitary personnel. The military is responsible to the Defence Minister, who is a member of the cabinet. The military budget was US$ 19.1 billion in 2004. Border issues are of substantial concern, particularly with Pakistan.

Prior to the tsunami, the Andaman and Nicobar Islands had become home to India’s first integrated forces, known as a Joint Services Command. This Command integrated the services of India’s three military forces—the army, navy, and air force—and a number of paramilitary forces. Of these services, the navy had the greatest presence; as of 2002, the navy had a fleet of 16 ships in Port Blair.

Due to their location, the Andaman and Nicobar Islands have been a strategically important military location for India. The islands are 1,200 km from mainland India, yet just 150 km from Indonesia, 273 km from Phuket, Thailand, and 300 km from Myanmar. Although the Andaman and Nicobar Islands had a large military presence, their presence throughout the island territory was not as great as that of the police, which did not have the same logistical capacity as the military, but was present in nearly all of the communities.

**Damage to Security System and Changes in Functions**

The tsunami heavily damaged an Indian Air Force station located on Car Nicobar, killing 116 personnel. The territory’s police and fire brigade also were severely damaged and 13-14 personnel were killed. Additionally, in the Nicobar Islands, police stations were damaged or destroyed, and the police wireless communications system was crippled, leaving police stations located on different islands with no means of communicating with one another.

Other than the above, no records were found related to damage of the military or law enforcement.

**Relief Responses in Security System**

Security forces played a large role in India’s responses to the tsunami, both nationally and internationally. Following the tsunami, the Indian army, navy, and air force launched Operation Sea Wave, the largest military peacetime operation in the country’s history. Operation Sea Wave triggered the deployment of 4,000 military personnel, 30 ships, 30 helicopters, and 25 large transport aircraft. Air force aircraft evacuated survivors and dropped urgent relief supplies, while navy ships ferried in huge quantities of food, water, and other needed relief items. Operation Sea Wave supported rescue and relief efforts in Tamil Nadu, Kerala, Andhra Pradesh, Puducherry, Sri Lanka, and the Maldives, but the help was the greatest in the Andaman and Nicobar Islands. However, while the military often was among the earliest to arrive to assist survivors, it was not the first. Local police and fire brigade personnel were in nearly every community impacted and typically were among the very first to respond.

In some situations, the police had to act with very little support and few resources. In Port Blair, the capital of the Andaman and Nicobar Islands, the Director-General of Police was alerted to a problem when seven police stations in the south were not responding; and he quickly coordinated with the navy and the coast guard to send support to the Nicobar Islands. Because the Andaman and Nicobar Islands are a union territory rather than a state, the navy, coast guard, and local police usually would wait for directions from the central government before launching a major operation, but local authorities realized that they had a crisis and decided not to wait to respond. By the morning of 27 December, approximately 500 police and military personnel were deployed from Port Blair to Car Nicobar.

Following this first deployment, navy ships and air force planes would continue to expand relief into the Nicobar Islands, and evacuated survivors from devastated islands. Due to serious logistical issues, the armed forces played a particularly
large role in the Andaman and Nicobar Islands. The police wireless communications system took anywhere from two days to a month to restore communication services on each of the Nicobari islands.

India also sent military personnel, supplies, and equipment to Aceh province in Indonesia within days of the earthquake and tsunami.\(^{121}\)

Recovery Responses in Security System
No information was obtained relative to recovery of the security system as there was little loss of function recorded.

Developments in Security System
No information was obtained relative to development of the security system.

Communications System

Pre-events
Unlike in the Pacific Ocean, there were no tsunami warning devices in the Indian Ocean basin that would have been useful in detecting the tsunami.

Damage to Communications System
As there was no tsunami warning system in place at the time of the tsunami, there was no damage. Little damage accrued to the communications system. Radio towers and transmission lines were affected. Major communication complexes were beyond the reach of the tsunami on the mainland, but it seems that substantial damage was inflicted on the communications systems in the Andaman and Nicobar Islands.

Changes in Communications System Functions
There were no timely warnings to any of the countries that a tsunami was approaching. The reasons for this are not clear. Initially, the seismic data were not translated into a tsunami warning, and the information that a huge tsunami had struck any of the countries was not generated. This occurred despite the fact that, with the exception of the Andaman and Nicobar Islands, there was abundant time to warn the Indian mainland of the approaching tsunami. However, communication was lost between the islands and the mainland as well as between the islands.

Due to communications damages some of the communities hardest hit by the tsunami, could not contact neighbouring communities to request help. This breakdown in communications was most acute and most isolating in the Nicobari Islands, where little communication infrastructure existed pre-event. But communication breakdowns also isolated several hard-hit communities along the Tamil Nadu coast, including communities in the state’s hardest hit district, Nagapattinam.\(^{37}\)

In the Nicobar Islands, it would take a long time before communications were restored and authorities outside the Nicobars could not understand the degree of the devastation the tsunami had caused there. The city of Chennai suffered few deaths and little damage compared to other coastal districts in the state; the city’s communications systems was not damaged. For this reason, at first, it was thought to have been the centre of the tsunami’s greatest devastation. However, within the next few hours, calls trickling in from police radios and a few cell phones from within harder hit regions prompted state authorities to realize that Chennai’s misfortunes represented only a small portion of the devastation that had occurred across the state.\(^{37}\)

Relief and Recovery Responses in Communications System
In Tamil Nadu, communication breakdowns were remedied quickly. Although it would be days before the fatalities and the damages were tallied and the authorities would understand the full extent of the devastation that had occurred, after the first day, communication breakdowns were overcome in mainland India.\(^{119,120}\)

Development in Communications System
A tsunami warning system for the Indian Ocean basin is under construction. No other information pertinent to medical care or public health was found.
Economy System
Pre-events

In 2004, India was the 10th largest economy in the world. However, approximately 26% of its population remained below the poverty line.¹²² In tsunami-impacted areas, the overall poverty rates generally were lower than in the country as a whole. In Tamil Nadu and the Andaman and Nicobar Islands, the two hardest hit regions, 21% of the population lived below the poverty line, and in Kerala, the percentage of the population living below the poverty line was only half of the national average, with only 13% of the population living below the poverty line.¹⁴,¹¹⁹

In indigenous communities in the Nicobar Islands, economic activities were limited. Indigenous communities relied on the natural resources around them to support a great deal of their needs, and few indigenous people accumulated capital. When they needed money to buy something from the market, they sold copra, dried coconut kernels, or purchased what was needed.⁹¹

According to World Bank classifications, India was a low-income country.² In 2004, the World Bank classified counties with a gross national income of $765/capita as low-income countries. But, India had one of the 10 fastest growing economies in the world. In Tamil Nadu, approximately 65% of the population relied on agriculture for their livelihood.¹⁴

Damage to Economy

The economic consequences for many impacted by the tsunami were huge. Many of those who survived would have to replace all of their belongings and repair damaged homes. Businesses were recently affected.

Changes in Economy System Functions

In the worst cases, some victims lost everything, including their livelihoods. Fishermen were among the hardest hit, and were most likely to have all of the tools of their trade located near shore and lost them to the sea when the tsunami retreated into the ocean.

Economic losses were also keenly felt among families in which the primary wage earning member had died. And, although family members of the deceased could receive financial compensation with proof provided by a death certificate, many families could not provide the body of a loved one in order to receive a death certificate. The tsunami scattered bodies far and wide, and in the approximately 24-hour timeframe between the victims’ death and body decomposition that prevented recognition, some of the deceased would never be identified.

Relief Responses in Economy

Victims benefited from a variety of economic assistance packages primarily provided by the government. Compensation packages targeted a wide range of people who had suffered losses due to the earthquake/tsunami, including those who had lost relatives, had been injured, and/or lost livelihoods due to the tsunami. But ensuring that those who suffered losses due to the tsunami were compensated while protecting against possible fraudulent claims for benefits, presented a formidable challenge.

In providing compensation for relatives of the deceased, the government also faced the formidable task of providing a large number of death certificates in a short period of time, often to people who could not provide a body to prove death. In Tamil Nadu, officials sped up the process by which death certificates were issued in order to facilitate compensation to their relatives by appointing more registrars. In order to enable people to more easily receive compensation benefits for lost relatives who likely had died due to the earthquake/tsunami, but had not been found, government officials expedited the process of declaring missing people as dead.³⁷

Proof of injury due to the tsunami also was challenging. For example, in Tamil Nadu, injury claims were made for many days following the tsunami; district administrators and health officials eventually decided that an injury claim made more than seven days following the tsunami...
required an evaluation of the injury to determine how old the injury was and if it likely had been caused by the earthquake/tsunami.

In the immediate aftermath of the tsunami, the central government provided a one-time, relief package for all tsunami-affected families of US$ 92/family along with rations of rice, fuel, and various household items. This was followed by several more monetary relief packages, including a second relief package to all tsunami-affected families of US$ 23 and US $12 worth of relief goods and relief distributed based on losses due to the tsunami. Other major national relief packages included a fund which paid US$ 2300 to the next of kin family member of each tsunami fatality and a fund paying anywhere from US$ 555 to US$ 11 000 to fishermen for lost or damaged fishing boats.

In addition to fair distribution of economic support, concerns also were raised about how money distributed to victims was spent. As an example, on the evening of 31 December, the day that the Tamil Nadu Government distributed the first of two installments of cash for recovery to survivors, the government closed 19 alcohol shops located along its coastal belt to help prevent survivors from spending the relief money on alcohol.

Recovery Responses in Economy
Livelihood compensation also was provided to victims and probably benefited fishermen more than any other sector. The government of Tamil Nadu provided fishermen with the most generous support allocating approximately US$ 100 million for livelihood restoration.

In the Nicobar Island, economic programmes initiated in indigenous communities that did not take traditional norms into account often failed to achieve project goals, and in some cases, created new problems. An Agriculture Department cash-for-work programme tried to spur greater cultivation in indigenous communities by asking them to allocate a portion of community property for use as community plantations. The project would pay people in the community to work in the plantations and the produce would be given to the community. But, the project clashed with indigenous norms. First, indigenous communities typically did not have communal land. All land was privately owned, and ownership of the fruits derived from a plantation was not determined by who owned the land, and who paid to have the plantation planted and maintained, but by who planted the trees. The failure to take these cultural factors into account, and the fact that the indigenous populations had more money in their pockets than they ever had before, doomed the project to failure. By the beginning of the first monsoon following the tsunami, not even half of the coconut and cashew saplings that had been provided for the project had been planted.

Additionally, the sudden injection of cash and free relief items into indigenous communities created an appetite for commodities that they had previously not known of or wanted. Having received more cash than they had ever had, indigenous people suddenly were purchasing a variety of high-ticket items including motorbikes, television sets, cell phones, as well as hard liquor and junk food. Consequently, the supply of free money and goods encouraged indigenous populations to become increasingly dependent on goods that could not be provided by their resource boundary, and accelerated the disintegration of the indigenous population’s unique culture.

Education System
Pre-events
The literacy rate in Tamil Nadu, last assessed before the tsunami in 2001, was 73.5% for the entire population and 82.4% for men, and 64.6% for women. The literacy rate in the Union Territory of Puducherry, also last assessed in 2001, was 81% for the entire population –89% for men, and 74% for women. In the Union Territory of the Andaman and Nicobar Islands, the literacy rate for the entire population also was 81%–86% for men and 75% for women. Finally, for the whole of India, the literacy rate as of 2001 was 65%.
Damage to Education System
It remains unclear as to the number of students and teachers who were injured or who died from their injuries and how many schools were damaged or destroyed. In the Andaman and Nicobar Islands the tsunami damaged at least 68 schools. 107,121

Changes in Education System Functions
Most schools in the areas directly impacted by the tsunami had to suspend classes. Thus, those children who survived were at home instead of at school further increasing the burdens on their respective families.

Relief and Recovery Responses in Education System
Almost all the schools reopened two to three weeks after the tsunami. Although some schools had to be reopened in tents rather than in school buildings, the early resumption of classes helped to restore a sense of normalcy for families within tsunami-impacted areas. 55

Coordination and Control Pre-events
Differences in governance resulted in considerable variations in the mechanisms and capacity to respond to disasters from one region to the next. At the national level, since 2002, the Ministry of Home Affairs had assumed responsibility for disaster management. 95 But, India’s national government’s engagement in disaster management at the local level varied depending on whether the region in question was a state or a union territory. Most of India consisted of states, which had a much greater role in managing their own affairs, including the management of disasters than did union territories. Union territories were administered by the President of India through lieutenant-governors, and relied heavily on the national government to manage their affairs, including the coordination of responses to a disaster. However, both on the mainland and in the territories, there was no formalized mechanism or agency with the mandate, resources, and authority to prepare for such a disaster or to manage one once it occurred. Many agencies were assigned the mandate, but were not provided with the authority (power) or the resources to administer the coordination and control of crises.

Each circumstance had advantages and disadvantages with respect to the management of disasters. On the one hand, greater reliance on local authorities than national authorities in the states tended to result in quicker decision-making and responses. However, greater reliance on national authorities in the territories gave the disaster responses in territories access to greater amounts of resources than in states. In the union territory of the Andaman and Nicobar Islands, two unique factors influenced the disaster management capacity. The islands were geographically isolated from the rest of the country, which made it difficult to deliver needed resources quickly, but also made it a strategically important. Consequently, the Andaman and Nicobar Islands had a sizable Indian armed forces and coast guard presence before the tsunami. 94 The armed forces, including the army, navy, and air force, in the Andaman and Nicobar Islands were unique in that their operations were coordinated under a Joint Services Command. Other than for the military, there was no unifying mechanism for coordination.

Damage and Changes in Coordination and Control Functions
There was no overall formal Coordination and Control mechanism in place, and hence, it was not damaged and did not have a change in function due to damage.

Relief responses in Coordination and Control
India maintained a considerably greater degree of control over the disaster responses within its borders than did Indonesia, the Maldives, or Sri Lanka. Although the tsunami had dealt a major blow to India, it had not rendered the country helpless. And, to communicate this fact to the international community, Indian officials announced that India did not need international
Indian government officials were concerned that another tsunami was about to occur after the Indian Meteorological Department found a warning on an American research group’s website. Although no method has been proven to be able to predict earthquakes in the short-term, the research group claimed to have instruments that indicated a tsunami-generating earthquake was likely to occur off the coast of Australia within just a few days. After having contacted the research group, the Meteorological Department passed its warning onto the Ministry of Home Affairs, which issued a warning as a precautionary measure. In the state of Tamil Nadu, however, local authorities received the warning with grave concern and quickly evacuated residents from coastal areas (Figure 4.10).11,125

The Health Sector Emergency Preparedness and Response Programme, which dated back to 1980, shaped the Indian “health sector’s” disaster response system. Under this system, designated government bodies and medical leaders at the central, state, and local levels took responsibility for coordinating health sector disaster responses. Coordination responsibilities were undertaken by the Emergency Medical Relief Division of the Ministry of Health and Family Welfare at the central level, a joint director or deputy director under the Director of Health Services at the state level, and by a chief medical officer or civil surgeon at the local level.50

In the Andaman and Nicobar Islands, an Integrated Relief Command was created to coordinate the territory administrative and Joint Services Command.127

In the Andaman and Nicobar Islands, the local disaster response coordination began on the day of the earthquake and tsunami, with a Disaster Management Committee meeting led by the Lieutenant-Governor. A control room was set up in the Port Blair office of the Deputy Commissioner to coordinate responses including search and rescue, evacuation, and relief activities.125 In the Andaman and Nicobar Islands, an Integrated Relief Command was created to coordinate the territory administrative and Joint Services Command.125

In Tamil Nadu’s three hardest-hit districts, NGOs were asked to register with the Collectorate. The donor funding or responses to support disaster efforts within the country, and even donated to other tsunami-impacted countries. India later amended this proclamation, stating that it would welcome donations to support long-term recovery projects.123–125 But India had sent a clear message to the international community indicating that it was in control of the disaster responses within its borders. As a result, India avoided the degree of chaos that emerged in Indonesia and Sri Lanka, where international and national NGOs largely operated without consulting local authorities.

In directing the disaster responses, the Indians engaged all levels of government. The Ministry of Home Affairs led the central government relief responses, state relief commissioners led state responses, and district collectors led the district responses. In the Andaman and Nicobar Islands, the locally stationed armed forces and coast guard took the lead in early rescue and relief in the Islands.94 In Tamil Nadu, district collectors played central roles in coordinating and initiating relief and recovery activities. While the responses of the central government were vital to India’s disaster responses, its response also was uniquely decentralized; state and district authorities took the lead in many basic societal system responses and particularly, in the medical response. While the central government played a greater role in Puducherry and the Andaman and Nicobar Islands, overall, local authorities took the lead for responses. Consequently, responses from one impacted state or territory varied from the next in their degree of coordination and effectiveness.

Some critics have highlighted the lack of coordination between the Ministry of Home affairs and the Defence Ministry.95 On 30 December, the Ministry of Home Affairs issued a warning that another earthquake and tsunami were likely to occur on the afternoon of that day. State governments quickly turned their attention and resources from relief to evacuation, but the information that the Ministry had received regarding a potential earthquake and tsunami turned out to be a hoax.94
Collector and other officers held coordination meetings with the NGOs. Early during the disaster meetings were held every day, and then, twice or three times each week after the first week of the disaster.37

**Recovery Responses in Coordination and Control**

In many ways, the state of Tamil Nadu represented the strongest of India’s local responses, making some of the strongest recovery progress in systems such as housing, despite having been particularly hard hit by the tsunami. On the other hand, the union territory of the Andaman and the Nicobar Islands represented some of India’s least effective responses. The Andaman and Nicobar Islands were two hardest-hit regions in India where the response frequently was implemented without consulting recipients about their needs and recovery tended to be slow.

**Development in Coordination and Control**

A regional meeting of the countries in South-East Asia was convened by WHO-SEARO in Bangkok, Thailand to discuss the health aspects of disaster preparedness and response. The Ministry of Health of India participated in the development of 12 benchmarks (see Chapter 29 for details).

Ten of the benchmarks relate to coordination and control. Each of the countries then defined where they were in relation to each of the benchmarks. India defined its current position relative to each of the benchmarks (Table 4.7).

To coordinate NGO relief efforts, three Indian NGOs—the South Indian Federation of Fishermen Societies, Nav Nirmaan, and the South India NGO, ACCORD helped to create the Tsunami-South India NGO Coordination Cell.94 Within approximately two months of the tsunami, 370 NGOs had registered with the coordination cell in Nagapattinam. The Nagapattinam Coordination Cell consulted aid recipients about their needs and conveyed those needs to NGOs and governmental bodies supporting relief and recovery efforts.

Every day, Nagapattinam Coordination Cell volunteers collected information on needs from aid recipients, which the Coordination Cell then reported to the government District Relief Officer. The Nagapattinam Coordinating Cell became a model that other districts tried to replicate.

**Summary**

The impact of the earthquake and tsunami was very different on the mainland of India compared to the Indian Territory of the Andaman and Nicobar Islands. The Island Territories were much closer to the epicenter of the earthquake and the origin of the tsunami, and were exposed to the extreme energy contained in both events. Unlike the mainland, the Island Territories suffered severe structural damage first from the earthquake followed in short order by massive tsunami waves. The earthquake cause shifts in landmass and shook down buildings. The losses were huge. It was not possible to identify the major effects on the minimal pre-event Medical Care and Public Health Systems. Relief efforts were hampered by the long distances and difficult travel conditions to reach the Islands from the mainland.

On the other hand, the earthquake was not a major factor on the mainland. Given the structural damage created by the tsunami, in general, India was able to quickly muster resources from neighboring states unaffected by the tsunami. Significantly, India did not request international assistance for its relief activities, but did request assistance for recovery. It manifest robust public health responses especially in surveillance activities. Recovery was slower than expected, especially in the provision of permanent shelter. Significant changes in the culture, especially in the Island Territories occurred. Of unknown significance and despite the rapid influx of health professionals into the area affected and the dispatch of teams from the medical facilities into the field, an average of only 36% of those injured by the tsunami survived. The dependence of the Public Health and Medical Care Systems on the Transportation and Logistics and Public Works and Engineering Systems was confirmed.
People interviewed
Jacob Dharmaraj, head of PREPARE, Chennai, India and former head and coordinator for the Tsunami-South India NGO Coordination Cell.

Samuel Manuel, tsunami witness from the district of Nagapattinam and disaster management specialist.

Priscilla Manuel, a Karaikal doctor who treated tsunami victims immediately following the tsunami.

Suresh Bada Math, Assistant Professor of Psychiatry, OCD clinic consultant, Department of Psychiatry, National Institute of Mental Health and Neurosciences, Bangalore, India.

Charian Varghese, WHO country office, India

Simron Jit Singh

Swapan Paul, Andaman & Nicobar Deputy Director of Health.

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Figure 4.1: Human toll of the tsunami in India. The fishing village of Tranquebar is located in the Nagapattinam district of the state of Tamil Nadu. Nagappatinam lost more lives than any other district in the country.


Figure 4.2: The Indira Point lighthouse once stood 3.5 metres above sea level at the southern-most point of the Andaman and Nicobar Islands. But, on 26 December 2004, the Sumatra-Andaman earthquake, dropped the lighthouse to 0.75 metres below sea level.


Figure 4.3: The forces of the tsunami waves combined with subsidence was so great in the Nicobar Island chain that it drastically altered island geography in some areas. In the photo to the left, the pre-tsunami island of Trinket is shown as a single island. But in the photo to the right, post-earthquake and tsunami the Trinket Island has been separated into three pieces.

Figure 4.4: Tsunami wave heights and run-ups in the hardest hit region of Tamil Nadu and Puducherry

Source: http://www.ias.ac.in/currsci/jun102005/1741.pdf

Figure 4.5: On the mainland, the tsunami took its greatest toll in the Tamil Nadu District of Nagapattinam. In Nagapattinam the tsunami took more than 6,000 lives and smashed hundreds of boats in the fishing harbour

Source: http://dod.nic.in/tsunami2.pdf

Figure 4.6: Pre-event causes of death in India

Figure 4.7: A truck driver unloads drums of phenyl, a disinfectant, at the Nagapattinam Deputy Director Health Service office in the state of Tamil Nadu.

Source: Associated Press, Gurinder Osan. Image ID 050104012955

Figure 4.8: Tsunami survivor receives treatment at GB Pant hospital on 11 January 2005.

Source: http://www.pibportblair.gov.in/PHOTOS/Tsunami%20photos/1101page1.htm

Figure 4.9: Remains of a mud house with thatched roof rest on a beach within 100 metres of the sea at Pakala Beach in Andhra Pradesh, where the tsunami damaged or destroyed 1,150 houses.


Figure 4.10: Volunteers and locals in Tamil Nadu’s Nagapattinam District run following a tsunami warning on 30 December 2004. The false alarm triggered tens of thousands of people to evacuate coasts.

Source: Associated Press, Gurinder Osan, Archive signature 7599455
Table 4.1: Population, population densities and kilometres of coastline by state and territory in the tsunami-impacted areas. (* = % number killed/10 000 impacted population.

<table>
<thead>
<tr>
<th>State/territory</th>
<th>Population</th>
<th>pop/ km² (1)</th>
<th>Coastline (km) (3)</th>
<th>Total Injured n (/10 000)*</th>
<th>Survived n (/10 000)*</th>
<th>Killed n (/10 000)*</th>
<th>Survivors/Injured (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tamil Nadu</td>
<td>64,279,000</td>
<td>28,715,588</td>
<td>494</td>
<td>1,076</td>
<td>11,441 (4.0)</td>
<td>3,432 (1.2)</td>
<td>8,009 (2.8)</td>
</tr>
<tr>
<td>Andaman &amp; Nicobar</td>
<td>395,000</td>
<td>395,000</td>
<td>49</td>
<td>5,029 (55.5)</td>
<td>15,14 (16.7)</td>
<td>35,15 (88.9)</td>
<td>30.1</td>
</tr>
<tr>
<td>Puducherry</td>
<td>1,029,000</td>
<td>906,123</td>
<td>2058</td>
<td>25</td>
<td>1,160 (12.8)</td>
<td>561 (6.2)</td>
<td>599 (6.6)</td>
</tr>
<tr>
<td>Andhra Pradesh</td>
<td>79,275,000</td>
<td>18,898,068</td>
<td>288</td>
<td>972</td>
<td>1,68 (0.1)</td>
<td>51 (0.03)</td>
<td>107 (0.5)</td>
</tr>
<tr>
<td>Kerala</td>
<td>32,803,000</td>
<td>7,800,166</td>
<td>841</td>
<td>590</td>
<td>1,806 (2.3)</td>
<td>1,629 (2.1)</td>
<td>177 (0.8)</td>
</tr>
<tr>
<td>Total</td>
<td>177,781,000</td>
<td>56,714,945</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Source: (1) Central Statistical Organization, Statistical Pocket Book India 2005; (2) Census of India, 2001 census data; (3) Harbor Engineering Department, government of Kerala; (4) Animal Husbandry and Fisheries department, government of Tamil Nadu Policy note; (5) APonline, AP Fact Sheet, government of Andhra Pradesh, (6) Ministry of Home Affairs report.

Table 4.2: Life expectancy in years, crude mortality rate/1000 population, infant mortality rate/1000, and maternal mortality rate/100 000 live births.

<table>
<thead>
<tr>
<th>Population health indicators</th>
<th>India</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>yr (source)</td>
</tr>
<tr>
<td>Life expectancy</td>
<td>62.5</td>
</tr>
<tr>
<td>Crude mortality</td>
<td>7.5</td>
</tr>
<tr>
<td>Infant mortality</td>
<td>5.8</td>
</tr>
<tr>
<td>Maternal mortality</td>
<td>30.1</td>
</tr>
</tbody>
</table>

Sources: (1) Central Statistical Organization, Statistical pocket book India 2005; (3) Ministry of Home Affairs
Table 4.3: Communicable disease incidence rates in India and tsunami-impacted states and territories prior to the tsunami (*number of cases/10 000 population; yr = year)

<table>
<thead>
<tr>
<th>Disease</th>
<th>India</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Incidence*</td>
</tr>
<tr>
<td>Vector borne</td>
<td>Malaria</td>
</tr>
<tr>
<td></td>
<td>Dengue</td>
</tr>
<tr>
<td></td>
<td>Scrub typhus</td>
</tr>
<tr>
<td>Water borne</td>
<td>Bacillary dysentery</td>
</tr>
<tr>
<td></td>
<td>Shigellosis</td>
</tr>
<tr>
<td></td>
<td>Cholera</td>
</tr>
<tr>
<td></td>
<td>Typhoid fever</td>
</tr>
<tr>
<td></td>
<td>Leptospirosis</td>
</tr>
<tr>
<td></td>
<td>Hepatitis</td>
</tr>
<tr>
<td>Direct contact</td>
<td>Measles</td>
</tr>
<tr>
<td></td>
<td>Pertussis</td>
</tr>
<tr>
<td></td>
<td>Diphtheria</td>
</tr>
<tr>
<td></td>
<td>Tuberculosis</td>
</tr>
<tr>
<td>Other</td>
<td>ARI</td>
</tr>
<tr>
<td></td>
<td>Acute diarrhea</td>
</tr>
<tr>
<td></td>
<td>Enteric fever</td>
</tr>
</tbody>
</table>

Sources: (1) Central Bureau of Health Intelligence Reported Cases, Public health statistics28 (2) World Health Organization25,29,

Table 4.4: Percentage of one-year-old Indian children vaccinated as of 2004

<table>
<thead>
<tr>
<th>Vaccine</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Measles</td>
<td>56</td>
</tr>
<tr>
<td>Three doses of diphtheria, tetanus, pertussis (DTP)</td>
<td>64</td>
</tr>
<tr>
<td>Three doses of Hepatitis B</td>
<td>79</td>
</tr>
<tr>
<td>BCG (tuberculosis)</td>
<td>73</td>
</tr>
<tr>
<td>Poliomyelitis</td>
<td>70</td>
</tr>
</tbody>
</table>

Source: WHO, India EPI fact sheet 200530
### Table 4.5: Medical care personnel and beds available/10 000 population and percentage of skilled birth attendance in India pre-tsunami

<table>
<thead>
<tr>
<th>Medical care indicators</th>
<th>India</th>
<th>Year(Source)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n/10 000 population</td>
<td></td>
</tr>
<tr>
<td>Physicians</td>
<td>5.9</td>
<td>2004(1)</td>
</tr>
<tr>
<td>Nurses</td>
<td>8.0</td>
<td>2003(1)</td>
</tr>
<tr>
<td>Midwives</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dentists</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Laboratory technicians</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Health workers</td>
<td>1.3</td>
<td>2003(2)</td>
</tr>
<tr>
<td>Hospital beds</td>
<td>9.0</td>
<td>2003(2)</td>
</tr>
<tr>
<td>Births attended by skilled personnel</td>
<td>42%</td>
<td>1999(3)</td>
</tr>
</tbody>
</table>

Sources: (1) Central Bureau of Health Intelligence50 (2) WHO51 (3) 1999 National Family Health Survey52

### Table 4.6: Types of public medical care facilities available in India.(n = number; pop = population)

<table>
<thead>
<tr>
<th>Facility Urban</th>
<th>Facility Description</th>
<th>n</th>
<th>Pop/facility</th>
</tr>
</thead>
<tbody>
<tr>
<td>District hospitals, teaching hospitals and specialized hospitals provide secondary and tertiary care</td>
<td>12 000</td>
<td>90 396</td>
<td></td>
</tr>
<tr>
<td>Family Welfare Centres</td>
<td>Primary healthcare services</td>
<td>3500</td>
<td>309 930</td>
</tr>
<tr>
<td>Community health centres</td>
<td>Each with approximately 30 beds, four medical specialists (i.e., surgeon, physician, gynecologist, and pediatrician) and 21 staff to serve a population of about 50 000</td>
<td>3043</td>
<td>356 476</td>
</tr>
<tr>
<td>Primary health centre</td>
<td>Each has a medical doctor and other paramedical staff and has 4-6 beds. Provides curative, preventive, and family welfare services to a population of about 30 000.</td>
<td>23 109</td>
<td>46 940</td>
</tr>
<tr>
<td>Sub-centre</td>
<td>Each staffed by an auxiliary nurse midwife and male health worker to serve a rural population of about 5 000</td>
<td>137 311</td>
<td>7900</td>
</tr>
</tbody>
</table>

Sources: Ministry of Health, Report of the National Commission on Macroeconomics and Health47 and World Health Organization, Country Health System Profile, India.48 WHO country cooperation strategy 2006-2011 India49
### Table 4.7: Nutritional status indicators for India prior to the tsunami

<table>
<thead>
<tr>
<th>Nutritional status indicator</th>
<th>India</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Value</td>
</tr>
<tr>
<td>Children &lt;5 years of age that are stunted (%)</td>
<td>45</td>
</tr>
<tr>
<td>Children &lt;5 years of age that are underweight (%)</td>
<td>47</td>
</tr>
<tr>
<td>Children &lt;5 years of age that are wasted (%)</td>
<td>16</td>
</tr>
<tr>
<td>Newborns with low birth weight (%)</td>
<td>26</td>
</tr>
<tr>
<td>Pregnant women with anemia (%)</td>
<td>88</td>
</tr>
<tr>
<td>Per capita protein supply (grams/day/person)</td>
<td>57.1</td>
</tr>
<tr>
<td>Per capita fat supply (grams/day/person)</td>
<td>47.9</td>
</tr>
<tr>
<td>Per capita energy supply (calories/day/person)</td>
<td>2428</td>
</tr>
<tr>
<td>Calories from cereal (%)</td>
<td>60</td>
</tr>
</tbody>
</table>


### Table 4.8: Status of India relative to the 12 SEARO preparedness benchmarks as of May 2005

<table>
<thead>
<tr>
<th>Benchmark Number</th>
<th>Benchmark</th>
<th>India Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Legal framework and functioning mechanism and organizational structure in</td>
<td>Present</td>
</tr>
<tr>
<td></td>
<td>place for health at all levels involving stakeholders.</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Regularly updated disaster preparedness and emergency management plan for</td>
<td>Present</td>
</tr>
<tr>
<td></td>
<td>health sector and SOPs (emergency directory, national coordination focal</td>
<td></td>
</tr>
<tr>
<td></td>
<td>point) in place. It must include: (1) standard operating procedures; (2)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>memoranda of understanding; (3) mechanisms for coordination and control;</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(4) responses; and (5) all-hazards and a hazard-specific approaches.</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Countries have a line item in their budget and system to assure financial</td>
<td>Present</td>
</tr>
<tr>
<td></td>
<td>resources are accessible to meet the immediate needs in case of a</td>
<td></td>
</tr>
<tr>
<td></td>
<td>catastrophic event. Essential personnel, equipment, and supplies also are</td>
<td></td>
</tr>
<tr>
<td></td>
<td>available in quantities necessary to cope with the damage created by an</td>
<td></td>
</tr>
<tr>
<td></td>
<td>event for which it is at risk. Accounting procedures for the use of such</td>
<td></td>
</tr>
<tr>
<td></td>
<td>resources are in place. Emergency financial (including national budget),</td>
<td></td>
</tr>
<tr>
<td></td>
<td>physical and regular human resource allocation and accountability</td>
<td></td>
</tr>
<tr>
<td></td>
<td>procedures have been established.</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Rules of engagement exist for the management of external actors.</td>
<td>Present</td>
</tr>
<tr>
<td>5</td>
<td>Capacity to identify risks and assess vulnerability levels has been</td>
<td>SOPs needed</td>
</tr>
<tr>
<td></td>
<td>established. Appropriate measures have been implemented to reduce the</td>
<td></td>
</tr>
<tr>
<td></td>
<td>vulnerabilities.</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Community-based response and preparedness capacities have been developed,</td>
<td>SOPs needed</td>
</tr>
<tr>
<td></td>
<td>and are supported with training and regular simulations and/or mock trials.</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Local capacity for emergency provision of essential services and supplies</td>
<td>Present</td>
</tr>
<tr>
<td></td>
<td>(shelters, safe drinking water, food, communication) is developed.</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Advocacy and awareness has been developed through education, information</td>
<td>SOPs needed</td>
</tr>
<tr>
<td></td>
<td>management, and communication (pre-, during-, and post-event).</td>
<td></td>
</tr>
<tr>
<td>Benchmark Number</td>
<td>Benchmark</td>
<td>India Status</td>
</tr>
<tr>
<td>------------------</td>
<td>--------------------------------------------------------------------------</td>
<td>----------------------------------</td>
</tr>
<tr>
<td>9</td>
<td>A community plan for mitigation, preparedness, and response that is based on risk identification and participatory vulnerability assessments, and backed by a higher level of capacity has been developed.</td>
<td>Present</td>
</tr>
<tr>
<td>10</td>
<td>Human resources capabilities are updated and maintained continuously. Appropriate programs to educate and train people to cope with events and disasters have been implemented. Adequate numbers of people are being trained, and trained experts are on-call in case of a disaster</td>
<td>Must incorporate regular refresher courses</td>
</tr>
<tr>
<td>11</td>
<td>Health facilities are built/modified to withstand expected risks and be able to continue to provide the required medical care during events and disasters.</td>
<td>New initiative has begun</td>
</tr>
<tr>
<td>12</td>
<td>Early warning and surveillance systems for identifying health concerns are established.</td>
<td>Needs improvement</td>
</tr>
</tbody>
</table>

(SOP = standard operating procedure)
Part III
Country Reports

Chapter 5
Indonesia
The Events

In 1907, people living on the island district of Simeulue in Aceh province (Figure 5.1) suffered a terrible disaster: a severe earthquake followed by a huge wave swept away the lives of many of the small islands’ residents. No one knows for certain how many Simeulue islanders died on that grim day, but according to local estimates, 70% of the island’s population perished. From generation to generation, islanders passed on the story of the day the earth violently trembled followed by what the islanders refer to as “Smong—the ocean coming onto land.”

On 26 December 2004, nearly 100 years later, the strong memory of the Simeulue population passed on verbally from generation to generation and the story of the smong resulted in many lives being saved when the island was again struck by a major earthquake. The earthquake’s epicentre was just 40 km north of Simeulue and 30 km below the seafloor. The earthquake resulted in a shift in the seafloor and the seawater above it, and enormous waves radiated outward. As tsunami waves charged toward Simeulue, islanders, remembering the story of the smong, did not linger near the shore to see what would happen next. Langi, the village closest to the earthquake epicentre, was hit by the tsunami just eight minutes after the earthquake. But as waves as high as 10 to 15 metres destroyed the village, the villagers had fled the coast and had run to the hills. None of its 800 residents died.

Although not everyone on Simeulue island survived the 26 December earthquake and tsunami, only an estimated 44 of a population of 78 389 (0.06%), are reported to have died. And, according to local authorities, most of those who died were the result of the earthquake rather than the tsunami, which they claim took only seven lives. Unfortunately, Simeulue Island represented only a small proportion of the Indonesians who experienced the tsunami. And, unlike the Simeulue islanders, other Indonesians did not anticipate the deadly waves and fled from shore. As a consequence, nearly 170 000 Indonesians lost their lives.

In Aceh Besar district’s village of Jantang, where an estimated 50% of the population is believed to have died, tsunami witnesses told researchers they had not been aware that there was an association between earthquakes and tsunamis. And, when they heard what sounded like explosions just before the arrival of the first tsunami wave, they interpreted them as gunshots due to the ongoing political conflict in the area, to which locals usually responded by staying.

*Only the health (medical care and public health) literature was extensively searched. Findings relative to the other basic societal systems were identified in the searches of the public health and medical care systems.
Simuelue island is 100 km from Aceh province’s mainland, and consequently, was distant from the province’s area of conflict. This may be one of the reasons Simuelue islanders were able to respond appropriately. Outside the conflict zone, Simuelue islanders were better able to preserve communal ties, and the history that helped them recognize the tsunami warning signs.2

The same earthquake that alerted Simeulue islanders of the approaching tsunami also affected several other regions of Indonesia. However, the shaking related to the earthquake was particularly acute in Simeulue island and other districts in Aceh. As the district closest to the earthquake epicentre, Simeulue may have endured the most violent tremors. But, many other districts in Aceh province, including Aceh Barat Daya, Nagan Raya, Aceh Barat, Aceh Jaya Aceh Besar, and Banda Aceh within 50 to 250 km of the epicentre, also endured heavy shaking.2 Researchers know little about how much or for how long the shaking lasted in Aceh province, but they do know that it began at 07:59 hours and that the earthquake took eight minutes to complete its rupture under the seafloor.

The tsunami waves in some parts of Indonesia were awesome not only in their upward reach, but also in their horizontal reach inland. Indonesians who normally could not even see or hear the ocean from their neighbourhoods, suddenly had seawater rushing through their homes and streets. The inland reach of the tsunami was greatest in areas with low elevations such as wetlands and river flood plains. In the lowland area of the city of Banda Aceh, tsunami waves reached more than 4 km inland.

Indonesians caught in the sea’s devastating attack had little chance for survival as billions of tons of water scoured their coasts. With each wave, water violently charged inland and then, just as violently, it was sucked back into the sea. Cars, slabs of concrete, refrigerators, windowpanes, and other debris sloshed back and forth in the dirty, dark torrent of seawater. All the while, those caught in the waves were drowned, smashed, and/or tangled in the churning water and debris. By the time the tsunami had finished pummeling Aceh’s shorelines and moved on to other coasts surrounding the Indian Ocean, some tsunami victims had survived as many as three or four large waves. Evidence of the tsunami’s colossal power lay scattered along the province’s coastline. The remains of more than 200 000 Indonesian homes lay buried in rubble or had become rubble. Roads ended at the banks of rivers where bridges once existed and the twisted
bodies of tens of thousands of automobiles sat at odd angles on rooftops, in trees, and in the debris. The greatest devastation that the tsunami left behind, however, was in the lives lost. Many lives could have been saved had people known that the violent earthquake shaking could result in a tsunami and that they should move away from the coast.

Tsunamis, however, occur rarely and outside of Simeulue island, few Indonesians knew that a large earthquake could result in a tsunami. Indeed, the vast majority of earthquakes do not result in tsunamis, and the earthquake that created the 2004 tsunami was the result of centuries of built up tension. However, that does not mean that Indonesia is safe from tsunamis until the fault line again builds up over centuries. The fault line responsible for the 2004 tsunami is not the only underwater fault line capable of producing a tsunami along Indonesia’s coastline. There is evidence that a section of a fault line south of the equator along the western coast of the North Sumatra province just south of Aceh province is likely to create another tsunami. Although it is not possible to predict when the tsunami will occur, some experts believe that seafloor shifts created by the 26 December 2004 earthquake and a subsequent earthquake that occurred in March 2005, may have increased the likelihood that the fault line will slip in the near future. With luck, Indonesians living in North Sumatra province will remember the lessons learned from the 2004 tsunami, and like their neighbors on Simeulue island, will evacuate the coasts before witnessing the ocean coming onto land.

Population Impacted
Although Aceh province’s 56,500 km² of land represents 3% of Indonesia’s total land area, its population represents just 1.86% of the total population. Prior to the tsunami, Indonesia had a population of approximately 216 million and Aceh province had a total population of about 4 million; Aceh province is less urban than the country as a whole. Estimates of the proportion of Indonesians who were living in urban areas in 2000 was 42.0% in 2000 and 48.3% in 2005. However, in Aceh province, only an estimated 23.6% of the population lived in urban areas in 2000, and 28.8% by 2005 (Table 5.1).

Aceh’s most densely populated areas generally were on the coast, particularly in the province’s northern and eastern regions. The greatest population densities are in three municipal districts (Banda Aceh, Aceh Barat, and Aceh Besar). The most dense is Banda Aceh with 29,16 people/km², followed by municipal districts of Lhokseumawe, with 854 people/km² and Langsa, with 525 people/km².

It should be noted that while the impact of the earthquake and tsunami was most acute in Aceh province, it was not limited to this province alone. The population in a district in Nias Island, located in North Sumatran province, also suffered fatalities and injuries due to the earthquake and tsunami. Nias island’s suffering was compounded in March 2005 when it was hit by an earthquake that resulted in yet another disaster. Due to the close timing of the 2004 earthquake and tsunami and the 2005 earthquake, many of the assessments conducted on Nias Island combined the damages from these two events. Consequently, discussions in this book will focus primarily on Aceh province where the vast majority of damages that resulted from the 2004 earthquake and tsunami occurred, and the damages assessed there in early 2005 were limited to those caused by the 2004 earthquake and tsunami.

Public (population/preventive) Health System
Pre-event
In Aceh province, 30 years of conflict burdened the population with insecurity, destroyed infrastructure, and forced many residents to flee their homes. The relative levels of conflict in Aceh province before the events of 26 December 2004 are mapped in Figure 5.2. The intensities of conflict were widely distributed with the bulk...
of the high conflict areas along the east coast and north central districts. The intensity of the conflict was relatively low in Banda Aceh. It is difficult to peer through the web of distress and accurately gauge population health in Aceh. Population health statistics for Aceh province often are incomplete, outdated, or their accuracy is questionable. Additionally, because much of the public health data collected before the tsunami excluded rural areas, due to security concerns, the data may be skewed.

In contrast to the relative peace enjoyed by most Indonesians prior to the tsunami, the people of Aceh province had been living under the burden of political conflict for 30 years. As a consequence, the health of its population in many ways was unique from the rest of Indonesia. However, although national pre-event health statistics may not accurately reflect the health status of the population in Aceh province, they offer the closest approximations available.

Before the tsunami, Indonesia’s population health indicators were lower than those for Sri Lanka, Thailand, and the Maldives, and approximately the same as those for India. The distribution of the causes of death in Indonesia are in Figure 5.3. Cardiovascular diseases and communicable diseases together with maternal and perinatal problems and nutritional deficiencies constitute 57% of the causes of death. Communicable, maternal, perinatal, and nutritional deficiencies and cardiovascular diseases were responsible for 57% of the deaths (Figure 5.3). Indonesia had an average life expectancy of 67 years, an infant mortality rate of 35 deaths/1 000 live births, and a maternal mortality rate of 307 deaths/100 000 live births (Table 5.2).9 Relative to public health indicators in Indonesia as a whole, the health indicators for Aceh province were mixed. Two conflicting factors influenced public health in Aceh province before the tsunami. Aceh’s high per capita public spending on health services positively influenced the health of its population, while 30 years of conflict negatively influenced health. Although there is limited information available on Aceh’s pre-event health status, the data collected suggest that its health status generally was poorer than in the rest of Indonesia. For example, Aceh’s reproductive health indicators lagged well behind the national averages with a maternal mortality rate of 373 deaths for every 100 000 live births and an infant mortality rate of 36.1 for every 1000 live births (Table 5.2).9 Also, Aceh’s fertility rate was higher than the national average and contraception use was low; 58% of married Aceh women between 15 to 49 years had never used contraceptives, compared to 72% nation-wide.6

Nias island did not face the conflict issues that burdened Aceh province, but the approximately 700 000 residents of Nias lived under a lower level of development, and also had low public health indicators. For example, Nias Island’s infant mortality rate of 41 infant deaths for every 1000 live births was higher than in Aceh province and than the national average.11

The health status of the citizens of Aceh province also suffered due to startlingly low vaccination rates. Although Aceh province, like the rest of Indonesia, had been vaccinating its population for many years, scarce resources and the burden of the conflict had diminished coverage. Indonesia began promoting child immunization against six major diseases 27 years prior to the tsunami. The immunizations took place under an Expanded Programme of Immunization (EPI), and included vaccinations against tuberculosis, diphtheria, pertussis, tetanus, polio, and measles; the programme was expanded to include a vaccine protecting against hepatitis B in 1997.12 However, in Aceh province, security concerns often prevented immunization services from reaching rural villages or confined coverage to areas located near health facilities.9 Additionally, Aceh’s cold chain system was not functioning properly in many districts,10 making it difficult to store vaccines in remote areas. As a result, Aceh’s immunization rates ranked much lower than the averages for the national rates.9

At the national level, immunization coverage among one-year-olds for the six EPI vaccinations,
ranged from a low of 51% for Hepatitis B to 88% for BCG in 2003 (Table 5.3). Estimates for Aceh’s coverage rates in some regions were much lower than were the national averages. For example, polio immunization coverage was estimated to be 72% at the national level in 2003; it was only 7% in Aceh province in 2004. Whereas measles immunization coverage was 78% nationally, it was only 30% in Aceh Province in 2004. The WHO estimates that in the years before the tsunami, measles coverage in Aceh province had decreased from 71% in 2001 to 31% in 2003. Coverage for the DTP3 vaccine, which helps to prevent diphtheria, tetanus, and pertussis, also was very low in Aceh province—estimates of DTP3 coverage ranged from 21% to 33%, compared to 66% nation-wide. And children in Aceh province were reported to have the second lowest tetanus vaccination coverage in all of Indonesia.

Indonesia had a number of problematic communicable disease concerns, including high rates of tuberculosis and malaria, and increasing rates of dengue. With a tuberculosis incidence of 24.5 cases/10,000 population, Indonesia was one of 22 countries with the highest occurrence of tuberculosis in the world. Also, with a malaria incidence of 33.7/10,000 population, Indonesia had a higher malaria incidence rate than Sri Lanka, India, Thailand, and the Maldives. Additionally, Indonesia’s malaria vectors included the Anopheles sundaicus, the only malaria-transmitting mosquito that could breed in brackish water. Dengue incidence rates were not particularly high, but had been increasing, and by 2004 had reached an incidence of 3.6/10,000 population.

Although Aceh province did not share all of the communicable disease issues that manifested at the national level, it had some communicable disease issues of its own (Table 5.4). The reported malaria rate in Aceh province, 9.85 cases/10,000 population, was high. Also, the high malaria incidence was confined primarily to areas in the province’s interior and was not particularly problematic along its coasts. Also, although Aceh province suffered an outbreak of dengue when 100 cases were reported in March of 2004, it still had a very low incidence of dengue, (0.54 cases/10,000 population). Tetanus rates also were low, but the disease persisted, despite the ease with which it can be prevented with the DTP3 vaccine and booster injections. Also, with an incidence of 0.09 cases/10,000 population, Aceh province had the highest tetanus rate among the five countries reported in this book.

Finally, although an incidence rate could not be found, outbreaks of scabies were also reported. In contrast to the above-noted diseases, cholera had not been a problem in Aceh province as in some other parts of Indonesia. The last case of cholera reported in Aceh province was in March 1996. Cholera was reported only sporadically in Indonesia in recent years with the peak transmission period being March through September.

Aceh’s overall morbidity rate from communicable diseases was similar to the national rates, but was considerably higher than in the neighboring provinces. In Aceh province, the morbidity rate for communicable diseases was 27%, while in other provinces on the island of Sumatra, the morbidity rate was 19%.

In Aceh province, communicable disease control authorities carried out their responsibilities under the double-burden of the ongoing conflict and chronic equipment shortages. Consequently, disease surveillance, vaccine delivery, and vector control were neglected. Unlike the other countries covered in this book, Indonesia had a decentralized disease surveillance system. Aceh’s surveillance system reported data to the national office annually, but otherwise operated independently of the national government. However, Aceh’s surveillance system had the capacity to do little beyond collecting data for the annual national report. Because data were collected and analyzed infrequently, the surveillance system could not be used to anticipate and respond to potential outbreaks. District offices reported communicable disease
data to the provincial office once a month, and provincial-wide data were only compiled and analyzed annually. Furthermore, what little data Aceh’s surveillance system did report often were incomplete and analysis was limited, since hospitals had little incentive to report the data.

Aceh province also had no system for investigating reports of unusual disease occurrences, since the transportation, computer systems, and other equipment needed to conduct investigations were not available. Laboratory capacity was limited, and for the most part, was located at the Provincial Public Health Laboratory in Banda Aceh; only the Provincial Public Health Laboratory could provide basic microbiology cultures required for clinical diagnoses. The number of public health personnel that were available in Aceh province could not be identified, but at the national level there were 0.3 public and environmental health workers/10,000 population.

**Damage**

In the immediate aftermath of the tsunami, the destroyed communications infrastructure largely prevented the earthquake and tsunami destruction in Aceh province and Nias Island from becoming known to the rest of the world. Initially, Sri Lanka was believed to have been hardest hit by the tsunami; it would be days before anyone fully understood the magnitude of the human losses suffered in Indonesia. On the day that the earthquake and tsunami occurred, the Indonesian Ministry of Health (MoH) estimated that 1875 Indonesians had died. By 29 December, bodies were still being found in trees and were being washed up onto the shores, and the MoH fatality estimate climbed to 27,174. In the weeks and months following the tsunami and earthquake, estimates on the number of fatalities fluctuated, but finally settled at about 130,000, with an additional 37,000 persons listed as missing, eventually for a total of 167,000 lives lost. With a population of about 21.6 million, the overall loss of lives comprised about 0.07% of the total Indonesian population. However, in Aceh province, the number of lives lost comprised approximately 4% of the Aceh population.

In Aceh province, 17 districts reported deaths from the earthquake and tsunami. The greatest number of people died in four districts along the province’s northwestern coast—Aceh Besar, Banda Aceh, Aceh Jaya, and Aceh Barat (Table 5.5, Figure 5.4). In just these four districts, 153,995 people were killed or reported missing (18.3% of the combined population). The greatest number of persons (107,342) and proportion of the population (35.09%) killed occurred in Aceh Besar and not in Banda Aceh. Of the four districts analyzed, the smallest, Aceh Jaya, 21.3% of its population was killed or was reported missing. Aceh Besar and Banda Aceh together accounted for 122,736 of the lives lost, or 73% of the total number of Indonesians who died as a result of the events. Using district population data, the highest fatality rate was in Aceh Jaya, where 278 out of every 10,000 people died. Population and fatality data available for a few coastal cities and towns suggest that if the population data were limited to coastal areas, the highest fatality rate would be many times higher. In Banda Aceh, for example, the tsunami reportedly killed 30,000 out of 40,000 residents in the sub-district of Meuraxa. In other words, for every 2.5 Meuraxa residents who survived the tsunami 7.5 residents died. An assessment team visiting communities in the district of Aceh Jaya estimated that approximately seven out of 10 people had died in the district’s capital, Calang.

In addition to fatality rate totals, there is a third perspective from which tsunami fatalities can be analyzed—number of fatalities/km of coastline. Along the 320 km coastline of Banda Aceh and Aceh Besar. An average of 380 people died/km of coast. In the neighbouring district of Aceh Jaya, the number of deaths/km was 87, and 198 in Aceh Barat. The variation in the number of fatalities in these districts can be explained, in part, by variations in population densities within these districts. For example, the population density in Aceh Barat was almost four times higher than the population density in Aceh Jaya.
It seems that the overwhelming majority of deaths that occurred in Aceh and Nias Island on the day of the tsunami were due to the tsunami rather than the preceding earthquake. However, it is probable that the earthquake also produced fatalities, and perhaps, many fatalities. Fatality reports, however, do not indicate how many died due to the earthquake rather than from the tsunami.

Little is known about those who survived injuries caused by the earthquake and tsunami. The cumulative estimate of the number of injured survivors was based on the number of injuries treated at the healthcare facilities. The injured victims reportedly were triaged into just two categories—“serious” or “minor”. Hospitals in Aceh and North Sumatra provinces reported 8119 victims with serious injuries and 150,146 with minor injuries. Of these, 6894 of the 8119 (85%) who had sustained serious injuries and 148,433 of the victims with minor injuries (99%) were treated in hospitals in Aceh province.23,33 It is difficult to determine how closely these cumulative estimates represent the actual number of injured survivors. In the chaotic aftermath of the earthquake and tsunami, it is likely that many healthcare workers did not keep track of the patients treated, particularly during the first hours and days following the tsunami. Additionally, many of those who survived the tsunami but who were seriously injured may have died before any medical care worker could treat or document their injury(ies). Many of the areas impacted by the tsunami were without medical care services for days after the tsunami. While the estimated number of injured survivors may seem questionably low when compared to the number of fatalities, anecdotal accounts suggest that injuries were not as common as expected in light of the scale of the damages.

The nature and the severity of the injuries inflicted by the tsunami in Aceh province are poorly understood. Medical care workers were not present to document the injuries during the first few days following the tsunami, and what information was documented was gathered ad hoc several days to weeks after the tsunami. However, documented injuries include flesh wounds, musculoskeletal injuries, and lungs damaged by the inhalation of dirty seawater that occurred when victims caught in the tsunami nearly drowned, were struck by debris, or wandered among the hazardous tsunami debris.

In one of the earliest reports documenting injuries, a report based on patients treated by a medical team in Banda Aceh from 31 December to 8 January, the greatest number of presentations involved the respiratory system. Some of these may or may not have been related to an injury due to seawater inhalation. Also, high on the list of complaints were what the case report referred to as “trauma” and “musculoskeletal” injuries.32 Injuries due to flesh wounds or near-drowning experiences following the tsunami were unique, in that the wounds and lungs of injured survivors were highly contaminated by dirty tsunami water. Tsunami water infused flesh wounds and lungs with dirt, pathogens, and other contaminants that caused more problems in the days and weeks that followed the tsunami. Wounds not properly treated immediately after the tsunami soon became heavily infected (Figure 5.5). And survivors who had inhaled dirty seawater soon developed aspiration pneumonia, or what became referred to as “tsunami lung”. Tsunami lung was difficult to treat and in some (number not attainable) cases, it progressed to sepsis (bacteria or toxins entered the blood) and spread to the brain and other organs, resulting in the formation of abscesses. Tsunami lung infections were likely the result of multiple microbes. In an analysis of three tsunami lung victims in Banda Aceh, two had been infected by *Burkholderia pseudomallei* and the third by a *Nocardia* species.33

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Damages impacting population health and disease control were not limited to fatalities, injuries, and pathogenic illnesses. Aceh’s already weak preventative health infrastructure also suffered due to the tsunami. The tsunami damaged laboratory equipment, buildings, and medical
records, leaving Aceh province with essentially no surveillance and no capacity to respond to disease threats. The Public Health Office was severely damaged losing all of its equipment and documentation. And, of the 35 people who staffed the Provincial Health Office’s Communicable Disease Control Department, only 28 survived the earthquake and tsunami. Consequently, in Aceh province, not only had the tsunami resulted in extensive damage to surveillance infrastructure, but there had been only minimal surveillance infrastructure in the first place.

Changes in functions
In the four districts noted above (Aceh Besar, Banda Aceh, Aceh Jaya, and Aceh Barat), the combined population of 830,589 was decreased by 145,556 persons (35.1%) (Figure 5.6). This was less than the number killed (153,993), which indicates that some of the persons migrated from one district to another. Banda Aceh’s population decreased the most. Thirty-seven percent of its population either was killed or was displaced. Thus, 90,000 persons resident in Banda Aceh were displaced from their homes into camps or into the homes of families and friends. The greatest proportion of migrants wound up in Aceh Besar—that also had the greatest proportion of its population killed. The reasons for this shift in population are not clear. Why did the greatest number of migrants move to an area that had sustained the greatest losses? Furthermore, these observations carry with them an immense shift in the locations of persons requiring medical care.

Following the tsunami, the resultant pools of stagnant water, crowded camps, contaminated water, piles of debris, and inadequate sanitation created favourable conditions for the spread of communicable diseases in the directly impacted areas. Fortunately, no disease resulted in an epidemic, but overall morbidity is reported to have increased, and some worrisome diseases emerged in isolated cases or as outbreaks. An outbreak of measles, an outbreak of tetanus, and increases in diarrhoea and respiratory issues confirmed concerns that the tsunami had increased vulnerabilities to communicable diseases. The number of acute respiratory cases reported after the tsunami quickly exceeded the average number of cases reported in previous years. Within four months of the tsunami, the number of acute respiratory infections reported in Aceh province climbed to 8854, eight times as many as were reported in 2003. Although part of the increase in reported cases may be attributable to increased surveillance in the aftermath of the tsunami, reports do suggest a significant increase of incidence.

An outbreak of measles after the tsunami occurred in several clusters, some of which were closely linked to IDP camps. In Aceh Utara, 35 cases of measles were detected among children five months to 15 years of age; 86% of the cases were detected among children who had been IDPs during the disease’s incubation period (Figure 5.7). Following the tsunami, the measles cases may have comprised an outbreak, but the outbreak did not escalate into an epidemic. Even as clusters of cases were being detected, some were cautious in calling the case reports an increase over Aceh’s usual measles incidence. One WHO report noted that the increase in reported cases in Aceh Utara may have been an artifact of enhanced surveillance, rather than a consequence of the earthquake and tsunami.

Following the tsunami, a tetanus outbreak also raised concerns. Between 30 December and 26 January, hospitals in four districts detected a total of 106 tetanus cases. The number of cases peaked in mid-January; 18.9% of the known individuals with tetanus succumbed to the disease. More than half of 15 tetanus cases treated in an International Committee of the Red Cross hospital in April required intensive care support.

Not all of the health issues expected after a tsunami emerged. No cases of cholera were reported, and malaria and dengue incidence rates actually declined. In the four months following the tsunami, only 987 cases of malaria were
detected, representing a decrease compared with the same months in previous years. Additionally, the average incidence rate for malaria during the same period for the past five years was 10 times higher than that detected after the tsunami. The average monthly incidence of malaria in the four months following the tsunami was 0.75/10 000 people, compared to 9.4/10 000 people for the same period over the last five years. By the end of 2005, a total of 25 000 malaria cases were detected in Aceh province.\textsuperscript{17} As for dengue, only 29 cases were reported in the four months following the tsunami.\textsuperscript{13}

Relief responses
Despite the fact that surveillance efforts in Aceh province faced greater challenges than in any of the other countries impacted by the tsunami; the system produced the most complete reporting. What little surveillance capacity existed in Aceh province had been destroyed, and yet, the need to detect and respond to outbreaks had soared. To resurrect local surveillance and meet heightened needs, both national and international support was needed; the Ministry of Health and WHO-SEARO quickly took the lead in this endeavour. The ministry reinforced Aceh’s Provincial Health Office with staff from Jakarta, and WHO-SEARO also sent staff to support the office and rented a building from which it could provide assistance. WHO-SEARO also collaborated with the Provincial Office to establish an early warning and response network system to quickly detect and respond to potential outbreaks.\textsuperscript{35}

In addition, WHO-SEARO recruited teams of communicable disease experts, identified disease risks, and rebuilt laboratory capacity. WHO-SEARO teams included WHO experts and experts recruited through its Global Outbreak Alert and Response Network (GOARN). In identifying disease risks, the WHO communicable disease experts created a preliminary list of communicable diseases that potentially could create outbreaks or flare up into epidemics in the earthquake and tsunami impacted areas of Indonesia, and then provided the list to local health authorities and NGOs for inputs.\textsuperscript{24} Once this list was finalized, it was published in a reporting form and distributed to temporary mobile health clinics, hospitals, health laboratories, and other healthcare units operating throughout the impacted areas. The form instructed health units to report on eight diseases and disease symptoms on a weekly basis: (1) acute watery diarrhoea; (2) bloody diarrhoea; (3) positive rapid diagnostic tests for malaria; (4) fever >38.5°C; (5) suspected measles; (6) acute respiratory infection; (7) acute-onset jaundice; and (8) meningitis. Additionally, the form instructed health units to report nine diseases and disease symptoms immediately when detected: (1) cholera; (2) typhoid; (3) bloody diarrhoea; (4) tetanus; (5) measles; (6) hepatitis; (7) increased detection of malaria cases; (8) dengue fever; and (9) meningitis.\textsuperscript{35} Weekly health coordination meetings and an epidemiological bulletin, published in English and Indonesian languages, helped to facilitate the collection and distribution of surveillance information. Wide distribution of surveillance information resulted in effective feedback and improved the usefulness of the surveillance data collected.\textsuperscript{36}

Because there was little laboratory capacity for testing samples early during the disaster, reporting forms included syndromic descriptions so that diseases could be identified based on presenting symptoms and signs. Simultaneously, WHO teams and other relief teams working in the area set up temporary laboratories to serve the immediate testing needs and helped to rebuild and improve local laboratory capacities. For example, during the relief phase of the disaster, the National Institute of Health Research from Jakarta and a US Naval Medical Research Unit established a laboratory on the grounds of the Aceh Provincial Health Laboratory located 200 metres from the province’s largest hospital.

In addition to strengthening surveillance, disease control efforts also included vector control. Some IDP camps received insecticide-impregnated plastic sheeting to use in tents and other temporary shelters;\textsuperscript{37} many survivors received
bed nets, and neighbourhoods and camps were sprayed with insecticide. UNICEF was among one of the biggest bed net distributors, providing nearly 100,000 bed nets to women and children; on 14 January 2005, the Indonesian government initiated an insecticide spraying campaign in Banda Aceh province to reduce the number of mosquitoes that could spread malaria. Bakornas sprayed 163 barracks in Aceh province including 100 in Banda Aceh, 16 in Aceh Barat, and 47 in Nagan Raya.

Following the tsunami, communicable disease experts were particularly eager to launch a campaign to immunize Indonesia’s tsunami-impacted population against measles. Compared to other tsunami-impacted regions, Aceh’s pre-tsunami measles vaccination coverage was low. Therefore, when displaced tsunami survivors crowded into relief camps, the MoH, WHO, UNICEF, the American Red Cross, and other concerned agencies quickly mobilized measles vaccination teams. Measles immunization began on 6 January in an army hospital in Banda Aceh and targeted children between six months and 15 years of age. Efforts then spread from Banda Aceh to surrounding districts; in the neighbouring district of Aceh Besar, for instance, a six-day measles campaign by WHO in January–February immunized 50,032 children. In mid-January, in Aceh Utara, an outbreak of measles among IDPs triggered a measles vaccination campaign that targeted children in IDP camps, and then extended to include surrounding non-IDP communities. During the campaign, immunization workers also distributed measles case management guidelines to local health centres. By the end of April, government data indicated that measles vaccinations had covered 1.1 million children <15 years of age (92.6% of the target population) in Aceh province. However, other surveys suggested that the coverage was lower, and in some cases, much lower.

A UNICEF survey published in September found that on the island of Nias, and in 18 Aceh districts, immunization of preschool age children (6 months and 5 years of age) had covered only 49.7% of such children, and 65.4% of children five to 15 years old. Part of the discrepancy between government data and the UNICEF survey may be explained by the fact that, in contrast to government data, the UNICEF survey did not include Banda Aceh or Aceh Baser, but did include Nias island, which is not part of Aceh province and which had a low coverage rate. The UNICEF survey also noted that coverage varied considerably between districts, and that some of the lowest coverage rates occurred in districts that also had the highest incidence of measles. Of the 20 districts surveyed, preschool age children in the mountainous inland district of Gayo Lues had both the lowest coverage for measles and also had the highest incidence of measles. Only 22.6% of these children had received measles vaccination compared to 49.7% of preschool age children in all of the 20 surveyed districts. And, while just a little over 1% of preschool age children in the 20 districts had measles, 6.3% of preschool age children in Gayo Lues had measles. Measles coverage also varied by age group, with coverage increasing with older age groups. Coverage was 22.9% among preschool age children, 57.9% among children 48-months to five years of age, and 65.4% among five-to-15-year-old children.

In response to the disaster, public health responders also launched an anti-cholera campaign. No cases of cholera had been detected in the tsunami-impacted area since the tsunami, or in Aceh province for more than three years, and in a cholera outbreak assessment conducted by the MoH in February

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78,870 IDPs >2 years of age—20,869 in Aceh Barat, 45,540 in Banda Aceh, and 12,461 in Aceh Jaya—with two doses of oral cholera vaccine administered one to two weeks apart. But the delivery of oral cholera vaccine proved to be difficult and the campaign fell short of its objectives. Of the targeted population of 78,870 people, only 54,627 (69.3%) were fully immunized. Cholera vaccine requires cold storage, must be administered twice, and takes almost 30 times the storage volume of other vaccines used in mass-vaccination campaigns. The high transportation and storage demands of the cholera vaccine were not always met, since cold-chain capacity and transportation in Aceh province was poor. Consequently, 11.7% of the vaccines provided were wasted. The overall logistical costs of delivering the vaccine were enormous, required large numbers of personnel, chartered helicopters and airplanes, and rented cold room facilities. By the time the campaign had been completed, US$17.55 had been spent for every person fully immunized.44

Interestingly, major immunization campaigns following the tsunami did not include tetanus, even though tetanus vaccination rates in Aceh province were incredibly low and tetanus cases emerging after the tsunami indicated that the disease posed a problem. Consequently, an opportunity to extend an important protective measure to the Acehnese population was missed. A tetanus vaccination campaign would not have prevented the cases of tetanus that occurred following the tsunami, but would have closed a major gap in Aceh’s vaccine coverage. Medecins sans Frontieres reported having immunized 6,200 people against tetanus in Aceh Selatan and Aceh Barat Daya.45 However, the public health relief effort did not result in a major tetanus vaccination campaign such as those launched for measles and cholera.

Although some have criticized the decision to launch a cholera campaign while missing an opportunity to provide needed tetanus vaccinations, overall disease control efforts in Indonesia appear to have been successful. A number of small outbreaks did occur, but there were no epidemics, and overall disease morbidity appeared to have declined once disease control efforts took hold. A UNICEF survey reporting on fevers, diarrhoea, coughs, skin infections, vomiting, and measles cases in March, and then again in September, resulted in a decline in the incidence of all six diseases.42 The greatest decline in incidence of communicable diseases occurred among the IDP populations. The proportion of preschool age children with diarrhoea, dropped from 35.7% to 9.5%. Although rates of measured disease symptoms were higher among IDP children than in non-IDP children in March, this pattern had reversed by September at which time estimates indicated disease symptom rates were higher among non-IDP children than IDP children.42 This finding may have been due to a disproportionately greater disease control effort among the IDP population.

The risk of contracting a communicable disease was not limited to the Acehnese people living in tsunami-impacted areas and in camps, but also threatened the relief workers. There is limited data about the rate at which relief workers suffered from communicable diseases, but some relief teams took strong precautions against communicable disease hazards among its members. For example, medical care relief workers on board USNS hospital ship Mercy, were restricted from shore duty at night when the probability for mosquito transmission of malaria would be highest.46 Also, members of the first arriving medical team from Australia reported the restriction of all beverages and food consumed to those rations they had brought into the area. Aside from a few examples of conscientious precautions, however, it is difficult to determine what the prevailing practices were among responding NGOs and aid agencies with respect to personal protective measures taken.

**Recovery responses**

Most early efforts to ensure the availability of laboratory services focused on setting up temporary laboratories, and consequently, the restoration of some of the local laboratories were
sidelined. However, WHO-SEARO took the lead to re-establishing and improving local laboratory capacities and gradually was joined by other agencies. In its efforts to rebuild and improve local laboratory capacity, WHO-SEARO initiated a project to improve capacity at the district hospital laboratory in Meulaboh, the Zeinol Abidin Hospital in Banda Aceh, the Provincial Public Health Laboratory (Labkesda) in Banda Aceh, LitiBangkes Laboratory in Banda Aceh, and the national laboratory services of the central government.48

Development
Relevant information about the development of the public health system in Indonesia could not be found.

Medical Care System
Pre-events
As with public health statistics for Aceh province, the statistics on Aceh’s pre-event medical care capacity also tended to be incomplete and unreliable. Consequently, it is difficult to determine how the positive influences of Aceh’s high per capita spending on health and the negative influences of the conflict balanced out in the Medical Care System. Official statistics suggest that the availability of healthcare personnel was better in Aceh province than in Indonesia as a whole. On the other hand, anecdotal reports and interviews have suggested a different reality, with serious personnel shortages and access limitations that forced many Acehnese to endure chronic illnesses for long periods of time without treatment.

According to the Ministry of Health as well as WHO statistics, the number of physicians and midwives per capita in Aceh province was higher than in the nation as a whole. However, Acehnese healthcare workers, hospitals, and clinics were heavily concentrated in urban areas, leaving many rural areas underserved. As a result, Acehnese were more likely to travel long distances to receive medical care services than were other Indonesians. In Aceh province, 38% of the population lived further than 5 km from the nearest healthcare facility, compared to 23% nation-wide. The proportion of Acehnese who had to travel more than 5 km to reach a healthcare facility was greatest among the province’s most rural districts, and ranged from a low of 12% in Banda Aceh, to a high of 74% in Aceh Selatan and Aceh Singkil. However, mothers in Aceh province reportedly were more likely to receive assistance from skilled personnel while giving birth than were mothers nationally. In Aceh province, 74.2% of births were attended by skilled personnel compared with 66.7% nationwide. However, skilled birth attendance varied considerably from district to district – from a high of 98.2% in Banda Aceh province to a low of 42.8% in Simeulue Island.11 Indeed, differences in healthcare access and skilled birth attendance are in some cases, staggering. In the southern coastal districts of Aceh Selatan and Aceh Singkil, >74% of the population lives >5 km from a healthcare facility compared to only 12.7% in the city district of Banda Aceh. And, while only 42.8% of births are attended by skilled personnel on the sparsely populated island district of Simeulue, more than 98.2% of births are attended by skilled personnel in Banda Aceh.11

Disparities in the availability of medical care services were exacerbated by civil unrest; healthcare workers were reluctant to work in rural areas where medical care facilities were more vulnerable to violence. Although medical care facilities are said to have not been intentionally targeted during the conflict, it was not uncommon for healthcare workers and facilities to get caught in the crossfire. Between 1999 and 2004, 20 healthcare staff lost their lives in the conflict and an additional 29 were subject to non-fatal violence. Within the first week of martial law in May 2003, 35 health facilities were burned to the ground.11

Additionally, although the number of doctors per capita in Aceh province compared favourably with the country as a whole, the availability of doctors in Indonesia and Aceh province was low when compared with other tsunami-impacted countries (Table 5.6). In Aceh province, there
were 1.9 doctors/10 000 population compared to 1.1 nationwide. However, both figures are far below those reported for countries like Sri Lanka, where there were five doctors/10 000 population, or the Maldives where there were 9.2 doctors/10 000 population. Consequently, staffing at the hospitals in Aceh province was poor when the tsunami struck, and specialists, particularly general and orthopaedic surgeons were in short supply. For example, at the Zainoel Abidin Provincial Hospital, there were just one or two specialists/unit, and there was an overall staffing shortage of about 30%. However, even though the number of hospital beds/capita was low, the occupancy rate in both public and private hospitals typically was <50%.

In Aceh province, the highest level of medical care services was located at a provincial hospital, the Zainoel Abidin Provincial Hospital, that was located in Banda Aceh. The hospital had 400 beds and was the largest in the province. Below the provincial hospital, there were 27 public and private hospitals operating in the province, six of which were located in Banda Aceh (Table 5.7).

In Meulaboh, the second most heavily populated area in Aceh province hard hit by the tsunami, there were two hospitals: a military hospital, and a civilian hospital. The civilian hospital, Cut Nyak Dhien Meulaboh Hospital, had 90 beds, 14 doctors, 120 nurses, an emergency department, and two operating theatres.

Some medical care services in Indonesia were also provided by facilities at the sub-district and village level (Table 5.7). At the sub-district level, medical care services provided by health centres included immunizations, antenatal and postnatal care, family planning services, nutrition and sanitation consultations, and dental services. The reach of the health centres was extended down to the village level by Community Health Posts. At the village level, medical services also were provided by Village Delivery Posts and Integrated Community Health Centres.

In 1968, Indonesia’s public Medical Care System adopted a community health centre concept in which it resolved to maintain a public referral hospital in each district, health centres in every sub-district, and community health posts in most villages. Twenty years after Indonesia adopted the community health centre concept, the medical care system underwent a second transformation with less positive results. Under the Suharto regime, the central government had been providing the managerial and financial responsibilities of the public Medical Care System. However, after the financial crisis of 1997 and the fall of Suharto in 1998, there was a push to decentralize the public medical care system; in 2001, managerial and financial responsibilities were decentralized to the district level. In the years following, the poor increasingly began to depend on self-treatment and traditional medicine over modern medicine. From 2000 to 2004, the proportion of Indonesians who relied on traditional medicine rose from 16.2% to 32.9%, and the number of Indonesians who relied on self-treatment increased from 62.8% to 72.4%.

An increase in the privatization of the healthcare system also followed decentralization. Although distinctions between public and private medical care services in Indonesia are blurry, private medical care providers are believed to have accounted for approximately one-third of all medical care services in Aceh—the Indonesian public and private medical care services are difficult to distinguish, because in Indonesia, public medical care professionals also work as private providers during non-working hours. Insurance coverage in Indonesia was low, with 84% of Indonesia’s population uninsured.

During December 2004, the MoH was nearing the end of its financial period and funds and supplies were running low. Also, the MoH’s resources had been stretched when it responded to earthquakes, disease outbreaks, and other emergencies earlier in 2004.

**Damage**

Along no other coast in any of the other countries, did the tsunami take as heavy a toll...
on the Medical Care System as it did along the impacted coasts of Indonesia, where it damaged or destroyed 554 health facilities and killed 250 healthcare workers. The damaged and destroyed medical care facilities included five hospitals, 31 health centres and 59 community health posts (Table 5.8 and Figure 5.8). The distribution of damaged healthcare facilities for the four districts noted above is in Figure 5.9. Medical facility damages were greatest in Banda Aceh, where 88% of health centres and community health posts were damaged or destroyed, and 16 out of 53 district health office staff were killed. In Aceh Jaya, 69% of the health facilities were severely damaged or destroyed. In Aceh Besar, Aceh Barat, Simeulue, and Nias Island, approximately one-quarter of the medical care infrastructure was destroyed or damaged.

In Banda Aceh, the tsunami badly damaged Aceh’s provincial hospital, Zainoel Abidin. The hospital was too far inland for the force of the tsunami waves to knock down the structure, but close enough for the tsunami to cover the premises in black, gelatinous, heavily-contaminated mud and render the hospital inoperable. As the tsunami flooded the hospital, many patients drowned; and after the water receded, the hospital was filled with bodies, ruined equipment, and mud that in some places was waist deep. Only two small Banda Aceh hospitals were not inundated by the tsunami: a military hospital, Kasdem, and a private hospital, Fakinah. However, although these hospitals were not inundated by the tsunami, they had been damaged by the earthquake and were abandoned in the immediate aftermath of the tsunami; the earthquake and tsunami also completely destroyed three out of six health centres in Banda Aceh, and the military hospital, one of only two hospitals in Meulaboh.

The tsunami took the lives of healthcare personnel throughout the impacted coastal region. As of April 2005, 205 healthcare workers were said to have died due to the tsunami, including 17 doctors, 3 dentists, 49 midwives, 30 nurses, 2 pharmacists, and 104 support staff; and an additional 489 were missing. By May 2005, the estimated number of healthcare worker fatalities increased to 250 and the number who remained missing dropped to 441. In Banda Aceh, the tsunami took a particularly heavy toll on medical care professionals. Most of the city’s medical personnel had been living in the most affluent part of the town that was completely leveled by the tsunami. The World Bank estimated that replacing personnel lost due to the earthquake and tsunami in Aceh province would cost the healthcare sector US$ 4.1 million. In addition to the healthcare workers who died, many healthcare workers also lost homes. Among the doctors, dentists and midwives, 61 homes were lost.

Other damages included 14 ambulances, one destroyed and three damaged pharmaceutical warehouses, the provincial health office, a WHO office, and four destroyed and four damaged health polytechnic schools. In addition to direct costs due to the damages, the World Bank estimated that the medical care system suffered an additional US$ 9.4 million in indirect costs. This included US$ 4.4 million in disaster public health activities, US$ 328,091 in facility cleanup, and US$ 581,543 in additional health treatment costs.

Changes in functions
Due to the damages sustained following the tsunami, provincial and municipal health services were operating at 20%-30% capacity. Meulaboh’s remaining hospital, a civilian hospital known as Cut Nyak Dhien Meulaboh Hospital, was located 3 km inland and survived undamaged, but only a fraction of its staff reported for duty. During the first few days of the disaster, only four of the hospital’s 14 doctors and 18 of its 120 nurses were available for work. The hospital’s remaining staff either perished in the tsunami, were looking for missing family members, or had fled to safety. The hospital also quickly ran out of medical supplies and on the third day of the disaster, had stopped providing medical care to patients. To make matters worse, hospital bed mattresses were
looted or had to be burned because survivors had placed decomposing bodies on them; the hospital was left with only 15 of its original 100 beds.50

The damages were such that none of the medical facilities and staff could provide the services available before the earthquake and tsunami. The functional state of the Medical Care System was severely compromised prior to the events, and now was unable to meet the daily needs of the population, as it encountered a surge of earthquake and tsunami victims. Tsunami damages to the pharmaceutical warehouses and drug storage areas in medical care facilities seriously reduced Aceh’s already limited capacity to store drugs and other medical supplies.58

**Relief responses**

Impacted areas of Indonesia received no outside medical support for several days following the tsunami. Instead, during the most medically critical period of the disaster, injured tsunami survivors had to rely on local residents and medical personnel. However, very few local medical personnel could provide care within the first days following the tsunami, and consequently, many seriously injured victims died. Additionally, the few medical personnel available to treat victims during the first few days of the disaster worked under primitive conditions. The availability of medical and clean water supplies were limited, electricity was not available, and few medical facilities could receive patients.

The earliest outside relief medical support came from the national government and the military. However, while military and government personnel and supplies were the first to arrive, their earliest missions to the area focused on providing basic necessities, such as water, and hence, only provided the most basic patient care. As military and governmental general relief responses commenced, the Ministry of Health’s Centre for Health Emergency Preparedness and Response (CHEPR) prepared a medical response, and on 27 December sent four tons of medical supplies and 519 body bags to affected areas.62 The next day, the MoH followed up by sending 103 nurses to Banda Aceh and by preparing to send the Brigade Emergency Team. The CHEPR assumed the responsibility for monitoring the disaster and coordinating responses with other departments and ministries. In the following days, medical teams from Surabaya, Yogyakarta, Medan, and Jakarta arrived to assist in tsunami-impacted areas.52

In most cases, national medical care teams began to arrive in the impacted areas on the fourth and fifth day of the disaster. In Meulaboh, a five-person medical team from Medan arrived on 30 December, and a 26-person medical team from Yogyakarta arrived on 31 December. The Medan team quickly ran out of medical supplies and had to return after only two days. However, the Yogyakarta team arrived with enough supplies for about 500 outpatients and 20 surgeries, and stayed in Meulaboh for approximately one week, after which a second Yogyakarta medical team relieved them. In one week, the Yogyakarta team treated approximately 500 patients and performed 10 surgeries.

Some medical care workers from other regions of Indonesia were reluctant to go to Aceh province to provide medical care relief due to security concerns. Indonesian doctors sent to Aceh province by the national government worried that they might be targeted for violence due to the ongoing conflict between Aceh separatists and the national government. Early during the disaster, military personnel closely guarded national medical teams until it became clear they were not in danger of being attacked by separatists.

The earliest international medical relief workers arrived in Indonesia soon after the national medical relief workers. In Banda Aceh, a medical team from Australia arrived on 30 December, and operated out of a private hospital, Fakinah, and a military hospital, Kasdem. Fakinah had not been functioning in the days immediately following the tsunami, but several doctors from Jakarta, who had arrived just before the
Australians, had begun to provide medications and basic wound care to some patients in the facility. When the Jakarta and Australian medical care workers arrived, Fakinah was unsuitable for providing medical treatment. The walls were riddled with earthquake cracks, there was no electricity, and the hospital’s water tanks had cracked leaving the hospital without clean water. The arriving Australian team brought a generator for electricity and scouted the area for other sources of clean water. Also, a building expert who accompanied the team examined cracks in the walls to determine which parts of the hospital were safest. Within 2–3 days of the Australian medical team’s arrival, one of the team members had repaired the hospital’s generator and Australian engineers had brought a water purification system to provide clean water. When the Australian team arrived, Kasdem hospital was more functional than was Fakinah, but was only able to provide basic care. At Kasdem, the Australian team found mostly military medical personnel providing mostly first aid, medications, and wound dressings. When the 26-member medical team arrived, they split up with half providing care out of the Kasdem hospital and half out of the Fakinah hospital. Injured survivors at the hospital had gone days without receiving treatment and many presented with badly infected wounds that required amputations; the team performed more operations than they had anticipated. Between the two hospitals, four operating tables were used to operate on victims all day every day. Fakinah and Kasdem hospitals also received numerous patients with tetanus. As the Australian team had little experience with tetanus, they deferred the care of patients with tetanus to Indonesian doctors who were better acquainted with the disease.

Scarcity availability of resources among the earliest arriving medical care teams limited treatment of some ailments. Consequently, many of the survivors with advanced tetanus died. Treating patients with aspiration pneumonia also proved to be difficult early in the relief response phase. Aspiration pneumonia, also referred to as “tsunami lung”, developed among survivors who had swallowed dirty tsunami water and did not receive antibiotics to minimize the likelihood of an infection. The earliest arriving national and international medical care relief teams had limited resources and staff, and had to make difficult decisions regarding the care of tsunami lung patients who required oxygen, mechanical ventilators, and continuous monitoring. Medical care teams had to decide whether to dedicate several medical care personnel to the care of one tsunami-lung patient, or to utilize them to treat many other patients in need of urgent care. As a result, some tsunami lung patients died without receiving definitive treatment.

Early arriving foreign medical personnel also included medical relief workers sent by the Singapore Armed Forces, including four medical officers and eight paramedical staff. The medical relief workers began providing medical care on 31 December from a clinic in northeastern Banda Aceh and alongside a camp with 1000 IDPs. Although the clinic had not been impacted directly by the tsunami, after the tsunami, its staff had dropped from 20 to one doctor and four nurses. At the clinic, the Singapore team treated 1021 patients over a nine-day period (achievement indicator). By 31 December, six field hospitals had been established in Aceh province. Three field hospitals had been established in Banda Aceh by the Indonesian military, police, national medical teams, a Jakarta health team, and by medical relief workers from Australia and Singapore. The remaining three were established by the Indonesian military and South Sumatra medical team in Sigli, Meulaboh, and Aceh Timur. In Banda Aceh, the medical care services received a big boost from a field hospital that was opened on 16 January by the International Committee of the Red Cross along with the Norwegian and Indonesian Red Cross. The ICRC field hospital became the city’s main referral hospital until local medical services could be restored.

International medical support also arrived on ships that included the Abraham Lincoln from...
the USA and USNS Mercy, India’s INS Nirupak, and Germany’s Berlin. Unlike the INS Nirupak, Berlin, and USNS Mercy, the USNS Abraham Lincoln was an aircraft carrier rather than a hospital ship; however, it arrived the earliest (1 January) and provided medical relief support including some medical supplies and medical personnel. The Berlin, a 22-bed hospital ship arrived just offshore of Banda Aceh on 12 January. The INS Nirupak, a 45-bed hospital ship arrived just offshore from the town of Meulaboh on 5 January. The INS Nirupak had four surgeons, an anaesthetist, several physicians, and paramedical teams, and was equipped with an operating theatre and three intensive care beds.

The USNS Mercy, a 1000-bed hospital ship arrived offshore Banda Aceh on 2 February 2005. This ship was one of the world’s two largest hospital ships, and arrived staffed with 210 civilian medical care volunteers and 275 military and US Public Health Service medical and medical support personnel. The ship had 12 operating rooms and could provide any treatment short of cardiopulmonary bypass and organ transplant. By the time that the USNS Mercy arrived, most of the injured tsunami survivors had received treatment or had succumbed. The ship’s medical personnel mostly delivered primary medical care; only 8.4% of the cases treated by the ship’s personnel were related directly to the disaster. In an approximately six-week period, the USNS Mercy medical personnel preformed 19 512 procedures for more than 9500 patients. The USNS Mercy departed after its mission ended on 16 March. But the ship’s return trip to the US was interrupted when it changed course to respond to a disaster on Nias after the 28 March earthquake. Doctors on board the ship noted that a greater proportion of the injuries treated on Nias after the 28 March earthquake were more acute than those treated off the coast of Banda Aceh after the tsunami, since the ship’s arrival was faster following the Nias earthquake than for the December 2004 earthquake.46

In addition to the medical relief efforts already mentioned, hundreds of additional humanitarian agencies offering medical support arrived and coordination became a chronic problem. The government of Aceh province asked WHO-SEARO to help coordinate the health aid agencies offering medical relief. In an effort to improve coordination, WHO-SEARO convened weekly health coordination meetings, conducted assessments to identify needs, and reviewed proposals for the health NGOs Bureau for Rehabilitation Reconstruction (BRR).26 These actions improved coordination, but did not provide a substantial solution to coordination problems that continued throughout the post-disaster period. There was no effort to accredit international relief workers offering medical services or the organizations which they represented. And, despite an abundance of health system coordination meetings, confusion continued about the services medical relief workers were providing, where they were providing them, and what medical supplies and equipment were available in the region. Consequently, mis-triage was common. Patients were sent from one hospital to the next until they eventually arrived at a hospital that could provide the services they needed.

With the influx of medical support from within Indonesia and abroad, the number of specialized medical personnel in Aceh province swelled to well above pre-tsunami staffing levels. For example, as of 16 January, the Cut Nyak Dhien Meulaboh Hospital had 21 surgeons compared to two prior to the tsunami. Early efforts to support medical personnel availability, however, seemed to focus on tertiary care personnel and neglected less specialized, but equally important, positions for the provision of primary health care (PHC). While the Cut Nyak Dhien Meulaboh Hospital received many surgeons, the number of nurses available at the hospital during the month following the tsunami remained well below pre-tsunami levels, while the hospital had 120 nurses before the tsunami, the number of nurses available at the hospital never exceeded 70 in the period following the tsunami. Due to a shortage of nurses, this hospital had to close three of its eight wards.51
Unfortunately, there were many mismatches between supplies and needs during the medical responses. Of all of the areas in which responders duplicated services, medical care has been said to have been responsible for the greatest waste. The well-equipped hospital ships were poorly utilized because the ships could not dock and patients could not reach them without being airlifted. Also, in some areas, too many doctors arrived. At one point, there were more doctors per capita in Aceh province than in any other Indonesian province. And, by the time many international medical relief workers arrived, most injured survivors had already received treatment. Additionally, those NGOs providing medical care services tended to congregate in easy-to-access areas, such as the Banda Aceh airport, and failed to penetrate areas where their services could have been more useful.

The excess of international medical relief workers resulted in both positive and negative outcomes. With a shortage of tsunami-injured patients to treat, doctors began treating non-tsunami-related complaints. This enabled some Acehnese to have tumours removed, receive dental treatment, and address other chronic medical needs. On the negative side, local medical care workers complained that the sudden influx of outside care negatively impacted the local medical care infrastructure which they said patients ignored in favour of outside medical care services. Indonesian doctors also complained that the international relief efforts often marginalized and failed to consult or support them. During a mid-January assessment from the US Abraham Lincoln, Indonesian doctors complained that the international medical relief workers brought enough provisions to support their own medical care services, but not Indonesian medical care services. Additionally, Indonesian medical care workers complained that international medical relief workers seemed to be trying to replace them rather than support them.

In addition to an excess of medical personnel, there was also an excess of medical supplies. Early during the disaster, there was a genuine need for supplementary medical supplies, including oxygen, surgical supplies, and medications. At the Kasdem hospital in Banda Aceh, some of the earliest operations were performed using poorly suited instruments. Also, there was a shortage of human tetanus immunoglobulin to treat patients with tetanus.

As bottlenecks in the supply chain were cleared, supply shortages were resolved. However, even after sufficient supplies had been received, donations continued to arrive until at one point, there was more medicine in Aceh province than in all of the rest of Indonesia.

Following the tsunami, Indonesia received 4000 tons of drug donations from at least 140 donors. As in Sri Lanka, however, many of the drugs sent were inappropriate. Sixty percent of the donated drugs were not on the national list of essential drugs, 70% were labeled in a foreign language, and 25% had passed their expiration dates. Consequently, many drugs had to be disposed of—at a cost of US$ 3.2 million. Drugs with inadequate expiration dates included drugs that had an expiration date within less than six months or had already expired on arrival. While some of the drugs sent were appropriate, they were sent in inappropriate quantities. For example, Aceh province received a six-year supply of dextromethorphan (15mg), a four-year supply of tetracycline (250mg), and approximately a 5–8 year supply of oral hydration salts—quantities that Aceh province could not possibly consume before large portions had expired. Additionally, inappropriate and overstocked drugs took up limited storage space, and became a burden in the hospitals. Zainoel Abidin, Bireuen, and Meulaboh hospitals had to convert office space and patient rooms into storage space in order to accommodate the overflow of drugs. In other places, drugs simply could not be stored securely; approximately 30 tons of drugs were stored in courtyards, open sheds, or other unsecured locations.

**Recovery responses**

Even after Aceh province had accumulated enough medical care supplies to last several years,
its medical care system could not yet operate independently. A great deal of infrastructure had to be rebuilt and repaired, and vacant positions within the local medical care system needed to be filled. Recovery efforts began early; at Zainoel Abidin, recovery efforts were underway within two weeks following the tsunami. The Indonesian military had cleared the hospital of bodies, and NGO-paid locals began clearing the hospital’s wards of mud. Additionally, an Australian team of engineers and medical care workers had arrived to help to make the hospital operational again. Within eight weeks of the tsunami, the hospital had been fully cleaned, its power and water supplies restored, and it was ready for use by Indonesian healthcare personnel.

Medical care infrastructure rebuilding was supported by international donors and the Indonesian government. In May 2005, the MoH asked the House of Representatives to approve US$ 106 million to rebuild the Medical Care System infrastructure in tsunami-impacted communities, and to add trauma centres to the medical care facilities in Banda Aceh, Sigli, and Lhoksemauwe. In the international efforts to rebuild the medical care system infrastructure, Germany and Australia were among the biggest supporters. By 19 May 2005, Germany and Australia offered US$ 23.6 million to restore and improve Zainoel Abidin and boost staffing. By 10 October, the German government would fund the restoration project with an additional US$ 13 million.

By November 2006, recovery efforts had built or repaired 324 healthcare facilities in Aceh, Nias, and Nias Selatan, including 67 facilities in Aceh Besar, 63 in Pidie, and 48 facilities in Aceh Barat. The rebuilt and repaired medical care facilities also included four hospitals, three in Banda Aceh and one in Nias. By the third-year anniversary of the tsunami, construction had been completed of 600 hospitals and clinics.

Restoration of the medical care system infrastructure required huge resources, but rebuilding the infrastructure proved to be easier than replacing lost local healthcare personnel.

By 2008, rebuilding efforts in Banda Aceh had restored the facilities that had been lost and had equipped the city with new medical care facilities that had not existed before the tsunami. But while the city’s medical care infrastructure and available medical equipment had increased beyond pre-event levels, it remained underutilized, because the facilities were understaffed. Efforts to replace and develop local medical care capacity proved difficult. Even before the tsunami, there had been a shortage of healthcare personnel not only to care for patients, but also to train new healthcare personnel, particularly specialized personnel.

Development
Aceh’s local education authorities and Canadian donors have been making an effort to address Aceh’s ability to meet local medical care personnel needs by increasing support to Aceh’s only medical school. These efforts have met with some success. For example, while Aceh province had only one anesthesiologist before the tsunami, by 2008, there were three. However, Aceh province still faces serious healthcare staffing shortages and requires ongoing support in effort to build up medical personnel capacity.

Water and Sanitation System
Pre-events
Although Aceh province was characterized by an abundance of water resources, it had a poorly developed water and sanitation infrastructure. Rainfall in Aceh province ranged from 1000 mm to as high as 3000 mm of rain/year. But even with an abundance of water resources, access to safe water remained well below the stated governmental goals of ensuring that 94% of its population had access to clean water by 2010. In 2004, Aceh province had a long way to go to reach that goal. Prior to the tsunami, only 48% Acehenese had access to clean water and only 29% of Acehenese had access to clean toilets.

The majority (77%) of residents living in Aceh province, particularly its rural residents, relied on independently or communally provided water sources, such as wells and pumps (boreholes), rather than piped water. Some residents also
relied on private vendors and other sources, while a slightly larger proportion relied on piped water; in Aceh province, 9% of the population received piped water. In areas that received piped water service, coverage ranged from 5%–50% of the population.23

In urban areas in the disaster-affected region, 11 government-owned water enterprises (PDAMs) provided an estimated 1500 litres of water/second. However, a Millennium Development Goals report concluded that the water distributed by PDAMs in Indonesia could better be described as clean water rather than drinking water, i.e., water that must be boiled before drinking. The report noted that although PDAMs treat water for direct drinking, poor distribution systems and irregular service led to contamination.76

Banda Aceh province drew its water supply from Kreung Aceh located 10 km inland. Pumps transported the water to a treatment plant that cleaned the water using flocculation, sedimentation, filtration, and chlorination. Steel transmission lines then distributed water from the plant to the city. In both urban and rural areas, residents relied on onsite facilities. Pit latrines and septic tanks were used primarily to dispose of wastewater. In urban areas, local government agencies emptied the septic tanks and transported the sludge to treatment plants (IPLTs).23

Damage
Most of the damage to the water and sanitation system appears to have been sustained by the water system. Of the estimated 276 billion Rupiah (US$ 30 498 000) of damage to the water and sanitation system: water supply damages accounted for 267 billion Rupiah (US$ 24 500 000) (97%). Private water providers accounted for 63% of the overall water supply damage.23 An estimated 60 000 wells and 15 000 hand pumps were destroyed.75

Changes in functions
Both the loss of water and latrines created a massive health issue that would take considerable time and resources to overcome. Following the tsunami, access to clean water was limited not only by the unavailability of water, but also the unavailability of water storage containers. Three weeks after the tsunami in the western districts of Aceh province, many families did not have adequate water storage containers.67 However, there were no reports of deaths due to dehydration.

An assessment of four western Aceh districts approximately three weeks after the tsunami found that the camps had few latrines. This caused the IDPs to defecate in open areas near the shelters, such as open fields or canals, compromising general sanitation and nearby sources of water.67

Relief responses
In Indonesia, defense forces and relief organizations took primary responsibility for providing water early during the disaster. The number of relief organizations that played a role in meeting water and sanitation needs grew rapidly. In the water and sanitation system alone, more than 250 organizations were working in Aceh province.77 Several UN agencies also played a role in water and sanitation relief and recovery efforts, with UNICEF taking the lead.78 Early during the disaster, relief efforts focused on providing survivors with an adequate supply of potable water, which was initially delivered primarily in bottles and tanker trucks. Later, temporary water treatment plants helped to provide adequate potable water. By 6 January 2005, the Singapore army had established a portable water-purification plant in Meulaboh that produced 4000 litres of potable water/day.50

Many organizations relied heavily on water brought by tanker trucks to supply affected communities for several months. For example, UNICEF provided 28 000 people with 15 litres of drinking water/day using water tanker operations.78 Because Aceh province generally had abundant water resources, relief efforts quickly achieved Sphere minimum standards for water supply.80
Although water tankers became an important source of water for many camps and impacted communities, there was no surveillance system for monitoring the quality of tanker truck water. Additionally, relief worker observations suggested that some tanker trucks might be obtaining water supplies from questionable sources. As an example, near Banda Aceh, truckers were filling tanks up at sources other than from the emergency water treatment plant set up in Lambaro, where they were instructed to fill tanks. At the time, the emergency treatment plant was the only major source of safe water for Banda Aceh and its surrounding areas. However, due to high demand, tanker trucks had to wait for an average of three hours to fill their tanks. Consequently, some filled their tanks at other sources in order to avoid waiting. In response to this discovery, WHO, CARE International, and the CDC conducted an assessment in June 2005 to test the quality of water being delivered by tankers. The assessment tested 54 samples from tanker trucks for E. Coli contamination and found that 17% were contaminated.81

At the household level, most tsunami-survivors were boiling drinking water to destroy pathogens.67 However, the Banda Aceh Epidemic Alert and Response Team reported that in the immediate aftermath of the tsunami, survivors were observed using untreated well water instead of the freely available purified water.82 In addition to addressing water quality issues on the supply end of the water system, some organizations also concentrated on improving water quality by focusing on household practices. CARE International provided survivors with more than one million bottles of concentrated sodium hypochlorite so that they could treat their own water and encouraged the use of sanitary containers for storing water.83

Recovery responses
As relief workers and local authorities tried to address the immediate issues in the quantity and quality of water supply, efforts were directed toward the need to restore long-term supplies, including those supplied by wells to rural populations as well as supplies for urban areas such as Banda Aceh and Meulaboh. WHO-SEARO’s Water and Sanitation team worked with PDAM to repair the Banda Aceh water treatment plant.84

Although tsunami damages to the Sanitation infrastructure were minor compared to damages to water infrastructure, the need for sanitation facilities grew disproportionately due to tsunami-survivors’ new living circumstances following the tsunami. To address these needs, organizations installed latrines and brought sanitation disposal services to the IDP camps. But, the delivery of and installation of latrines was challenging and the equipment required to address sanitary disposal needs was in short supply. To help address disposal issues, UNICEF provided Aceh province with a desludging truck and three bulldozers to enable the province to empty septic tanks and dispose of solid waste. By the end of 2005, UNICEF planned to finalize a design for a sludge treatment facility that would triple Banda Aceh's capacity to treat sludge.85

Within two years of the tsunami, access to water and sanitation had improved, but still remained less than ideal.

Development
By the end of 2006, more than 50% of Aceh’s population had access to water from an improved source such as protected wells and boreholes, and 58% had access to basic sanitation.9

Shelter and Clothing System
Pre-events
Aceh province has a tropical climate with the warmest temperatures near its coasts and cooler temperatures in the mountains. Aceh province receives anywhere from 1000 to 3000 mm of rain each year, most of which between September and February. The dry season lasts from March to August. Aceh’s southern and western districts generally receive more rain than do the province’s other districts.86

With generally mild weather, many Acehnese could and did manage with modest housing,
particularly in rural areas. Nearly one in five Acehese homes used leaves or sugar palm fibers for roofing. And the walls of nearly 70% of houses were constructed of materials other than brick. In rural areas, more than 75% of homes had walls constructed of materials other than brick.87

Some of the homes constructed of the most modest materials may very well have been temporary; they were inhabited by the poor and sometimes by people who had fled their original homes due to the ongoing civil conflict. In addition to the usual homelessness problems encountered in the provinces throughout Indonesia, Aceh province also had a fluctuating population of people displaced from their homes by the conflict. The number of IDPs in Aceh province fluctuated with the intensity of the conflict. Before the declaration of martial law in May 2003, Aceh province was estimated to have had about 1000 IDPs living in camps. Estimates for the number of IDPs, jumped to 38 000 in the two months following the declaration of Martial Law. After this two-month period, however, many were believed to have returned to their homes and the number of IDPs is believed to have dropped to 14 950.9

Census data for Aceh province indicate that approximately 83% of the residents owned their homes, approximately 8% rented, and 3% were living in housing provided by the government. However, of those who claimed to own their homes, only 10% could provide legal title for their land.23

Damage

The Shelter and Clothing Basic Societal System accounted for the greatest proportion of the infrastructure damage sustained during the earthquake and tsunami. Of the 41.4 trillion Rupiah (US$ 4.8 billion) in damage, 13 trillion (US$ 1.48 billion) (32%) was sustained by the housing sector.23 An estimated 19% of building units in the affected districts suffered an estimated 50% damage in the aftermath of the earthquake and tsunami, and an estimated 14% were completely destroyed. Damage occurred primarily within 3.2–6.4 km of the shore (Figure 5.10).

Most of the damage occurred in the districts of Banda Aceh, Aceh Jaya, Aceh Besar, and Sabang, where more than 80% of the houses were either damaged or destroyed.23 The distribution of the number of homes destroyed in the four districts (Aceh Barat, Aceh Besar, Aceh Jaya, and Banda Aceh) are in Figure 5.11). A total of 54 643 houses were destroyed in these four districts or 657/10 000 population.

Changes in functions

The greatest burden for the four districts was homely Aceh Jaya with 1146 houses destroyed/10 000 population followed by Aceh Barat with 963 homes destroyed/10 000 population. The number of homes destroyed does not correlate with either the number of those killed or missing or with the number of IDPs. These observations require further study.

Generally, most assessments of the number of people displaced after the earthquake and tsunami have estimated that about 400 000 people were displaced, although some estimate that more than 500 000 were displaced. Of these, approximately 125 000 were located in the west coast districts, 130 000 in Banda Aceh, and 150 000 in the east coast districts (Figure 5.12).67,88

Destruction of houses in the tsunami compounded the suffering of many people who already had been displaced at least once before the tsunami. Additionally, the tsunami occurred during the rainy season, a time when it was more difficult to live without shelter. When more than 400 000 Acehnese fled from the rubble of coastal neighbourhoods and headed inland for safety, they crowded initially into public buildings and homes that remained standing, or they constructed temporary shelters out of debris. It is estimated that nearly half of the 400 000 IDPs in Aceh province found shelter with host families.88 Those IDPs who did not find shelter with host
families, settled into spontaneous camps or in public buildings such as schools and mosques.89

Even with the tents and other makeshift housing to shelter many of the displaced tsunami survivors, public buildings and host families were overwhelmed. Consequently, public services were disrupted and generosity strained host families’ resources. Schools crowded with IDPs could not hold classes, disrupting education.89

Relief responses
When outside help arrived, the Acehenese survivors received temporary shelters to protect them from the elements. Tents, plastic sheeting, and mosquito nets made the rounds as government agencies, NGOs, and international agencies came pouring into tsunami-impacted areas.

An assessment conducted in four western districts of Aceh province approximately three weeks after the tsunami noted that schools were crowded with more than 2000 IDPs.67 Additionally, while host families shared their space, facilities, and in many cases, food and water with displaced tsunami survivors, relief workers often failed to recognize their needs, particularly early during the disaster (Figure 5.13).

By the end of January, international agencies had directed most of their assistance to IDPs in camps and spontaneous settlements, but had done comparatively little to meet the needs of IDPs living with host families.88 Some responders recognized the discrepancy and tried to ease the burden on host families. In February 2005, the government of Switzerland launched a programme that would provide host families US$ 40/month for housing an IDP. The Swiss government provided US$ 850 000 for the first phase of this programme, which was known as the Cash for Host Families Programme.90

Recovery responses
The need to move the IDPs out of public buildings, tents, and host families’ houses was pressing. But, even while donors from all over the world flooded Aceh province with donations for building houses, it would be a long time before many Acehnese moved back into permanent homes. The effort to rebuild houses progressed slowly not only because houses take a long time to build, but also because the tsunami had created great confusion over land ownership.

In the interim, workers set about trying to at least improve IDP living conditions by providing temporary shelters. After the first few weeks following the tsunami, some of the IDPs began to move out of tents and into transitional shelters known as “barracks”, which were constructed of wooden planks and consisted of 12 or more rooms (Figure 5.14). Each room measured five by four metres and exited onto a 1.5 metre-wide terrace. At least one, and sometimes two or three, families would share a single barrack room.91 By the end of February 2005, 397 of the 997 barracks planned had been completed.92

The building of both barracks and permanent housing progressed slowly; many displaced families lived in tents for much longer than expected. By July 2005, tens of thousands of people had been living in tents for six months as they waited for permanent housing to be built. Tents had become tattered and would provide poor shelter during the oncoming rainy season. Consequently, several organizations recognized a need for transitional shelters for those IDPs currently living in tents, and formed a Transitional Shelter Working Group chaired by the IFRC to address the issue.93 During an 18 August 2005 meeting participants concluded that, when possible, tents should be replaced with sturdier shelters, such as the collapsible containers that had been certified for use in the local climate, until permanent houses had been completed. They also concluded that when enough transitional shelters could not be provided, tattered old tents should be replaced with new ones.93 By the end of the year, although more tsunami survivors were living in temporary shelters, an estimated 67 000 people were still living in tents and 70 000 were living in temporary shelters. Additionally, an unknown number of displaced survivors continued to live with host families.94
Efforts to build permanent homes were slowed by unsorted land ownership issues and new regulations guiding where and how houses should be built, including initial plans that Indonesia had enacted to prevent building along coastlines; later, these plans had to be dropped. The BRR had set a target of 130,000 permanent houses to be built by the end of 2006. However, by the end of 2006, NGOs, international agencies, and the BRR had built only 57,123 permanent houses for tsunami survivors. Of the 57,123 houses built, the NGOs and international agencies built 40,229 (70.4%), and the BRR built 16,894 (29.6%). Also, by the end of 2006, 14,986 temporary houses and shelters had been built. By the third year anniversary of the tsunami, more than 100,000 homes had been built, although approximately 3000 families continued to live in shelters around Banda Aceh. The IFRC was the leading builder in Aceh province following the tsunami. Of the 108,756 houses built by April 2008, the Red Crescent Red Cross built 13,388 (12%), with an additional 3484 under construction, and another 3049 planned. Despite the pressing need for permanent housing, some of the houses built for survivors were not occupied.

In addition, some of the housing structures were built hastily, were poorly located, and quickly became dilapidated. For example, one year after the tsunami, a 130-unit housing project hastily built for government workers just two months earlier had begun to deteriorate and stood unoccupied. An NGO had built the housing units using cheap plywood that had begun to warp. Some of the project’s houses, which had been built on stilts on donated land near Banda Aceh, hovered above ponds of water that had accumulated on the property.

Food and Nutrition System
Pre-event
Before the tsunami, Indonesia presented a bleak picture of nutritional health. Nearly 13 million Indonesians suffered chronic undernourishment, and two-thirds of Indonesians consumed less than 2,100 calories/day (Table 5.10). In addition, nearly one-third of Indonesian pre-school children were underweight and almost 10% were severely underweight. Information on the pre-event nutritional status in Aceh province is considerably less reliable than for the rest of the country. But Aceh’s nutritional status is believed to have been considerably worse than that of the country as a whole. Estimates on the percentage of Aceh pre-school children who were underweight range as high as 52.1%, higher than in any other province in Indonesia but one. While data on underweight prevalence below the provincial level is even less reliable than for the province as a whole, underweight prevalence among children under five years of age appeared to have been highest in three districts in Aceh province—Aceh Utara, Aceh Barat, and Aceh Besar.

Important local food resources in Aceh province included several grains, legumes, cassava, and fish. Annually, Aceh and Nias produced 158,578 tons of wild caught fish and 24,602 tons fish from aquaculture. In Aceh province, there was only one canning facility; most of the fish caught were consumed locally. Figures for protein consumption as a whole, indicate that Indonesians obtain 58% of their animal proteins from fish.

As for agricultural products, Aceh’s primary food crops included rice, maize, soybean, peanuts, and cassava. Rice, by far, was the leading, locally produced product. In 2003, farmers cultivated 367,600 hectares of rice paddy in Aceh province producing 1.5 million tons of rice.

Damage
Although information on damage to the food supply due to the tsunami are largely limited to damages to the fishing and agricultural sectors, the tsunami also destroyed a large quantity of food stored in homes, shops, and other places. The extent to which survivors suffered from food shortages immediately following the tsunami is unknown.
Damages to local food production suggested tsunami-impacted regions would need more than just short-term support. An estimated 92,000 farms were lost or damaged due to the tsunami and nearly 40,000 hectares of agricultural land was inundated by seawater. Seawater deposited salt, sediment, and debris over agricultural land. In addition, some areas was permanently submerged. Most of the damaged and lost land was on the western coast, where 2900 hectares were lost to the sea, and 17,500 hectares required major and long-term rehabilitation before it could be used again. Additionally, a total of 17,050 hectares of agricultural land were moderately to lightly damaged on both the west and east coasts.

Aside from agricultural land, Aceh province also lost approximately 1.7 million livestock, 1.4 million of which were poultry. Livestock losses appear to have been greatest in Aceh Besar, where a total 478,000 animals were lost, including 400,000 poultry and 48,000 cattle. The fishing sector also took a hard hit; a total of 3229 fishing vessels were damaged or lost.

Changes in functions

It was clear that damages to stored food supplies, markets, fishing, agriculture, and overall infrastructure had created a need for food assistance. In January 2005, the WFP estimated that among those affected by the tsunami, approximately 700,000 people needed food assistance. Unfortunately, because there was scant pre-event data on the nutritional status of Aceh’s population, and because relief efforts quickly supplemented the diets of survivors soon after the tsunami, it was difficult to gauge the impact damage to the food sector had on the nutritional status of tsunami survivors. However, a nutritional survey of children in Aceh and Nias eight months following the tsunami suggested that many children did not meet their nutritional needs. A September 2005 survey of preschool children in 20 districts in Aceh province and Nias island noted that 44.2% of the children were underweight, 40.2% were stunted, 8.9% were wasted, and 9.8% suffered from acute malnutrition.

Communities neighbouring the tsunami-impacted areas may have assisted in meeting the food needs of the survivors until international assistance arrived—survivors may have had to make do with what they could salvage from the debris.

Relief responses

Although hundreds of organizations donated food for tsunami survivors, one organization took a leading role in coordinating the food relief response. Early during the disaster, the MoH designated WFP as the agency responsible for coordinating food assistance activities in Aceh province. The WFP quickly appealed for funding to feed one million people for six months and began an assessment to determine the survivors’ access to food. From 3 January to 1 February 2005, the WFP conducted an assessment titled Post-Tsunami Emergency Needs in Aceh province that aimed primarily at defining the nutritional issues.

The flood of food donations was difficult to monitor, and in some cases, the safety of the food being received was questioned. As with the donation of medicines, some of the food received from donors had expired. In at least one instance, tsunami survivors reported stomach cramps after having eaten expired food. To prevent the development of food-borne illnesses, the Indonesian Agency for Food and Drugs Supervision destroyed truckloads of expired and unlabeled food donations.

Recovery responses

The quality of the food being received also became a concern with respect to whether people were receiving the required micronutrients. This was of particular concern with respect to women and children; many organizations established programmes to ensure that women, and particularly children, did not become malnourished. To supplement children’s diets, humanitarian agencies provided children with vitamin A capsules and sachets of the micronutrient supplement “Vitalita”, which was distributed primarily by Helen Keller.
As of September 2005, the percentage of Indonesian children six months to five years of age that had received vitamin A was very high. 82% of all children in this age range in the 20 Aceh province districts surveyed had received vitamin A supplements. The same survey found that 12.1% of children six months to five years of age had received Vitalita within the last week.

Distribution of vitamin A capsules and Vitalita varied considerably from district to district, and reached a greater proportion of IDPs and older children than non-IDPs and younger children. For instance, Vitalita reached 0% of the children in nine Aceh districts, but 81.3% of the children in Aceh Jaya. Differences in the distribution of vitamin A from district to district was less extreme, but also considerable. The number of surveyed children who received vitamin A capsules ranged from 49% in Aceh Tenggara, to 96% in Aceh Tengah and Bireuen.

The distribution of Vitalita also was disproportionate between IDPs and non-IDPs. While the differences in distribution of vitamin A were negligible, distribution of Vitalita was almost five times higher among IDPs than non-IDPs. Of the children between six months and five years of age, 49.9% of those living with IDP households had received Vitalita; only 7.9% of those living with non-IDP families had received the micronutrient supplement.

Finally, the percentage of children who received Vitalita or vitamin A capsules increased with age. While only 8% of children between six months and 11 months had received Vitalita, 15% of children 48 months to five years of age had received the supplement. Of children six months to 11 months old, 72% had received vitamin A capsules, while 85% of children 48 months to five years old had received vitamin A capsules.

Some estimates of stunting and underweight prevalence among children from six through 59 months of age were minor. Estimates for stunting dropped from 37.2% to 36.6%, and underweight estimates increased slightly from 42% to 43%.

The incidence of wasting of children from 6 through 59 months by 10 tsunami-impacted districts also indicated a decline from 11.0% in March to 8.8% in September. The wasting in all 10 districts declined among children 6 through 59 months of age to 8.8%. The greatest decline occurred in northwestern Aceh province.

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Of all of the nutritional indicators reported, estimates for the prevalence of anaemia were the highest. Although the report from which anaemia data were drawn did not report child anaemia rates for March, the overall rate in September was 50%. The report noted that although many factors can contribute to anaemia, the high rates in Aceh province were likely due to an inadequate supply of micronutrients. Estimated anaemia rates in September were highest among the youngest children surveyed and lowest among the oldest children surveyed; 73% of the...
children from 6–11 months of age were anaemic, compared to 35% of children from 48–through 59 months of age. From district to district, the incidence of anaemia among children from 6–59 months of age ranged from a low of 31% in Langsa to a high of 65% in Aceh Singkil.

In addition to describing changes in nutritional status over time, the March and September data also describe differences in nutritional status between IDP and non-IDP households. For the most part, only minor differences were found between IDP and non-IDP households.42

As of the end of 2006, the prevalence of stunted and underweight children under five years in Aceh and Nias indicate that many children in tsunami-impacted areas were not having their nutritional needs met. In both Aceh and Nias, 35% of children were found to be stunted. Additionally, 41% of children under five years in Aceh province, and nearly 49% in Nias island were found to be moderately or severely underweight.95

Indicators in food production appear to be more promising. Despite damages to agricultural land and farming equipment losses, Aceh province produced an estimated rice surplus of about 200 000 metric tons in the 2005/2006 marketing year.107

Energy Supply System

Pre-event

The delivery of electricity in Indonesia was dominated by Perusahaan Listrik Negara, a government-owned and vertically integrated electricity utility company. In 2001, Indonesia generated 95.78 billion kilowatts in electrical power using fossil fuels (86.9 %), hydropower (10.5%), and other sources (2.6%).108 None of the electrical energy generated in Indonesia is obtained from nuclear power facilities.

Although 94% of Aceh province’s approximately 5500 villages received electricity, power outages were common, and only 60% of Indonesian households had access to electricity. Most of the large power plants that supply Aceh province are located in North Sumatra province. The other source of electrical power for the province is through small diesel generators.21

A state-owned oil company was the sole supplier of petroleum fuels (including bottled LPG) for all of Indonesia. It owned and operated all fuel storage and distribution depots. The large natural gas reserves are being extracted by Exxon Mobil according to a contract with the government.

Damage

The earthquake and tsunami damaged and destroyed many primary assets belonging to the government-owned Perusahaan Listrik Negara. Damaged and destroyed utility assets included 3437 km of medium and low voltage distribution lines, 754 transformers, consumer lines and equipment for 92 013 customers, six substations, 69 distribution cubicles, six office buildings and seven diesel power plants.109

There was heavy damage to the depots that were close to the impacted areas. Storage tanks were ruptured resulting in fuel leaks.110

Changes in functions

Damages to the energy infrastructure compromised Aceh’s electricity system for one month following the tsunami. Electrical power to the medical facilities was at least temporarily interrupted. Many of the medical facilities, including the hospitals, did not have generators which affected the cold chain, preservation of blood, and the utility of many pharmaceuticals. Lighting and electrical power are essential for hospital operations. This failure was simultaneous with the initial surge of injured. Its impact on survival of the injured could not be determined.

Relief responses

Generators provided the earliest sources of energy in areas that had lost power due to the tsunami. Some relief teams brought their own generators, as did the Australian medical team that arrived in Aceh province on 30 December.
**Recovery responses**
No information was available in the material accessed that related to recovery of energy systems as they pertain to the medical care, public health, water and sanitation, food and nutrition, and shelter and clothing societal systems.

**Development**
No information was available in the material accessed that related to development of energy systems as they pertain to medical care, public health, water and sanitation, food and nutrition, and shelter and clothing societal systems.

**Public Works and Engineering System**

**Pre-event**
The disaster-affected areas of Aceh province were served by six major roadways totaling 1587 km and 875 bridges. Four of the six roadways were national roads totaling 1136 km and 600 bridges, the other two roadways were provincial. An average of 2000–3500 vehicles used these roads each day and up to 8000 vehicles/day in the urban areas surrounding the capital.

On the northern portion of Sumatra island, the main airports were operated by PT Angkasa Pura II, one of two nationally owned airport corporations. Banda Aceh’s largest airport, Sultan Iskandar Muda, was also operated by PT Angkasa Pura II, and had a 2500 metre runway able to handle B737s and similar aircraft. The airport handled approximately 15 flights/day and was located approximately 13 km from shore. Polonia Airport, the largest airport on the island of Sumarta and located 2 km from Medan, typically handled 60 to 70 flights/day. Polonia was located 500 km from Banda Aceh, and had a 2900 metre runway and was able to manage larger international aircraft.

Before the tsunami, the local government’s capacity to manage wastes was limited. Years of conflict and poor funding had crippled the waste management infrastructure, and often, dumpsites were nothing more than an open pit with few or no controls for potential environmental contamination. The primary landfill site for Banda Aceh was Gampong Jawa, which covered 4.5 hectares and was located north of Banda Aceh—near the sea. Dinas Kebersihan dan Pertamanan (DKP) was the government sanitary department in Banda Aceh.

**Damage**
Damages to public works and engineering systems dominated the infrastructure losses in Indonesia. Of the US$ 876.8 m lost in infrastructure, 61%, (US$ 535.9 m) was lost in the transportation and logistic and public works and engineering systems. Of the transportation damages due to the tsunami, 35% was to roads, 59% to land transport, and 5% to ports. Approximately 316 km of the 3145 km of major roadway in the affected areas were damaged. Of the 9999 km of other roads approximately 1621 km were destroyed (Figure 5.16).

Because Indonesia has a steep topography, and socioeconomic activities are concentrated in coastal areas, its transportation infrastructure also was concentrated along coastal areas. It seems that most of the damage to the public works and engineering infrastructure was due to the tsunami. However, the earthquake damaged airports and ports and roads. Additionally, the earthquake may have weakened structures later struck by the tsunami. The amount of debris left behind by the tsunami in Aceh and Nias island was so vast that few have ventured to estimate its enormity (Figure 5.15). Tsunami debris was particularly problematic in the urban areas. A waste management adviser from UNDP estimated that in Banda Aceh alone, the tsunami had created between 7 and 10 million cubic metres of waste. The tsunami also destroyed half of Gampong Jawa, Banda Aceh’s primary landfill, 37 of the 40 refuse collection vehicles, and killed one quarter of the Dinas Kebersihan staff.

**Changes in functions**
Not only had the tsunami created a huge amount of debris that had to be cleared, but damages incurred also had halted the collection
of household wastes—both of these problems presented a health hazard.  

Relief responses
Removing the rubble, muck, and sludge that covered the affected cities and towns along the tsunami-impacted coasts of Indonesia presented a daunting task. But life in tsunami-impacted areas could not resume logistically or emotionally without tackling it. The government and the UNDP played central roles in the clean-up effort, prioritizing key public facilities such as hospitals and schools. The government financed private contractors to remove debris from roads, markets, and buildings. Due to the urgent need to clear these areas, contractors often piled debris into temporary dumpsites on private land, paddies, ponds, or other inappropriate locations.

Recovery responses
As contractors initiated debris-clearing efforts, the UNDP and government officials prepared to implement sustainable solutions to handling the tsunami debris. In January, the Aceh Sanitary Department (DKP) and UNDP coordinated to initiate the Tsunami Recovery Waste Management Programme; by March 2005, the programme initiated a coordinated and pragmatic response to clearing debris. Under the programme’s direction, cleared debris that had been haphazardly piled onto temporary dumpsites in coastal communities was removed to proper dumpsites where they would not leak chemicals or toxins into water sources and create other hazards. By May 2005, the programme had removed more than 1 million cubic metres of debris—the equivalent of 70 football fields piled one-storey high.

Restoring transportation to tsunami-impacted regions required not only vehicles, but usable roadways. Repairing the road system required huge amounts of human and material resources that involved more than just pouring pavement. The roadways not only required repairs, but also the removal of millions of tons of debris. It took years to restore the country’s road network. However, by the third anniversary of the tsunami, almost all of the damaged and destroyed roadways had been restored with approximately 1996 km of road rebuilt in Aceh province.

Residents in tsunami-impacted areas also provided some independent clearing of debris and sometimes burned it rather than removing it to another location. However, burning of some debris created dangerous fumes that polluted the air. Debris burning also posed a secondary hazard of burning out of control, and is believed to have been responsible for a fire that burned through Banda Aceh on 24 January. The fire, fueled by debris and gas cylinders from destroyed homes, roared through a 1 km area of the city. Indonesians whose ruined homes were burned by the fire could no longer salvage what was left of their belongings or continue their search there for the remains of missing relatives.

In addition to debris removal, the clean-up also included recycling efforts. By early June 2005, UNDP had recycled 9000 cubic metres of debris to be used to rebuild infrastructure projects in Banda Aceh, including Ulee Lheue port.

Development
No information was retrieved that had relevance to the public health and medical care systems.

Social Structures*
Pre-event
In Aceh province, religion and ethnicity largely unified the population’s cultural identity. Ninety percent of the population was Acehnese; the remaining population consisted of Gayonese, Alas, and Tamiang. Aceh province also was Indonesia’s most conservative Muslim province. Islam influenced personal decision-making, including decisions regarding the use of contraceptives and the age at which children could make their own decisions with respect

*Cultural components including art, music, and some customs are not included
Islam’s influence on Acehnese daily life was strengthened in 2002 with the imposition of Islamic Sharia law, which integrated Islamic values into law, including a ban prohibiting women from wearing revealing clothing.

Although unified culturally, in many other ways, Aceh province was a fragmented society. Decades of conflict fractured Aceh province into relatively safe regions and poor regions plagued with violence. A local separatist movement, fueled largely by a struggle over local oil resources, devastated impacted communities and amplified the need for mental health support. The conflict was greatest in rural areas, and people who had the means to do so often fled to the cities in an effort to escape the violence.

Although it had suffered a great degree of trauma due to the conflict, Aceh’s population had very limited access to mental health care. On paper, Indonesia appeared to have established many of the components central to providing strong mental health services. The country had a mental health policy, therapeutic drug policy, substance abuse policy, a national mental health programme, and 1% of its health budget allocated to mental health. Although the country did not have specific mental health legislation, it was integrated into general health law. However, there was no plan or allocated budget to implement the mental health policy and the existing mental health legislation was insufficient. Consequently, the mental health policy was useless, and a huge vacuum existed with respect to mental health legislation. Mental health legislation did not define mental health illness and failed to address issues of involuntary treatment or violations of human rights.

In the 1970s, Indonesia’s mental health system was ahead of mental health services in other developing countries. However, in the following decades, mental health services in Indonesia stagnated, and then fell far behind those of other countries. By 2004, for every 10,000 people, Indonesia had only 0.4 psychiatric beds, 0.02 psychiatrists, and 0.03 psychologists. Additionally, most care was provided in provincial mental health hospitals, in which conditions generally were poor, and almost no care was provided at the community level. Part of the decline in mental healthcare services in Indonesia can be attributed to the decentralization of the country’s public healthcare system in 2001, and increasing pressure on the hospital system to generate its own funds. Decentralization dissolved centralized powers and placed district-level services at the whim of district governments. In addition, increased pressures to generate funds resulted in cutbacks in the least profitable services, including mental health care.

In Aceh province, the mental health system was worse than for the nation as a whole. For every 10,000 people, Aceh province had only 0.01 psychiatrists and 0.007 psychologists. Districts accorded mental health services extremely low priority and limited resources. At both the provincial and district level, there was no specific unit or programme officer responsible for mental health. Rumah Sakit Jiwa Banda Aceh was the only psychiatric hospital; its location at the northernmost tip of the province made it difficult for many Acehnese to reach it. The hospital served the mental health needs of the province without the help of any mental health centres and with only three psychiatrists, three psychologists, and 252 paramedics. At the time of the tsunami, the hospital was providing care for 315 in-patients, although it had only 250 beds. When patients’ treatment had been completed, many of the mental health hospital’s patients refused to return to conflict areas, causing the hospital’s inpatient population to exceed the number of beds available.

**Damage**

The tsunami gravely damaged the psyche of many Acehnese. Nowhere else in the Indian Ocean basin did the tsunami decimate communities, homes, livelihoods, and human lives to the extent that it did in Aceh province. The loss of life was so great, some families lost more members than those who survived. The
tsunami took a particularly heavy toll on the most vulnerable, killing a disproportionately large number of women, children, and the elderly.

In some instances, the disproportionately high female fatalities rates were startling. Out of 366 tsunami fatalities reported in four Oxfam-surveyed villages in the Aceh Utara district, 284 (78%) were female. In a survey of IDPs in nine districts, 57% of the reported fatalities were female. Interviews with survivors suggested that in many rural coastal areas impacted, men were safely fishing at sea when the tsunami struck, or were working in fields away from shore; most of the women were in homes along the coast caring for children. Also, men were more likely to be able to swim and more likely to have the physical strength to hold onto trees to survive the forces brought by the tsunami.

Age was also a factor in the associated mortality rates. The lowest mortality rates (10.5%) occurred in 20–29 year-olds, the rates for children <10-years of age was 19.8%. As for the elderly, fatality rates were higher still, reaching 28.1% among those ≥70 years of age. UNICEF estimated that approximately half of the individuals who died from the earthquake and tsunami were children. Because a large number of the fatalities were children, the number of orphaned children was limited. By late February, 60 children had been found without parents or any other adult that they knew before the tsunami to watch over them. Other children who had lost parents, had either one remaining parent or other relatives to care for them.

Although the mosques generally survived the tsunami better than did other buildings, tsunami damages to religious buildings was not insignificant. The loss due to damage to mosques and religious centres are estimated at US$ 51 million.

**Changes in functions**

In addition to the trauma of losing family members, the tsunami killed a large number (100,000) of Indonesians at once; most survivors could not find and identify the bodies of deceased loved ones. The absence of a body to confirm the death complicated the grieving process for the bereaved. Without cold storage to preserve bodies, visual identification quickly became unfeasible, and the fatalities remained largely unidentified before being buried; some bodies were washed far out to sea and never recovered; 10 days following the tsunami, some bodies were reportedly found as far away as the Maldives. Without a body to confirm death, many bereaved nurtured the hope that their loved ones were still alive. Their hopes were fueled by the occasional news story reporting a husband that found a missing wife or mother that found a missing child.

Tsunami-related traumas increased the need for psychosocial and mental health services in Aceh province. Yet, in the immediate aftermath of the tsunami, local mental health services were essentially non-existent. The tsunami had flooded Aceh’s only psychiatric hospital and killed 26 of its 252 paramedics. Survivors seeking religious support were unable to obtain it as religious institutions also had been damaged.

While religion may have provided a tremendous refuge for many of those who were struggling with mental trauma following the tsunami, it also may have complicated some survivors’ interpretations of the disaster. Acehnese survivors frequently told mental health relief workers they thought the disaster was a punishment or warning from Allah for immoral behaviour.

**Relief responses**

Estimates of the number of NGOs that engaged in mental health relief activities following the tsunami range from 130 to as high as 300. This strong NGO response helped supplement the local mental health support capacities, which were almost non-existent prior to the tsunami. However, many of the mental health relief responses by NGOs were inconsistent, sometimes inappropriate, and presented a huge coordination problem.

To bring some order to this chaotic mental health response, provincial, national, and
UN mental health authorities created the PsychoSocial Coordination Group, which began holding meetings on 24 January. The Group’s meetings were conducted by the Provincial Ministry of Health and Department of Social Welfare and facilitated by WHO-SEARO and the UNICEF. Although the efforts of the Group did not eliminate chaos from the mental health response, it did pull together many of the disaster’s foremost mental health providers and developed a consensus on the general approach that should be taken in responding to the mental health needs. More than 60 agencies attended the Group’s bi-weekly meetings and built a consensus regarding the provision of mental health relief activities in a manner that also would facilitate the development of the local mental healthcare system.

In the months following the tsunami, the most effective NGOs were those that worked closely with local authorities, were actively engaged in the Group meetings, and contributed to local mental healthcare capacity, such as International Medical Corps, International Organization for Migration, and organizations that had worked closely with the Acehnese prior to the tsunami, such as the University of Gadjah Mada-Yogyakarta, and the University of Indonesia-Jakarta.

Body recovery teams successfully identified some bodies using personal items found on them such as identification cards, SIM mobile phone cards, and jewellery. But, for the most part, identification efforts were minimal. Almost all the bodies collected were disposed of in mass graves; very few were cremated. The largest mass grave was located in Lambaro just outside Banda Aceh. This mass grave was called ‘Banda Aceh’, covered 6–9 acres of land and is said to contain as many as 60,000–70,000 bodies. Many additional mass graves were created throughout the tsunami-impacted region. In just the area surrounding Banda Aceh, there were 13 mass graves in addition to the Lambaro grave. Finding suitable government land to accommodate the many graves was difficult, and some human remains were buried close to communities. In the instance of smaller, village graves, some were located directly within the villages. This unsettled some returning survivors, who later exhumed the remains to move them away from their homes. The unceremonious burial of fatalities also prompted survivors to exhume bodies. In the month following the tsunami, some Acehnese reportedly began reopening mass graves in order that the dead could receive proper religious burials.

Although bodies were buried with a sense of urgency, and not delayed by identification efforts, impacted communities lived with dead bodies in their midst for weeks, and in some cases, even months. Bodies appear to have been collected and buried at the greatest rate during the second week following the tsunami. The total burial rate in Aceh Barat, Aceh Timur, Aceh Besar, and Banda Aceh, climbed from 3000 bodies/day during the first few days of the disaster to a high of 5000 bodies/day by 6 January. By 22 February however, it tapered off to about 300 to 400/day. The military was the primary coordinator for the body recovery, which lasted several months and also involved the police and 42 organizations including international and national NGOs, such as the Indonesian Red Cross and religious organizations. The military was the earliest to commence body recovery efforts. By 8 January, Red Cross volunteers, police, and the Tentara Nasional Indonesia (TNJ) – Indonesian National Armed Forces had recovered 31,576 bodies. It would take months to collect and bury all the bodies that had been scattered along the coast (Figure 5.16). As late as 22 March 2005, the Indonesian Red Cross was still recovering between 40 and 50 bodies/day.

Recovery responses
In contrast to the health ministries in other tsunami-impacted countries, the Indonesian MoH decided to concentrate on recovery and development of the mental health system during the emergency, and allowed NGOs to take care of community-level mental health activities, with
the provincial and district health offices providing coordination. WHO-SEARO assisted both the MoH and the provincial and district-level health offices in these tasks. In other countries, the MoH, with support from WHO-SEARO, engaged directly in community-level support programmes.130

In addition to mental healthcare services, it was clear that a rapid return to normalcy in Acehnese daily life also was central to survivors’ recovery from tsunami-related traumas. Mental health relief workers widely agreed that the restoration of houses, livelihoods, and other aspects of the survivors’ lives was important to the mental well-being of impacted communities. However, management of the dead bodies received remarkably little attention as a mental health issue. Bodies were unceremoniously collected in black bags and buried in mass graves. Claims that bodies needed to be quickly recovered and disposed of in order to prevent the spread of disease were false, but the removal of dead bodies from impacted communities was an important step in restoring a sense of normalcy. Additionally, religious customs among some of Aceh’s Muslim communities instructs followers to bury bodies within 24 hours of death. At the same time, the need to identify missing loved ones and the desire to observe proper burial rituals were strong among the impacted population.

Development

At the request of the MoH, WHO-SEARO, with the help of the Centre for International Mental Health and the Department of Mental Health and Substance Abuse, provided recommendations for developing Aceh’s mental healthcare system. Some of these recommendations ran counter to that of many other organizations. Many organizations had recommended that the government establish trauma centres independent of the local mental healthcare system. However, WHO-SEARO believed that, over the long run, trauma centres ultimately would weaken mental health services in the province. Trauma centres developed in other countries following disasters tended to focus on the post-traumatic stress disorder; they also pulled skilled staff away from the public mental health system. Many such centres became irrelevant within two to three years of being implemented.

Thus, rather than creating trauma centres, WHO-SEARO recommendations promoted the development of a mental health system that would rely heavily on the primary health care system and community-based health services. The MoH adopted these recommendations as part of its plan of action for developing mental healthcare in Aceh province. As a result, government programmes have trained doctors and nurses to provide mental health services in primary care centres, and when needed, visit households in need of mental health support. Doctors trained in mental health are referred to as “GP+” (general practitioners trained in mental health) and trained nurses as “community mental health nurses”. In addition to the doctors and nurses trained in mental health, approximately 1000 community members were educated and trained to become “village mental health volunteers”. Village mental health volunteers identify individuals who are mentally ill or at risk of developing mental illnesses, and provide basic psychological first-aid. Village mental health volunteers were only recruited from villages in which the village head and council had approved the training programme.

The resulting mental health system in Aceh province has been so successful that it has become a model for other Indonesian provinces. In 2008, the MoH decided to hold its annual mental health meeting in Banda Aceh in order to expose national and district mental health authorities to the model of mental health that had been developed in Aceh province, and to discuss how a similar model might be developed in their own regions. While the mental health system developed in Aceh province has been widely regarded as a success, external funds committed to support Aceh’s mental health system in response to the tsunami are drying up.
Consequently, the continuation of Aceh’s newly developed mental health services depends on whether district governments allocate funds in their respective budgets in order to sustain them.

Since the tsunami, progress in the national mental health system has been slow when compared with the progress achieved in Aceh province. Mental health care continues to be provided primarily by provincial mental health offices; community-based care remains rare. However, in June 2008, national mental health authorities and the Centre for International Mental Health established the National Task Force on Mental Health System Development to strengthen the MoH mental health capacities. Targeted improvements included the MoH’s ability to plan, implement, and evaluate mental health systems at the national, provincial, and district level, and improve community-based mental health services throughout the country.127

Transport and Logistics System

Pre-events

Land transport is generally provided by private organizations and individuals. The total registered vehicular fleet in Aceh province consisted of 414,773 vehicles. Of these, 95,500 were motorized (33% were trucks, 27% buses, and 40% light vehicles). There were 320,000 motorcycles registered prior to the tsunami.131

There were four public ports in northern Sumatra island owned and operated by PT Pelindo I, a state-owned port corporation. Prior to the tsunami, plans were being developed to transfer ownership of smaller ports to the communities. This was not completed prior to the tsunami. For the most part, shipping services were privately owned. However, the state owned a general cargo shipping line that operates services between the tsunami-affected areas.

Damage

Of 414,773 registered vehicles in Aceh province, an estimated 29,800 (7.2%) were destroyed or seriously damaged. Of these, 6,000 motor vehicles and 23,400 motorcycles and other small vehicles were destroyed or seriously damaged. The replacement value was estimated at Rp 1,592 billion (US$ 180,000). Almost all of the destroyed and seriously damaged vehicles were privately owned. However, many vehicles were lost in essential service sectors. The provincial hospital lost all but one of its 15 ambulances.131

There was heavy damage to nine of the public ports in Aceh province, especially those serving Banda Aceh. Many smaller ports were damaged along the west coast. Also, heavy damage occurred to five public ports in North Sumatra. Replacement costs were estimated at Rp 222 billion (US$ 25 million).

Changes in functions

With transportation seriously damaged in many tsunami-impacted areas, some of the communities in serious need of outside help remained largely isolated for days. In addition to the losses sustained by the destruction/damage to vehicles, severely damaged roads forced transport inland, markedly increasing the time and distance required to move goods and services.131 In addition, it was not possible to reach many areas using land transport.

In the days following the tsunami, the sudden surge of outside relief organizations into the area also obstructed the delivery of aid, by overwhelming local transportation resources. For example, the Polonia airport, just outside Medan, from handling 60–70 flights/day started handling as many as 500 flights/day after the earthquake and tsunami. Nearly every relief team destined for Banda Aceh stopped in Medan first. Consequently, the airport grew congested with planes carrying relief items and access became difficult.116 Banda Aceh also experienced an increase in air traffic, sometimes reaching as many as 200 flights/day.132

Lost transportation resources made it difficult to distribute medical and food supplies flown into the Polonia airport and Banda Aceh airport...
and, consequently, the supplies piled up at the airports.125

**Relief responses**

Early in the disaster, when responders realized that damaged roads prevented relief from reaching many hard-hit communities, the Indonesian government sent military helicopters and planes to reach these isolated communities. Even delivering supplies by helicopter to isolated places had its challenges—often, there were few suitable places in impacted areas for helicopters to land, and survivors sometimes became a landing obstacle as they crowded beneath the helicopters trying to land. International military units soon followed suit, sending helicopters and ships carrying helicopters to the region. Singapore, Malaysia, Australia, and New Zealand all sent military planes and helicopters to assist with transportation to and within the disaster areas.104 One week following the tsunami, US aircraft carrier Abraham Lincoln arrived off the shore from Banda Aceh bringing 12 Seahawk helicopters for use in the tsunami and earthquake-impacted areas of Indonesia.104

Helicopters unable to land in devastated areas due to crowds gathering beneath them, dropped supplies from safe altitudes. Later, Indonesian soldiers cordoned off landing sites to allow helicopters to land.104 Organizations transporting relief supplies and relief workers into the affected region had to work in coordination with the military, which controlled the three major supply hubs operating during the disaster, located in Jakarta, Medan, and Banda Aceh.133

As the relief effort continued, more and more international aid organizations began arriving in their own vehicles, typically white Land Cruisers or pickup trucks, and sometimes hired help to drive them. In some cases, locals interpreted the proliferation of costly vehicles for transporting relief workers as a message that aid workers were more concerned about the needs of their own staff than the needs of the victims. An Indonesian newspaper article titled “The Humanitarian Lords of Aceh”, cited aid worker’s transportation choices and hired drivers as evidence of immodest concern with their own needs.134

**Recovery responses and development**

In association with UNDP, the Indonesian government established the Banda Aceh-Nias Reconstruction and Rehabilitation Agency (BRR—Badan Rehabilitasi dan Rekondisi for Nanggroe Aceh Darussalam and Nias). It was anticipated that the population would steadily increase during the next 20 years. It was recognized that this increase would require substantial investment in the transportation and logistics system including development of container ports and additional tourist accommodation. These changes will require the development of a ring road connecting ports, a Banda Aceh to Medan roadway, and enhanced railroad capacity. It recommended that the government establish a public-private Banda Aceh Port Corporation to guide and finance the development of the above transportation infrastructure. At one year following the earthquake-tsunami, 235 km of roads were restored and a west coast road project had been started. In addition, five ports were under reconstruction, but had not yet been completed.135

**Security System**

**Pre-events**

Security was a major issue in Aceh province prior to the tsunami. Cultural differences and control over Aceh’s lucrative offshore natural gas fields fueled a conflict that killed thousands of people over several decades. Aceh province is Indonesia’s most conservative Muslim region, and 97% of its population follows the Islamic Sharia law. Long-standing Islamic nationalist tendencies and disputes over the province’s oil wealth fueled conflict in the province in which the Free Aceh Movement (Gerakan Aceh Merdeka (GAM)) wanted autonomy from the nation’s central government. However, the GAM movement was not a religious movement. And, although ethno-nationalism had been strong in Aceh province, it did not dominate. Additionally, GAM had never been able to control Aceh province or influence
local politics to the same extent as the LTTE accomplished in Sri Lanka.

At the time of the tsunami, Aceh province was in the midst of one of Asia’s longest running conflicts. For nearly three decades, GAM had been contesting Indonesia’s sovereignty over the province. In the initial years following the formation of GAM in 1976, the insurgency remained small and did not pose a significant challenge to Indonesian forces. But the insurgency gradually grew, and by 1989, the rebellion killed several thousand people. With the collapse of President Suharto’s authoritarian regime in 1998, the conflict intensified further, and by 1999, GAM had claimed control of large parts of the province. The most recent of the two cease-fire agreements was brokered as part of a peace deal signed in December 2002 in which GAM agreed to give up its weapons and Indonesia agreed to give Aceh province greater autonomy and allow the province to keep 70% of its oil and gas revenues. But over the course of the next five months, the peace deal suffered numerous setbacks; by 19 May 2003, the government declared Martial Law and the conflict resumed.

Between 1999 and 2004, negotiations between GAM and Indonesia resulted in two cease-fire agreements, both of which eventually fell apart. The most recent of the two cease-fire agreements was brokered as part of a peace deal signed in December 2002 in which GAM agreed to give up its weapons and Indonesia agreed to give Aceh province greater autonomy and allow the province to keep 70% of its oil and gas revenues. But over the course of the next five months, the peace deal suffered numerous setbacks; by 19 May 2003, the government declared Martial Law and the conflict resumed.

Following the declaration of Martial Law, the government began restricting nearly all independent observers including aid workers from venturing into Aceh province. Those who were allowed in were rarely allowed beyond the provincial capital, Banda Aceh. As the government made it increasingly difficult for international agencies to operate in Aceh province, the number of international agencies, including NGOs, dwindled. Of those that remained, most focused primarily on conflict-related problems. As of 2004, the handful of international agencies that had a presence in Aceh province included the ICRC, Save the Children, and the World Bank. Save the Children, which had left Aceh province in 1998, was able to re-establish a presence in the province in 2000 by avoiding the use of expatriate staff. The ICRC maintained its continuous presence in Aceh province, but with limited access and no more than two foreign staff at any one time. Finally, the World Bank remained active in Aceh province through loan programmes. Until shortly before the tsunami, Oxfam also had a presence in Aceh province, but it left in 2003.

In addition to limiting the number of international agencies in Aceh province, political conflict also limited the research done to collect baseline data about the region. Surveys to determine Indonesia’s health status often were limited to urban areas within Aceh province, or excluded Aceh province entirely. A 2002–2003 Badan Pusat Statistik-Statistics Indonesia (BPS) demographic and health survey of Indonesia, for example, provided detailed baseline data on many health indicators involving maternal and child health, but because of security issues, excluded Aceh province. Consequently, there are few robust measurements of health indicators, and little data to illustrate how the conflict had impacted people’s lives before the tsunami.

Following the collapse of the peace agreement in 2003, Indonesia’s army reduced GAM control in Aceh province, and by mid-2004, the conflict had de-escalated to a state of ‘civil emergency’, although the government continued to restrict access to the province and the military continued to play a key role. By 2004, more than two decades of low-intensity political conflict in Aceh province had taken the lives of approximately 10 000 people, displaced approximately 35 000 people, and degraded basic infrastructure and services including education and health. The conflict also had seriously compromised judicial governance in Aceh province, resulting in a virtual collapse of the justice system. Before the earthquake and tsunami, many courts and prosecution offices had closed due to attacks that destroyed buildings or intimidated staff.

Damage

Both the military and GAM lost members to the disaster. According to one estimate, as many
as 2000 soldiers and dependants were killed, including 300 who were swept away from a unit stationed in Meulaboh. The number of GAM members in Aceh province remains unknown. Counter-insurgency operations, however, had recently pushed GAM into the mountains and the areas where GAM was most active were not particularly hard-hit by the tsunami.

**Changes in functions**

Earthquake and tsunami damages and the new circumstances that emerged with the disaster created new security issues in Aceh province. Suddenly, the Acehnese, who had viewed the military with mistrust, were dependent on the military for relief. And the Indonesian military, which had tightly restricted outside access to the region, came under strong pressure to open the region to thousands of relief workers. To some degree, the disaster put the conflict on hold; the sudden major international presence in the area and large number of deaths from the tsunami put pressure on GAM and the Indonesian military to avoid violent confrontations.

For the most part, fears that relief workers would be attacked or otherwise harmed due to the ongoing conflict between Indonesia and GAM did not materialize. Attacks on relief workers were rare; however, a couple of notable exceptions drew attention. In two separate incidents in June 2005, two aid workers were attacked at night in their vehicles and shot while travelling through rural areas of Aceh province. Also, there were numerous reports of cases in which NGOs reported that the military had extorted resources from them, including orders to send tanks of water headed to relief camps to military settlements.

**Relief responses**

Early during the disaster, international responders exhibited a limited awareness of, and sensitivity to, conflict-related issues. International responders’ concerns over the conflict, for the most part, were restricted to issues over staff safety, access to disaster areas, and receiving permission from the military. In response to these security concerns, CARE initiated an international NGO security working group. With changes in Indonesian military operations, control of access within Aceh province shifted with inland regions and parts of Pidie, Aceh Utara, and Aceh Jaya districts that generally had been among the most difficult areas to access, was relaxed so that, for the most part, relief workers reported they had relatively free access to the affected areas, particularly after Indonesia ended Aceh’s civil emergency status in May 2005.

A few of the international NGOs worried that the Indonesian military would use the disaster as an opportunity to ramp-up counter-insurgency efforts and crush GAM. As the responses to the tsunami slowly gained traction, there were allegations that aid was slow to arrive because the military was preventing relief from entering the region, and was not itself helping, and that the national government was withholding aid to punish the province for its rebelliousness. For the most part these allegations proved to be unfounded. The delivery of aid was slow primarily because the communications, public works and engineering, and the transportation and logistics infrastructures had collapsed.

**Recovery responses**

Despite the scope of the disaster, the large congregation of international military forces in a conflict region in Aceh province caused Indonesia to be apprehensive. Consequently, Indonesia announced that by the end of March, all foreign troops assisting tsunami survivors must leave the country. Both the Indonesian military and GAM appeared to have generally tried not to block relief and recovery efforts.

**Development**

Following the earthquake and tsunami, both the Indonesian government and GAM declared amnesty. And, although small clashes between the military and GAM continued on an almost daily basis, peace talks began; and by May 2005, the government ended Aceh’s civil emergency status. On 15 August 2005, GAM and the Indonesian government signed a peace treaty in Helsinki to end hostilities in Aceh province.
Communication System

Pre-events
Due to 30 years of conflict, the Acehnese media had long been operating under restrictions and political pressures that made it difficult for them to report freely, particularly on the activities of GAM and the government. Restrictions became particularly tight in 2003, when the government strengthened its counter-insurgency push against GAM and the Aceh Military Emergency Administrator issued two decrees that restricted access to and reporting from Aceh province.\(^{136}\)

Additionally, relative to its population, Aceh province relied on a small base of local news sources. Although the province had a population of approximately 4 million, it had only one local newspaper, one local television station, approximately 45 radio stations, and approximately 1000 journalists.\(^{140}\) Aceh’s only local newspaper, the Serambi, had a staff of approximately 200.\(^{141}\)

Prior to the tsunami, the most popular mass media in Aceh province was television, followed by newspapers and radio. A survey of respondents in 82 communities in 12 districts indicated that before the tsunami, 74% of the population relied on television as a primary source of information, while only 23% of respondents relied on radio and 37% relied on newspapers. All of the television stations except one were national.\(^{141}\)

In terms of language, most Acehnese spoke two languages. Indonesia’s national language is Bahasa Indonesia,\(^{138}\) and although the Acehnese generally prefer to speak their own language—primarily Bahasa Aceh—most also speak Bahasa Indonesia.\(^{141}\)

Damage
Due to the tsunami, the telephone service (PT-Telekom) lost 18 employees and US$ 5.9 million in assets in Aceh province, including 22 of its 44 switching and transmission facilities and the disruption of 35 000 of 99 000 telephone lines.\(^{142}\)

In the tsunami-impacted areas, only the military, which had satellite phones, had phone service. GAM also had satellite phones, but generally was concentrated inland away from the hardest-hit regions, and thus, not affected.

In addition to logistical communications, damages from the earthquake and tsunami had also affected the local media. Approximately 100 Aceh journalists were killed, and three-quarters of its radio stations were damaged or destroyed by the tsunami.\(^{140}\) Serambi lost 54 of its staff, its offices, printing press and equipment, while the province’s only television station lost 12 staff and a studio.\(^{140,141}\)

Changes in functions
Civilian communications in tsunami-impacted areas of Aceh province collapsed. Consequently, for approximately two weeks following the tsunami, survivors and relief workers relied on rudimentary means of communication. At one point, the UN used motorcycles to relay messages from arriving staff at the airport to its Banda Aceh base.

The earliest public coverage of the disaster was reported by an Indonesia media organization based in Jakarta. Within a few hours of the earthquake and tsunami, a private Indonesian television network flew a reporter and a cameraman from Jakarta to Banda Aceh. But due to the collapse in communications in Banda Aceh, the network, Metro TV, did not receive footage of the disaster until the morning of 27 December.\(^{88}\) Although international media disseminated images of tsunami destruction appeared within 12 hours of the events, images of destruction from the tsunami in Indonesia were not seen by the international community until two days after the tsunami had occurred.\(^{143}\)

Within Aceh province, local media coverage and infrastructure for delivering news to people in the region had been seriously compromised. Broadcast capacity at the Aceh branch of TVRI, the only local TV station in Aceh province, was limited due to damages inflicted by the tsunami.
As of August 2005, the station was on the air only from 15:30 to 17:00 h each day.141

In addition to damages to infrastructure and local media organizations, the dissemination of information was also hindered by language barriers. Many Indonesian NGOs did not attend UN-OCHA meetings because they did not have interpreters to translate the discussions from English to Bahasa Indonesia. Similarly, many foreign agencies lacked interpreters to translate proceedings of government meetings held in Bahasa Indonesian.88

Relief responses
In the immediate aftermath of the tsunami, responders filled gaps in communications infrastructure by delivering more satellite phones into tsunami-impacted regions of Aceh province and restoring mobile phone services, which could be restored faster than could land line services. Restoration of mobile phone services began within a day of the tsunami.

Effective communication in the aftermath of the tsunami depended not only on infrastructure, but also on the ability of the government, humanitarian agencies, media, and other organizations to effectively communicate with one another and with the beneficiaries of the relief. Unfortunately, the flow of information following the tsunami was disappointing and resulted in negative consequences for the relief effort and beneficiaries. Agency failures in reporting on what was being done where resulted in some communities receiving more aid than necessary, while other communities received insufficient aid.88

Early during the disaster, a few organizations tried to take a leading role in encouraging responders to communicate with one another, even when communication infrastructure was poor. For example, UN-OCHA convened meetings on a tennis court in Banda Aceh province, where people could exchange information. And in January, as communications infrastructure improved, UN-OCHA began posting data on a website that agencies could access to maximize the effectiveness of their responses and avoid duplication. The website, the “Humanitarian Information Centre” (HIC), included thematic maps, information on who was doing what and where, assessments, meeting schedules, and other disaster-related information.88

The HIC staff arrived in Banda Aceh on 3 January 2005, but due to internet connectivity issues and other technological problems, the HIC website for the Indonesian earthquake and tsunami disaster did not become operational until 20 January. Early participation in posting information on the website was weak. Of the over 200 agencies known to have been in Aceh province as of 24 January 2005, only 46 responded to an UN-OCHA request for reports on their activities. Also, few agencies used the standard assessments form that the HIC had posted on the website. However, by March 2005, responses to requests for information improved, with UN-OCHA receiving 170 responses.88

In the Public Health and Medical Care Systems, communication was central to avoid wasteful duplication and ensure that all of the affected populations and persons were receiving the support they needed, and to detect and prevent the development and spread of diseases. In an effort to help ensure the flow of surveillance data, WHO-SEARO disseminated a weekly epidemic bulletin to the MoH, NGOs, and to district health offices, published in both English and the national language.83 By mid-January, WHO-SEARO developed a mapping application that would facilitate communication within the health community on the geographic distribution of health needs and progress in the tsunami-impacted region. WHO implemented the application, known as “HealthMapper”, in WHO-SEARO and MOH offices that aggregated surveillance data for the health community working in impacted areas. The system was functional by mid-January 2005.83

Beneficiaries also needed to be able to communicate both with one another and

By mid-January, WHO-SEARO developed a mapping application that would facilitate communication within the health community on the geographic distribution of health needs and progress in the tsunami-impacted region.
with those responding to their needs. Several organizations recognized that tsunami survivors needed communications support in order to reunite families that had been separated. The ICRC collected information about survivors and who they were looking for using “I am alive and I am looking for” forms; the information then was disseminated using the Internet, local newspapers, and public postings. Additionally, the ICRC used satellite phones to help 800 survivors call relatives.  

Despite the aforementioned efforts to facilitate communication, overall communication after the tsunami remained poor. As a consequence, considerable resources were wasted and many needs remained unmet. But while agencies responding to the earthquake and tsunami may have done a poor job of communicating with each other, they did an even poorer job communicating with the beneficiaries. Eight months following the tsunami, survivors felt overwhelmed and left in the dark about what was being done to restore their communities and how they could access programmes that would help them restore their former lives. A UNDP study that was used to survey 82 communities across 12 districts in Aceh province found that only 7% of the surveyed population felt very informed, 15% felt sufficiently informed, and 78% felt insufficiently informed. 

Respondents expressed frustrations over relief workers’ failure to explain decisions made on their behalf or why certain programmes were implemented and then stopped. For example, cash for work programmes appeared and then disappeared without explanation. 

With responders providing little information to the beneficiaries, accountability was weak. As a means of communication, the media both encouraged greater accountability and encouraged irresponsible relief responses. In some instances in which there was an information void, the media improved the relief effort by disseminating information on the circumstances on the ground. Indeed, in some cases, relief responders received a great deal of the earliest information on what was going on in impacted areas from the media. Also, the media reporting on poor relief responses helped to encourage greater accountability. 

However, media coverage also put pressure on relief organizations to create the perception of accountability among donors, at the cost of their accountability to beneficiaries. With donors from abroad watching them through the media, NGOs quickly bought and delivered supplies such as boats and ambulances without waiting to find out if what they were delivering was what beneficiaries actually needed. But, while the supplies being delivered to tsunami-impacted areas might not have been what the survivors immediately needed, the quick delivery of supplies, made NGOs appear capable and efficient. 

At times, the media also encouraged inappropriate relief responses by presenting a skewed picture of what was actually occurring in tsunami-impacted areas. Media reports focusing on injuries magnified the perceived need for medical treatment in disaster areas, resulting in a medical response that did not necessarily match the actual needs. Although the tsunami and earthquake had injured only a limited number of people, 12 days into the disaster, media reports turned their focus to injuries and, in particular, injured patients being treated at two Banda Aceh hospitals. 

Local media did little to improve circumstances. Due to a history of strong restrictions on media in areas of Indonesia impacted by the earthquake and tsunami, local media outlets did little to drive accountability or advocate for vulnerable groups. Consequently, transparency and public accountability of responding agencies and organizations was poor. Additionally, local media took some time to fully recover from the tsunami and fill the role of informing tsunami survivors of the relief efforts. Five days after the tsunami, for example, the Serambi resumed publishing, but distribution remained a big challenge.
Recovery responses
Some donors and organizations recognized the local media’s important role in informing the tsunami-impacted public and strongly supported the recovery of the media in Aceh province. For example, UNESCO launched an appeal for US$ 600 000 to restore Aceh’s radio broadcasting system.\(^{141,145}\) Although communication service restoration began early, it would be some time before reliable services could be restored. Within one year of the tsunami, however, the Serambi’s circulation had increased by 25% over its pre-tsunami circulation.\(^ {146}\)

Development
No information was available in the material accessed that related to development of communications systems as they pertain to the Medical Care, Public Health, Water and Sanitation, Food and Nutrition, and Shelter and Clothing Societal Systems.

Economic System
Pre-events
Economic development lagged in Aceh province despite an abundance of natural resources, including a rich fisheries sector, natural gas and oil. The discovery of natural gas in Aceh province in the 1970s brought new money to the province, but the newfound wealth left most of the Acehnese behind. Following the discovery of natural gas, the industrial complex that developed around the newly discovered resource needed workers to exploit it. Having relied primarily on forestry, farming, and fishing for livelihoods, few Acehnese had the skills required by the gas industry. Consequently, the industry imported workers from other parts of the country, and most Acehenese received little of the wealth generated by its natural gas resources. Most of the people who benefitted from the new gas profits were newly immigrated workers, primarily Javanese.\(^ {79}\) Gas and oil played a central role in Aceh province’s economy, accounting for 43% of the regional GDP in 2003.

Because of its gas and oil reserves, Aceh province was not a poor province. Aceh’s per capita GDP was approximately US$ 1021 compared to US$ 927/capita nation-wide. But the gas and oil wealth was unevenly distributed. Gas and oil reserves resulted in a high per capita GDP in Aceh province, but they did not contribute to lower poverty levels. In fact, between the development of Aceh’s gas resources in the 1970s and 2004, Aceh’s poverty rate grew to become one of the highest in Indonesia. In 2004, Aceh province had a poverty rate of 28.4% compared to 16.7% for the rest of Indonesia.\(^ {17}\) In Aceh province, the poverty rate was greatest along the east coast and among rural populations.\(^ {134}\) Aceh’s increased poverty rates were due, in part, to the economic crisis that hit Indonesia in 1997. But as the rest of the country began to recover in 2000, and poverty rates began to decline in all other provinces, poverty rates continued to increase in Banda Aceh. The primary cause of Aceh’s economic woes was the political conflict that had plagued the province for nearly three decades.

Aceh’s economic woes also were reflected in its unemployment rates, – 11.2% compared to 9.5% nation-wide. Among the employed, traditional employment sectors remained the mainstay for most of the population. Although oil and gas claimed the largest share of Aceh’s GDP, other sectors representing smaller shares of the GDP employed a greater number of people. Agriculture, for example, represented 32% of Aceh’s GDP, but employed 47.6% of its population. The fisheries sector was of lesser importance to the economy as a whole, but provided an important source of employment in the region struck by the tsunami. The fisheries sector accounted for 6.5% of Aceh province’s GDP, but employed more than 100 000 people in the areas impacted by the tsunami. Aceh province and the North Sumatra province district of Nias Island had a strong fisheries sector that produced 158 578 tons of wild caught fish and 24 602 tons of fish from aquaculture.\(^ {14,93,104,140}\)

Both the conflict and the economic crisis had important economic ramifications for finances in the health sector. Following the economic
crisis of 1997, government spending on healthcare in Indonesia declined. Government spending per capita fell by 25% between 1996/1997 and 1999/2000. Adjustments in government spending also occurred following the decentralization of the healthcare system in 2001. As of 2000, the central government spent approximately US$ 5.50/capita on healthcare; this dropped to about US$ 3.50 per capita by 2005. And, while on paper, district governments supposedly contributed an additional US$ 3 per capita around the same period, a lack of budgetary transparency at the district level had allowed other interests to siphon off money for non-health related projects.11

Although Aceh province spent relatively more per capita on health than the country as a whole, a large portion of what was spent was used for salaries and for building new facilities, thus constraining the amount of money for health facility maintenance and operations. Consequently, Aceh’s higher per capita spending on health did not result in significantly better health outcomes. In Aceh province, about 86% of all public spending on health was undertaken by the provincial and district governments.16 In 2004, Aceh province’s Human Development Index (HDI) score of 68.7 was the same as the national average, but more than seven points lower than the HDI score of Indonesia’s most populous district, DKI Jakarta. North Sumatera had an HDI score of 75.8.145

Agriculture contributed 32% of the provincial GDP and employed 48% of the workforce. Some 70% of the population relied on agriculture (including livestock) for their livelihoods. The fishing industry had an annual output of 158 578 tons of fish in 2003. Fishing accounted for 6.5% of the Acehinese GDP. The fishing industry employed 100 000 people in the tsunami-impacted areas of Aceh province. Much of the fishing was done by canoes close to the shore. Aquaculture was a growing industry especially along the northern and eastern coasts of Sumatra Island.

Damage

Losses and damages due to the earthquake and tsunami amounted to an estimated US$ 4.45 billion or about 2% of Indonesia’s GDP. These economy-related losses refer to disaster-related losses in productivity due to the disaster during the four years following the tsunami. Seventy-eight percent of the damages and losses were in the private sector and 22% in the public sector. And while the damages accounted for only 2% of the national GDP, it accounted for nearly 100% of Aceh province’s GDP.147

Economic losses to the agriculture sector are estimated at Rp 1 105.2 billion (US$ 124 million) and to the fishing industry at Rp 3,807 billion (US$ 426 million).147 Estimated damage and losses in agriculture totaled Rp 2.2 trillion (US$ 246 million).

An estimated 15%-29% of fishermen were killed by the earthquake and tsunami and most of the infrastructure was destroyed or damaged. As much as 50% of the aquaculture facilities were damaged.

There were only a few large enterprises in Aceh province and enterprises accounted for only 0.7% of the total employment. However, inventories were severely damaged (including motorcycles).

The damage to the banking sector was estimated at Rp 1 trillion (US$ 112 000). However, this does not include probable losses from inability of the affected population to repay their loans.

Economic losses in the medical care system were huge, and were particularly acute in the public sector. Of the US$ 83 million in direct damage costs in the medical care system, US$ 57.5 million were due to damages in the public sector and US$ 23.5 million in the private sector. Hospital damages were also particularly heavy, accounting for US$ 66.9 million out of US$ 83 million in direct damages.103, 148
Changes in functions
In Aceh province, more than 600,000 people, or 25% of its population, lost their source of livelihood. The hardest-hit sectors were agriculture, fisheries, and small traders. The people who lost their livelihoods included 130,000 farmers, 300,000 fishermen, and 170,000 small businessmen.

Poverty increased in Aceh province from 28.4% in 2004 to 32.6% in 2005. While there was an increase in Aceh’s poverty level, in Indonesia, as a whole, it declined. Poverty increases in 2005 were most pronounced in those areas directly hit by the tsunami. In the year following the tsunami, high inflation rates ensued, which reached a peak of 41.5% in December 2005, compared to a rate of 17.1% nation-wide.

Relief responses
Monetary donations arrived quickly, and threatened to overwhelm the capacity of national agencies/authorities to absorb them. About three months following the tsunami, the Indonesian government asked the World Bank to set up a Multi-Donor Trust Fund that could pool and manage financial donations to ensure the efficient and coordinated distribution of financial support to impacted communities that would also fall into line with the government’s overall recovery plan. The trust fund held its first steering committee meeting on 10 May 2005 and continued to hold meetings every few months.

Money to support disaster responses also came from the Indonesian government. During just the relief phase of the disaster, which lasted until April, the Indonesian government channeled US$ 265.8 million in aid for earthquake and tsunami relief. Approximately 63% of these funds came from the government budget; the remainder was received from the Indonesian general public through 1200 state sponsored collecting agencies.

Recovery responses
Following the tsunami, the world’s largest reconstruction project commenced in Aceh province and Nias island. An estimated US$ 7.5 billion was pledged for reconstruction efforts in Aceh and Nias for a five-year period extending from 2005 to 2009. Donated money was distributed to impacted communities through projects to restore infrastructure and directly to tsunami survivors. In the aftermath of the tsunami, aid was targeted based on who was affected, rather than on income levels. Consequently, the percentage of non-poor that benefited from humanitarian aid as were the poor nearly equalled the percentage of poor households benefiting from aid.

Development
Information pertaining to the economic development of the medical care and public health systems as related to the pre-event status was not found.

Educational System
Pre-events
In Indonesia, primary school and junior high school are compulsory; attending high school is optional. Indonesia’s education system includes public and private schools. The Ministry of National Education oversees the country’s public schools and the Ministry of Religious Affairs oversees the country’s religious schools, most of which emphasize Islamic values and thinking. Per capita spending on education was high in Aceh province compared with the rest of Indonesia as was the number of teachers available. Consequently, Aceh province maintained high literacy rates with only small differences in literacy rates between women and men. The literacy rate of 95.7% in Aceh province as of 2004 was higher than the national average literacy rate of 90.4%. Gender disparities in literacy rates were considerably less in Aceh province than in Indonesia as a whole. In Aceh province, there was a 4.1% literacy rate difference putting men ahead of women, whereas in all of Indonesia there was a 7.2% literacy gender difference. On the other hand, in Nias Island, educational indicators were lower than the national indicators, with a literacy rate of 82.9%, and a 13.7% literacy rate difference.
between women and men. In addition to high literacy levels, Aceh province also had student enrollment levels that were higher than national enrollment levels in all income groups, and in particular, among the poor.

Aceh achieved relatively high educational indicators despite sometimes major destruction to schools due to the ongoing conflict. Just two days after the imposition of Martial Law in May 2003, 248 schools were burned and in most cases, destroyed. The incident disrupted schooling for more than 60,000 students. Since 1998, more than 900 schools in Aceh province have been seriously damaged or destroyed. Because the conflict was greatest in rural and remote areas, teachers tended to concentrate in urban areas resulting in high levels of school absenteeism in rural areas.

In the medical care and public health systems, Aceh province had only one medical school, the Syiah Kuala University Medical School in Banda Aceh and three midwifery schools in Banda Aceh—Poltekkes Aceh, Muhammadiyah, and Mona. The educational system for medical personnel in Aceh province exhibited some weaknesses. Nearly 90% of the healthcare staff had not received refresher training in the management of common illnesses, malaria treatment, immunization, medical emergency management, or maternal and child health for 10 to 15 years.

**Changes in functions**

In areas most heavily impacted by the tsunami, damages to schools resulted in a decline of 68% in access to junior high school; the number of students per functional school increased and overall enrollment levels declined. As many as 100,000 students needed temporary schooling. An estimated 1870 teachers had to be permanently replaced and 3000 had to be replaced temporarily. Facilities had to be cleaned, sanitation systems repaired, and books and supplies replaced.

**Relief and recovery**

UNICEF provided emergency facilities including 2000 one-classroom tents and 2000 sets of school-in-a-box. There was an immediate need for 4000 teachers in the IDP camps. Great effort was expended to restore the schools. Occupation of the students was essential so that parents and relatives could earn a living during the day.

**Development**

Considering the serious shortage of Acehnese medical personnel, international humanitarian agencies sought not only to repair the medical care infrastructure, but to improve it, so that Aceh province might be better able to meet its own medical personnel needs. At the Syiah Kuala University, Canadian donors and Rotary International supported a capacity-building project to better enable the university to educate medical personnel. As a result, enrollment increased, and by 2008, the school was admitting 250 medical students a year. Additionally, the programme helped to introduce a new curriculum to the university’s medical school programme, including a curriculum that would teach medical students how to respond to disasters.

**Coordination and Control System**

**Pre-events**

In Indonesia, the National Disaster Management Board (BAKORNAS) headed the national disaster response structure. Although BAKORNAS was...
key to the disaster response system and had been in place for many years, it did not have the capacity to mobilize relief quickly and efficiently at the national and local levels. BAKORNAS was supported by coordinating provincial units (Satkorlak) and district units (Satlak), but did not have contingency plans (Disaster Response Plans).

In its nearly 40 years of existence before the tsunami, the BAKRONAS mandate had evolved from one focused on emergency relief to victims to one that also facilitates coordination between integrated systems and sectors related to disasters. BAKORNAS was chaired by the country’s Vice President and had a core staff of approximately 40 people. Ministry members of BAKORNAS included the ministries of Home Affairs, Social Affairs, Health, Settlement and Regional Infrastructure, and Communications. The Chief Commander of the armed forces and the police also were members. Each member ministry was allocated a contingency budget. However, in case of an emergency, contingency budgets were released by the authority of the Ministry of Finance rather than by BAKORNAS, which limited the Board’s authority with regard to spending decisions made in the event of an emergency.

While BAKORNAS exhibited weaknesses at the national level, weaknesses at the local level in Aceh province were particularly acute. Years of political tug-of-war between the government and the GAM forces had left authority muddled in many parts of Aceh province. When the tsunami struck, Aceh’s Provincial governance had just begun to re-establish itself in villages that had long been under GAM control and was among the weakest provincial governments in Indonesia.

Additionally, should a province need international assistance in case of a disaster, little would be immediately available. Due to strict restrictions on foreigners in Aceh province in 2003 and 2004, few international NGOs or aid agencies had offices in the Province before the earthquake and tsunami. Of the few that were present, most focused on improving human rights and advocacy. Foreigners wanting to travel in Aceh province outside the city of Banda Aceh after June 2003, had to receive a pre-approved “blue book” from Jakarta authorities granting access. Approved blue books were difficult to acquire and severely limited access to the province by international aid workers and foreign correspondents.

**Damage**

The earthquake and tsunami decimated what remained of the administrative and disaster management infrastructure in Aceh province. Coordinating provincial units and district units supporting BAKORNAS and other provincial and district level disaster management structures were destroyed, along with a great deal of other administrative infrastructure. On the west coast, more than 90% of district and sub-district government offices were destroyed, and more than 40% of government staff died. Additionally, the tsunami killed and destroyed NGO staff and offices, including the Indonesian Red Cross office in Aceh.

**Changes in functions**

Following the earthquake and tsunami, national disaster management infrastructure in Jakarta remained intact.

**Relief responses**

In the Armageddon-like aftermath of the tsunami, few had the wherewithal to immediately comprehend the extent of the disaster that had engulfed Aceh province. With many administrative structures either severely damaged or completely destroyed, there were few likely catalysts for initiating a structured response. A breakdown in the province’s Communications and Transportation and Logistics Systems inhibited national efforts to respond. Consequently, the initial response was largely autonomous, unstructured, and chaotic. To compound the confusion, the Aceh Provincial government’s status was uncertain, and it was unclear as to who should assume responsibility for making key decisions regarding the disaster. Several actors had claims to
governance in Aceh province following the tsunami, including the civil emergency military commander, the surviving local government, and the Aceh Satkorlak, the provincial unit of BAKORNAS. 

On the day of the tsunami, the Indonesian government declared a national disaster and said it would accept support and funds though inline ministries, but did not make an international appeal for help. At the national level, the enormity of the disaster in Aceh province did not really become apparent until the day after the tsunami occurred. On the second day of the disaster, Indonesia formed a special Disaster Coordination Committee to manage the situation. And, on 29 December, national authorities took action to facilitate the delivery of aid to Aceh province from international sources by easing restrictions on foreigners and declaring that blue books were no longer required to enter the province. The government also declared that international donors could send donations to earthquake and tsunami-impacted areas without being taxed.

Because communications and transportation infrastructure were severely damaged by the earthquake and tsunami, military assistance was central to the early relief responses. Approximately 50,000 Indonesian troops descended on Aceh province along with 4500 foreign troops from 11 different countries, all operating under the overall command of the Indonesian military. Early in the disaster, Defense Minister Juwono Sudarsono and Armed Forces Chief General Suharto were assigned to coordinate all international relief efforts. The 4500 international troops that arrived, included 900 troops from Australia and 640 troops from Singapore. Some of the troops from Australia spoke Bahasa Indonesia and had attended Indonesian military staff colleges. The Singapore military also had ties with the Indonesian army. In addition to the 4500 foreign troops that arrived on land, more worked offshore on aircraft carriers, including the USS Abraham Lincoln.

Coordination between the Indonesian military and foreign military reportedly was smooth. But, in the early aftermath of the tsunami, collaboration between the Indonesian military and civilian aid workers apparently was problematic, particularly when it came to international NGOs. The relationship between international NGOs and Indonesian military following the earthquake and tsunami has been described as bordering on hostility. The Indonesian military was said to be suspicious of international NGOs, whom the GAM often courted as part of their insurgency efforts. Also, the Indonesian military had not forgotten the role some international NGOs had played in East Timor’s successful struggle for independence from Indonesia. On the other hand, many international NGOs viewed the Indonesian military as a source of human rights abuses in Aceh province, and disapproved of the militarization of the relief effort generally.

In the first week following the earthquake and tsunami, few NGOs were present in the hardest-hit areas of Indonesia, but their numbers grew rapidly thereafter. For example, in the city of Meulaboh, there were only four NGOs as of 2 January; two weeks later, there were 40 NGOs with more than 500 relief workers. Many of the foreign NGOs arrived unable to support their own operations because they lacked the tools and experience needed to operate in the area, including maps, means of transportation, and knowledge of the local language. Most foreign NGOs had no previous experience in Indonesia and had to acquire local contextual knowledge and language skills as they worked and by hiring local personnel. However, jobs offered by international aid agencies drew skilled staff away from local organizations, which impaired the local disaster response capacity.

It is not known for certain, how many NGOs responded to the tsunami disaster in Aceh province, but estimates range in the hundreds. In April 2005, an International Council of Voluntary Agencies report estimated that 2000 foreigners representing 300 NGOs had arrived in Aceh.
By September 2005, the BRR registered 438 international NGOs operating in Aceh province. These numbers likely underestimated the true number of NGOs that responded, since many organizations may not have registered with Indonesian authorities.

Coordinating the enormous humanitarian response to the tsunami was overwhelming, and most coordination efforts met with only limited success. Coordination was weakest among the foreign NGOs, and was particularly poor between large well-resourced NGOs and small or local NGOs with fewer resources. The smaller, local NGOs complained that they were marginalized by the larger NGOs, and competition for funds, staff, and other resources fueled tensions. Within the NGO sector, local NGOs were the most informed and initiated the earliest efforts to coordinate. Within 24 hours of the earthquake and tsunami, local NGOs established the Civil Society Coalition for Tsunami Victims, a group of 18 local NGOs that coordinated their respective relief efforts.

While at times coordination of the humanitarian response seemed to be futile, notable international and national efforts were made to try to reign-in the chaotic response. The Office for the Coordination of Human Affairs (UN-OCHA), took the lead in overall coordination of the humanitarian community and in Banda Aceh, it developed a Humanitarian Information Centre where NGOs could register and where NGOs and UN agencies could post their activities. The UN-OCHA also conducted bi-weekly meetings at which humanitarian responders could report activities, coordinate, and report the needs of the impacted communities. The government also convened regular meetings with humanitarian responders in both Jakarta and in Banda Aceh. Efforts directed to documenting who was doing what and where also were made in smaller communities impacted by the tsunami. In Meulaboh, authorities required international organizations to register with a Relief Organization Registration Center in the town upon their arrival.

During the relief phase of the disaster, assessing damages and humanitarian needs also presented a formidable challenge. With communications inoperative early in the disaster, little was known about the extent of the damages and the relief needed. Early on, most information came from the media and situation reports. BAKORNAS began producing situational reports on the day of the tsunami. But, security and logistical issues inhibited efforts to assess damages and needs, and the first formal assessments were not completed until several days following the tsunami. Some of the earliest formal assessments completed included a 31 December UNDAC report and a 19 January Bappenas and World Bank Preliminary Damage and Loss Assessment.

As the days and weeks progressed, assessments proliferated, but their usefulness often was limited. Assessments conducted early during the disaster quickly became outdated and had little influence on humanitarian relief actions. Additionally, most assessments were geographically limited to just a portion of the impacted region. This was particularly true of multi-sectoral assessments. Some assessments covered just four or five districts whereas others covered as many as 22. Also, agencies conducting assessments typically did not coordinate with other agencies conducting similar assessments, resulting in duplicated efforts.

From 13 January to 19 January, an inter-agency effort was made to coordinate assessment efforts in the public health and medical care systems from the USS Abraham Lincoln. A multi-agency team was formed to conduct assessments along Aceh’s west coast. The team, known as the Interagency Rapid Health Assessment Team, drew more than 30 members from Tahitian Noni International (TNI), the Ministry of Health (MoH), the US military, the US Agency for International Development (USAID), the OFDA, the Australian Agency for International Development (AusAID), the US Centres for Disease Control and Prevention (CDC) Atlanta, WHO, UN-OCHA, the High Commissioner for Refugees (UNHCR);
the United Nations (UN) Children’s Fund (UNICEF), the World Food Programme (WFP), the Save the Children Foundation (SCF) UK, and the International Rescue Committee (IRC). Team members were sent to towns in four west coast districts, Aceh Besar, Aceh Jaya, West Aceh, and Nagan Raya. Having started nearly three weeks following the earthquake and tsunami, the Inter-Agency Offshore Health Assessment was not particularly timely, but was the earliest attempt at a comprehensive health assessment following the UNDAC 31 December assessment.

Poor structure and methods for collecting data also limited the usefulness of most assessments. Many of the people and agencies conducting assessments had little training in conducting proper assessments and rarely used standardized formats for collecting information. There were, however, a few exceptions. Those assessments that have been noted for their rigor and methodology include the World Bank Damage and Loss Assessment, the WFP Emergency Needs Assessment, the UNICEF Nutrition Assessment, and the IOM Settlement and Livelihood Needs and Aspirations Assessment.

Despite efforts to collect assessment data, ultimately relief responses were driven primarily by the media and pressure from donors to use funding quickly. Many agencies received more funding than they had requested or had the logistical capacity to use and yet were under pressure to demonstrate that they were putting donated funds to use quickly. Relying on incomplete data on beneficiary needs and under pressure to put enormous funds to work quickly, humanitarian agencies delivered many unneeded donations to impacted communities while genuine needs remained unmet. At least one major NGO, however, recognized and sought to avoid this wasteful cycle. Less than one week after the tsunami, Medécins Sans Frontières (MSF) had received more donations than it had requested and made the controversial decision to stop accepting donations. The MSF explained that it made the decision to stop accepting donations in an effort to ensure that its programmes were driven by the needs of beneficiaries rather than the need to spend surplus funds.

Recovery responses

In April 2005, the Indonesian government announced that the disaster responses had transitioned from the relief phase to the recovery phase. Even during the recovery phase, however, a great deal of coordination of needs to return to the pre-event state remained unmet. In response, both the government and humanitarian agencies created new coordinating bodies. On 16 April 2005, the Indonesian government established Badan Rehabilitasi Dan Rekonstruksi (BRR) to coordinate community-driven reconstruction and development in Aceh and Nias. The BRR was assigned the responsibility to bring project proposals together; help local government and civil bodies implement projects, and to monitor project progress. However, the BRR was not responsible for executing and implementing projects or directing the NGOs. Additionally, BRR’s mandate would end in April 2009, leaving oversight of unfinished reconstruction projects to local authorities.

After jointly assessing the effectiveness of government coordination and communication mechanisms in several tsunami-impacted districts in June 2005, UN-OCHA, the Humanitarian Information Centre, and UNDP recommended the establishment of a new, district-level coordination mechanism. In late July, the Humanitarian Action Forum (HAF) was launched. The HAF addressed gaps in humanitarian needs by holding monthly district meetings, identifying unmet needs, ensuring commitments are made to address unmet needs, and monitoring progress.

Each month, a meeting was held in a different tsunami-impacted district to address that district’s unmet needs, which were identified using data collected by a Norwegian Rescue Committee transitional settlement monitoring mechanism. The meetings’ attendees included the District Chief of the Provincial Development Planning Board, Satkorlak, the BRR, UN agencies,
and NGOs. Initially, UN-OCHA chaired the meetings, but eventually turned the chairmanship over to the district chiefs. The first HAF meeting held in Aceh Besar presented a list of immediate unmet needs to 30 meeting participants and received commitments to cover approximately 66% of the needs.

Development
The government of Indonesia also recognized the need to establish strong disaster coordination mechanisms not only for the tsunami disaster, but also for future disasters and in the years following the tsunami, it initiated legislation with these goals in mind. Indonesia adopted a new law in 2007 establishing a national disaster agency to coordinate efforts to reduce the likelihood that disasters will occur and to provide leadership should a disaster occur. The law was first drafted in 2005. In 2007, Indonesia passed several major reform measures restructuring the way it manages disasters. Indonesia launched the National Plan for Disaster Risk Reduction, the House of Representatives passed the Disaster Management Bill, and a bill on the Management of Coastal and Small Island Areas.

At a meeting convened by WHO-SEARO in Bangkok, 21-23 November 2005, 12 benchmarks standards to be achieved by each of the countries impacted by the earthquake-tsunami were developed. Each country was asked to describe where it was at that time relative to the 12 benchmarks. The responses from Indonesia are in Table 5.12. Progress had begun, but there was a long way to go to achieve the benchmarks.

Summary
Sumatra island of Indonesia was impacted by two major destructive events, both the earthquake and the tsunami, with a minimal interval between them. Essentially, there was no warning of the tsunami, as, unlike the residents of Simeulue Island, there was no recognition that the tsunami could follow the largest earthquake recorded in 40 years. More than 150,000 residents succumbed to the forces exerted by the events and major portions of the impacted population lost family members and friends and all of their worldly belongings. Survivors migrated from the shore into camps or with families and friends creating a public health challenge and a shift in the catchment area for those medical care systems that survived. Aceh province had been affected with conflict for 30 years before the events of 26 December 2004. The functioning medical care system was hardly able to provide the needed primary care services prior to the events. Both the absorbing and buffering capacities that remained were inadequate to meet the challenges and the burdens of injuries and deaths that overwhelmed parts of the systems that survived. This ongoing conflict compromised the ability of the Aceh government to respond to the further loss of functions related to the damage created by the events. The Medical Care and Public Health Systems were further compromised by the loss of essential staff and ability of the injured to reach medical facilities. The available services were complicated further by the conveyance of the dead victims to the hospitals.

For the most part, international assistance arrived too late to provide emergency surgical services, but seemingly were effective in providing needed primary and secondary healthcare services. Despite the crowded conditions in the camps and other factors making the population more vulnerable to communicable diseases, no epidemics followed the events, which is testimony to the effectiveness of the public health efforts, mainly coordinated by WHO-SEARO. There was an outbreak of tetanus that most probably was related to the relatively poor immunization status pre-event.

Initial responses were provided by the Indonesian military and eventually by the military forces of many countries. It is not known how many persons with potentially survivable injuries succumbed because they could not receive adequate care for their injuries or even reach medical facilities. Records that could reveal this information could not be obtained.
Humanitarian organizations flooded into the affected areas. Unfortunately, for the most part, the activities of these organizations were not coordinated resulting in unnecessary duplication of interventions or the interventions not reaching areas in which they were needed. No single agency in Indonesia was vested with the mandate, authority, and resources to cope with this catastrophe. Medical supplies came in abundance, but often were of little use for meeting the needs of the affected population, and piled up at the airports and ports.

Recovery of the Medical Care and Public Health Systems (as well as many others) has been slower than anticipated. The dependence and interdependence between the Basic Societal Systems (especially between the Public Health, Medical Care, Water and Sanitation, Shelter and Clothing, Food and Nutrition, Transportation and Logistics Systems) became apparent during the relief and recovery responses. The psychosocial issues were and remain major elements in the recovery processes.

People interviewed

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TEUKU RINALDI, a physician in Banda Aceh, Indonesia

ASTRID KARTIKA, health advisor for the United Nations Development Programme

MALIKAH AMRIL, DRR programme officer, United Nations Development Programme, Indonesia

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HENDRO WARTATMO, Sardjito Hospital Supporting Unit for Human Resources Development and Health Services Reconstruction in Aceh, Yogyakarta, Indonesia

HARRY MINAS, director, Centre for International Mental Health
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Other References


Figure 5.1: The red dot marks the earthquake epicentre location relative to Aceh province. On the map, the island just below the epicentre is Simeulue. It was once part of the district of Aceh Selatan, but now is its own district. Areas highlighted in yellow were directly impacted by the tsunami.


Figure 5.2: Levels of conflict in Aceh districts. http://siteresources.worldbank.org/INTINDONESIA/Resources/Publication/280016-1200376036925/acehpoverty2008_en.pdf

Figure 5.3: Causes of death in Indonesia. Source: http://www.who.int/chp/chronic_disease_report/media/impact/en/index.html
Figure 5.4: Number of deaths in Aceh province by districts impacted.

**Source:** HIC Sumatra http://www.humanitarianinfo.org/sumatra/mapcentre/docs/01-General_map/SUM01-001_Aceh_Disaster_Area_HIC_2005-04-08_A3.pdf

Figure 5.5: Deaths and missing persons due to the earthquake/tsunami in four selected districts in Aceh province, Indonesia (percentages and absolute numbers).


Figure 5.6: A healthcare worker treats a badly infected wound on the arm of a tsunami victim. http://www.yalenuwhavenhealth.org/emergency/2005CONGRESS/Day2Track2/As3.pdf
Figure 5.7: A three-year-old Acehnese boy displaced by the tsunami, rubs traditional medicine on his skin to heal his measles as he stands outside his family’s temporary shelter in Lambaro Siron village on 15 April.

Source: Associated Press. Photographer Binsar Bakkara Image ID 050415012264

Figure 5.8: Health facilities damaged by the earthquake and tsunami. Blue crosses indicate light damage, yellow crosses moderate damage, and red crosses heavy damage.

Figure 5.9: Percentage of public health facilities damaged or destroyed by the earthquake/tsunami over the total population in four selected districts in Aceh province, Indonesia.

Figure 5.10: A man sits in the ruined remains of his home in Banda Aceh. Photo: SEARO repository. 20050195.jpg

Figure 5.11: Number and percentage of houses destroyed by the earthquake and tsunami in four selected districts within Aceh province, Indonesia.


Figure 5.12: Number of IDPs in Aceh province as of January 2005. http://www.reliefweb.int/rw/RWB.NSF/db900SID/LDOK-68LPZC/OpenDocument?rc=3&cc=idn
Figure 5.13: Changes in the location of the population due to deaths and migration in four selected districts within Aceh province, Indonesia following the 26 December 2004 earthquake and tsunami.


Figure 5.14: Barracks provided transitional shelter for IDPs while they waited for permanent housing to be built.

Source: Family Care Foundation http://images.google.com/imghdr?imgurl=http://www.familycare.org/getinvolved/images/tsunami/indonesia/tsunami_indonesia_17.jpg&imgrefurl=http://www.familycare.org/getinvolved/tsunami_indonesia03.html&h=318&w=500&sz=54&hl=en&start=1&tbnid=gy6SOs5TDCFXKM:&tbnh=83&tbnw=130&prev=/images%3Fq%3Dbarrack%2BIndonesia%26gbv%3D2%26svnum%3D10%26hl%3Den%26sa%3DG

Figure 5.15—Areas of damages in Aceh Province, Areas of greatest damage highlighted in red. http://www.reliefweb.int/w/RWB/NSF/db9005ID/LDOK-68JQMQ/DefaultDocument&rc=3&cc=idn
Figure 5.16: A damaged bridge inhibits travel between Meulaboh and Banda Aceh. http://siteresources.worldbank.org/PHILIPPINESEXTN/Resources/08_banda_aceh.pdf

Figure 5.17: Vehicles travel on roadways recently cleared of debris in Aceh.

Figure 5.18: In Aceh, military and relief workers took months to recover victim remains from debris and were still uncovering 1,000 bodies a day one month after the tsunami.
Table 5.1: District by district population and population densities in Aceh province. *Italicized districts are districts without coastal boundaries.* Population densities in Aceh province. 

<table>
<thead>
<tr>
<th>District</th>
<th>Population</th>
<th>People/km²</th>
<th>km of coastline</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aceh Singkil</td>
<td>148 277</td>
<td>41.5</td>
<td>265.72</td>
</tr>
<tr>
<td>Aceh Selatan</td>
<td>191 539</td>
<td>52.5</td>
<td>196.57</td>
</tr>
<tr>
<td>Aceh Barat Daya</td>
<td>115 676</td>
<td>68.7</td>
<td>52.42</td>
</tr>
<tr>
<td>Nagan Raya</td>
<td>123 743</td>
<td>31.7</td>
<td>78.96</td>
</tr>
<tr>
<td>Aceh Barat</td>
<td>150 450</td>
<td>62.0</td>
<td>69.67</td>
</tr>
<tr>
<td>Aceh Jaya</td>
<td>60 660</td>
<td>16.4</td>
<td>193.14</td>
</tr>
<tr>
<td>Aceh Besar</td>
<td>296 541</td>
<td>110.4</td>
<td>293.85</td>
</tr>
<tr>
<td>Banda Aceh</td>
<td>177 881</td>
<td>2916.1</td>
<td>29.08</td>
</tr>
<tr>
<td>Pidie</td>
<td>474 359</td>
<td>114.0</td>
<td>96.65</td>
</tr>
<tr>
<td>Bireuen</td>
<td>351 835</td>
<td>185.1</td>
<td>79.56</td>
</tr>
<tr>
<td>Aceh Utara</td>
<td>493 670</td>
<td>149.7</td>
<td>51.65</td>
</tr>
<tr>
<td>Lhokseumawe</td>
<td>154 634</td>
<td>854.3</td>
<td>23.74</td>
</tr>
<tr>
<td>Aceh Timur</td>
<td>304 643</td>
<td>50.4</td>
<td>173.16</td>
</tr>
<tr>
<td>Langsa</td>
<td>137 586</td>
<td>525.1</td>
<td>30.67</td>
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<tr>
<td>Aceh Tamiang</td>
<td>235 314</td>
<td>121.3</td>
<td>135.66</td>
</tr>
<tr>
<td>Sabang</td>
<td>28 597</td>
<td>240.3</td>
<td>86.43</td>
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<tr>
<td>Simeulue</td>
<td>78 389</td>
<td>38.2</td>
<td>608.72</td>
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<tr>
<td>Aceh Tengah</td>
<td>160 549</td>
<td>27.8</td>
<td>0.00</td>
</tr>
<tr>
<td>Bener Meriah</td>
<td>106 148</td>
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</tr>
<tr>
<td>Gayo Lues</td>
<td>72 045</td>
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<tr>
<td>Aceh Tenggara</td>
<td>169 053</td>
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</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>4 031 589</strong></td>
<td><strong>68.5</strong></td>
<td><strong>2466.05</strong></td>
</tr>
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</table>
Table 5.2: Life expectancy in years, crude mortality rate/1 000 population, infant mortality rate/1 000 live births and maternal mortality rate/100 000 live births.

<table>
<thead>
<tr>
<th>Population health indicators</th>
<th>Indonesia</th>
<th>Aceh province</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>indicator</td>
<td>yr(source)</td>
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<tr>
<td>Life expectancy (years)</td>
<td>67</td>
<td>2003(1)</td>
</tr>
<tr>
<td>Crude mortality/1 000</td>
<td>10</td>
<td>2002(2)</td>
</tr>
<tr>
<td>Infant mortality/1 000 live births</td>
<td>35</td>
<td>2002(2)</td>
</tr>
<tr>
<td>Maternal mortality 1/100 000 live births</td>
<td>307</td>
<td>2002(2)</td>
</tr>
</tbody>
</table>

Sources: (1) World Health Statistics, WHO; (2) Demographic and Health Survey, BPS; (3) Tsunami Recovery Programme, WHO; (4) Bererapa Indikator Penting Sosial-Ekonomi, (BPS); (5) Human Development Report, UNDP

Table 5.3: Percentage of one-year old children vaccinated in 2004. (DPT = diphtheria, pertussis, and tetanus)

<table>
<thead>
<tr>
<th></th>
<th>Indonesia</th>
<th>Aceh</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>%</td>
<td>yr(source)</td>
</tr>
<tr>
<td>Measles</td>
<td>78</td>
<td>2003(1)</td>
</tr>
<tr>
<td>Three doses of DTP</td>
<td>66</td>
<td>2003(1)</td>
</tr>
<tr>
<td>Three doses of Hepatitis B</td>
<td>51</td>
<td>2003(1)</td>
</tr>
<tr>
<td>BCG</td>
<td>88</td>
<td>2003(1)</td>
</tr>
<tr>
<td>Poliomyelitis</td>
<td>72</td>
<td>2003(1)</td>
</tr>
</tbody>
</table>

Sources: (1) Demographic and Health Survey, BPS; (2) Aceh Public Expenditure Analysis, World Bank; (3) Tsunami Recovery Programme Indonesia Final Report, WHO

* DTP3—third dose of diphtheria toxoid, tetanus toxoid and pertussis vaccine BCG—Baccille Calmette Guérin vaccine (a vaccination protecting against tuberculosis) HepB3—third dose of hepatitis B vaccine
<table>
<thead>
<tr>
<th>Disease incidence /10 000 population</th>
<th>Indonesia incidence</th>
<th>yr(source)</th>
<th>Aceh province incidence</th>
<th>yr(source)</th>
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</thead>
<tbody>
<tr>
<td><strong>Vector borne</strong></td>
<td></td>
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<tr>
<td>Malaria</td>
<td>53.70</td>
<td>2004(2)</td>
<td>9.85</td>
<td>2000-04(2)</td>
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<td>Dengue</td>
<td>3.63</td>
<td>2004(4)</td>
<td>0.54</td>
<td>2004(6)</td>
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<tr>
<td>Scrub typhus</td>
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<tr>
<td><strong>Water borne</strong></td>
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<tr>
<td>Shigellosis</td>
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<td>16.83</td>
<td>2002(5)</td>
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<tr>
<td>Cholera</td>
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<td>2004(2)</td>
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<tr>
<td>Typhoid fever</td>
<td></td>
<td></td>
<td>11.97</td>
<td>2002(5)</td>
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<tr>
<td>Leptospirosis</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hepatitis</td>
<td></td>
<td></td>
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<tr>
<td><strong>Direct contact</strong></td>
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<tr>
<td>Measles</td>
<td>1.35</td>
<td>2004(3)</td>
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<td></td>
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<tr>
<td>Mumps</td>
<td></td>
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<tr>
<td>Tetanus</td>
<td>0.03</td>
<td>2004(3)</td>
<td>0.09</td>
<td>2003(2)</td>
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<td>Pertussis</td>
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</tr>
<tr>
<td>Diphtheria</td>
<td>0.01</td>
<td>2004(3)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tuberculosis</td>
<td>24.5</td>
<td>2004(1)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Other</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Acute respiratory infection</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Diarrhoea</td>
<td>91.85</td>
<td>2002(5)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Sources:**
(1) Core health indicators, WHO;17 (2) CRED report;18 (3) Department of Immunization Vaccines and Biologicals, WHO;19 (4) Dengue/DHF, WHO;19 (5) Indonesia communicable disease profile, WHO; (6) Indonesia Health Profile, MoH;21 (7) Weekly Epidemiological Record, WHO22
Table 5.5: Number of lives lost in districts impacted by the tsunami.\(^{8,27}\) Deaths and deaths per kilometre for Banda Aceh and Aceh Besar are aggregated. Number of deaths per kilometre of coastline calculated using coastal measurements provided by BRR.\(^{28}\) Also, for Nias and Nias Selatan the source did not indicate whether the deaths listed were entirely due to the December 2004 events and not the March 2005 earthquake.

<table>
<thead>
<tr>
<th>District</th>
<th>Dead + missing</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>total</td>
<td>per 10 000 population.</td>
<td>per km of coastline</td>
</tr>
<tr>
<td>Aceh Singkil</td>
<td>26</td>
<td>0.17</td>
<td>0.09</td>
</tr>
<tr>
<td>Aceh Selatan</td>
<td>2652</td>
<td>13.80</td>
<td>13.49</td>
</tr>
<tr>
<td>Aceh Barat Daya</td>
<td>3</td>
<td>0.03</td>
<td>0.06</td>
</tr>
<tr>
<td>Nagan Raya</td>
<td>1942</td>
<td>15.69</td>
<td>24.59</td>
</tr>
<tr>
<td>Aceh Barat</td>
<td>13 785</td>
<td>91.63</td>
<td>197.86</td>
</tr>
<tr>
<td>Aceh Jaya</td>
<td>16 874</td>
<td>278.17</td>
<td>87.37</td>
</tr>
<tr>
<td>Aceh Besar/Banda Aceh</td>
<td>122 736</td>
<td>258.71</td>
<td>380.07</td>
</tr>
<tr>
<td>Pidie</td>
<td>5 278</td>
<td>11.13</td>
<td>54.61</td>
</tr>
<tr>
<td>Bireuen</td>
<td>519</td>
<td>1.48</td>
<td>6.52</td>
</tr>
<tr>
<td>Aceh Utara</td>
<td>2316</td>
<td>4.69</td>
<td>44.84</td>
</tr>
<tr>
<td>Lhokseumawe</td>
<td>200</td>
<td>1.29</td>
<td>8.42</td>
</tr>
<tr>
<td>Aceh Timur</td>
<td>52</td>
<td>0.17</td>
<td>0.30</td>
</tr>
<tr>
<td>Langsa</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aceh Tamiang</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sabang</td>
<td>133</td>
<td>4.65</td>
<td>1.54</td>
</tr>
<tr>
<td>Simeulue</td>
<td>45</td>
<td>0.57</td>
<td>0.07</td>
</tr>
<tr>
<td>Nias</td>
<td>802</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nias Selatan</td>
<td>177</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>167 540</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Table 5.6: Medical care indicators
Sources: (1) Tsunami Recovery Programme, WHO;10 (2) Human Development Report, UNDP;9 (3) Health system assessment, WHO;48 (4) Indonesia Health Profile, MoH;21 (5) Preliminary Damage and Loss Assessment, BAPPENAS and World Bank23

<table>
<thead>
<tr>
<th>Healthcare personnel and hospital beds available/10 000 population and skilled birth attendance by %</th>
<th>Indonesia</th>
<th>Aceh</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>yr(source)</td>
</tr>
<tr>
<td>Physicians</td>
<td>1.1</td>
<td>2003(4)</td>
</tr>
<tr>
<td>Nurses</td>
<td>6.5</td>
<td>2003(4)</td>
</tr>
<tr>
<td>Midwives</td>
<td>2.9</td>
<td>2003(4)</td>
</tr>
<tr>
<td>Dentists</td>
<td>0.3</td>
<td>2003(4)</td>
</tr>
<tr>
<td>Hospital beds</td>
<td>6.2</td>
<td>2004(4)</td>
</tr>
<tr>
<td>Births attended by skilled personnel</td>
<td>68</td>
<td>2003(4)</td>
</tr>
</tbody>
</table>

Table 5.7: Medical care facilities available in Aceh province53

<table>
<thead>
<tr>
<th>Facility</th>
<th>Facility Description</th>
<th>#</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hospitals</td>
<td>Of the 27 hospitals in Aceh, seven were private. The provincial hospital, Zainoel Abidin, was Aceh’s largest hospital had 400 beds and handled 13 000 in-patient admissions/year. Tertiary care was almost exclusively provided at Zainoel Abidin.</td>
<td>21</td>
</tr>
<tr>
<td>Health Centres (puskesmas)</td>
<td>Operated at the sub-district level; they typically served a population of about 30 000 people. Most, but not all, had at least one, and sometimes two, doctors. In Aceh, 82 of the 240 health centres had beds, 5–6 nurses, and 6–7 midwives.</td>
<td>240</td>
</tr>
<tr>
<td>Community Health Posts (pustu)</td>
<td>Also known as sub-health centres. Staffed by nurses and midwives.</td>
<td>739</td>
</tr>
<tr>
<td>Village Delivery Posts (polindes)</td>
<td>Also known as Community Maternity Polyclinics.</td>
<td>3,763</td>
</tr>
<tr>
<td>Integrated Community Health Centres (posyandu)</td>
<td>Also known as Health Posts. A monthly health service post run by volunteers. Promoted maternal and child health.</td>
<td>4,875</td>
</tr>
</tbody>
</table>
Table 5.8: Number of health centres, clinics, hospitals and health offices damaged or destroyed due to the earthquake and tsunami. Sources: (1) Phuket presentation, MoH;56 Preliminary Damage and Loss Assessment, BAPPENAS and World Bank23

<table>
<thead>
<tr>
<th>Health Centres, clinics, hospitals, labs and offices</th>
<th>Destroyed</th>
<th>Damaged</th>
<th>Damage in US$ million</th>
</tr>
</thead>
<tbody>
<tr>
<td>Health centres</td>
<td>26</td>
<td>15</td>
<td>3.3</td>
</tr>
<tr>
<td>Community health posts</td>
<td>37</td>
<td>22</td>
<td>22</td>
</tr>
<tr>
<td>Village delivery posts</td>
<td>172</td>
<td>218</td>
<td>46.1</td>
</tr>
<tr>
<td>Public hospitals</td>
<td>1</td>
<td>3</td>
<td>20.8</td>
</tr>
<tr>
<td>Private hospitals</td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Private clinics</td>
<td>2</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>Mobile health centre</td>
<td>39</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Health laboratory</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Provincial health office</td>
<td></td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>District health offices</td>
<td>1</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Port health office</td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Food &amp; drug control office</td>
<td></td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Other private facilities</td>
<td></td>
<td></td>
<td>2.7</td>
</tr>
<tr>
<td>Other public facilities</td>
<td></td>
<td></td>
<td>4.6</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>283</strong></td>
<td><strong>265</strong></td>
<td><strong>$83.3</strong></td>
</tr>
</tbody>
</table>

Table 5.9: Injuries treated by one medical team from 31 December to 8 January in Ulee Kareng, a heavily populated area of Banda Aceh.28

<table>
<thead>
<tr>
<th>Nature of injury</th>
<th>cases</th>
<th>% of total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Respiratory</td>
<td>325</td>
<td>36.56</td>
</tr>
<tr>
<td>Trauma</td>
<td>254</td>
<td>28.57</td>
</tr>
<tr>
<td>Musculoskeletal</td>
<td>111</td>
<td>12.86</td>
</tr>
<tr>
<td>Dermatological</td>
<td>105</td>
<td>11.81</td>
</tr>
<tr>
<td>Other</td>
<td>94</td>
<td>10.57</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>889</strong></td>
<td><strong>100.00</strong></td>
</tr>
</tbody>
</table>
Table 5.10: Nutritional indicators.

<table>
<thead>
<tr>
<th>Nutritional status indicator</th>
<th>Indonesia</th>
<th>yr(source)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stunted &lt;5 years of age</td>
<td>NA</td>
<td></td>
</tr>
<tr>
<td>Underweight children &lt;5 years of age</td>
<td>27%</td>
<td>2002(1)</td>
</tr>
<tr>
<td>Wasted children &lt;5 years of age</td>
<td>NA</td>
<td></td>
</tr>
<tr>
<td>Newborns with low birth weight</td>
<td>9%</td>
<td>2002(2)</td>
</tr>
<tr>
<td>Pregnant women with anaemia</td>
<td>64%</td>
<td>2000(1)</td>
</tr>
<tr>
<td>Per capita protein supply (grams/day)</td>
<td>64.2</td>
<td>2000(1)</td>
</tr>
<tr>
<td>Per capita fat supply (grams/day)</td>
<td>55.1</td>
<td>2000(1)</td>
</tr>
<tr>
<td>Per capita energy supply (calories/day)</td>
<td>2,902</td>
<td>2000(1)</td>
</tr>
<tr>
<td>Calories from cereal</td>
<td>64%</td>
<td>2000(1)</td>
</tr>
</tbody>
</table>

Sources: (1) Nutritional profiles, WHO42 (2) World Health Statistics, WHO10

Table 5.11: Nutritional indicators as measured among children between six and 59 months living in IDP and non-IDP households.

<table>
<thead>
<tr>
<th>Household type</th>
<th>Underweight</th>
<th>Stunting</th>
<th>Wasting</th>
<th>GAM</th>
<th>Anemia</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>March</td>
<td>Sept</td>
<td>March</td>
<td>Sept</td>
<td>March</td>
</tr>
<tr>
<td>IDP</td>
<td>42.7</td>
<td>42.1</td>
<td>39.8</td>
<td>35.6</td>
<td>10.3</td>
</tr>
<tr>
<td>Non-IDP</td>
<td>42.0</td>
<td>43.6</td>
<td>36.8</td>
<td>36.8</td>
<td>11.2</td>
</tr>
<tr>
<td>Total*</td>
<td>42.1</td>
<td>43.4</td>
<td>37.2</td>
<td>36.6</td>
<td>11.0</td>
</tr>
</tbody>
</table>

*Totals for underweight prevalence, stunting, wasting and GAM are not weighted, however, the report from which estimates on anaemia were drawn was not clear on whether or not it had been weighted.
<table>
<thead>
<tr>
<th>Benchmark Number</th>
<th>Benchmark</th>
<th>Indonesia Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Legal framework and functioning mechanism and organizational structure in place for health at all levels involving stakeholders</td>
<td>National Disaster Law still to be endorsed</td>
</tr>
<tr>
<td>2</td>
<td>Regularly updated disaster preparedness and emergency management plan for health sector and SOPs (emergency directory, national coordination focal point) in place. It must include: (1) standard operating procedures; (2) memoranda of understanding; (3) mechanisms for coordination and control; (4) responses; and (5) all-hazards and a hazard-specific approaches.</td>
<td>SOPs need at national level</td>
</tr>
<tr>
<td>3</td>
<td>Countries have a line item in their budget and system to assure financial resources are accessible to meet the immediate needs in case of a catastrophic event. Essential personnel, equipment, and supplies also are available in quantities necessary to cope with the damage created by an event for which it is at risk. Accounting procedures for the use of such resources are in place. Emergency financial (including national budget), physical and regular human resource allocation and accountability procedures have been established.</td>
<td>Amounts should be increased</td>
</tr>
<tr>
<td>4</td>
<td>Rules of engagement exist for the management of external actors.</td>
<td>Ministerial decree present, but must be communicated</td>
</tr>
<tr>
<td>5</td>
<td>Capacity to identify risks and assess vulnerability levels has been established. Appropriate measures have been implemented to reduce the vulnerabilities.</td>
<td>Needs assistance</td>
</tr>
<tr>
<td>6</td>
<td>Community-based response and preparedness capacities have been developed, and are supported with training and regular simulations and/or mock trials.</td>
<td>Quick Brigades present in 21 of 33 provinces</td>
</tr>
<tr>
<td>7</td>
<td>Local capacity for emergency provision of essential services and supplies (shelters, safe drinking water, food, communication) is developed.</td>
<td>Present for medical supplies, water, and sanitation</td>
</tr>
<tr>
<td>8</td>
<td>Advocacy and awareness has been developed through education, information management, and communication (pre-, during-, and post-event).</td>
<td>Education on Emergency Response Plan in place in one province</td>
</tr>
<tr>
<td>9</td>
<td>A community plan for mitigation, preparedness, and response that is based on risk identification and participatory vulnerability assessments, and backed by a higher level of capacity has been developed.</td>
<td>Safe communities programmes in 7 of 33 provinces</td>
</tr>
<tr>
<td>10</td>
<td>Human resources capabilities are updated and maintained continuously. Appropriate programmes to educate and train people to cope with events and disasters have been implemented. Adequate numbers of people are being trained, and trained experts are on-call in case of a disaster</td>
<td>Inclusion of curricula in universities</td>
</tr>
<tr>
<td>11</td>
<td>Health facilities are built/modified to withstand expected risks and to able to continue to provide the required medical care during events and disasters.</td>
<td>Only in Aceh has this been started, but training also has begun</td>
</tr>
<tr>
<td>12</td>
<td>Early warning and surveillance systems for identifying health concerns are established.</td>
<td>Need improvement</td>
</tr>
</tbody>
</table>
The Maldives

Going about their day-to-day lives in an isolated corner of the Indian Ocean, Maldivians have eluded major disasters for many decades. But on 26 December 2004, the Indian Ocean tsunami abruptly uprooted the Maldives’ peaceful isolation. The tsunami charged through 2400 km of ocean east of the Maldives and resulted in the largest disaster in the country in living memory. While the Maldives was just one of many nations that suffered the impact of the tsunami, a number of its unique geographic features influenced the tsunami’s behaviour in ways not seen in other South-East Asian countries. In the Maldives, moments before the tsunami struck, water swelled out of freshwater wells and the ground. And, when the tsunami waves did arrive, they were like a rapidly rising tide, rather than as turbulent waves. The Maldives was the only country where the impact of the tsunami was so wide-spread that it was declared a national event.

Geography explains much about the Maldives’ unique tsunami experience. Of the five countries hardest-hit by the tsunami, the Maldives has the smallest land mass and greatest exposure to the ocean. Its 298 km² of land area is scattered over 13 423 km² of ocean and divided among 1190 islands, which are small in area and stature. The flat, sandy islands rise to an average land elevation of only 1.5 metres above sea level and all but 28 have a land area of < 1 km². Consequently, no point of land extends far from the ocean, and when waves 1-4 metres high arrived on the morning of 26 December 2004, they washed entirely over many of the islands. The tsunami severely affected nearly one-third of the county’s population and required evacuation from 14 islands.

The Maldives’ 1190 islands form a double chain that runs from north to south, and each belongs to one of 26 natural atolls. The islands hardest hit by the tsunami were in the Maldives’ south central atolls, including Thaa Dhaalu, Meemu, Vaavu, Gaafu Alifu, and Laamu (Figure 6.1). Some researchers suggest the tsunami’s impact in the northern atolls was attenuated by Sri Lanka, which is located northeast of the Maldives.

Witnesses generally reported one to three waves, the first of which arrived at about 09:15 hours local time. When the tsunami waves arrived, they washed away 108 persons, displaced 20 000 people, contaminated scarce fresh water resources and crippled the economy. However, several factors limited the impact of the waves. Compared to the tsunami waves that impacted Indonesia, Sri Lanka, Thailand, and India, the waves that struck the Maldives appear to have been less turbulent (Figure 6.2). In the capital city of Malé, researchers found tsunami water marks on unbroken plate glass windows. And researchers analyzing a video of the tsunami...
The tsunami energy that was not reflected or refracted away from the Maldives islands also had to overcome a reef that runs parallel to a large portion of the country’s eastern-most coastlines.

The Maldives’ islands are perched along a steep oceanic ridge that meets the open ocean along a sharply descending seafloor. In other countries hit by the tsunami, a gradually inclining seafloor slowed tsunami waves as they approached shore. In response, tsunami waves converted wave length into wave height, growing taller and taller as they neared shore. But, upon reaching the steep wall of the seafloor leading up to the Maldives, the tsunami did not slow down or grow to great heights. Instead, much of the tsunami’s energy was reflected back into the ocean or refracted around islands through one of several deep, east-west channels separating some of the atolls. The tsunami energy that was not reflected or refracted away from the Maldives islands also had to overcome a reef that runs parallel to a large portion of the country’s eastern-most coastlines. Reefs along the eastern shores of the country were particularly protective because the tsunami waves traveled toward the country from the east. And, although witnesses reported that on some islands, tsunami waves also approached from the west, westerly approaching waves were the result of refraction, and generally, were smaller than waves approaching from the east.

Although the tsunami waves were the climax of the unusual events that unfolded in the Maldives on 26 December 2004, they were not the only abnormal occurrences that Maldivians observed that day.

Although little has been published on how much shaking Maldivians felt before the tsunami’s arrival, a record of 25 Maldivian responses to a USGS survey documenting earthquake shaking reports provides some clues. The Maldives is the furthest point from the earthquake epicentre from which the USGS survey received reports of earthquake shaking. Nonetheless, the survey’s results suggest earthquake shaking was greater in the Maldives than it was in some places closer to the earthquake epicentre. The 25 Maldivians who reported shaking ranked the shaking as IV on a scale of I to X using the Modified Mercalli Intensity Scale, indicating that they felt light shaking. The survey did not report the duration for which respondents felt shaking, but one Ministry of Health report indicated that there was shaking for five minutes.

Earthquake shaking was not the only abnormal phenomena witnesses observed before the tsunami. Just before the tsunami arrived, groundwater migrated upward, flowing out of freshwater wells. In most cases, unusual well water behaviour was observed just moments before the tsunami waves arrived, although on an island in the Laamu Atoll, witnesses observed changes in well water levels more than an hour before the arrival of the tsunamis. On some islands, water also came straight out of the ground. Water welling out of the ground just before the tsunami arrived filled a garbage dump on one island, and, in some areas, pressure created by the upwelling water buckled cement floors in houses.

One explanation for such unusual groundwater behaviour in the Maldives is because the islands are very porous, each consisting of a coral platform perched on a submerged volcanic ridge. When the tsunami approached the Maldives, pressure from the approaching tsunami waves pushed groundwater through the porous coral to the surface.

The powerful tsunami waves had stirred the Indian Ocean like a bowl of soup, and in the days following the tsunami, strange things began washing up onto island beaches. In a country in which there are no grassy fields to feed large livestock, Maldivians found the ocean had delivered them a cow. The cow was dead and of no use by the time it reached the Maldives. However, not everything that drifted onto the
Maldives after the tsunami was useless. Maldivians happily harvested non-native trees that had washed ashore (Figure 6.3). The hardwood trees were larger than any that grow in the Maldives and had traveled across the ocean from Indonesia.\textsuperscript{13,14}

Although the tsunami delivered several valuable hardwood trees to the Maldives, it delivered much more in the way of sorrow and hardship. Mercifully, the tsunami took relatively few lives in the islands. However, the economic ramifications of the tsunami in the Maldives made it among one of the most heavily impacted countries. The economic impact of the tsunami was equivalent to 62% of the country’s GDP, setting the country’s development backward by about a decade.\textsuperscript{15} Additionally, the tsunami worsened a number of public health issues the Maldives had been struggling to overcome, such as the provision of clean, fresh water.

**Population impacted**

Before the tsunami, the Maldives had an estimated population of approximately 289,480.\textsuperscript{16} Of these, approximately 70,000 lived in the country’s largest city, Malé. Maldivians inhabited only 200 of the country’s 1190 islands. Of the 200 populated islands, 70% had a population of less than 1000, and one-third had a population of less than 500.\textsuperscript{2} Maldives’ 28 geographic atolls are divided into 20 administrative atolls.\textsuperscript{2}

Despite the relatively small populations living on most of the islands, the Maldivians generally lived within close proximity of their fellow islanders. For example, among the islands impacted by the tsunami, the most densely populated island, Komandoo, had a population density of 25,847 people/km\textsuperscript{2}—more than seven times that of Sri Lanka’s most densely populated district, Colombo, with 3464 people/km\textsuperscript{2} (Table 6.1).

In addition to the approximately 200 inhabited islands of the Maldives, another 87 islands had been developed as tourist resorts. The greatest number (43) of tourist resort islands were located in the same atoll as Malé—the Kaafu Atoll.\textsuperscript{18}

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**Public (population/preventive) Health System**

**Pre-events**

In the years leading up to the tsunami, the Maldives was developing rapidly. Just six days before the tsunami, the UN General Assembly had recommended that the Maldives be removed from its list of least developed countries.\textsuperscript{19,20} And, as the Maldives’ development level improved, its public health indicators also improved (Table 6.2). Between 1980 and 2003, the life expectancy of the Maldivians climbed from 50 to 71 years, and from 1992 to 2004, the crude mortality rate in the Maldives fell from 6/1000 population to 3/1000 population.\textsuperscript{21,22} The decline in the crude mortality rate was due, in part, to decreases in reproductive health mortality rates. The largest decline in Maldives’ reproductive mortality rates may have been in its maternal mortality rate. In 1990, the maternal mortality rate was grim, with some estimates reaching as high as 500/100,000 births. By 2003, the maternal mortality rate had dropped to 78/100,000 live births.\textsuperscript{21} However, a 2005 Millennium Development Goals Country Report indicated that the accuracy of the 1990 maternal mortality rate data is questionable. Infant mortality rates in the Maldives also had been in decline when the tsunami struck, but still remained high. Of all of the deaths that occurred in 2003, 7% were due to infant deaths; and of those infant deaths, 61% occurred among infants \textless 7 days old, which the Ministry of Health identified as an indication of inadequate newborn care. For the most part, mortality rates were approximately the same in Malé, as they were in the rest of the country. One notable exception, however, was the under-five year old mortality rate (USMR). By 2003 the national USMR had declined to 18/1000 live births. But, a large disparity in the USMR existed between Malé and the atolls. While the USMR was only 10/1000 live births in Malé, it remained more than twice that in the atolls, where there were 24 deaths for every 1000 live births.\textsuperscript{21} Health authorities have attributed much of the decline in the mortality rates to the successful
control of a number of key communicable diseases. The Ministry of Health Department of Public Health was responsible for disease control and prevention, and healthcare workers were required to report significant infectious diseases. As with the other four countries reported in this book, the Maldives had adopted the Expanded Programme for Immunization through which it provided infants with five vaccines covering measles, polio, diphtheria, tetanus, whooping cough, tuberculosis, and hepatitis B. By the time the tsunami struck, the Maldives had achieved excellent coverage rates, with immunization rates among one-year-old children reaching 96% for all EPI vaccines (Table 6.3). As a result, polio, neonatal tetanus, whooping cough, and diphtheria were at the brink of elimination. While tuberculosis persisted, the Maldives also had achieved considerable success in limiting this disease; from 1991 to 2003, the number of tuberculosis cases being treated dropped from 676 to 82. Unfortunately, the Maldives did not have the same success with all vaccine-preventable diseases. Although measles vaccination coverage was 95% from 1994 to 2004, the disease continued to pose a public health problem. Prior to the tsunami, the last major outbreak of measles was in 1995 with 3070 cases. A smaller outbreak occurred in 2002, when measles infected at least 915 people. The occurrence of the disease dropped to more manageable levels following the 2002 outbreak, but still infected 75 people in 2003, and 37 in 2004.

Other communicable diseases, included acute respiratory infections, viral fevers, conjunctivitis, and diarrhoea. Of these four communicable diseases, acute respiratory infections and viral fevers were the most common (Table 6.4). Forty-one percent of all reported communicable diseases were acute respiratory infections, and 31% were viral fevers. However, acute respiratory infections were considerably more problematic in Malé than elsewhere in the Maldives. In 2003, the incidence rate of acute respiratory infections in Malé was 306/10 000 population compared to 154/10 000 population in the atolls.

As with its success in reducing the incidence of several vaccine-preventable diseases, the Maldives also had made notable achievements with respect to vector-borne diseases (Table 6.4). By 2003, the Maldives had eradicated malaria, and has not reported indigenous cases of malaria for more than 20 years. Unfortunately, the reports of vector-borne diseases do not include malaria, and shortly before the tsunami, the Maldives had suffered setbacks with respect to two other vector-borne diseases: scrub typhus and dengue. Although the Maldives has a long history with both diseases, before 2002, there had been no detected cases of scrub typhus since 1941. During 2002, scrub typhus, which is spread from rats to humans via mites, reappeared primarily in the Gaafu Dhaalu atoll. Of the 168 cases detected from May 2002 to April 2003, 74 were reported in the Gaafu Dhaalu atoll. The Gaafu Alifu and Raa atolls also reported a relatively high incidence of scrub typhus of 21 and 14 cases respectively.

Between 1998 and 2003, dengue generally had a low profile in the Maldives. Between 2000 and 2003, the number of dengue and dengue haemorrhagic fever cases ranged between 27 and 180 cases/year, with only 38 cases reported in 2003. But in the year before the tsunami, the number of reported dengue cases rose considerably, with 743 cases of dengue and dengue hemorrhagic fever cases reported in 2004, reaching a peak approximately 11 weeks before the tsunami.

In addition to the communicable diseases and public health issues, the Maldives had two unique health issues. The first, worm infestations were closely linked to the country’s water quality problems. Maldivian children had a high prevalence of worm infestations in the years before the tsunami, despite the struggle to rid its population of parasites. In 2001, the Ministry of Health estimated that between 50% and 75% of the country’s school-age children were infested with some type of worm.

Second, the Maldives had among one of the world’s highest incidence of thalassaemia, a
genetic disease that results in anemia and blood that cannot carry enough oxygen to meet the body’s needs. An estimated one in five Maldivians carry the gene that can cause them to have children with the disease. Maldivians with the disease require regular blood transfusions, and accounted for more than 60% of the country’s blood requirements.

All methods of contraception, including condoms, required a prescription, and legal barriers made it difficult for unmarried couples to receive contraception.

Damage
Of the five tsunami-impacted countries covered in this book, the Maldives lost the fewest lives and suffered the fewest injuries. But, relative to the size of its population, the country suffered a greater loss of life due to the tsunami than did India or Thailand. In the Maldives, 82 people died and 26 people were missing for a total of 108 lives lost due to the tsunami; far fewer than the number of lives lost in any of the other four countries covered in this book. However, the 108 lives represented 0.03% of the Maldives population or one in every 2680 Maldivians (Table 6.5). In contrast, the lives lost in Thailand represented 0.01% of the country’s population and in India the number of lives lost represented even less than 0.01% of the population. To be fair, India and Thailand are huge countries. But, this example illustrates the importance of keeping fatality data in perspective, and that the magnitude of the disaster in the Maldives was greater than the statistics might suggest.

The tsunami took more lives in the Maldives than did any other earlier disaster. The losses were concentrated in four atolls clustered in an area approximately 100 to 200 km south of Malé. Together, the Meemu, Dhaalu, Thaa, and Laamu atolls lost 91 lives. The islands that lost the greatest number of lives were the islands of Vilufushi in the Thaa atoll, and Kolhufulushi, in the Meemu atoll. Eighteen deaths occurred in Vilufushi and 16 in Kolhufulushi. In terms of the number of lives lost relative to the population of the islands, the losses were greatest on Gemendhoo in the Dhaalu atoll, where eight lives were lost. But relative to its population of just 322 people, those eight lives represented a fatality rate of 248/10 000 population.

Unfortunately, little data have been found about the causes of deaths of the victims. Consequently, it is unknown as to whether people died because they were drowned or because they were struck by floating debris or due to some other tsunami-related cause.

Changes in functions
The Indira Gandhi Memorial Hospital in Malé received its first victims with tsunami-related injuries from its main airport. Thereafter, injured victims began trickling in from other islands as well.

Early reports from the Ministry of Health indicated that 1421 people had been injured, of which 108 died. But a breakdown of the injuries by type indicated that the injured included persons with pathogen-related health and psychosocial issues. When the numbers of these victims with these health issues are eliminated from the calculations, 907 persons reported with physical injuries; 799 persons that survived their injuries had sustained long-bone fractures, head injuries, musculoskeletal injuries, lacerations, minor injuries, aches and pains, and/or near drowning (Table 6.6). Of these, the greatest number of injured survivors, 269 had injuries that were categorized as “minor”, followed by 165 with lacerations. A large number of survivors had sustained injuries that were undefined and labeled as “other”.

A little more than one week after the tsunami, Ministry of Health reports increased the estimated number of injured persons to 2214. However, a breakdown of the types of injuries included in the new estimate or an explanation as to why the estimate suddenly increased could not be found. The reported increase may be attributable to increases in disease symptoms and psychosocial issues included in the earlier estimate, rather than to injuries directly inflicted by the tsunami. Consequently, the authors believe 799 is likely the closest estimate of the number of injuries.
In addition to the immediate toll the tsunami damaged the infrastructure needed to support a healthy population. Damage to medical facilities, sanitation facilities, energy sources, and other infrastructure threatened the health of the surviving Maldivians. When flooding from the tsunami disrupted power supplies and inundated healthcare facilities, contaminated water ruined equipment and supplies and power failure resulted in interruption of cold storage required for vaccines, pharmaceuticals, and blood products. Consequently, damages sustained disrupted some disease control measures, although, for the most part, these disruptions did not last long. The Maldives’ Directly Observed Treatment, Short course (DOTS) treatment for tuberculosis (TB), was interrupted only for three to four days. The country’s immunization programme was also disrupted, but resumed after only a four to five week delay. The tsunami, however, had created other vulnerabilities that lasted much longer, and put the population at greater risk for contracting a disease. This was particularly true for Maldivians who lost access to sanitation, clean water, and shelter.

Despite increased vulnerability to pathogens, the population did not suffer from epidemics following the tsunami. Although outbreaks of mumps, measles, and an increased incidence of diarrhoea did occur, they were well-contained. Mumps was detected beginning on 30 January 2005, when a three-year-old boy in an IDP camp on Hulhumale Island complained to healthcare workers of fever and had swollen salivary glands. Soon, more children at the camp began to develop similar symptoms and by 23 March, the camp reported 16 cases of mumps. However, mumps infections were not limited to families living in the Hulhumale camp; other people on Hulhumale Island and on 29 other islands also reported symptoms compatible with mumps. The total number of reported mumps cases was 20 in January, but increased to 100 cases by the end of February, and 209 cases by the end of March. Before the year’s end, more than 5400 cases of mumps were reported. Of the 29 islands that reported mumps cases, the greatest number of cases was reported among those islands heavily hit by the tsunami or harboring large numbers of IDPs, such as Male, Eydhafushi, and Hulhumale, each of which reported more than 30 cases of mumps.

The number of reported measles cases did not accumulate as quickly as did the number of reported mumps cases, but rapidly exceeded the number of cases detected the previous year. Between the beginning of January and 26 March, 2005, measles infected 63 people compared to 37 in 2004. No cases of measles had been reported during the month leading up to the tsunami, but in the month following the tsunami, two cases were reported, followed by an additional 16 in February and 45 in March. By the end of October 2005, 1,345 people had been infected with measles, 82% of which were between five and 25 years old. These cases occurred despite the reported 96% measles vaccination coverage pre-event.

The number of cases of diarrhoea reported also increased considerably following the tsunami. Although no outbreak was declared, the number of cases of diarrhoea reported in January 2005 (n = 2050) was more than double the number (n = 879) reported for the same period the preceding year. The number of cases of diarrhoea reported declined over the next three months, but remained higher than the number reported for the same period in 2004.

In addition to the increased incidence of measles, mumps, and diarrhoea that occurred during the first few months following the tsunami, an increase in the incidence of dengue was also reported. During 2005, 987 cases were reported compared to 743 in 2004, or an increase from 2.75/10 000 people to 3.65/10 000 people.

*DOTS (Directly Observed Treatment. Short course) is a system of TB treatment not only to treat the disease, but also to prevent relapses, the spread of TB, and development of drug resistant strains of TB by helping patients complete drug treatments.
However, the increase in reported dengue cases did not gain momentum until November 2005, nearly a year after the tsunami. Additionally, the number of reported dengue cases already had been on the rise prior to the tsunami. Consequently, it is difficult to determine how much the tsunami contributed to the continuing increase in the incidence of dengue that occurred in 2005.

Following the tsunami, epidemiologists became concerned that several islands might be harboring the West Nile virus, a virus that normally infects birds, but also has been known to infect humans. Two days following the tsunami, an unusual increase in disease-related fatalities in crows was detected on two southern islands. However, the West Nile virus was not detected among the birds.

As of 1 February 2005, the Ministry of Health reported that 275 people with acute respiratory infections and 252 with viral infections had been detected. The Ministry reported that as of 1 January 2005, there were 419 cases of acute diarrhoea, 287 cases of viral fever, and 16 cases of viral fever with vomiting. By 8 January 2005, the government reported that except for the Laamu Atoll, the health situation in the Maldives had stabilized.

Following the tsunami, two out of five women who had been using contraception before the tsunami, stopped using contraceptive interventions, and only 4% of those who had not been using contraception methods started using contraception. Thus, nearly 80% of women were not using any form of contraception after the tsunami compared to approximately 70% who were using contraceptive methods prior to the event. In a Ministry of Planning survey, 40% of the women who had stopped using contraception linked the change in their practice to the tsunami, noting that they had lost their contraceptives or lost contraceptive records.

**Relief responses**

In each of the countries impacted by the tsunami, relief workers faced a set of unique challenges in reaching tsunami-impacted communities. In the Maldives these challenges included disease control efforts in tsunami-impacted communities that were isolated by hundreds of kilometres of ocean. Monitoring a population living on 200 separate islands that extend for more than 320 km north and 540 km south of Malé, presented a formidable challenge in light of the damages caused by the tsunami. In response, the Ministry of Health heightened surveillance, requiring daily reporting on 12 diseases and disease symptoms—acute gastroenteritis, viral fever, acute respiratory infection, dengue, typhoid fever, measles, meningitis, leptospirosis, hepatitis, chicken pox, scrub typhus, and mumps. Although the Maldives’ laboratory infrastructure suffered little damage due to the tsunami, the urgent need for thorough surveillance exposed weaknesses in the country’s ability to detect diseases. Fortunately, post-tsunami surveillance efforts received support from outside agencies, in particular, WHO-SEARO, which provided surveillance supplies, logistical support, and communicable disease experts to help strengthen disease detection. As in all of the countries covered in this book, WHO’s Global Outbreak Alert and Response Network (GOARN) established an electronic disease outbreak surveillance system in the Maldives, known as the Early Warning and Response Network (EWARN). Communicable disease experts also offered logistical support during the relief phase of the disaster, and trained Maldivian communicable disease control workers to improve disease surveillance. When the Ministry sent an inspection team to two southern islands to investigate an increase in disease-related crow deaths, WHO provided the team with experts to help determine whether the birds had contracted West Nile disease. In February 2005, WHO sent an epidemiologist for five months to help the Department of Public Health’s Epidemic Control Unit improve its ability to detect communicable diseases.
workshop in field epidemiology for Maldivian health workers.\textsuperscript{19}

In addition to strengthening surveillance, the Ministry of Health also took preventative measures against the spread of disease. Early during the disaster, the Ministry distributed chlorine to tsunami-impacted islands, to be used to disinfect water and other possible sources of contamination created by tsunami. And, in preparation for any possible outbreaks that might occur, the government modified a school near the Indira Gandhi Memorial Hospital in Malé, so that it could be used for isolation of victims with a communicable disease.\textsuperscript{34,50} Preventative disease activities like these also received support from WHO. For example, by 9 January, WHO-SEARO had delivered eight tons of chlorine after the initial relief efforts had depleted government supplies and the Ministry of Health had requested more.\textsuperscript{51-54}

Unfortunately, some disease control efforts had unintended consequences. When rotting fish and animal carcasses fouled some islands for days after the tsunami, government officials warned citizens that the carcasses posed a health hazard and encouraged islanders to use chlorine sent to disinfect water to also disinfect rotting organic matter.\textsuperscript{54} Additionally, the Department of Public Health asked health centres throughout the Maldives to dispose of such carcasses in deep holes filled with chlorine.\textsuperscript{56} Consequently, when government stocks of chlorine arrived, islanders liberally used undiluted chlorine on organic matter, and quickly depleted stocks needed to disinfect water.\textsuperscript{57} Additionally, it soon became clear that the practice of disinfecting rotting organic matter with chlorine was unnecessarily polluting the environment with excess quantities of chlorine. Consequently, health and environmental authorities created guidelines for chlorine use, recommending that the chemical be reserved for more key concerns such as disinfecting water, and that organic matter be burned rather than doused with chlorine.\textsuperscript{58}

**Recovery responses**

With routine immunization disrupted, the government made plans to fully resume routine immunization by the end of January 2005.\textsuperscript{52} After the tsunami, disease prevention efforts also were undertaken to prevent the Maldives’ high vaccination rates from slipping and creating new vulnerabilities to pathogens. In this context, UNICEF played a central role by helping to restore and strengthen the Maldives’ capacity to deliver immunization and provided more than US$ 40 000 in vaccines and cold chain equipment.\textsuperscript{43,59} The vaccines were used to provide routine EPI immunization for children <23 months of age—the government resumed the vaccination programme during February 2005.\textsuperscript{60-62}

**Development**

Disruptions to routine immunization services were minimal and pre-tsunami immunization rates were high (Table 6.3). But, increases in disease incidence rates after the tsunami, including outbreaks of measles and mumps, suggested that more could be done to strengthen the Maldives’ vaccination profile. Consequently, the Ministry of Health initiated vaccination campaigns to obtain coverage one step beyond the pre-tsunami coverage levels. For example, during December 2005, the Ministry of Health introduced a measles and rubella catch-up campaign targeting individuals over the age of six years and up to 25 years among men and 35 years for women.\textsuperscript{62} And, during April 2007, the Ministry of Health launched measles, mumps, and rubella vaccination campaign, adopting a protective measure against mumps which had not been a part of the pre-tsunami immunization programme.\textsuperscript{42}

**Medical Care (curative) System**

**Pre-events**

The geography of the Maldives complicated the delivery of medical care. To address these logistical barriers, the government provided a five-tier medical care system defined, in part,
by its geographic features. While some private medical services were also available, such services were limited and operated primarily in Malé. Consequently, it was left to the public Medical Care System to provide medical care services to citizens living on hard-to-reach islands, and ensured that all Maldivians could reach a doctor without leaving their atoll. At least some minimum level of health care was available on most of the islands; however, most of the islands had no doctors, and some had no medical care services. The arrangement by which these medical care services were distributed was dictated by the five-tier system which stratified the public medical care facilities according to geographic coverage and the services provided (Figure 6.7). At the apex of this system was the central tier, followed by the regional tier, two atoll tiers, and finally, an island tier. At the island-tier, healthcare centres provided the most rudimentary and widely-available healthcare services, and at the central tier, the Indira Gandhi Memorial Hospital in Malé provided the highest level of public medical care services. It provided general and specialty services and operated as the tertiary referral hospital for the entire country.

At the next highest tier, six regional hospitals strategically distributed throughout the atolls, provided secondary-level, curative services and preventive health services. Of the five-tier system, two atoll-tiers provided medical care through 10 atoll hospitals and 65 atoll health centres. Atoll hospitals provided laboratory, surgical, and gynaecological and obstetrical services, while the smaller atoll health centres provided basic healthcare and amenities in maternal health services. Finally, health posts and family health sections operated at the lowest tier of the five-tier system—they were the only healthcare facilities that did not have doctors on the staff, but other health posts were staffed by community health workers, and in some cases, family health workers or traditional birth attendants. When the tsunami struck, there were 52 health posts in the Maldives.

Although the Maldives Medical Care System relied primarily on the public sector and a diversified private sector, a number of healthcare NGOs also supported the provision of healthcare services. In 2004, there was one major private tertiary hospital and 50 private clinics of which only 13 were in rural areas. Together, the public and private medical care facilities provided a total of 759 hospital beds (one bed for every 381 citizens). Prominent NGOs operating in the healthcare sector before the tsunami included: Society for Health Education (SHE), Care Society, Maldives Eye Society, Maldives Association for the Handicapped, and the Cancer and Diabetic Society.

The Indira Gandhi Memorial Hospital shared the central tier of the five-tier system with several administrative healthcare institutions in Malé: the Department of Public Health; the National Thalassemia Centre; the Public Health Laboratory; the Maldives Water and Sanitation Authority; and the Ministry of Health, which was responsible for formulating the Maldives’ overall health policy and health development objectives. Thus, in the Maldives, specialized clinical health services were concentrated in only a few locations, i.e., the capital city Male, whereas, basic services were available in all the atolls and islands.

In addition to the geographic barriers, the medical care system also faced a chronic shortage of healthcare professionals (Tables 6.8 and 6.9) that has hampered the sustainable development of the country’s medical care systems; the country relies on health professionals from outside the country (expatriates). For example, during 2001, 83% of the 203 doctors, 58% of the nurses, 29% of the laboratory technicians, and 3% of other paramedics employed in the public sector, were expatriates. In the private sector, reliance on expatriates was even greater: 98% of the 60 doctors, 88% of the nurses, 96% of laboratory technicians, and 63% of the paramedics.

By 2003, the expatriate to local healthcare worker ratios had shifted in both the public and private sector; public sector reliance on expatriate doctors increased while public sector reliance on expatriate nurses decreased. Of a total of 277
doctors in the public sector in 2003, 98% were expatriates, and of a total of 739 nurses, 35% were expatriates. On the other hand, the public sector became less reliant on expatriates in 2003 than during 2001; of a total of 38 private doctors, 71% were expatriates, and of a total of 46 private nurses, 82% were expatriates.22

In addition to heavy reliance on other countries for healthcare professionals, the Maldives did not manufacture any drugs and the country’s entire drug supply had to be imported.71 Also, the medications supply lay primarily in the hands of the private sector. Although the public medical care system provided some drugs free of charge, most had to be purchased by the individual from private pharmacies.23 The Maldives also had 148 pharmacies.66 Most of the islands had at least one private pharmacy and some hospitals included a pharmacy. Essential medicines were free of charge only when provided by a family health worker; but, family health workers’ drug supplies were limited. Those healthcare professionals prescribing medications often were expatriates with little motivation to prescribe economically. Combined with the fact that the supply of medications is mostly private-based, the prescribing habits of healthcare professionals resulted in a heavy use of brand name medications rather than generics.71

With respect to preparedness of the medical care system for disasters, there were no comprehensive disaster preparedness and response plans for the hospitals. However, an airport emergency plan included protocols for the operation of the Indira Gandhi Memorial Hospital in Malé during a crisis.72,73

**Damage**

Compared to Maldivian houses, the healthcare infrastructure stood strongly against the tsunami waves. For example, on Vilufushi Island, the medical centre was one of only two buildings that remained standing after the tsunami receded. However, even though health care buildings remained standing, many suffered structural damages and lost essential personnel and costly supplies and equipment.

At the central level of the public medical care system, the Indira Gandhi Memorial Hospital did not suffer structural, supply, or equipment losses. But some healthcare facilities at each of the remaining four levels of care did. Structural, supply, and equipment losses affected one regional hospital, two atoll hospitals, 19 health centres, 21 health posts, and 33 family sections. Structural damage occurred at a few of the affected facilities, while equipment and supplies losses occurred at almost all of the affected facilities.74 The largest affected healthcare facility was the regional hospital located on Muli Island in the Meemu Atoll, where 21 people lost their lives and some of the greatest destruction occurred.7 Direct losses in the health-related basic societal functions (BSFs) due to the tsunami totaled US$ 5.6 million, and assessments estimated that approximately US$ 12.2 million would be needed to restore healthcare services to pre-tsunami levels.2

**Changes in functions**

Even without damaged healthcare facilities, the damage caused by the tsunami seriously affected the delivery of healthcare services. When the tsunami water retreated into the ocean, some healthcare facilities emerged only partially functional and some failed to function; four damaged health posts were entirely non-functional, and 11 were only partially functional. Additionally, six health centers failed to function and one was partially functional. The six health centers that failed to function were located in those atolls that lost personnel. Health Centres failed to function in the Shaviyani, Raa, Kaafu, and Thaa atolls, and two failed to function in the Laamu atoll, and one of the two damaged atoll hospitals also was unable to function. The Gaaf Alif atoll hospital, located on the island of Vilingili, was unable to function after the tsunami ruined all of the hospital’s equipment and machinery.53

After the tsunami, the medical care system suffered a second setback that affected its ability
to function. Along with the many nationals who were traumatized, many healthcare expatriates were shaken by their experience and returned to their home countries. Their departure left gaps in the staffing of the medical care system and further impeded the delivery of medical care.53,75

As a consequence of lost healthcare services, Maldivians lost access to some crucial services among hard-to-reach islands. For example, of the approximately 4000 pregnant women in the country when the tsunami struck, at least 500 were left without access to birthing facilities.76 In the immediate aftermath of the tsunami, however, the local medical care system generally managed to meet the most acute medical care needs of its citizens. Seriously injured survivors were reported to have received treatment within 24-48 hours of the disaster.23

**Relief responses**

In the immediate aftermath of the tsunami, the first medical care provided to injured survivors was by locally available healthcare professionals, and where healthcare professionals were not immediately available, friends and neighbours provided what assistance they could. In some cases, friends and neighbours quickly ferried injured survivors to other islands to obtain medical care services. Some of the islands that suffered the greatest human toll due to the tsunami also had lost their healthcare facilities, for example, Vilufushi Island in the Thaa atoll lost 14 lives, more than for any other island.

Following the initial medical relief responses in the islands and atolls, the second wave of medical care support came from the central government. With the central medical care services generally intact, the government acted quickly to support medical care services in the hardest-hit atolls. By the evening of 26 December 2004, the government began delivery of medical supplies using the military and the National Security Service to some of the hardest-hit atolls.61 Most of the tourists who were injured sought care at the private ADK hospital in Malé, because it accepted insurance and credit cards, whereas IGMH does not. On the day of the tsunami, the ADK treated approximately 80 tourists.67

Although the immediate medical needs were met by local and national medical care personnel, the Maldives later received medical support from several international agencies. WHO-SEARO, UNFPA, and the IFRC, in particular, offered medical supplies and sent volunteers and played central roles in supporting medical care services from the relief phase well into the recovery phase. By 28 December 2004, WHO-SEARO had pledged US$150 000 in medical supplies, and UNFPA had designated a large portion of a US$ 50 000 pledge to meeting the reproductive health needs of the affected populations.77

Unfortunately, the needed supplies did not arrive as quickly as did the pledges. The WHO-SEARO medical supplies began trickling in by 30 December, when the Ministry of Health received five medical kits from the agency. Each New Emergency Health Kit contained basic medications and medical supplies such as latex gloves and forceps, and each was designed to support a population of 10 000 for three months.79 This first shipment of WHO Emergency Health Kits was soon followed by two more. On 4 January, five additional Emergency Health Kits were delivered, followed by another five kits on 6 January. Within the first 10 days following the tsunami, WHO had also had delivered 100 000 packets of oral rehydration salts, which arrived 03 January, and 10 surgical kits, which arrived on 04 January.54,80

UNFPA also delivered medical supplies that included blood delivery and transfusion supplies and contraceptives.39,49 Additionally, UNFPA sent two boats fully equipped to deliver emergency care for pregnant women and for childbirth complications.57 The IFRC also made early contributions of medical supplies; the Canadian Red Cross sent 605 medical treatment and medication kits.52
In addition, many other NGOs and donors delivered a wide range of medical supplies. But, scattered reports indicating which NGO or donor sent what supplies often were vague—some were identified only by cumulative weight, while others used undefined units. Consequently, it is not possible to determine the identities and quantities of various medical supplies sent to the Maldives.*

In many cases, it has also been difficult to determine what influenced donors to send the quantities and types of medical supplies that were sent. In some cases, the Ministry of Health made specific requests that donors and agencies tried to meet. In January, the Ministry of Health informed relief agencies that it had identified an urgent need for equipment to treat patients with respiratory problems, including 80 oxygen concentrators, 120 nebulizer pumps, and 500 respiratory rate assessment timers. In response, the WHO country office worked with WHO-SEARO to seek funding to supply the requested equipment.53 To discourage unneeded medical supplies, the Ministry of Health indicated that medical supplies that had not been requested or approved would not be welcomed.23

In addition to medical supplies, assistance was also received in the form of skilled volunteer services. Donor-supported and volunteer healthcare professionals from all over the world arrived to help deliver healthcare services. The logistics involved in sending healthcare professionals to the Maldives, however, delayed their arrival by days and sometimes weeks. So, although these volunteers were able to fill staffing gaps within medical services, they generally did not play a role in treating those injured in the immediate aftermath of the tsunami. Thus, their impact on the healthcare delivery system remains to be defined.

Some of the earliest healthcare professionals arrived from Japan and Australia—both countries sent medical teams that included doctors and nurses. The Australian team, sent by the Australian government on 30 December 2005, included a wide range of healthcare professionals: the team included a team leader, three general practitioners, two public health physicians, two emergency physicians, an infectious disease physician, an anaesthetist, three nurses, a paramedic, an environmental health officer, and a logistics officer.81** The Japanese Disaster Relief Medical Team also arrived within a week of the event and provided its services on Muli Island, where the atoll regional hospital had been damaged. The team with 10 members including two doctors and four nurses supported healthcare services from 1 to 8 January 2005,12,83

Recovery responses

Although most of the healthcare professionals who volunteered to provide relief remained only for a matter of weeks or a few months; a few remained longer. One international organization encouraged their volunteer healthcare professionals to remain in the Maldives beyond the event’s first-year anniversary. On 19 January 2005, the Commonwealth, an association of 53 nations, undertook a programme to send medical doctors to volunteer in the Maldives with the request that the doctors commit to three to 12 months to supporting medical care services in the Maldives;84 23 doctors volunteered. One year after the tsunami, 15 of the 23 doctors continued to volunteer their services.85

In addition to the healthcare professionals sent from Japan, Australia, and the Commonwealth, many other international agencies, NGOs, and other donors also sent healthcare professionals. International healthcare professionals who arrived in response to the disaster included one surgeon and two gynaecologists sent by UNFPA,86 four doctors who arrived from Thailand, and six doctors sent by the Voluntary Services Organization.87 In addition to providing skilled

*The government did make efforts to keep track of medical donations as well as other donated items. This is discussed in greater detail in the Transportation and Logistics system section.

**The team originally included three emergency physicians, but one was later sent to Sri Lanka instead.
medical care professionals, some international responders also provided the locals with skills training: UNICEF trained 61 community health workers.61

Finally, the Maldives needed help not only for relief healthcare medical care services, but for assisting with restoring its ability to independently provide its population with these services. As mentioned, more than 30 healthcare facilities, including one regional hospital and two atoll hospitals were damaged or lost supplies due to the tsunami —damages that would cost approximately US$12.2 million to repair. Many international organizations, agencies, and donors stepped in to meet these needs, and perhaps none more than Germany and the German Red Cross. Overall donations committed to meet the rehabilitation needs of the Maldives’s healthcare facilities, however, were below the amount needed. By March 2005, donors had committed US$ 6.5 million to the German Red Cross and two UN agencies to rebuild and re-equip healthcare facilities representing approximately half of the estimated healthcare system rehabilitation costs.88

Germany and its partner agency, the German Red Cross, played a major role in supporting the reconstruction of the medical care system, providing US$ 5.8 million of the US$ 6.5 million committed.89 The German Red Cross helped to rebuild healthcare facilities and restock supplies and equipment in clinics.61  And, by July 2007, it had rebuilt 24 health facilities.88

Despite shortages in funding, some healthcare facilities were restored within months of the tsunami. By July 2005, the Meemu Muli Regional Hospital, the largest health facility damaged, was almost fully restored to its pre-tsunami operating level.90 Within two years of the tsunami, most healthcare facilities had been restored, with 24 health posts, six health centres, two Atoll hospitals, and one regional hospital repaired or rebuilt.91

Efforts were also made to improve the tsunami survivors’ access to needed medications by providing a supply sufficient for several months of free, essential medications. In March, WHO-SEARO investigated what would be required to provide 12 000 people with six months of free medications.92 Subsequently, WHO-SEARO and the IFRC supplied the Ministry of Health with a stockpile of essential medications that the Ministry distributed free of charge for as long as these supplies lasted. On some islands, these supplies lasted for four to six months.23

Development

Efforts to not only restore, but also improve the medical care system were also made after the tsunami. The Ministry of Health revised its family planning guidelines and WHO staff traveled to regional hospitals to introduce the guidelines for healthcare personnel.93 Also, by July, the Ministry of Health began developing a comprehensive emergency preparedness and response plan for the health’s basic societal  functions (BSF) systems.74  WHO-SEARO, UNICEF, UNFPA, and Red Cross/Red Crescent worked together to develop a consolidated list of medical supplies and equipment that each agency could provide when needed.71

Water and Sanitation System

Pre-events

When the tsunami contaminated freshwater wells and washed away water tanks, it did not create a new water problem, but made an already existing water problem much worse. The Maldives has no rivers or lakes—when the tsunami struck, clean fresh water already was a scarce commodity.

Although a few fresh-water lagoons dot some of the islands, the Maldives’ natural reserve of freshwater is found almost entirely in shallow pockets of ground water known as freshwater lenses. The thin, shallow freshwater lenses have formed 1 to 1.5 metres below the surface of each island from years of accumulated rainwater, and float on the seawater that infiltrates the islands from below. The freshwater lenses never grow more than a few metres thick.394 Consequently, freshwater lenses are vulnerable
to contamination, and by the time the tsunami arrived, ongoing development and human occupation had contaminated many of them. As a result, most Maldivians had been forced to find alternative sources of water, relying on rainwater, desalinization plants, or imported bottled water.

By the time the tsunami arrived, only 39 out of 200 inhabited islands could rely on untreated groundwater for drinking.3 On the other islands, heavy abstraction of freshwater, poor management of wastewater, and other human activities had salinated and polluted the freshwater lenses. Of the islands that no longer could rely on groundwater, 54% had unsuitable groundwater due to salt water intrusion, and 46% due to pollution.75

How each island dealt with the needs for drinking water in the face of degraded groundwater supplies differed according to three arbitrary divisions within the water and sanitation systems: the Malé metropolitan area; other residential islands; and the resort islands.

In the capital of Malé, Maldivians faced with the need for an alternative water source, turned to desalinated water. The Malé Water and Sewerage Company supplied desalinated, treated, and piped water, providing the capital’s entire population with access to an improved source of drinking water.* Desalination plants are costly and energy intensive, and require the use of imported fuel;21 but, due to Malé’s high population density, rainwater harvesting was impractical. Outside of Malé, only two other residential islands received desalination services: the small, but densely populated islands of R. Kadholhudhoo, and Sh. Kommandhoo, approximately 200 km north of Malé.18 However, of the approximately 75 000 people who relied on desalinated water—more than 70 000 (28% of the Maldives’ total population) lived in Malé. Resort islands also turned to desalinated water. The resort islands, were responsible for providing their own water supply services using bottled water and small desalinization plants.18 There were two desalinization plants in operation before the tsunami. Each plant had a capacity to produce 30 000 litres of potable water/day.100

On the residential islands other than Malé, rainwater harvesting was the preferred method for obtaining potable water. During 2004, rainwater provided potable water to 90% of all households outside of Malé. However, at times, rainwater was insufficient, and 30% of the atoll population reported drinking water shortages.21 With so many atoll islands struggling to maintain short-term water supplies, there was no excess water to set aside for emergencies.95

However, the Maldivians on the outer islands were not without recourse when supplies dwindled. When rainwater ran out at the end of the dry season, island residents often turned to mosque wells, which could provide cleaner water than their own wells. The water drawn from mosque wells tends to be cleaner than water drawn from other island wells for three primary reasons: (1) mosques typically are located near the centre of the island; (2) mosques have a buffer zone that separates them from other buildings; and (3) the mosques are surrounded by thinly vegetated cemeteries. By being located in the centre of the island, mosques draw water from the freshwater lenses where they were the thickest. The buffer zone separating mosque wells from other buildings also protects them from the salinating impact of surrounding wells and from pollution leached from septic tanks. And, because the cemeteries surrounding the mosques tend to be sparsely vegetated, more water percolates through the ground and back into the freshwater lenses than in areas where thicker vegetation extracts water before it reaches the lenses. Additionally, mosque wells use dhonis to manually draw water up one bucket at a time (Figure 6.5), rather than pumps, which draw large quantities of water out of wells.

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*Malé is divided into five wards, one of which includes the nearby island of Vilingili and the nearby island of Hulhumalé, which supports the Malé airport. The Malé Water and Sewerage Company served all five wards and Hulhumalé with desalinated water.
quickly. The use of dhonis helps to maintain the freshness of a well for two reasons: (1) manual removal limits how much water can be drawn from the well, thus lowering the impact on the level of freshwater in the well; and (2) manual removal avoids saltwater intrusion into the well.

After rain tanks run dry, mosque wells generally provide atoll residents with enough water until the wet season arrives and rain refills tanks and recharges the freshwater lenses. When even mosque well water is insufficient or too dirty, and all of the island’s rainwater has been used, islanders turn to other solutions, such as using coconut water for drinking, and traveling to neighbouring islands to find freshwater.

While well water played a shrinking role in supplying drinking water, it remained very important in the outer atoll islands where it was used throughout the year. With the exception of the end of the dry season, well water was typically used for non-potable purposes. But, in order to conserve precious drinking water, Maldivians in the outer atoll islands still relied heavily on groundwater for washing and bathing and other non-potable purposes. When Maldivians needed to use well water for drinking or cooking, such as when mosque wells are used during the dry season, they generally boiled or chlorinated it.

Unfortunately, both fresh groundwater supplies and surrounding saltwater resources had become contaminated by poor wastewater management. Sewage treatment systems were rare prior to the tsunami, and contamination of freshwater lenses, lagoons, and surrounding seawater by chemical contaminants and pathogens was a major problem. Consequently, the Maldives encountered a number of water-borne diseases and parasites, including worm infestations and the spread of diarrhoea.

In Malé, all household wastewater was released as untreated sewage into the ocean. The Malé Water and Sewage Company, which supplied wastewater disposal services as well as desalination services in the Malé area, disposed of household wastewater using a conventional gravity flow system. This system carried untreated sewage water into deep ocean waters where it was released. In the atolls, most households relied on septic tanks; groundwater contamination from improperly built and poorly maintained septic tanks posed a problem. Additionally, some toilets in the atolls discharged wastewater directly into the groundwater. Finally, on the resort islands, resorts generally discharged untreated water directly into surrounding coastal waters.

Oversight of water supply and wastewater disposal were the responsibility of the Maldives Water and Sanitation Authority (WASA), which was established in 1973. The authority set water quality standards and regulations, and enforced and monitored them. But, while WASA had a clear mandate for regulating water quality and wastewater disposal in Malé, it had little or no presence among the outer atoll islands. With the exception of seven government-installed, small-bore sewage systems, almost all households outside of Malé were responsible for providing and monitoring their own sewage system services. For the most part, these households managed their own water and wastewater disposal using well water and rainwater, septic tanks, and soakaways. Unfortunately, public education on the proper maintenance of wells and septic systems was insufficient and poorly maintained septic systems were allowed to contaminate groundwater with nitrates, phosphates, ammonia, and bacteria. Septic tanks, designed to capture sediment from sewerage water before it is released into the environment, were rarely desludged. And the soakaway pits, into which settled septic tank water is released, often were dug close to the water table. Consequently, these household wastewater systems did not operate as they were designed to.
designed and contamination of groundwater was common.99

**Damage**

After the last tsunami wave retreated into the sea, ponds of seawater dotted the islands; some would remain for as long as eight days.101 In the interim, the Maldives’ fragile freshwater supplies had suffered severe damages. The tsunami had inundated groundwater with saltwater, released wastewater pollutants, washed away tanks of collected rainwater, and ruined rainwater harvesting equipment (Figure 6.6).

In February, island offices reported the loss of 500 tanks of rainwater (approximately 800 000 litres). However, reports were received from only some of the island offices, and as many as 1 000 community rainwater tanks and 6 000 household rainwater tanks are estimated to have been lost.2 Furthermore, with tsunami water having elevated the salinity and fecal coliform levels in wells, groundwater became even less suitable for drinking than before.21 There is no information on precisely how many wells the tsunami contaminated or how severely they were contaminated. But, the number of tsunami-contaminated wells found on each island is believed to correlate with the extent to which each island had been inundated.98

In addition to water supplies, the tsunami also damaged the already weak wastewater disposal infrastructure, destroying toilets, damaging septic tanks, and blocking sewage systems. An estimated 5 000 toilets were damaged or destroyed,88 and on some of the hardest-hit islands, as many as 90% of toilets were destroyed.21 In addition, 1 500 islands reported that their sewage systems were blocked.96 Many septic tanks were damaged when an upwelling pressure wave that preceded the tsunami wave lifted and cracked septic tanks.102 The pressure wave and the tsunami waves are believed to have damaged an estimated 1 500 septic tanks and septic tank connections.99

All told, the tsunami is estimated to have caused US$13.1 million in damages to the water and sanitation systems infrastructure. But, the cost of restoring the infrastructure would cost much more. A February 2005 Joint Needs Assessment estimated that restoring the water and sanitation system would cost US$ 45.6 million.2 The reasons for the differences between the damage costs and replacement cost are not clear.

**Changes in functions**

Disruptions of the supplies of water were widespread following the tsunami; rainwater tanks were damaged, groundwater sources were contaminated, and water supplies were disrupted on 70 of the country’s 200 inhabited islands.97 To make things worse, the tsunami contaminated wells and swept away supplies of carefully collected rainwater just shortly after the rainy season had ended and months of the dry season stretched ahead.

There is little information on the extent to which Maldivians on the tsunami-impacted islands suffered water shortages in the first few days following the tsunami. Communication and transportation difficulties hampered efforts to accurately gauge how limited the water supplies were from one island to the next. However, updates posted by UN agencies suggested that many islands suffered critical shortages early during the disaster. As of 29 December 2004, the UN country team reported that 37 islands had no source of safe drinking water or wastewater collection facilities.98 By 2 January 2005, the water situation on these islands remained grim; 37 islands still reported having little or no water with an additional 20 islands having only “contaminated” water.102

Unfortunately, water concerns in the atolls extended beyond the first few days and weeks following the tsunami. As rainwater harvesting equipment was damaged or destroyed, some Maldivians did not have the ability to collect more rainwater to replace that lost during the tsunami. The 2005 dry season, which began shortly before the tsunami, was the driest season in the Maldives in eight years with only 58% of the usual amounts of rainfall. In a normal year,
the dry season accounts for about 7%–10% of the year’s total rainfall. The wet season, which began in May, helped to relieve the water shortages, but the total rainfall for all of 2005 was the lowest recorded since 1995. This low rainfall made it difficult to fill rainwater tanks and slowed the recovery of groundwater sources. Approximately 30% of the average annual rainfall seeps through the islands’ sands and recharges freshwater lenses. Consequently, when rainwater averages fall, so does the rate at which freshwater is restored in freshwater lenses.

In the first few days following the tsunami, the Maldives’ three water purification companies reported that demand had exceeded capacity.

### Relief responses
Little has been reported on how Maldivians coped with serious drinking water shortages until national and international relief efforts reached them. However, importantly, no reports of deaths due to dehydration could be identified. It may not be unreasonable, however, to presume that they relied on many of the same coping techniques used during previous shortages. Traditionally, residents of the outer islands relied on neighbours and communal resources to sustain them through periods of water shortages. Islanders who had water shared with those who did not, and when the neighbours ran out of drinking water, islanders usually could find suitable water at the mosque well. When neither the mosque well nor island neighbours could provide water, then islanders would drink coconut water and/or travel to other islands to find drinking water.

On islands where the tsunami seriously contaminated and damaged groundwater and rainwater supplies, the residents may have had to rely on coconut water and neighbouring islands to meet drinking water needs before outside help arrived. There are many reports of islanders from the least impacted islands traveling to heavily impacted islands to help islanders who were in need. Presumably, these islanders also helped provide water, when possible, or ferried islanders to islands where water could be found.

When national and international responders arrived, early drinking water relief came in the form of imported water and water purification kits and chemicals. The Maldivian military (National Security Services) distributed bottled water and chlorine from State Trading Organization stocks to impacted islands, using boats and seaplanes (Figure 6.7).

Internationally, UNICEF, WHO, OXFAM, and the Red Cross played leading roles in responding to the islands’ water needs. Initially, international responses also focused on supplying imported water and water purification kits and chemicals. However, gradually, shipments shifted away from imported water and began to include basic equipment and supplies Maldivians could use to supply and store their own water. Three large relief shipments arriving between 5 and 7 January included imported water, purification kits, and a few basic supplies for carrying and procuring water. The first of these, delivered on 5 January, supplied 40 tons of bottled water flown in by the British government’s Department for International Development and donated by Scottish Water and Strathmore Water. A second and slightly larger shipment of bottled water was delivered the next day along with supplies to help Maldivians procure and store their own water. On 6 January, Oxfam flew a 55-ton shipment of bottled water, donated by the British supermarket chain Somerfield, to supply 2000 Maldivians with a two-week supply of water. Along with the bottled water, an Oxfam shipment also delivered water supply equipment, including pipes, pumps, and water tanks. Finally, a shipment delivered on 7 January, provided water containers and treatment supplies. A UNICEF shipment of 694 basic family water kits arrived on a cargo plane. Each kit was designed to provide for 10 families and included 500 water purification tablets, 20 collapsible water containers, 72 bars of soap, and 10 buckets with lids. In the early relief responses, at least one mobile desalinization plant also provided water early on. On 14 January, a US marine ship with the capacity to desalinate and distribute 95 000 litres/day arrived in the Maldives.
With many national and international actors responding to the water needs, coordination efforts were needed to ensure that all Maldivians facing water shortages were receiving help, that resources were not being wasted, and that water contamination was controlled. Consequently, every two weeks, a water and sanitation meeting attended by the UNICEF, UNDP, IFRC, and OCHA was held to address sludge management and water quality issues.94 Further coordination within the UN Country Team was achieved by assigning UNICEF to lead the response in the water and sanitation societal functional system.23 As the UN’s lead agency in the Water and Sanitation Cluster (Basic Societal Functional System) responses, UNICEF partnered with OXFAM and the Red Cross to provide 69 islands with water relief supplies, including bottled water, disinfection tablets, and water and hygiene kits.108

Recovery responses

In the weeks following the tsunami, national and international responders in the water and sanitation Basic Societal System turned their attention from imported water to more sustainable methods of providing water. Donor organizations had three possible freshwater sources to consider: (1) desalination seawater; (2) rainwater, and (3) groundwater. Of these, desalination seemed to be the best choice. Although a few donor organizations also supplied rainwater tanks and rainwater harvesting equipment, the greatest resources seem to have been invested into equipping atoll islands with desalinization plants. Attempts to restore groundwater received little attention as a possible sustainable source of potable water.96

Even at an estimated cost of US$ 75 000 each, donor organizations seemed eager to send desalinisation plants to the Maldives. UNICEF sent 23 desalination plants and at least one donor, Singapore, sent a desalinisation plant worth US$ 600 000.109 Desalinization plants began arriving in February 2005, and by 2007, at least 38 islands had received desalinization plants.110

In addition to the desalination plants installed on islands, some of the donated plants were placed on boats in order to provide water to several islands on a rotating basis. Five of the 23 desalination plants sent by UNICEF went from island-to-island by boat.112

Although desalination plants had a long history of use on the resort islands and in Malé, they were new to many of the atoll islands that received them following the tsunami. Consequently, these islands had no one with the skills to operate and maintain them. By July 2005, more than 15 islands had received desalination plants and operation difficulties due to lack of skilled maintenance began to emerge. The individuals who had been nominated to operate and maintain donated desalination plants generally were volunteers who had other jobs. And, although the volunteers received basic operating instructions when the desalinisation plants were installed, there was no system in place to provide them with basic support and answer questions after completing their initial training.99 Additionally, maintenance and operation of the desalination plants was made more complex by the fact that donors provided multiple, different desalination models. At least five different desalination plant models were sent to the Maldives, each of which required slightly different operating instructions and different spare parts.107

To fill the skills gap, the South African Water Sector and UNICEF convened a two-week training workshop in September 2005 to train 20 Maldivians in desalination plant operation and maintenance.*

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*The South African Water Sector indicated that the training workshop lasted two weeks, while a UNICEF report indicated that the training lasted one week.107,111
Rainwater and groundwater—they lacked the infrastructure to support public water services. And because the Maldives imported all of its fuel and desalination plants are energy-intensive, the costs of operating the plants were high. For example, an Oxfam desalination plant installed on Muli consumed a gallon of diesel for every 100 gallons of water it produced.\(^\text{112}\)

Once the dry months following the tsunami ended and monsoon rains resumed, many islands shut down their desalination plants,\(^\text{107}\) and left them idle until the next emergency. However, desalination plants are designed to operate continuously rather than sit idle. If a desalination plant is turned off without being properly disassembled, the plant’s membranes dry out, internal machinery stops working, and when an emergency occurs, it no longer may be operational. To be properly maintained, desalination plants not in continual use may need to be kept in a centralized location, where they are more likely to receive proper maintenance and from which they can be deployed to outer islands in the case of an emergency. Otherwise, costly desalination equipment may fall into a state of disrepair and lay waste to this major investment into the Maldives Water and Sanitation System.\(^\text{102}\)

Although, the wisdom and sustainability of sending so many desalination plants to the Maldives has been questioned,\(^\text{107}\) they provided a medium-term solution to bridge the gap between short-term and long-term solutions. In the end, most of the atoll islands searching for long-term solutions to tsunami-aggravated water problems returned to traditional water sources. Although rainwater and groundwater availability had been limited by the impact of the tsunami, restoration and improvement of these two water sources presented the most sustainable long-term water supply for most atoll islands. Post-tsunami research has demonstrated that freshwater lenses could recover over time, and rainwater harvesting practices could be improved to increase water availability.

**Development**

As the Maldives transitioned from short- and medium-term solutions to long-term solutions, the authorities identified an information gap in precisely where and to what extent the tsunami had damaged their freshwater resources. Consequently, the Water and Sanitation Authority requested that WHO-SEARO undertakes a water system assessment. Beginning in May 2005, WHO funded a team of consultants to investigate the impact of the tsunami on water resources and water governance arrangements in the Maldives.\(^\text{113,114}\)

The team’s detailed observations of well contamination levels and rainwater collection practices on three tsunami-impacted islands, provided authorities with a clearer understanding of the post-tsunami state of the water and sanitation societal functional system and how best to respond. The team found that rainwater harvesting practices could be improved to collect considerably more water than had been collected pre-event. The team reported that nearly all households could double the amount of rainwater harvested each year by expanding the roof area from which run-off is collected and by increasing storage tank volume.\(^\text{101}\)

Although donors did not pour the same level of resources into providing rainwater harvesting equipment as they did desalination plants, a number of islands did receive rain harvesting supplies. By September 2006, donors had supplied 90 islands with more than 17 000 household rainwater tanks, each with a capacity to store 2500 liters. In addition, some of the islands also received communal rainwater tanks for schools, hospitals, and mosques—these tanks held anywhere from 2500 to 5000 litres of water. The IFRC and UNICEF were the two leading donors, with the IFRC distributing more than 15 000 household rainwater tanks to 79 islands, and UNICEF distributing 1500 household rainwater tanks to eight islands by September 2005.\(^\text{115}\) In supplying rainwater tanks, the IFRC and UNICEF coordinated their efforts, the IFRC focused on household rainwater tanks
and UNICEF focused on communal rainwater tanks. In addition to the 1,500 household rainwater tanks, UNICEF also distributed 2,500 communal rainwater tanks.

However, the donated rainwater tanks were not always equipped with the connections and platforms needed to use them. Thus, while the number of donated rainwater tanks exceeded the estimated number of rainwater tanks lost due to the tsunami, the actual number of new rainwater tanks that islanders were able to use during the 2005 wet season was lower than was the number distributed. Follow-up visits to islands that had received tanks sometimes found them lying unused and empty along beaches.

Improving rainwater harvesting represented an important step in achieving sustainable water supplies, but in the atolls, people also needed fresh groundwater supplies to support their needs. After the tsunami, donors gave less attention to groundwater as a drinking water source than to the collection of rainwater, and far less than desalinated water. Like rainwater, however, groundwater is free and does not require the technical skills, distribution infrastructure, or fuel that desalination plants require. And when islanders run out of rainwater, groundwater provides them with an important back-up supply of drinking water.

Although the tsunami elevated contamination levels in many of the freshwater lenses, with time and careful extraction and sanitation practices, groundwater lenses eventually could recover their pre-tsunami freshwater levels. There is little information on the rate at which freshwater lenses did or did not recover following the tsunami. The WHO-funded water system assessments, however, provide some clues as to how groundwater contamination levels responded to the tsunami and conditions following the tsunami. The assessment team estimated that those freshwater lenses impacted would take anywhere from two to three years, to recover, but could take as long as nine years depending on a number of factors including its size, the degree to which it was salinated; larger lenses recover more slowly than do small lenses.

The recovery rate of freshwater wells also depends on human factors. For example, on the tsunami-impacted island of Kulhuduffushi, water contamination measurements taken in March and April of 2005 found that the tsunami increased the salinity of 92% of the island’s wells; similar measurements in July 2005 indicated that 24% of the impacted wells had become fresher, while 76% actually became more saline. The assessment team suggested that the salinity increased in many wells because water usage had exceeded the rate at which freshwater was recharging the island’s freshwater lenses.

On inhabited islands, freshwater lenses rely on two primary sources of freshwater to recharge them: rainwater and wastewater. Although rainwater is the ideal source of freshwater recharge, on many islands without wastewater, the freshwater lenses would become saline and consequently useless. Following the tsunami, however, many donors pushed to install sewage systems on islands that would dispose of all wastewater into the ocean and thus reduce wastewater pollution of the freshwater lenses. But the WHO-funded assessment team warned that, although the removal of an island’s dirtiest water might not be a bad idea, disposing of all of an island’s wastewater into the ocean would be a mistake.

On most residential atoll islands, grey water and household-treated black water have been allowed to filter through the ground and back into freshwater lenses. Although filtration through the ground helps clean some of the impurities from wastewater before it reaches the freshwater lens, the return of wastewater still introduces pathogens and pollution into the groundwater. At the same time, without wastewater, freshwater may be extracted from a lens faster than it is recharged, and thus, salinate the lens. And once a freshwater lens has become saline, it ceases to be useful for drinking, cooking, bathing, or any other domestic use. On the other hand, well water
with low levels of wastewater contamination, can be used for domestic purposes, such as washing and gardening, and for drinking and cooking when boiled or chemically treated.

When groundwater is used for potable and domestic uses, it is important to know when it is safe to use with and without treatment, and when it is not safe to use. And with wastewater pollution leaching from damaged septic systems following the tsunami, the need to be aware of well water contamination levels was heightened. Consequently, some of the responses to the tsunami also sought to improve water quality awareness in the islands by providing atoll healthcare workers with water quality training. From 13 to 16 September 2005, the Public Health Laboratory of the Ministry of Health and the Maldives Water and Sanitation Authority organized a water and sanitation workshop to educate and train 28 Laamu Atoll healthcare workers representing all of the atoll’s islands. During the workshop, participants learned water quality testing, and water quality monitoring and reporting, and how to design and implement water safety plans.117

In the months following the tsunami, the government not only sought to improve the atoll-level capacity to manage water quality, but also to improve management at the national level. In July 2005, the government restructured its responsibilities in the provision and oversight of water resources and sanitation. A new ministry was created to share responsibilities with WASA. The new Ministry of Environment, Energy, and Water, assumed responsibility for overall water policies and for the design and procurement of outer island water supply and sanitation infrastructure.118

Shelter and Clothing System

Pre-events
The Maldivian islands are blessed with warm temperatures, but suffer a housing shortage. Average temperatures range from 25.5°C to 30.4°C with high humidity that is moderated by constant sea breezes. From May to September, monsoon rains bring heavy winds and rough seas to the islands, with May and October generally receiving the greatest amount of rainfall.

The northern atolls generally were drier and warmer than were the southern atolls, with an average annual rainfall of 2540 mm in the north and 3810 mm in the south. In October and November, the Maldives shift from a wet season to a dry season, with the southern atolls transitioning into the dry season later than the central and northern atolls.58

With an annual rainfall of 2540 to 3810 mm, there is a shortage of shelter for the people to protect them from the rain. Because the country has few resources of its own, most housing materials are flown or shipped, making building supplies and housing costly. On many of the heavily populated islands, severe land shortages have exacerbated the high cost of housing. There are a few trees on the islands that could be used for building houses, and thus, in rural areas, residential homes often are built using coral reef and lime.74 Due to shortages in housing, household size was generally high, but had been declining. In Malé, household size decreased from 8.7 persons in 1997 to 8.0 persons in 2004. And in the atolls, household size declined from 6.2 to 6.1 people during the same period.97

Most of the land in the Maldives was publicly owned; there was no tribal land and very little privately owned land. Plots of land for housing could be used free by citizens on formally inhabited islands for which government infrastructures had been established. Land used for industrial or commercial purposes had to be leased from the government.45 The population of the Maldives was widely dispersed. To curb the difficulties of serving a population widely distributed over hundreds of islands, the government had developed a resettlement plan in an effort to consolidate the population.45

Damage
The tsunami damaged or destroyed 5347 houses, of which, 1847 (36%) were completely
destroyed. The Shelter and Clothing Societal System lost an estimated US$ 64.8 million. Residential homes, which were often made of coral and lime, suffered greater damage than did government-built buildings such as schools, health centres, and offices. All the 192 houses on Villufushi island were destroyed; only the island’s school and medical centre were left standing.57

The impact of the tsunami on housing varied from island to island. Nearly total housing destruction occurred on 14 islands comprising a total of 951 households. On 22 islands comprising a total of 1688 households, most housing units were heavily damaged or destroyed, and on 33 islands comprising 2660 households, nearly one-quarter of the housing units were damaged. Only nine of the 200 inhabited islands were not flooded, and the remaining 122 islands experienced flooding, but no structural damage.97

Changes in functions
Housing damages and evacuations from hard-hit islands displaced approximately 7% of the country’s population (29 577 IDPs) in the immediate aftermath of the tsunami.74 Among those evacuated from islands, most were women and children.76 When possible, IDPs found refuge in the homes of friends and family; consequently, household sizes increased. In Malé, the average household size climbed from 8.0 to 8.1 persons, and in the atolls, it climbed from 6.1 to 6.2 persons.97 These changes may appear small, but in Maldives, the numbers of residents per household were high pre-event; any increase put great pressure on the host families. However, in some cases, there was simply not enough room in undamaged households to accommodate additional persons, and the IDPs either had to crowd into public buildings, such as schools, or construct their own makeshift shelters.

In addition to having been displaced from their homes, 12 000 Maldavians were displaced from their islands. This migration created increased demands for resources on the islands that received them.74 Mass migrations occurred all over the Maldives following the tsunami, with IDPs generally migrating either to other islands within their own atoll, or to Malé. Approximately 1000 people evacuated to Malé, where many of them found shelter in one of four schools being used as temporary housing.76 The IDPs arriving in Malé constituted a 1.4% increase in Malé’s population, which was about 70 000 before the tsunami. However, for other islands hosting IDPs, the arriving IDPs constituted a much greater proportion of the population increase and generated a considerable burden on local resources and infrastructure. In the Raa atoll, for example, the population of Hulhudhuffaaru Island doubled, and the population of Ugoofaaru more than doubled when the entire population of nearby Kanholhudhoo Island evacuated.120 Following the tsunami, Kanholhudhoo’s population of 2700 migrated primarily to islands within the same atoll including Hulhudhuffaaru, Ugoofaaru, and Alifushi.121 Similarly, approximately 1500 Maldivians from islands in the Meemu atoll evacuated to the atoll’s least affected island, Mulah, which doubled the island’s population.17 And, from Vilufushi Island in the Thaa Atoll, approximately 1000 people were evacuated to the nearby Guraaidhoo Island nearly doubling its population as well.37 Sudden increases in island populations quickly led to crowding and exceeded the capacity of the local infrastructure. This overcrowding created new communicable disease concerns.17

Tsunami damages were so great on some islands that some of the population redistribution in the islands produced long-lasting changes. Approximately one year after the tsunami, Kandholhudhoo Island remained uninhabited and many of the island’s former inhabitants continued to live on Hulhudhuffaaru and Ugoofaaru. More than one year after the tsunami, Hulhudhuffaaru Island had a population of 1516 compared with a pre-event population of 939, and Ugoofaaru Island had a population of 1516 compared with 2988 before the tsunami.121 Also like Kandholhudhoo, Gemendoo Island in the Dhaalu atoll, and Madifushi Island in the Meemu atoll remained abandoned, and Vilufushi Island in the
Thaa atoll remained almost entirely depopulated. More than one year after the tsunami, Vilufushi Island had a population of just 16 residents, compared to 1155 people before the tsunami. Germedoo and Madifushi Islands had populations of 322 and 122 residents, respectively, before the tsunami. Relief responses

In the first few weeks following the tsunami, governmental and humanitarian agencies sent tents to those islands that were impacted. These tents aimed to provide emergency shelter and to relieve host families and public facilities of the burden of sheltering IDPs. Additionally, the government relocated some of the IDPs in an attempt to free up public buildings and to settle IDPs on islands where relief efforts could better reach them. Many IDPs were relocated to Hulhumale Island, a reclaimed island close to Malé. Near the end of January 2005, the government sent 72 IDPs that had been living in the Majeediyya schoolhouse in Malé, and 120 IDPs from Guraidhoo to Hulhumale, thereby allowing the school to reopen for classes and easing the IDP burden on Guraidhoo.

Work on transitional shelters began early during the disaster, but the country had no previous experience in assisting large numbers of IDPs. Additionally, conditions in the initial transitional shelters were poor, providing only 2 m² of space/IDP. The IFRC offered to fund all of the building materials needed to provide transitional housing, but drew the government’s attention to the fact that the Sphere Standards indicate that the shelters must provide a minimum of 3.5 m²/IDP. However, following the first couple of months after the tsunami, the government improved its capacity to respond to the needs of the IDPs, it requested expert advice for supporting IDPs, and began to address shortfalls in the transitional shelters that had been provided.

In February, the National Disaster Management Centre created the Unit for the Management of Internally Displaced Persons within the Ministry of Gender. This unit assumed the responsibility for registering IDPs, and for providing technical advice on how to protect and assist IDPs. Also, at the request of the government, UN-OCHA led a mission to assess IDP conditions in the Maldives. From 25 February to 7 March, they found that the transitional shelters failed to meet the Sphere Standards and that IDPs were anxious because they had been provided with little information concerning their future. The government quickly responded to improve IDP conditions and received support from several international agencies. For example, UN-OCHA improved the conditions within IDP communities by establishing 15 IDP committees involving approximately 340 people from the IDP and host communities.

Recovery responses

Within one year of the tsunami, 46.3% of the IDPs were living in transitional shelters, 35% with host families, 18.3% in damaged houses, and 0.5% in tents. Transitional shelters fell into two general categories: rooms and apartments. Transitional apartments provided anywhere from one to two bedrooms. The building of transitional shelters continued beyond the first year until 396 rooms and 855 apartments had been completed on 27 islands in eight atolls. During the first year following the tsunami, the repair and rebuilding of damaged houses also had begun, but progress was slow. Approximately one year following the tsunami, none of the displaced tsunami survivors had been provided with new houses, and only 85 houses had been repaired. Due to extremely high transportation costs and tsunami-damaged infrastructure, building new homes in the Maldives was costly. In 2005, it was estimated that while an 85 m² house might cost US$ 5000 to US$ 6000 to build in Sri Lanka, a similar house would cost as much as US$ 28 000 to build in the Maldives. As of 2005, the homes planned for the IDPs in the Maldives were anticipated to cost US$ 19 500 each. But expansion of original house plans from two bedrooms to three, and increasing labour and material costs quickly drove reconstruction costs upward. By September 2006, it was estimated that the cost of rebuilding would cost...
US$ 30,000/house; and on some islands, as much as US$ 40,000 to US$ 45,000/house.128

Also, disagreements over who should receive housing assistance and where new houses should be built presented major stumbling blocks in the efforts to build new houses. On Kolhu Island, the British Red Cross halted a construction project to build 55 houses after long disputes delayed progress. While the British Red Cross was bound by a donor deadline to use the designated funds by 2007, by June 2006, the island community and the Maldivian government had failed to reach an agreement on beneficiary lists and on where the new houses should be built. As the disagreement continued, the cost of retaining the contractor who had been hired to rebuild houses on the island, ate away at the funding earmarked for the project.61,129

Although the tsunami destroyed just 1,847 houses, tsunami survivors required 2,980 new ones. Some IDPs permanently evacuated their islands regardless of whether they had a damaged or undamaged home to return to, and required new homes to be built for them. Although the tsunami initially damaged just 3,500 houses, the number of tsunami-damaged houses increased over time due to soil erosion. Engineers assessing damages following the tsunami found that in the weeks following the tsunami, the highly porous soil in some places had begun to sink, thus damaging houses and requiring some of these houses to be knocked down. Consequently, the number of houses requiring repair increased to 5,814.

The house rebuilding effort received strong support from the Red Cross movement and the UNDP, but the pace of building failed to meet expectations. Two years after the tsunami, only 1,103 houses had been repaired and 158 houses rebuilt.128 And three years following the tsunami, 2,255 houses had been repaired and 584 rebuilt.

By April 2007, the IFRC had completed building a total of 308 permanent houses out of the 1,485 it had committed to build. Of the remaining 1,177 that it had committed to build, 70% were under construction.130 And although the number of IDPs declined rapidly in the first few days and weeks following the tsunami, IDP numbers dropped slowly thereafter. One year after the tsunami, there were approximately 11,000 registered IDPs,124 and as of September 2007, nearly three years following the tsunami, the number of IDPs had dropped to 7,725.131

Development
No information relative to developments in the housing and shelter system as pertaining to the public health and medical care systems in the Maldives was found in extensive searches.

Food and Nutrition System
Pre-events
The Maldivian diet was sufficient in quantity and in protein, but was deficient in diversity and in fresh vegetables. Maldivians generally ate three meals/day consisting primarily of fish, rice, and a few vegetables. A typical Maldivian breakfast consisted of rotti and tuna. For lunch and dinner, Maldivians commonly ate a watery curry, rice, and clear fish soup. In addition to the three meals consumed each day, Maldivians typically also ate a morning and afternoon snack.132

While the Maldives were surrounded by fertile fishing grounds, the soil was poor for growing vegetables, grains, or legumes; there was heavy reliance on imports. Domestic food sources met only approximately 10% of the country’s food needs, requiring the country to import large quantities of food. For example, rice and flour are Maldivian staples, but have to be imported.72

Despite the heavy reliance on imported food, food security was not a major issue pre-event. In a one year period, approximately 7% of the population experienced some sort of food crisis. Seventy-nine percent of food crises, however, were due to lack of money rather than non-availability of food on the islands.

Between 1997 and 2004, malnutrition problems had declined considerably, but remained an important issue. A high proportion of children...
were malnourished (Table 6.10). Malnourishment appeared to have been caused by eating habits, the limited range of food available, and how often young children were being fed. While 31% of children <5 years of age were underweight, 22% were stunted, and 20% were wasted. Additionally, an estimated 22% of newborns were of low birth weight. 51% of women of childbearing age were anaemic, and 23% had a body mass below 18.5%. Fifty-six percent of pregnant women were anaemic.

National efforts to address malnutrition issues included programmes to administer vitamin A to children, de-worming programmes, and improvements in food access. The Maldives developed its first national comprehensive nutrition plan of action in 1997. Nutritional and food security issues also received support from outside humanitarian agencies. However, as with other societal systems, at least one important organizational figure was missing. The WFP had an office in the Maldives at one point, but it had closed it in 1989. Consequently, when the tsunami arrived, the WFP had no food delivery mechanism in place in the country.

Of the domestically produced foods, home gardens and fishing played an important role in supplying the population with fresh produce. Although agriculture was limited, on most of the islands, each house had a garden that provided an important source of food. And, of the approximately 122,200 metric tons of fish caught in the Maldives, approximately 29,800 metric tons (18%) were consumed locally.

**Damage**

Direct tsunami damages to food availability included damages to fishing boats and equipment and to crops and cropland. The tsunami severely damaged or destroyed 120 fishing vessels and partially damaged an additional 50. Additionally, fishermen lost fishing gear and equipment, and many of the jetties and harbours they depended on for access to islands were damaged.

On the land, the tsunami destroyed 30% of agricultural land and many home gardens including many banana, papaya, and chili farms. Approximately 2000 farms lost crops to the tsunami, and an additional 11,700 homesteads lost backyard plots and agricultural tools. Trees also fell victim to the tsunami; more than 700,000 fruit trees were damaged.

**Changes in functions**

The consumption of vegetables is said to have been reduced due to agricultural damages. Although sand deposits and erosion both contributed to degradation of cultivable land, the most detrimental impact of the tsunami on local agriculture was soil salination. However, rains following the tsunami generally washed salt out of porous island soils, particularly in the southern atolls. Interestingly, little damage or changes in function occurred in fishing.

**Relief responses**

Local communities were the first to meet the immediate food needs of the tsunami survivors, followed by the national government. The Maldivian military and the National Security Service, began food distribution to some islands as early as the evening of 26 December. Within days of the tsunami, the government had distributed free food to all of the impacted islands. The free food delivered came not only from government stores, but also from international humanitarian organizations, including WFP and UNICEF. Although WFP had no local offices in the Maldives, its responses were quick. Within 48 hours of the tsunami, WFP delivered 2000 metric tons of food including rice, vegetable oil, pulses, and sugar. Food aid arriving in Malé was distributed through government channels and transported to impacted islands by the National Security Service. In the initial aftermath of the tsunami, communities were provided with food irrespective of whether or not they had been directly impacted by the tsunami. In January, WFP conducted a needs assessment after which food distribution was limited to those found to be in need and vulnerable.
In February, the government and WFP launched a feeding programme targeting 41 000 people on 91 islands. In June, WFP had planned to end the programme, but at the government’s request, it continued donations, but reduced the number of people to whom food would be distributed from 41 000 to 20 000. By the end of 2005, the number of people receiving food through the programme dropped further to 13 000.

Limiting food donations to groups identified as having the greatest need proved challenging, particularly as food programme began reducing donations in the months following the tsunami. Families not identified as those most in need pressured island chiefs to distribute food donations evenly among island inhabitants rather than just to those families for which they had been intended.

While WFP focused primarily on providing sufficient quantities of food, UNICEF focused more on ensuring good nutrition, particularly among children. UNICEF activities included an infant and child feeding nutrition assessment conducted in September, and the provision of baby food to 6800 children <5 years of age. The survey found that rates of children being underweight or wasting were higher in non-IDP children than in IDP children.

Aside from preventing food shortages and malnutrition, relief activities also aimed to ensure food was not being contaminated. From 9–20 January 2005, WHO-SEARO conducted a food safety assessment that was used to facilitate improvements in the capacity to ensure food safety. Following the assessment, WHO-SEARO helped to improve food safety capacity. The Department of Public Health and Public Health Laboratory identified and procured food safety monitoring tools. WHO-SEARO also helped review and develop guidelines addressing food safety issues including the safe handling of fish.

These activities helped address concerns over the safe handling of food donations delivered to tsunami-impacted populations within the islands, and also helped develop the capacity to ensure food safety.

Recovery responses
Post-tsunami activities also sought to help local food systems recover from tsunami damages. The International Fund for Agricultural Development prepared a US$ 4.99 million programme to help restore the agricultural and fisheries sectors and improve food security. Of these funds, US$ 3.04 was to be used for the fisheries. The agricultural component of the programme targeted primarily poor farming households who had lost crops and farming equipment due to the tsunami. An estimated 5000 families benefitted from this programme. The bulk of the programme was to be financed by an International Fund for Agricultural Development (IFAD) loan of US$ 4.1 million. The remaining costs were financed through grants from IFAD and the Italian government, and by the government of the Maldives.

Development
No information relative to development in the food and nutrition system as pertaining to the public health and medical care systems in the Maldives was found in extensive searches.

Energy Supply System
Pre-events
As of 2004, all of the inhabited islands within the Maldives had at least some electricity generating capacity. However, on some islands, the generation capacity was limited or electricity was so expensive that a large number of inhabitants could afford only limited use. For example, on three of the islands, power was available for an average of less than six hours/day.

A number of organizations provided the Maldives with electricity; the largest supplier was a government-owned enterprise known as the State Electric Company Limited (STELCO). This agency served Malé and 25 larger outer islands. Islands not served by STELCO are served by Island Development Committees, cooperatives, NGOs, and/or small private companies. On resort islands, private resort operators provide their own electrical power. There was no ability to generate electricity through hydroelectric stations.
In addition, the Maldives did not have any native sources of fuel other than a few trees. Essentially all fuel had to be imported and was very expensive. Fuel reserves were minimal. All of the islands’ power is supplied by diesel-based generators. Due to transportation difficulties, and the fact that 100% of the energy needs of the Maldives relied on imports, providing energy was costly.

**Damage and changes in functions**

Damages to the energy societal functional systems included damages to everything from generators and power cables to street lights. The tsunami disrupted electricity supplies on 98 islands, and damaged 24 power houses, 104 generators, 652 street lights, 34 switchboards, 632 distribution boxes, and 121 kilometres of cables. Twenty-six islands lost electricity due to the tsunami. By 29 December, 14 islands still remained without any form of electricity. The damages to the Energy Supply System due to the tsunami were an estimated US$ 4.6 million.

**Relief responses**

The relief responses to energy needs following the tsunami focused primarily on providing generators to the hardest-hit islands and restoring damaged infrastructure. Generators were sent by many donors. The Japanese government provided 20 electrical generators which arrived in Malé on 31 December, the IFRC airlifted and installed 32 generators on various islands, and the British Navy sent a team of 10 people to assess generator damages and make generator repairs as needed.

Unfortunately, in the early phases of the disaster, transportation slowed the delivery of donated generators. In January, the Maldivian military noted that some of the donated generators could not be distributed to the islands where they were needed because there was a shortage of vessels small enough to access islands with harbours that could not accommodate large vessels.

**Recovery responses**

Restoration of energy infrastructure progressed quickly. By 5 January 2005, the State Electric Company reported that it had restored electricity to all but five of the islands that had lost power due to the tsunami.

**Development**

In addition to providing generators, some donors also introduced renewable energy technology. For example, the Canadian Red Cross supported a wind power project on Dhuvafaru Island in an effort to reduce dependency on imported energy.

**Public Works and Engineering System**

**Pre-events**

The Maldives faced several environmental issues prior to the tsunami, including the degradation of reefs, erosion, management of wastes, and low land elevation. The dredging of sand and gravel from reef flats was a common practice. Of the 198 inhabited islands, 88 suffered continual beach erosion. The average elevation of the islands was only 1.5 metres above sea level which made them vulnerable to rising sea levels, with the potential to completely cover some of the islands.

Waste was also a growing concern, particularly with the growth of tourism and consumerism. Before the tsunami, an estimated 50 000 cubic metres of mismanaged household waste were scattered among the islands. Formal waste management included the central landfill facility of Thilafushi, which served Malé, Vilingili, Hulhumale, and the resort and industrial islands. For the remaining atolls, there was no formal waste management system other than the Kuldhufushi and Hithadoo landfill sites. Solid waste management practices, including hospital waste management practices, were poor. With respect to healthcare waste management, poor awareness of the importance of healthcare waste management, under-funding, and a lack of management policies undermined proper healthcare waste management.

The country had a small paved road system that included 60 kms of road in Malé and 28 km of
road in the Laamu and Addu atolls. In addition, there were about 250 km of compacted coral, village roads, which were maintained by the Ministry of Construction and Public Works, and an unknown length of compacted coral village roads not maintained by the Ministry.

**Damage**

The harbours sustained the bulk of the damages, accounting for US$ 15.8 million out of the total US$ 24.45 million in damages to the Transportation and Logistics System (Table 6.12). The tsunami damaged a total of 19 200 metres of quay walls, sea walls, and breakwaters. It also damaged 1600 metres of jetties (36 jetties), 300 metres of causeway, 25 12-mile light beacons, 185 entrance markers, and 2-mile reef markers. The international airport near Malé and two regional airports also suffered damages.

When the tsunami waves mounted the Maldives islands, and then withdrew, sucking water back into the sea, they churned up massive quantities of waste material. Pieces of collapsed buildings, bits of boats, dumpsite waste, and other debris were sloshed over the islands and reefs until the waves had passed. The tsunami scattered an estimated 290 000 cubic metres of waste over the Maldives.

**Changes in Functions**

The scattered wastes that added an almost four-fold burden on the existing problem of waste in the country contained just about a bit of everything, from uprooted vegetation to bricks and asbestos to hazardous materials leached out of generators and dumpsites. Dumpsites all over the Maldives spilled refuse into the sea, and in some cases, the dumpsites were entirely washed out. Dumpsites on several islands including, HA. Filadhoo, M. Muli, M. Kolhuushi, Th. Vilufushi, Th. Guraidhoo, and K. Huraa, were completely washed into the sea. On Guraidhoo Island, the tsunami washed up the island’s beach side landfill, and carried garbage into neighbourhood streets.

In addition to the waste churned up by the tsunami, relief efforts had contributed some of its own waste. Plastic water bottles distributed throughout the islands generated a second wave of waste over the islands. An assessment team visiting Thilafushi Island in late January noted that vegetable oil containers and plastic water bottles littered the entire island. Some researchers speculate that poorly managed tsunami waste and increased construction work may have provided mosquitoes with more breeding habitat, and consequently, accelerated an increase in the spread of dengue.

**Relief responses**

After the tsunami, the Ministry of Environment and Construction was worried that survivors might encounter dangerous wastes released by the tsunami, and requested that the UNDAC conduct a rapid assessment of the environmental impacts of the tsunami. The UNDAC deployed its environmental unit, UNEP, which arrived on 28 December. Following an assessment of environmental damages, including an assessment of the Maldives’ waste disposal island, the UNEP worked with local environmental authorities to clean up hazardous wastes. The clean up effort targeted 100 islands and educated and trained 35 island officials on hazardous waste management.

Unfortunately, some of the relief responses contributed to hazardous waste problems. Early during the disaster, for example, the Ministry of Health distributed bleach (chlorine) to tsunami victims and disaster responders. Recipients applied the undiluted chemical to decaying organic matter, such as rotting fish and vegetation, as a means of reducing the odour of decay. Within the first week, the MoH depleted its stocks and ordered an additional eight metric tons through WHO.

Other agencies also assisted in the clean up efforts and to protect survivors from hazardous wastes. For example, WHO-SEARO provided the MoH and UNEP with drums for storing the hazardous waste and contracted a consulting group to assess healthcare waste management in healthcare facilities in Malé.
Recovery responses
A shelter reconstruction project funded by UNDP and the Australian and Canadian Red Cross, required that the project funds be used only to build shelters in areas cleared of hazardous waste. The Canadian Red Cross and Australian Red Cross initiated a waste management programme. To coordinate waste management efforts, the Ministry of Environment Energy and Water held an interagency meeting every two weeks. Agencies attending the meetings included the IFRC, UNEP, UNICEF, and UNDP.

Development
Between May and September 2005, workers employed in the healthcare system were sent to Bangalore, India to receive education and training on healthcare waste management. Agencies trained hospitals to better separate hazardous materials from non-hazardous materials and provided both hospitals and general waste management facilities with equipment needed to improve the handling of waste materials. Mechanisms for the appropriate disposal of the wastes related to relief activities, such as the disposal of plastic water bottles, could not be identified.

Social System
Pre-events
The Maldives has a homogenous society, sharing the same culture, language, and religion. The official language is Dhivehi, which is only spoken in the Maldives, but is related to the Sinhalese language spoken in Sri Lanka. The Maldives also has an official religion, Sunni Islam, to which the government requires all of its citizens adhere. Before the Maldives converted to Islam in 1153 AD, Buddhism was the predominant religion. Women in the Maldives faced a number of social and legal disadvantages. Cultural and social restrictions on women’s mobility generally limited their employment options to income earning opportunities that were close to home, such as farming. Women also participate in the country’s two largest industries, tourism and fishing. However, many jobs in the tourism industry require traveling away from home, and many tourism-related jobs are considered inappropriate for women. Only 4% of the employees of the tourist industry are women. Women who do work in the tourism industry generally are limited to lower level positions as cleaners, sweepers, and cooks. Participation of women in the fishing industry also was low; and those who did work in the industry usually processed the fish. In contrast, women’s participation in the agricultural sector is high. Women can own land in Maldives, but they generally have fewer assets than men.

Mental health professionals in the Maldives were scarce. There were only two psychiatrists, one was Maldivian, and one expatriate; both were in Malé working at the Indira Gandhi Memorial Hospital at the time of the events. Additionally, there was no legislation specific to regulating mental health care. Mental health care regulations were addressed only under the general health laws, which describe when a mental health patient should be considered dangerous—they do not address patient needs specific to mental health. There were no clear policies on the use of psychotropic medications that were available at the regional, atoll, and island tier hospitals. However, many chemist shops dispense psychotropic medications, and the government had a programme through which patients could receive the medications without charge.

Damage
As in other countries, there were more female than male fatalities associated with the tsunami—but the female: male ratio was closer than in the other counties (Table 6.11). While the disparity between male and female fatalities was slim, tsunami fatalities did take a disproportionate toll on the young and the old. Children, comprised 46% of the fatalities. And, while those aged 65 years and over accounted for just 3.1% of the population, they represented almost a fifth of the tsunami fatalities.
Changes in functions
Loss of loved ones, personal belongings, livelihoods and displacement left an estimated 6800 people severely traumatized in the wake of the tsunami.\textsuperscript{15}

Relief responses
Within two weeks of the tsunami, the government established a Psychological Unit within the National Disaster Management Centres to support programmes to assist those who suffered mental health problems due to the damage.\textsuperscript{128} In preparation for a community-based psychosocial support campaign, the Centre recruited individuals interested in providing psychosocial support to those affected by the tsunami, and included volunteers with counselling experience as well as inexperienced volunteers; volunteers were all Maldivians. Inexperienced volunteers received training, and all were assigned into Emotional Support Brigade teams. These teams travelled to the affected islands to provide support.\textsuperscript{152} The Red Cross and WHO-SEARO supported volunteer training and UNFPA and UNICEF helped to facilitate and fund travelling expenses.\textsuperscript{128}

Recovery responses
The government was quick to accept assistance from UN agencies to support its efforts to provide mental health services in the aftermath of the tsunami, but restricted access to affected areas allowing mostly Maldivian mental health responders who spoke the local language and understood cultural norms. Entry permits were given only to select agencies after careful screening,\textsuperscript{135} and the government expelled faith-based international NGOs, that distributed religious materials.\textsuperscript{122} After the tsunami, WHO estimated that 30% to 50% of those affected would need psychosocial/mental health support. But, by March, there had not been a qualitative and comprehensive assessment to accurately determine the mental health needs, and the government asked WHO-SEARO to help develop a psychosocial assessment process.\textsuperscript{128}

After the tsunami, it was clear, that the Maldives’ mental health services were insufficient to meet the needs of the populations, particularly, in the atolls. However, the government was reluctant to invest resources into training doctors in the atolls for the provision of mental health support, because nearly all of the public sector doctors working outside of Malé were expatriates.\textsuperscript{128} The American Red Cross established a programme through which it would provide psychosocial support to six atolls for three years.\textsuperscript{122}

Development
No information relative to development in the Social System as pertaining to the public health and medical care systems in the Maldives was found in extensive searches.

Transport and Logistics System
Pre-events
The Maldives is a chain of islands that stretches over 900 km of the Indian Ocean. Therefore, marine and air transportation was central to the transportation and logistics system.\textsuperscript{156} Of the 1190 islands, 198 were inhabited, and only 28 had a land mass larger than 1 km\textsuperscript{2}.\textsuperscript{74} The Maldives had an international airport located on an island near Malé; four regional airports were distributed throughout the country.\textsuperscript{4} The main port was in Malé, and there were 90 manmade harbours that provided access to the other islands. Islands that did not have manmade harbours relied on natural harbours or jetties and approach channels, and many lacked proper facilities to handle marine traffic.\textsuperscript{74} Additionally, some of the inhabited islands were separated by shallow water, and could not be accessed by large ships.\textsuperscript{157}

Inter-island transportation relied heavily on water vessels, particularly on dhonis. Water vessel transportation was important to atoll inhabitants, who often travel by boat to access many basic services. However, boat trips connecting the atoll populations to Malé and the capitals of the atoll were limited. In 2004, 36% of the atoll population lived on islands serviced by fewer than three dhoni trips to Malé/month; 26% of the atoll
population lived on islands that were serviced by fewer than three dhoni trips to their respective atoll capitals per month. The limited number of trips between atolls and islands, where social services could be accessed, may be explained, in part, by the limited number of water vessels available. In 2004, 43% of the population lived on islands with more than 100 people/water vessel. Additionally, although island accessibility had increased with improvements in jetties and harbours, many islands were accessible only for limited periods of the day or could only be accessed with small dhonis. In 2004, only 60% of the atoll population lived on islands that always were accessible during the day, and 70 inhabited islands that only could be accessed by small dhoni.

Transportation also was a limiting factor with respect to medical care, which offered access to only a few transportation resources. There were only seven ambulances in the Maldives; five of them located in Malé. There were no water ambulances to transport patients from health posts to atoll hospitals. The Maldives had an established airport emergency plan and practiced drills regularly.

**Damages**
The estimated damage to the public works and engineering system are summarized in Table 6.12. Although no specific information was identified that related to damages directly to the transportation and logistics system, it seems clear that the damage to the public works and engineering system severely impacted the transportation and logistics system.

**Changes in functions**
The international airport in Malé was closed following the tsunami until 6:00, 27 December 2004. After reopening, the airport could not immediately accommodate incoming night flights, since the tsunami had destroyed required navigational aids.

Large public health and medical-relief packages started arriving at the airport, such as those sent by the Red Cross, WHO-SEARO, and other UN agencies. The damage to harbours and jetties severely limited the ability of the Transport and Logistics System to deliver needed personnel and supplies and equipment. Large ships that would have been required to deliver the large relief packages were unable to navigate the shallow waters surrounding some of the country’s inhabited islands and were unable to dock. Supplies and equipment had to be broken down and repacked to fit onto small marine vessels. Materials had to be transferred to smaller boats to reach the islands (Figure 6.8). By the fifth day following the tsunami, aid shipments arriving at the international airport began to clog limited airport warehouse capacity.

**Relief responses**
Transportation in the immediate aftermath of the tsunami relied heavily on locals and private sector companies who used their private boats to help distribute provisions from islands that had surplus supplies to islands suffering shortages, and to evacuate people from affected islands.

From Malé to impacted atolls, the government relied on the National Security Service, the military, and coast guard to reach and report back from islands rapidly. Within two to three days, the coast guard had visited all of the inhabited islands. However, there were not enough coast guard vessels to meet distribution and transportation needs; and private vessels played an important role in transporting the goods needed and to move people who were stranded to other islands. The Bangladesh Armed Forces assisted with medical evacuations.

Due to the limited availability of transportation, the Ministry of Health requested that responding agencies limit visits only to those that were most essential. Five days following the tsunami, the government also made an urgent request asking relief agencies and others sending aid donations to provide manifests documenting what was being sent with aid donations. On 7 January 2005, UNICEF
sent a Rubb Hall warehouse tent to store incoming relief supplies. On 6 January 2005, in cooperation with OXFAM, Virgin Atlantic Airline flew a shipment of bottled water and equipment. HO-SEARO provided the Ministry of Health with two speed boats for transporting patients and medical supplies to and from remote islands and to monitor healthcare activities.

Recovery responses
No information could be found relative to the health aspects of the tsunami.

Development
By May 2005, the French Red Cross had donated two ambulances to support medical care services on the island of Gan in the Laamu atoll. The Brunswick Corporation donated five ambulance boats to the Ministry of Health to support regional hospitals across the atolls. The Ministry of Health received the boats in July 2006. Each of the twin-engine boats was assigned to a regional hospital and is worth US$ 330,000.

Security System
Pre-events
Although generally a peaceful country, on 12 and 13 August 2004 (just three months prior to the tsunami), civil unrest stirred in Malé with protestors demanding the release of a pro-reformist and the resignation of the President—the largest protest in the country’s history. On 13 August, the Maldivian National Security Service cracked down on the demonstration, using tear gas and batons to disperse protesters. No one was killed, but several demonstrators were severely injured, and for only the second time in its history, the President declared a state of emergency in Malé. The demonstrations were the result of reform activities that had begun in 2003.

Security in the Maldives was maintained by one unit. Until 2004, the Maldives army, air force, and coast guard were combined into one unit, known as the National Security Services (NSS). However, in mid-2004, the Maldives separated its police unit from the NSS in an effort to separate military and domestic law duties.

Damages
During November 2005, tensions between local Hulhudhuffaaru island residents and a group of tsunami IDPs relocated to the island erupted in violence.

Relief and recovery responses and development
By 19 July 2005, a Family Protection Unit had been established at IGMH. The Unit offered counselling services and support to improve health sector responsiveness to child abuse and gender-based violence. Additionally, UNFPA trained IGMH medical care personnel to recognize and appropriately respond to cases of abuse and violence.

Communications System
Pre-events
Communications infrastructure was difficult to maintain among the many rural islands. Only one telecommunications company, Dhiraagu, was operating in the country, and access to telecommunications was limited. As of 2002, there were just 10.2 telephone lines/100 population and 15 mobile phone subscribers/100 population. There were 7.1 computers/100 population, and 5.3 Internet users per 100 population.

In case of a disaster, the Maldives had no backup Communications Systems or designated information focal points. There was also no Humanitarian Information Centre (HIC). However, there were three emergency numbers available: 1-1-7 to reach police; 1-1-8 for fire and rescue; and 1-0-2 for IGMH ambulance services. The media exercised caution in criticizing the government, which had the power to close media outlets. Prior to the tsunami, all of the radio outlets in the country were publicly owned.

Damage
No information could be found relative to communications as applicable to the health aspects of the tsunami.
Changes in functions
In the immediate aftermath of the tsunami, communications among the islands were difficult with 188 islands could not be contacted for 11 hours following the tsunami. Although direct communications were restored to many atolls within the first 24 hours of the event, direct communications with three central atolls—Laamu, Thaa, and Dhaal—remained dysfunctional as of 28 December 2004 and, consequently, information about the damages and needs on 41 uninhabited islands was limited. As of 1 January, 29 islands remained without direct communication links; however, five of these islands had mobile phone service and some islands were only able to communicate using other indirect communication devices such as high frequency radios on fishing boats. The entire atoll of Laamu had no telephone communications for several days following the tsunami. In the year leading up to the tsunami, a Ministry of Health report published just months before the tsunami noted that a decline in either the fishing or tourism industries could result in major consequences for Maldivians’ standard of living.

Relief responses
In the immediate aftermath of the tsunami, islands with failed communications system relied on the Coast Guard, local fishermen, and commercial boats to relay information using high frequency radios. In addition, WHO-SEARO issued daily situation reports updating responders and the community on public health sector activities.

Recovery responses
No information could be found relative to communications as applicable to the recovery of the health aspects of the tsunami.

Development
No information could be found relative to communications as applicable to the development of the health aspects of the tsunami.

Economic System
Pre-events
Although the Maldives had a relatively high per capita GNP, the country depended on a very narrow economic base with heavy reliance on two sectors—tourism and fishing. Although significant economic progress was being made in the year leading up to the tsunami, a Ministry of Health report published just months before the tsunami noted that a decline in either the fishing or tourism industries could result in major consequences for Maldivians’ standard of living.

During 2004, tourism represented the largest industry, accounting for 32% of its gross domestic product (GDP) and more than 60% of its foreign exchange receipts. Additionally, the government received more than 90% of its tax revenue from import duties and tourism-related taxes. During the period 2000–2004, the fishing sector’s share of the GDP paled in comparison to the tourism sector, with an average of only 6.4% of the GDP. However, the fishing sector played an important role in the economy in terms of employment, livelihoods, and exports, and accounted for about 60% of Maldives exports and employed approximately 11% of the population.

Overall unemployment rates were 2% as of 2000, with higher unemployment rates in Malé, higher than in the Maldives as a whole. In Malé, the unemployment rate was 2.9% compared with 1.5% in the atolls. Between 1997 and 2004, the proportion of the population with an income of less than one dollar/day dropped from 3% to 1%. And, as of 2003, the annual per capita income was US$ 2400. Income statistics indicate that 50.8% of the income-earning population received less than US$ 42/month. Women and people living in rural areas were more likely to earn lower wages, with 69% of women and 54% of people in rural areas earning less than US$ 42/month.

Due to the dispersed population, which is spread out in at least 198 islands, delivery of social services are expensive and economies of scale difficult to attain.

From 1996 to 2002, the percentage of the government budget for healthcare decreased from 11.3% to 9.4%, but returned to 11.3% in 2004. In allocating 11.3% of its budget to healthcare in 2004, the government spent
approximately US$ 33 million on health. Estimates on how much of the government’s healthcare expenditure was spent on preventive health versus support and curative services were estimated by the Ministry of Health report was 37% had been spent on public health, 20% on medical care services, and 43% on support services.22

**Damage**

In proportion to the size of its economy, the Maldives suffered the greatest economic losses due to the tsunami. The tsunami caused $298 million in direct losses. Total losses, however, including indirect losses, such as wages, were an estimated US$ 470 million, or 62% of the GDP. In 2005, the economy contracted for the first time in recent history; after several years of strong growth, the Maldives posted a negative growth rate of 4.5%.172

Economic losses were particularly evident in the tourism and fishing sectors. Of the country’s 87 resorts, 21 closed due to tsunami damage and of these, five were badly damaged. The hotels sustained damage as well. A 2005 damage assessment indicated that of the 5042 beds out of operation after the tsunami, 1200 had been badly damaged and would not become operational before the end of 2005. Additionally, the assessment estimated that it would cost approximately US$ 100 million to rebuild damaged resorts.74 Relatively few boats and little fishing gear was lost due to the tsunami.97

**Changes in functions**

In the immediate aftermath of the tsunami, about one-third of the Maldives’ hotel, safari, and guesthouse beds were out of operation. During what would usually be the peak tourism season, arrivals dropped in the weeks following the tsunami. In the first 11 days of January 2005, there were 20,308 airport arrivals compared to the first 11 days of January 2004.74 Many resorts reduced staff due to lower occupancy rates after the tsunami. Resort staff who retained their jobs also felt the impact of lower occupancy rates, since a 10% service charge typically provided 50% of their income.74

**Relief responses**

Government spending on relief and recovery, resulted in a 35% increase in government expenditures in 2005. Tsunami relief programmes accounted for most of the expenditure, including US$ 12.48 million used to support the National Disaster Management Centre.166

**Recovery responses**

Following the tsunami and sharp decline in tourism arrivals, the Tourism Promotion Board and the private sector ramped up tourism marketing efforts in order to restore tourist arrivals to pre-tsunami levels. Additionally, the government undertook a tourism sector expansion programme, which included the leasing of 35 additional islands for resort development. Consequently, tourist arrivals had largely returned to pre-tsunami levels by the end of 2006.91

In the fishing sector, FAO trained 30 boat builders in the use of fiberglass reinforced plastics technology to boost recovery.111 By February, WHO had pledged US$ 5.8 million to meet urgent health needs in the Maldives as part of the UN Flash Appeal.91

**Development**

No information could be found relative to development as applicable to the health aspects of the tsunami.

**Educational System**

**Pre-events**

Primary education was available on all of the 199 inhabited islands.21 There were 5239 teachers, 62% of whom were nationals and 37% of whom were expatriates, largely from Sri Lanka and India.26 In the secondary schools, about three-quarters of the teachers were expatriates.21

Maldivians seeking an education in the healthcare profession either could go abroad or enroll in one of the healthcare programmes offered at
the Faculty of Health Sciences of the College of Higher Education in Malé. The college’s primary healthcare educational programmes included programmes for nurses, laboratory technicians, pharmacists, community health workers, family health workers, and trained birth attendants. Although the school had been expanding its healthcare programmes in the years prior to the tsunami, there was a shortage of qualified teachers, and consequently, the local demands for healthcare professionals could not be met.

Pre-tsunami, the capacity for human resources for health was limited, especially in terms of professionals.

**Damage**

In general, school buildings resisted the force of incoming tsunami waves better than did houses. The tsunami damaged 37% of the schools, including six that were destroyed; 63% of the schools were not damaged. In addition to damage to buildings, the educational system also lost materials and equipment such as text books, library books, school records, and computers. Students also lost materials. For example, on the 14 islands most affected by the tsunami, four out of five children lost books and/or uniforms.

Institutions of higher education were also damaged. A college on the Haa Dhaalu atoll island of Kulhudhufushi that provided education and training on several vocations, including nursing, suffered both structural damage and loss of supplies. Overall damages to the education sector were estimated to cost US$ 21.1 million to repair.

**Changes in function**

The tsunami delayed the beginning of the academic year by one month. And, when schools opened on 25 January 2005, only about 60% of the expatriate teachers reported to work. Additionally, the schools in Malé suffered overcrowding when displaced families from the atolls shifted to the most populous island.

**Relief responses**

To address setbacks in the educational system, the Ministry of Education established the Post-Tsunami Task Force in Education to collect information on damages and support relief efforts. Additionally, the government delayed the beginning of the school year from 9 January to 25 January. To make up for shortages of teaching staff, the Ministry deployed student teachers under training and engaged large schools in Malé in technical support activities for tsunami-impacted schools.

**Recovery responses**

Recovery of the educational system received support from several international sources. By 13 January, outside donors had committed approximately US$ 10 million as well as technical support. Major donors included the World Bank and UNICEF.

**Development**

No information could be found relative to development as applicable to the health aspects of the tsunami.

**Coordination and Control System**

**Pre-events**

The Maldives faced few natural hazards other than the threat posed by rising sea levels, and had done little to prepare for disasters that may result from natural events. The country had a national emergency plan, but it was out of date. The government had no policy, no legal or institutional framework, or disaster management expertise. Personnel had been trained to respond to small-scale events, including airplane crashes and oil spills, but not for large-scale disasters. Also, the Maldives did not have an Emergency Operation Centre, backup communications systems, designated information focal points, emergency shelters, or warehouses for storing emergency supplies. At one point, there was a Committee on Natural Disasters, but later it merged with the National Commission for Protection of the Environment. Consequently, it was understood that the Ministry of Home Affairs would take charge should a disaster occur.
There were also very few national or international NGOs in the country when the tsunami struck. It was difficult for NGOs to register in Male, since they were legislated under the same laws as opposition parties, and therefore, had difficulty raising money from outside sources. With just five organizations in the Maldives—the United Nations Development Programme (UNDP), the United Nations Children’s Fund (UNICEF), United Nations Population Fund (UNFPA), the World Health Organization (WHO), and the United Nations Volunteers (UNV)—the UN was the Maldives’ main development partner. There was no Red Cross/Crescent Society presence, no bilateral donor offices, only one INGO (a British charity known as Voluntary Services Overseas), and few national NGOs, although there was a wide range of community-based organizations.

Damage and changes in functions
With so little disaster preparedness and response capacity, the country was unprepared to respond to a large-scale disaster. Essentially, there was no specific agency designated to provide coordination and control. Thus, there were no tsunami-related damages or changes in function.

Relief responses
The Maldivian military, known as the National Security Service, played an important role in providing early relief, while the government scrambled to pull together ad hoc task forces and other mechanisms to fill the gaps in coordination. Within hours of the tsunami, the President organized the Ministerial Committee and Task Force, which was joined by the Ministry of Environment and Construction. In turn, the Task Force established the National Disaster Management Centre (NDMC) to facilitate and coordinate emergency relief and recovery responses. The NDMC addressed emergency relief work through several divisions including the National Disaster Relief Coordination Unit (NDRCU), National Economic Recovery and Reconstruction Programme (NERRP), and the Transportation and Logistics Unit.

Recovery responses
The NDRCU assumed responsibility for coordinating and providing temporary shelter, repairing damaged homes and social infrastructure, and providing general relief support. The NERRP planned and coordinated redevelopment programmes to support the country’s economic recovery and also assisted in the repair and reconstruction of damaged homes. Finally, the Transportation and Logistics Unit coordinated transportation and logistics recovery plans.

In addition to these three Disaster Management Centre divisions, the government also set up a trust fund to oversee the disbursement of donations and other funds designated for relief and recovery efforts. The government created the fund to increase transparency and ensure efficiency in the distribution of funds.

Early during the disaster, the government quickly recognized that it would not be able to handle the disaster on its own and opened its borders to a greater international presence. To facilitate the international response, the government waived customs and clearance fees on in-kind contributions made to assist in the relief and recovery efforts. The government also allowed international responders to establish new offices and expand old ones. Several UN agencies without offices in the Maldives established new offices, including the WFP, FAO, UNEP, and OCHA. In addition, some of the UN agencies that had offices in the Maldives when the tsunami struck expanded their offices. For example, UNDP increased its staff from 15 in 2004 to 80 in 2005, and also launched a Disaster Risk Management Programme to reduce the risk that a disaster will occur in the future, and to encourage sustainable development.

Development
Since the tsunami, the Maldives, with support from UNDP and other organizations, has done much to improve its capacity to respond to events/disasters. By June 2007, the Maldives had established a Project Steering Committee to work on a disaster management institutional framework.
and mechanisms, and had completed a proposed National Policy on Disaster Management. For managing disaster information, a disaster information and inventory management system and database was initiated. Also, a vulnerability and risk profile were completed in 2006, so that informed disaster policies could be developed. Efforts were also made to ensure that disaster response mechanisms could reach beyond Malé. In addition to establishing a National Operations Centre, five regional Emergency Operational Centers were also established. The Maldives also set about developing a national disaster plan, in addition to plans at the community level on 13 islands in two atolls. Finally, the Maldives established an Early Warning System.174

Medical care and public health disaster preparedness were also developed. A team of Maldivian doctors, nurses, and healthcare practitioners, including 14 senior healthcare workers from major hospitals, traveled to Singapore to participate in a six-day disaster management programme held in February 2005. It was organized by the National University of Singapore and John Hopkins University. The programme focused on teaching the basic principles of handling humanitarian and medical emergencies.175 Additionally, the government assembled a Disaster Health Working Group to develop an emergency medical care preparedness plan.176

Although disaster preparedness was poor in the country prior to the tsunami, information on tsunami-impacted areas generally was good due to a Ministry of Planning Vulnerability and Poverty Assessment that had been completed just months prior to the tsunami. In response to the tsunami, the Ministry conducted another vulnerability and poverty assessment from July–August 2005, called the Tsunami Impact Assessment.97 Like the Vulnerability and Poverty Assessment before it, the Post-tsunami Partial Assessment also focused on socio-economic issues. But, unlike the first two assessments, the Post-tsunami Assessment also included surveys of psychosocial and reproductive health issues.177

The Republic of Maldives, World Bank, Asian Development Bank, and United Nations also conducted an assessment following the tsunami titled Tsunami: Impact and Recovery, which aimed to provide a comprehensive overview of the tsunami’s impact and includes a brief overview of the tsunami’s impact on medical care.74

A regional meeting of countries in WHO’s South-East Asia Region was convened by WHO-SEARO in Bangkok, Thailand to discuss the health aspects of disaster preparedness and response.76 India’s Ministry of Health and Family Welfare participated in the development of 12 benchmarks (see Chapter 29 for details). Ten of the benchmarks relate to Coordination and Control. Each of the countries then defined where they were in relation to each of the benchmarks. The Maldives defined its current position relative to each of the benchmarks (Table 6.13). Only a few of these standards were in place at the time of the meeting.

Summary
The public health and medical care systems of the Maldives were well-developed before the tsunami. However, none of the basic societal systems were prepared for the events of 26 December 2004. The development of such systems was constrained by the geography, which placed many logistical barriers to development including the lack of natural resources. Much of the materials and personnel (including physicians, nurses/midwives, and school teachers) required full time had to be imported, and therefore, were expensive.

The tsunami had a very different character than it did when impacting the other countries. The waves were not very high but were more like a very sudden rise in the tide, many islands were completely washed over. Therefore, the tsunami was very destructive with little of the land mass left untouched. The number of persons injured and those killed was huge relative to the comparatively small population of the country.
The primary barrier to the delivery of relief and recovery responses were the logistics related to travel. Several outbreaks of diseases occurred following the tsunami, but were contained by the implementation of good public health measures. The tiered medical care system provided basic healthcare services to most of the population. Information obtained primarily was relative to this public care system and little was obtained relative to the services provided by the private sector. Routine healthcare services (primary care) were transiently impacted and injured and ill victims often had to be transported by boat to where the needed services were available (tourists generally sought care in the private sector).

Adequate sources of water suitable for drinking presented a progressive problem before the tsunami. Desalinating plants were provided as a partial solution, but for the most part were not maintained or operated full time (especially during the rainy season). No deaths due to dehydration were reported.

The need to leave their damaged/threatened homes required many to move to islands other than their residence. Initially, these migrants were welcomed, but in many instances outstayed their welcome, occasionally resulting in violence. The construction of temporary shelters often was delayed due to the logistics associated with obtaining the materials required. The provision of needed food was complicated by insensitivities to the culture.

The Maldives have little in the way of natural resources. Fuels required for generation of electricity and for the operation of desalinating plants had to be imported. Other than in Malé, roads were sparse, as were airports. The primary source of income was through fishing. Significant damage to the piers and jetties limited the ability to deliver needed supplies and equipment to the islands in need. Early in the disaster, essential supplies, such as water, were delivered by the military.

Initially, there was no single entity with the responsibility for the provision of Coordination and Control. Gradually, the government has taken actions and mandate for Coordination and Control, but has provided the necessary resources and authority that will be required to cope with the next events.

People interviewed:
Laila Ali, Maldives WHO-EHA focal point.
Clive Carpender, GWP consultants head of water resources and chief hydrologist

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References


159. WHO: Maldives country report to conference on the health aspects of the tsunami. WHO conference on the health aspects of the tsunami disaster in Asia. Phuket, Thailand. 4–6 May 2005


Other references


Figure 6.1: On the left, a satellite image of the Raa Atoll, one of the Maldives’ 26 natural atolls. The atolls commonly appear as a ring of islands. On right, a map of the Maldives. The country’s 26 natural atolls are divided into 20 administrative atolls and Malé, the capital city. The atolls have official geographic names as well as code names. This map lists atolls by their code names in black and atoll capitals in red. The central atolls, including Thaa Dhaalu, Meemu, Vaavu, Gaafu Alifu, and Laamu, were hit the hardest.

Map source: WHO Image source: http://www.oceandots.com/indian/maldives

Figure 6.2: The tsunami floods Kandholhudhoo Island in the Raa Atoll in this grainy picture copied from an amateur video filmed during the tsunami. The researchers have used the video to help them understand the nature of the tsunami’s arrival in the Maldives, and it has been widely posted on the Internet. The tsunami killed three people on Kandholhudhoo Island. Source: (Editor’s note: this image and the video it came from are all taken online and hence not able to be accredited.)


Figure 6.3: Maldivian fishermen retrieve an Indonesian hardwood tree that traveled more than 8000 km across the ocean. Photo: UNDP


Figure 6.4: Causes of death in the Maldives.

Figure 6.4: Causes of death in the Maldives. Source: http://www.who.int/chp/chronic_disease_report/media/impact/en/index.html

Figure 6.5: A dhani sits propped beside a mosque well. The dhani is used to manually draw water out of the ground, one bucket at a time. Photo: GWP Consultants http://www.who.org.mv/LinkFiles/Reports_MrCliveCarpenter.pdf.

Figure 6.6: A child wanders down a flooded street on Maatugroodhoo Island in the Shivani Atoll. On some of the most heavily flooded islands, standing seawater lingered for days saturating the ground with salt and contaminating groundwater tables. Source: Maldives National Disaster Management Center. http://www.tsunamimaldives.mv/

Figure 6.7: Maldivian soldiers load cases of bottled water onto a ferry leaving Malé for an isolated island. Source: Dhivehi Observer http://www.dhivehiobserver.com/tsunampictures/ (Note: cut line also the Dhivehi Observer's)

Figure 6.8: A UNICEF reverse osmosis unit is loaded onto a barge. Photo: UNICEF http://www.unicef.org/infobycountry/index_25681.html.
Table 6.1: Population, population densities, and length (km) of coastline of Maldivian islands that were among the hardest hit by the tsunami. Population estimates were based on the results of a 2000 census, which were reported in a 2006 census report. Population densities and length of coastline also were estimated using information from the same report.

<table>
<thead>
<tr>
<th>Atoll</th>
<th>Island</th>
<th>population</th>
<th>people/km²</th>
</tr>
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<tbody>
<tr>
<td>Shaviyani</td>
<td>Komandoo</td>
<td>1525</td>
<td>25 847</td>
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<tr>
<td>Raa</td>
<td>Kandholhudhoo</td>
<td>2717</td>
<td>24 237</td>
</tr>
<tr>
<td>Kaafu</td>
<td>Gulhi</td>
<td>623</td>
<td>12 460</td>
</tr>
<tr>
<td></td>
<td>Guraidhoo</td>
<td>1225</td>
<td>6731</td>
</tr>
<tr>
<td>Alif Dhaal</td>
<td>White Sand</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vaavu</td>
<td>Thinadhoo</td>
<td>114</td>
<td>1252</td>
</tr>
<tr>
<td>Meemu</td>
<td>Dhillgaru</td>
<td>876</td>
<td>12 016</td>
</tr>
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<td></td>
<td>Hakuraa Club</td>
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<td></td>
</tr>
<tr>
<td></td>
<td>Kolhufushi</td>
<td>936</td>
<td>1248</td>
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<td>Madifushi</td>
<td>122</td>
<td>1119</td>
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<td></td>
<td>Mulah</td>
<td>1200</td>
<td>2076</td>
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<td></td>
<td>Muli</td>
<td>787</td>
<td>2722</td>
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<td></td>
<td>Naalafushi</td>
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<td>3315</td>
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<td>Dhaalu</td>
<td>Gemendhoo</td>
<td>322</td>
<td>6851</td>
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<td></td>
<td>Rinbidhoo</td>
<td>420</td>
<td>2609</td>
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<td></td>
<td>Velaavaru</td>
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<td>Thaa</td>
<td>Vilufushi</td>
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<td>Dhanbidhoo</td>
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<td>1290</td>
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<td>Fonadhoo</td>
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<td>Mundoo</td>
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<td>Gaaf Dhaal</td>
<td>Vaadhoo</td>
<td>733</td>
<td>438</td>
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<td>Gnnaviyani</td>
<td>Fuahmulakhi</td>
<td>7528</td>
<td>1792</td>
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</table>
Table 6.2: Life expectancy in years, crude mortality rate/1 000 population/day, infant mortality rate/1 000 and maternal mortality rate per 100 000 live births.

<table>
<thead>
<tr>
<th>Population health indicators</th>
<th>Maldives</th>
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<tr>
<td></td>
<td>indicator</td>
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<td>Life expectancy</td>
<td>71</td>
</tr>
<tr>
<td>Crude mortality rate/day</td>
<td>3</td>
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<tr>
<td>Infant mortality rate</td>
<td>14</td>
</tr>
<tr>
<td>Maternal mortality rate</td>
<td>78</td>
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Sources: (1) Ministry of Health;22 and (2) Ministry of Planning and National Development.25

Table 6.3: Percent of one-year-old Maldivian children vaccinated in 2004. (DPT = diphtheria, pertussis, and tetanus; BCG = Bacillus Calmette Guerin)

<table>
<thead>
<tr>
<th>Vaccine</th>
<th>%</th>
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<tbody>
<tr>
<td>Measles</td>
<td>96</td>
</tr>
<tr>
<td>Three doses of DTP</td>
<td>97</td>
</tr>
<tr>
<td>Three doses of HepB</td>
<td>97</td>
</tr>
<tr>
<td>BCG</td>
<td>98</td>
</tr>
<tr>
<td>Polio</td>
<td>97</td>
</tr>
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Source: Ministry of Health21
<table>
<thead>
<tr>
<th>Disease incidence / 10 000 population</th>
<th>Maldives</th>
<th></th>
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<tbody>
<tr>
<td></td>
<td>Incidence</td>
<td>Year(source)</td>
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<tr>
<td><strong>Vector-borne</strong></td>
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</tr>
<tr>
<td>Malaria</td>
<td>0.00</td>
<td>2003(1)</td>
</tr>
<tr>
<td>Dengue</td>
<td>2.75</td>
<td>2004(4)</td>
</tr>
<tr>
<td>Scrub typhus</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Water-borne</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shigellosis</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cholera</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Typhoid fever</td>
<td>3.04</td>
<td>2003(1)</td>
</tr>
<tr>
<td>Leptospirosis</td>
<td>2.75</td>
<td>2004(4)</td>
</tr>
<tr>
<td>Hepatitis</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Direct contact</strong></td>
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<tr>
<td>Measles</td>
<td>2.80</td>
<td>2003(1)</td>
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<tr>
<td>Mumps</td>
<td>1.52</td>
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<tr>
<td>Tetanus</td>
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<tr>
<td>Pertussis</td>
<td>0.00</td>
<td>2004(3)</td>
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<tr>
<td>Diptheria</td>
<td>0.00</td>
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<tr>
<td>Tuberculosis</td>
<td>5.08</td>
<td>2004(2)</td>
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<tr>
<td><strong>Other</strong></td>
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<tr>
<td>Acute Respiratory Infections</td>
<td>1,955.9</td>
<td>2003(1)</td>
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<tr>
<td>Diarrhea</td>
<td>513.3</td>
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<tr>
<td>Enteric fever</td>
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<td>Viral fever</td>
<td>1,476.9</td>
<td>2003(1)</td>
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</tbody>
</table>

**Sources:** (1) Ministry of Health 2004 Health Report; (2) World Health Organization core health indicators; (3) World Health Organization EPI fact sheet; and (4) WHO Regional Office.
Table 6.5: The number of fatalities and persons missing by island and atoll. Atolls listed in order from northern-most atolls to southern most atolls.

<table>
<thead>
<tr>
<th>Atoll</th>
<th>Island</th>
<th>Fatalities and missing</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td><strong>total</strong></td>
</tr>
<tr>
<td>Haa Dhaal</td>
<td>Naivaadhoo</td>
<td>1</td>
</tr>
<tr>
<td>Shaviyani</td>
<td>Komandoo</td>
<td>1</td>
</tr>
<tr>
<td>Raa</td>
<td>Kandholhudhoo</td>
<td>3</td>
</tr>
<tr>
<td>Kaafu</td>
<td>Gulhi</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Guraidhoo</td>
<td>4</td>
</tr>
<tr>
<td>Alif Dhaal</td>
<td>White Sand</td>
<td>1</td>
</tr>
<tr>
<td>Vaavu</td>
<td>Thinaadhoo</td>
<td>1</td>
</tr>
<tr>
<td>Meemu</td>
<td>Dhiigguru</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Hakuraa Club</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Kolhufushi</td>
<td>16</td>
</tr>
<tr>
<td></td>
<td>Madifushi</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Maduuvari</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>Mulah</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Muli</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>Naalafushi</td>
<td>1</td>
</tr>
<tr>
<td>Dhaalu</td>
<td>Gemendhoo</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td>Rinbidhoo</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Vaanee</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Velaavaru</td>
<td>2</td>
</tr>
<tr>
<td>Thaa</td>
<td>Vilufushi</td>
<td>18</td>
</tr>
<tr>
<td></td>
<td>Madifushi</td>
<td>1</td>
</tr>
<tr>
<td>Laamu</td>
<td>Dhanbidhoo</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Fonadhoo</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Isdhoo</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>Kalhaadhoo</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Maabaidhoo</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Mundoo</td>
<td>7</td>
</tr>
<tr>
<td>Gaaf Alif</td>
<td>Dhaandhoo</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Villingili</td>
<td>1</td>
</tr>
<tr>
<td>Gaaf Dhaal</td>
<td>Vaadhoo</td>
<td>2</td>
</tr>
<tr>
<td>Gnaviyani</td>
<td>Fuahmulakh</td>
<td>1</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td><strong>108</strong></td>
</tr>
</tbody>
</table>

Source: Maldives Disaster Management Centres.34
Table 6.6: Injuries reported among the survivors in the Maldives after the tsunami

<table>
<thead>
<tr>
<th>Nature of injury</th>
<th>cases</th>
<th>% of total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minor injuries</td>
<td>269</td>
<td>33.67</td>
</tr>
<tr>
<td>Other</td>
<td>186</td>
<td>23.28</td>
</tr>
<tr>
<td>Cut injuries</td>
<td>165</td>
<td>20.65</td>
</tr>
<tr>
<td>Other muscular skeletal injuries</td>
<td>80</td>
<td>10.01</td>
</tr>
<tr>
<td>Aches and pains</td>
<td>52</td>
<td>6.51</td>
</tr>
<tr>
<td>Fracture</td>
<td>31</td>
<td>3.88</td>
</tr>
<tr>
<td>Near drowning</td>
<td>9</td>
<td>1.13</td>
</tr>
<tr>
<td>Head injury</td>
<td>7</td>
<td>0.88</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>799</td>
<td>100.00</td>
</tr>
</tbody>
</table>

Table 6.7: The five-tier public healthcare facilities in the Maldives before the tsunami
(IGMH = Inira Gandhi Memorial hospital; n = number)

<table>
<thead>
<tr>
<th>Tier level</th>
<th>Facility</th>
<th>Facility description</th>
<th>n</th>
</tr>
</thead>
<tbody>
<tr>
<td>5th Central</td>
<td>IGMH</td>
<td>General and specialty services. Also, served as tertiary referral hospital. Located on Malé.</td>
<td>1</td>
</tr>
<tr>
<td>4th Regional</td>
<td>Regional Hospitals</td>
<td>Secondary-level medical care services and public health services. Located on six atolls.</td>
<td>6</td>
</tr>
<tr>
<td>3rd Atoll</td>
<td>Atoll Hospitals</td>
<td>Basic laboratory and operating facilities with gynecological and obstetric services. Located on 10 atolls.</td>
<td>10</td>
</tr>
<tr>
<td>2nd Atoll</td>
<td>Atoll Health Centers</td>
<td>Basic healthcare and maternity services. Services provided by physicians and community health workers. Located in all administrative atolls.</td>
<td>65</td>
</tr>
<tr>
<td>1st Island</td>
<td>Island Health Posts</td>
<td>Family health worker and traditional birth attendant services. Located in island offices.</td>
<td>52</td>
</tr>
<tr>
<td></td>
<td>Family Health Sections</td>
<td>Family health worker and traditional birth attendant services? Located in island offices.</td>
<td>?</td>
</tr>
</tbody>
</table>
Table 6.8: Numbers of expatriate (Exp) and local healthcare workers by public and private sectors in 2003

<table>
<thead>
<tr>
<th>Type of Healthcare worker</th>
<th>Public</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Exp</td>
<td>Local</td>
<td>Exp</td>
<td>Local</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Doctors</td>
<td>223</td>
<td>54</td>
<td>27</td>
<td>11</td>
<td>315</td>
<td></td>
</tr>
<tr>
<td>Nurses</td>
<td>260</td>
<td>479</td>
<td>38</td>
<td>8</td>
<td>378</td>
<td></td>
</tr>
<tr>
<td>Community healthcare workers</td>
<td>0</td>
<td>119</td>
<td>0</td>
<td>0</td>
<td>119</td>
<td></td>
</tr>
<tr>
<td>Family health workers</td>
<td>0</td>
<td>333</td>
<td>0</td>
<td>0</td>
<td>333</td>
<td></td>
</tr>
<tr>
<td>Traditional birth attendants</td>
<td>0</td>
<td>409</td>
<td>0</td>
<td>0</td>
<td>409</td>
<td></td>
</tr>
<tr>
<td>Paramedics</td>
<td>454</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dental health workers</td>
<td>1</td>
<td>7</td>
<td>5</td>
<td>0</td>
<td>13</td>
<td></td>
</tr>
<tr>
<td>Pharmacists</td>
<td>0</td>
<td>0</td>
<td>174</td>
<td>74</td>
<td>248</td>
<td></td>
</tr>
</tbody>
</table>

Table 6.9: Healthcare personnel and hospital beds available/10 000 population and skilled birth attendance by percent. (n = number; yr = year)

<table>
<thead>
<tr>
<th>Medical care Indicators</th>
<th>Maldives</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n/10 000 population</td>
</tr>
<tr>
<td>Physicians</td>
<td>9.2</td>
</tr>
<tr>
<td>Nurses</td>
<td>27</td>
</tr>
<tr>
<td>Midwives</td>
<td></td>
</tr>
<tr>
<td>Dentists</td>
<td>0.4</td>
</tr>
<tr>
<td>Lab technicians</td>
<td>5.1</td>
</tr>
<tr>
<td>Health workers</td>
<td></td>
</tr>
<tr>
<td>Hospital beds</td>
<td>26.2</td>
</tr>
<tr>
<td>Births attended by skilled personnel</td>
<td>70%</td>
</tr>
</tbody>
</table>

Sources: WHO,67(2) WHO Core health indicators,68 (3) Ministry of Planning and National Development Statistics. Maldives—key indicators 2006;69 and (4) WHO 2006 World Health Report.70,71
Table 6.10: Nutritional status in the Maldives prior to the tsunami.

<table>
<thead>
<tr>
<th>Nutritional status indicator</th>
<th>Maldives</th>
<th>Year (source)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stunted children &lt;5 years old</td>
<td>22%</td>
<td>2004 (1)</td>
</tr>
<tr>
<td>Underweight children &lt;5 years old</td>
<td>31%</td>
<td>2004 (1)</td>
</tr>
<tr>
<td>Wasted Children &lt;5 years old</td>
<td>20%</td>
<td>2004 (1)</td>
</tr>
<tr>
<td>Low birth weight newborns</td>
<td>22%</td>
<td>2001 (2)</td>
</tr>
<tr>
<td>Pregnant women with anemia</td>
<td>56%</td>
<td>2001 (3)</td>
</tr>
<tr>
<td>Protein supply in grams/day</td>
<td>113.1</td>
<td>2000 (4)</td>
</tr>
<tr>
<td>Fat supply in grams/day</td>
<td>65.8</td>
<td>2000 (4)</td>
</tr>
<tr>
<td>Energy supply in calories/day</td>
<td>2,592</td>
<td>2000 (4)</td>
</tr>
<tr>
<td>Calories from cereal</td>
<td>40%</td>
<td>2000 (4)</td>
</tr>
</tbody>
</table>

Sources: (1) Ministry of Planning and National Development; (2) WHO/UNICEF; (3) Ministry of Health; (4) SEARO nutritional profiles.

Table 6.11: Deceased and missing persons in the Maldives following the tsunami.

<table>
<thead>
<tr>
<th></th>
<th>Children</th>
<th>Adults</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Deceased</td>
<td>Missing</td>
<td>Deceased</td>
<td>Missing</td>
</tr>
<tr>
<td>Male</td>
<td>17</td>
<td>7</td>
<td>22</td>
<td>1</td>
</tr>
<tr>
<td>Female</td>
<td>21</td>
<td>12</td>
<td>22</td>
<td>6</td>
</tr>
<tr>
<td>Total</td>
<td>38</td>
<td>19</td>
<td>44</td>
<td>7</td>
</tr>
</tbody>
</table>

Source: National Disaster Management Center.

Table 6.12: Estimated costs of transportation sector damages in US$ million.

<table>
<thead>
<tr>
<th></th>
<th>US$ millions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jetties</td>
<td>0.20</td>
</tr>
<tr>
<td>Harbors</td>
<td>15.80</td>
</tr>
<tr>
<td>Dredging</td>
<td>2.05</td>
</tr>
<tr>
<td>Marine navigational aids</td>
<td>0.50</td>
</tr>
<tr>
<td>Causeways</td>
<td>1.70</td>
</tr>
<tr>
<td>Malé Commercial Harbor</td>
<td>0.27</td>
</tr>
<tr>
<td>Malé International airport</td>
<td>3.93</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>24.45</strong></td>
</tr>
<tr>
<td>Benchmark Number</td>
<td>Benchmark</td>
</tr>
<tr>
<td>------------------</td>
<td>---------------------------------------------------------------------------</td>
</tr>
<tr>
<td>1</td>
<td>Legal framework and functioning mechanism and organizational structure in place for health EPH at all levels involving stakeholders</td>
</tr>
<tr>
<td>2</td>
<td>Regularly updated disaster preparedness and emergency management plan for health sector and SOPs (emergency directory, national coordination focal point) in place. It must include: (1) standard operating procedures; (2) memoranda of understanding; (3) mechanisms for coordination and control; (4) responses; and (5) all-hazards and a hazard-specific approaches.</td>
</tr>
<tr>
<td>3</td>
<td>Countries have a line item in their budget and system to assure financial resources are accessible to meet the immediate needs in case of a catastrophic event. Essential personnel, equipment, and supplies also are available in quantities necessary to cope with the damage created by an event for which it is at risk. Accounting procedures for the use of such resources are in place. Emergency financial (including national budget), physical, and regular human resource allocation and accountability procedures have been established.</td>
</tr>
<tr>
<td>4</td>
<td>Rules of engagement exist for the management of external actors.</td>
</tr>
<tr>
<td>5</td>
<td>Capacity to identify risks and assess vulnerability levels has been established. Appropriate measures have been implemented to reduce the vulnerabilities.</td>
</tr>
<tr>
<td>6</td>
<td>Community-based response and preparedness capacities have been developed, and are supported with training and regular simulations and/or mock trials.</td>
</tr>
<tr>
<td>7</td>
<td>Local capacity for emergency provision of essential services and supplies (shelters, safe drinking water, food, communication) is developed.</td>
</tr>
<tr>
<td>8</td>
<td>Advocacy and awareness have been developed through education, information management, and communication (pre-, during-, and post-event).</td>
</tr>
<tr>
<td>9</td>
<td>A community plan for mitigation, preparedness, and response that is based on risk identification and participatory vulnerability assessments, and backed by a higher level of capacity has been developed.</td>
</tr>
<tr>
<td>10</td>
<td>Human resources capabilities are updated and maintained continuously. Appropriate programs to educate and train people to cope with events and disasters have been implemented. Adequate numbers of people are being trained, and trained experts are on-call in case of a disaster</td>
</tr>
<tr>
<td>11</td>
<td>Health facilities are built/modified to withstand expected risks and to be able to continue to provide the required medical care during events and disasters.</td>
</tr>
<tr>
<td>12</td>
<td>Early warning and surveillance systems for identifying health concerns are established.</td>
</tr>
</tbody>
</table>
Part III

Country Reports

Chapter 7

Sri Lanka
Events

Sriyani de Silva was up early, shopping at a market near the sea in the south Sri Lankan city of Matara. It was a holiday weekend, and Sriyani’s visiting daughter, son-in-law, nine-year-old grandson, and husband were waiting for her at home. After shopping, she walked home, down a coastal road. Just as she returned home, her daughter began shouting that water was gushing through holes in the house’s parapet wall. Sriyani heard a loud bang and momentarily thought a bowser must be outside cleaning the drains; but when she looked toward the sea through the house’s glass sliding doors, she saw a wall of water rushing towards her. Before she had a chance to react, the wall of water crashed through the glass sliding doors and pushed her into the courtyard. The water continued to surge for five to ten minutes while she clung to furniture that had been pushed into the courtyard in an effort to keep her head above water.

When the water subsided, Sriyani was relieved to find all of her family members had survived unharmed. About 10 minutes after the water had subsided, Sriyani’s daughter noticed another wall of water on the horizon; everyone ran into the courtyard and braced themselves for the second wave, which was even more powerful and higher than the first wave. The de Silva family again survived unharmed, but their alarm had grown. Moments after the second wave withdrew, neighbours yelled to Sriyani and her family to join them in the second floor of their two-storey house. The family carefully navigated the debris between the two houses; and just as they had climbed the stairs to the second floor of their neighbour’s house, a third wave arrived. The third wave was more powerful still, and Sriyani and her family watched from the second story of their neighbour’s house as bodies, cars, and debris swept past. While the two-storey house kept de Silva family safely out of reach of the third and final wave, other people in the neighbourhood were less fortunate. In a Roman Catholic church in front of de Silva house, 25 people lost their lives. The church had been holding Sunday morning mass when the tsunami struck, dragging a car in with it.

On the morning of the tsunami, Christians were not the only Sri Lankans who gathered in worship. In addition to being a day when Christians traditionally gather for mass, 26 December also was Unduvap Poya Day—a day when many of Sri Lanka’s largely Buddhist population set aside worldly pursuits and gather around temples to worship. The tsunami devastated many countries on the morning of 26 December, but the international community first recognized the tsunami’s awesome path of destruction in Sri Lanka. When the day began, however, there was little evidence the day would pass any differently than any other.
At 07:00 hours (h), 10 minutes after sunrise, and about two hours before the arrival of the first tsunami waves, seismic waves from the Sumatra-Andaman earthquake sent tremors through Sri Lanka. The tremors represented the first in a chain of events that would bring disaster to Sri Lanka, but failed to alert many Sri Lankans of the impending disaster. By the time the seismic waves had travelled 1700 kilometers from the earthquake’s epicentre to Sri Lanka, they had weakened considerably, and few Sri Lankans felt them (Figure 7.1).\(^1\)\(^2\) Even if earthquake shaking had been considerably stronger in Sri Lanka, it is doubtful that anyone there would have anticipated the subsequent tsunami.

Tsunamis are a rare occurrence in Sri Lanka; before 26 December, Sri Lankans had no living memory of tsunamis in their country.\(^3\)\(^*\) Consequently, they failed to recognize the signs of the approaching tsunami, and were mystified by the sea’s strange behaviour. Along most coasts, witnesses would observe two distinct tsunami waves; the first was believed to have been about one metre tall and, for the most part, did little damage; about 10–15 minutes later, this wave was followed by a second and much larger wave.\(^4\) However, before the second tsunami wave heaved its bulk against Sri Lanka’s coasts, the sea shrank away from beaches, exposing reefs and leaving fish flopping along the exposed seafloor.\(^5\) Many of the tourists and Sri Lankans who failed to flee while the sea withdrew, were caught helpless when the sea turbulently returned to the exposed seafloor and beyond.

Before the Sumatra-Andaman earthquake had even finished rupturing, seismic waves from the earthquake traveled 1700 kilometers northwest to Sri Lanka, arriving just four minutes after the onset of the rupture. Although the earthquake passed through Sri Lanka largely unnoticed, 15 Sri Lankans responding to a USGS survey reported having felt some shaking. The Sri Lankan responses to the survey were rated according to the Mercalli Intensity Scale used to assess earthquake intensity on a scale of I to X, with I indicating no shaking was felt and X indicating extreme shaking and damage. Of the 15 Sri Lankan respondents who experienced shaking, 14 indicated very weak shaking for a score of II on the scale and one indicated having felt weak shaking for a score of III on the scale.

The tsunami’s impact along Sri Lankan coasts was not uniform. The eastern and southern coasts were in the direct path of the tsunami, and along with the northern coast, were exposed to the largest tsunami waves. It is along these shores that the highest run-up heights were measured, including a run-up height of 12.5 metres in the southern district of Hambantota.\(^5\)\(^**\) But, as the tsunami rushed through the Indian Ocean and past Sri Lanka, it wrapped around the island also exposing the west coast to its waves.

In addition to the two to three tsunami waves witnessed in Sri Lanka between about 09:00 and 09:30 hours, witnesses in the districts of Kalutara and Galle reported yet another tsunami wave that arrived hours later. The later wave is reported to have arrived at about noon and was several metres high. This late arriving wave is believed to have been deflected off India or the Maldives after the tsunami had passed Sri Lanka.\(^6\)

Although run-up heights of more than 10 metres were measured in the aftermath of the tsunami, such measurements were uncommon and other means of measuring the tsunami resulted in more modest results (Figure 7.2). The same study that measured a tsunami run-up height of 12.5 metres

\(^*\)More on earthquake shaking can be found in the Earthquake Shaking in Sri Lanka text box found in this section.

\(^**\)Although a mythological story suggests a devastating tsunami may have occurred in Sri Lanka about 2075 years ago, modern-day Sri Lankans have had no experience with tsunamis.

\(^*\)Although run-ups were a popular measuring method for the tsunami, in many cases, run-ups exaggerate the overall level to which tsunami waters rose. Run-up measures the vertical elevation of the land at the very last inland point that the water reaches, which may be quite high in areas where coastal topography is steep and the force of the wave may “splash” upward against hills or cliffs.
in Sri Lanka, measured a maximum tsunami elevation height of only 8.7 metres.\(^5\) While still impressive, it was nearly four metres short of the reported maximum tsunami run up.\(^7\)**

Inundation was limited to a narrow strip of coast no wider than 500 metres. In a few unusual cases, however, key geographic features facilitated much greater inundation.\(^8\) For example, west of Yala in the district of Hambantota, shoreline orientation, offshore topography, and other factors allowed the tsunami to reach as far as 2 km inland (Figure 7.3).\(^4\) Moreover, natural features also can limit a tsunami’s reach and impact. Areas protected by sand dunes, mangroves and other natural barriers, were almost entirely shielded from the impact of the tsunami.\(^5\)

Unfortunately, most people in the tsunami-impacted areas of Sri Lanka lived along developed shorelines that did not benefit from the protection of mangroves or dunes. Consequently, the tsunami uprooted many lives. De Sriyani and her husband lost the Matara home they had built and lived in for 30 years. In the initial aftermath of the tsunami, some 800000 people were believed to have been displaced, and at least 35000 Sri Lankans died.

**Population impacted**

Before the tsunami, 11 million of the 19.4 million population (57%) lived in one of the 14 coastal districts.\(^9\) Sri Lanka had a population density of approximately 310 people/km\(^2\), with densities ranging from 3305 people/km\(^2\) in Colombo to fewer than 100 people/km\(^2\) in the districts of Vavuniya, Mullaitivu and Moneragala, and Mannar (Table 7.1).\(^10,11\)

Of the areas impacted by the tsunami, Colombo was the most densely populated. However, the impact of the tsunami was minimal in Colombo compared to districts further south, to the east, and in the north-east. The coastal region hardest hit by the tsunami extended from the Galle district in the south to the Jaffna district in the north. Within this stretch of coastline, the most densely populated areas included coastal areas within the districts of Galle and Matara in the south, Ampara and Batticaloa to the east, and also coastal areas in Jaffna (Figure 7.4).

**Public (population, preventive) health system**

**Pre-event**

Compared with its neighbours, Sri Lanka’s public health system had achieved high standards. In spite of scarce resources, innovative public health schemes, strong support of key public health programme, an impressive midwifery workforce, adoption of an essential drug list, and a strong immunization program will improve life expectancy and reduced vaccine-preventable diseases.\(^12\) Fewer people died in Sri Lanka from communicable diseases and nutritional and reproductive health issues than in India, Indonesia, Thailand, or the Maldives. Sri Lanka also exhibited among the best population health indicators with respect to longevity and reproductive health. Life expectancy in Sri Lanka was 73 years, higher than that in Indonesia, India, Thailand, and the Maldives (Table 7.2).\(^13\)

And, with a maternal mortality rate of 47 deaths/100000 births,\(^14\) only Thailand had a lower maternal mortality rate (24 deaths/100000 live births). For decades, Sri Lanka had focused on institutional deliveries and skilled birth attendants, thereby contributing to the relatively low maternal mortality rate in the country.

Additionally, Sri Lanka had considerably reduced its population’s vulnerability to several important communicable diseases. Its annual immunization programme provided excellent coverage rates.

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\(^5\) Tsunami elevation measures the height of the wave above sea level. To measure tsunami elevations, researchers often use mud lines on houses and debris left in trees. See Chapter 3 for more on tsunami measuring methods.

\(^7\) Additional measurements can be found in a Korean report that gathered 108 measurements obtained by various research teams. Most of the measurements were run-ups and the highest run-up cited in that report was 10.87 metres.
In 2004, vaccine coverage for measles, DPT3, BCG, and polio was 96% or higher, and coverage with BCG had reached 99%. High immunization coverage and other prevention efforts had resulted in a downward trend of vaccine-preventable communicable diseases. The last time Sri Lanka reported a case of polio was in 1993; the number of measles cases declined from nearly 13000 in 1984 to 86 in 2004, the number of tetanus cases declined from 1243 in 1980 to 49 in 2004; and the incidence of whooping cough declined from 542 cases in 1980 to 45 in 2004. Although Sri Lanka had shown progress with regard to control of a number of important communicable diseases before the tsunami, some diseases continued to be problematic. Just months before the tsunami, the incidence of dengue surged and infected a record number of people. Outbreaks of dengue had occurred on and off ever since the first case had been detected in 1965. Although the outbreaks grew larger with time, before 2000, no outbreak had infected more than 1700 people. However, in 2004, the incidence of dengue reached a new high, infecting more than 15000 people, and killing 88.

In 2004, Sri Lanka was also struggling to rid its population of another mosquito-borne disease, malaria. Although the incidence of malaria had declined from a peak of nearly 300000 in 1999 to a low of 3700 reported cases in 2004, Sri Lanka’s long history with the disease proved that malaria could bounce back from near-eradication with a vengeance. Although DDT programmes had nearly eradicated the disease in 1963, DDT-resistance in the vector mosquito allowed malaria to re-emerge, infecting a record number of nearly 400000 people in 1992.

The principle malaria vector in Sri Lanka was *Anopheles culicifacies*, which breeds in freshwater, as does Sri Lanka’s principal vector for the spread of dengue, *Aedes aegypti*. The *Anopheles sundaicus*, infamous brackish water breeding malaria vector found in Indonesia and the Andaman and Nicobar Islands of India, did not live in Sri Lanka. The peak transmission season for malaria in Sri Lanka was from December to February, while peak transmission season for dengue was in May. Also high on the list of commonly reported diseases in 2004, was shigellosis, sometimes referred to as bacillary dysentery. In 2004, Sri Lanka had an incidence of 5.24 shigellosis cases for every 10000 people.

Sri Lanka had a long-standing and well-established surveillance system. The Epidemiology Unit of the Ministry of Health (MoH), which served as the surveillance system’s central agency, generally was well-staffed, and the laws supporting communicable disease control dated back more than a century. Sri Lanka’s Quarantine and Prevention of Diseases Ordinance, which had been implemented since 1897, required medical care workers to report diseases listed as “notifiable”. Hospitals and the medical officer of health were required to keep notification registers and the medical officer of health was required to send a communicable disease report to the Epidemiology Unit weekly. Although overall, Sri Lanka had a strong surveillance system, a number of key weaknesses in the system prevented optimal surveillance. For example, infected patients who do not become sick enough to be admitted to a hospital easily could go undetected, since the surveillance system did not capture morbidity data on outpatients, and there was no planned routine case-detection system. Additionally, although both the government and private hospitals were required to report notifiable diseases, cooperation was often poor in the private sector.

The effective delivery of public health services in Sri Lanka has been hailed as a model for other developing countries. The achievements in the health system as well as the health indicators occurred despite the fact that the country’s GDP was not high. Sri Lanka provided preventive healthcare services through 276 medical officers of health offices, also known as “Health Units”. Each office was staffed by a Medical Officer of Health. Along with Medical Officers of Health,
public health services were also supported by regional epidemiologists, public health nurses, public health inspectors, and public health midwives (also known as “family health workers”). Within the public health system, mother and child healthcare services were also supported by Gramodhaya Health Centres, also known as “Village Health Centres”.

Although Sri Lanka’s public health system had achieved a great deal for a country that, until 2004, had a per capita GDP of <US $1000, its good health and strong public health services were not equally distributed. In the northern and eastern districts, where the population had been living under 20 years of conflict, the key population health indicators lagged behind national averages. For example, in 2000, the north-east provinces were estimated to have a maternal mortality rate of 810/100000 live births, with the districts of Kilinochchi, Mullaitivu and Batticaloa reporting the highest rates.21,22 Unfortunately, the degree to which public health in these districts lagged behind the rest of the country is difficult to determine, since the conflict also often disrupted data collection and limited access by central public health programmes. Malaria cases, for example, were tracked by a national case reporting system maintained by the Anti-Malaria Campaign Directorate of Ministry of Health, one of the few institutions that had access to non-cleared areas during the conflict.23 Although the Anti-Malaria Campaign Directorate did have access to non-cleared areas their efforts to monitor malaria were sometimes hampered due to the conflict, and the quality of reporting was negatively impacted by the conflict in the north and east (Table 7.4).21

Preventive health services in the north east provinces also lagged behind the rest of the country. For example, in 2001, the number of health officers in Sri Lanka’s coastal districts ranged from 21.8/100000 in Jaffna, to 112.1/100000 people in Colombo.24,25

### Damage to the public health system

Of all of the damages the tsunami inflicted on Sri Lanka, the most tragic was measured in lives lost. All told, more than 35000 people in Sri Lanka died or disappeared due to the tsunami—more lives lost than in any other country except Indonesia (Figure 7.5).26-29 With a population of 19.6 million, Sri Lanka lost 0.18% of its population, greater than in any other country impacted by the tsunami.

Of Sri Lanka’s 14 coastal districts, 13 reported tsunami-related fatalities; districts along the northern, eastern, and southern coasts reported the highest fatality numbers (Table 7.5). The number of reported fatalities ranged from seven in the northwestern district of Puttalam, to 11312 in the southeast district of Ampara. Following Ampara, Hambantota reported the next highest number of fatalities, with 5463 lives lost (Figure 7.6).30-31

Using the district population data, the highest fatality rate occurred in Mullaitivu, where 247 out of every 10,000 people died. However, while Mullaitivu had the greatest fatality rate, it only had about half as many fatalities/km of coastline as did Ampara. Differences in the two districts’ population densities explain some of the discrepancy; Ampara’s population density was about four times higher than that of Matara.

It appears that most of the people who died during the tsunami died due to drowning or due to injuries sustained during or shortly after the tsunami. In a survey of IDPs in the district of Ampara, most participants reported that the people they knew who had died during the tsunami had drowned. Deaths due to drowning were followed by deaths caused by injuries and/or crushing. Only four of the deaths that the surveyed IDPs reported were not tsunami related. Of the 446 reported fatalities, 99% occurred within three days of the tsunami; no

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*A 27 January 2005 Centre for National Operations Maps indicates that 30959 people died, and 5644 people were missing, for a total of 36603 lives lost.*
fatalities occurred more than a week after the tsunami. The fact that no deaths occurred for approximately 80 days following 2 January, suggests that the mortality rate actually fell below normal mortality rates for a displaced population. Based on expected crude mortality rates for displaced populations, approximately six of the 3076 people represented by the survey would be expected to have died during this period. The reported low death rate during this period might be partially explained by what is known as the “harvesting effect”, which occurs when a disaster kills a disproportionately large number of vulnerable people, such as the children, elderly, disabled, and those with chronic medical conditions.

In addition to the lives lost, Sri Lanka’s population also suffered non-life-terminating injuries. Sri Lankans tossed around in the waves with wood, glass, metal, and other debris suffered flesh wounds, broken bones, and near-drowning. A total of 23059 survivors were reported to have been injured. Interestingly, high fatality rates did not necessarily correspond with high injury rates. For example, the district of Matara reported only 1342 fatalities, and 6652 injured survivors. The district of Ampara, on the other hand, reported 10436 fatalities, with only 120 injured survivors. It is difficult to determine how closely these numbers represent the actual number of people who were injured by the tsunami. Generally, injury estimates were based on the number of injuries hospitals reported having treated in the aftermath of the tsunami. However, in the chaotic aftermath of the tsunami, healthcare facilities in some of the most heavily impacted areas might not have recorded all of the injured victims that healthcare workers treated, particularly during the first hours following the tsunami. Additionally, reports on the total number of persons injured reveal nothing about the types of injuries the victims suffered.

However, knowing the nature of the injuries that the tsunami inflicted on survivors is crucial to understanding the health impact of the event. Two thousand injured survivors with mostly cuts and bruises present a less formidable health burden than do 2000 injured survivors with near-drowning injuries, broken bones, and/or deep flesh wounds. Injury estimates on the number of injuries without information on the nature of the injuries can present a skewed picture of the medical burden created by the event. For example, the fact that Matara reported more injuries than any other district may suggest that the immediate healthcare needs were more acute in Matara than in any other district. However, a personal account from a Sri Lankan health expert who visited the Matara General Hospital the day following the tsunami suggests otherwise. According to his account, the hospital received great demand as a mortuary, but little demand from injured survivors. On the day following the tsunami, a number of hospital beds remained empty, and hospital records showed that most of the patients treated following the tsunami presented with minor injuries; few had required surgery.

Although there is no complete record documenting the nature of each tsunami-inflicted injury, a few available case reports offer some clues about the injuries survivors sustained. A report documenting the injuries of patients who presented to a Galle teaching hospital shortly after the tsunami, found that the greatest number of injuries were related to near-drowning experiences. Of the 488 documented patients with injuries, 43% were related to near-drowning experiences, 25% were recorded as “other injuries of specified and multiple body regions”, 16.0% were superficial injuries, 10.2% were fractures, and 1.8% involved crush injuries and amputations. The remaining 2.4% were reported

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* A January 2005 CNO map indicated that approximately 15200 people had suffered injuries. However, a February 2005 report increased that number to 23059.
**The report does not indicate precisely when or over what period of time the injured victims were received, but that the data are based on patients admitted to the hospital “soon after the tsunami”.
***The report did not offer any explanation of what types of injuries fell into this second category.
as dislocations, sprains and strains, wounds infected by tsunami water, injured internal organs, and burns such as those cause by electrocutions. At the Jaffna Teaching Hospital, most of the patients who had suffered from near-drowning experiences and who were alive beyond the second day following the tsunami, survived. Most of those who died following a near-drowning experience, died within two days of the tsunami, and most of those who died in the Jaffna area appeared to have died immediately.32

Changes in public health functions

Later during the disaster, general respiratory issues appear to have replaced near-drowning injuries as the leading complaint. In a study examining 3186 patient complaints received by a Korean medical team in the Matara district from 2–8 January 2005, 32% were diagnosed as respiratory problems, 17% as injuries, and 11.6% as musculoskeletal disorders. Most conditions were considered to be mild; 92.1% were discharged after a short period of observation and management.33 The study only discriminated between tsunami-related and other complaints with respect to injuries, and found that just 34% were reported as having occurred during the tsunami, while 32% were reported as having occurred before the tsunami, and 34% of the complaints were believed to have occurred after the tsunami.33 Some of the injuries reported as having occurred after the tsunami may have occurred due to hazards created by the tsunami, such as sharp debris.33

The detrimental impacts of the tsunami on survivor’s health included more than the injuries sustained. Tsunami damages to clean water supplies, camps crowded with people who had been displaced by the tsunami, and other environmental and public services disruptions created new vulnerabilities to pathogens. Despite heightened vulnerabilities, however, the epidemic spread of disease that some public health practitioners feared might occur, did not happen. Cases of diarrhoea, measles, meningitis, hepatitis, malaria, tetanus, fever, and lower respiratory infections were reported in the weeks following the tsunami, but none resulted in an outbreak.33,34 Clusters of communicable disease cases remained small, were quickly contained, and generally reflected the usual morbidity of the areas in which they emerged. In fact, in the first three months following the tsunami, the incidence rates of diseases generally were the same in Sri Lanka as they had been for the same period a year earlier; some had declined. Epidemiological Unit data on disease incidence in camps recorded up to 18 March also reflected the usual morbidity levels found in the local population (Table 7.6).35

Perhaps most notably, the rates of malaria and dengue declined to less than half of what they had been in the year before the tsunami. For example, malaria rates declined from 1.91 cases/10000 population before earlier in 2004 to 0.84 in 2005. At the district level, changes in the malaria rates varied and some districts did report an increase in the malaria rate from 2004 to 2005. But, most of the tsunami-impacted districts reported declines in the incidence of malaria. And the few tsunami-impacted districts that reported malaria rate increases—Colombo, Gampaha, and Puttalam—were the least impacted. Additionally, researchers conducting malaria research in Sri Lanka after the tsunami suggest that malaria increases detected along the west coast may have been the result of incidental outbreaks rather than the tsunami.27

Additionally, researchers tracking populations of Sri Lanka’s primary malaria vector, Anopheles culicifacies, did not find any evidence that the environmental impacts of the tsunami had resulted in increased breeding of this vector. In January 2005, an Anti-Malaria Campaign entomologist team in the tsunami-impacted district of Hambantota did not find even a single vector - the principle malaria vector in Sri Lanka.28

No information was found on whether increased breeding was found among the principle dengue vector in Sri Lanka, Aedes aegypti.

Sri Lanka avoided the epidemic spread of disease following the tsunami despite the compromised...
living circumstances following the disaster and the damages to the public health system. Although monetary damages were greater in the medical care BSF System than in the Public Health BSF System, the tsunami damaged more public health facilities than medical facilities. Out of 92 tsunami-damaged health facilities, 57 were in the public health system, including 12 medical officers of health offices and 41 Gramodhaya health centers. Additionally, weakened local disease control capacity, including surveillance activities and the displacement of survivors into camps, increased the likelihood of the rapid spread of infectious diseases.

Although Sri Lanka had a well-established surveillance system prior to the tsunami, its level of functioning and weakened capacity and surveillance system were unable to keep up with the needs. The key disease surveillance staff, including medical officers of health and public health inspectors faced increased workloads and did not have access to transportation required to reach the IDP camps. Consequently, in some of the hardest-hit regions, there were gaps in IDP camp surveillance for several days following the tsunami. Vaccination programmes infrastructure and supplies were also lost. In the districts of Ampara and Matara, the tsunami-inundated regional pharmacies in which the vaccines and vaccination supplies were stored, were contaminated with dirty seawater, or deteriorated when the tsunami caused interruption of electrical power. Vaccination supplies were also lost in hospitals in other districts where damages or disrupted power supplies disabled the refrigerators that preserved them. However, the losses were regional and were quickly replaced by other regional stocks. Consequently, the losses did not disrupt routine vaccinations and Sri Lanka’s high vaccination levels were maintained.

**Relief responses in public health**

Strengthening the surveillance system, restoring and strengthening the cold chain, and quickly containing emerging disease clusters have been widely credited with preventing epidemics and maintaining routine vaccination services in Sri Lanka following the tsunami. The Ministry of Health acted quickly to heighten surveillance; by 27 December, it had sent epidemiologists to all the tsunami-impacted districts, including the conflict areas. The usefulness of the surveillance data collected early in the disaster, however, was limited by difficulty in interpreting the data; no standard indicators were used, and there was little feedback.

In its effort to provide optimal surveillance and other preventive health measures, the MoH received help from many UN agencies, including WHO-SEARO and UNICEF, which strongly supported the surveillance systems implemented for detecting disease, and interventions to help sustain the cold chain system. Early during the disaster, WHO-SEARO collaborated with the MoH to establish an early warning and response network system to quickly detect and respond to potential outbreaks. New investigation forms were developed for 10 diseases —leptospirosis, dengue, dengue hemorrhagic fever, acute flaccid paralysis, tetanus, viral hepatitis, whooping cough, rabies, rubella, and measles. Also, WHO-SEARO collaborated with the Director-General of Health Services for providing guidelines for use by the healthcare workers and maternal and child workers who were responsible for providing health care in the IDP camps. Initially, these duties were divided among whatever officers were available at a given camp, but later were assigned to the relevant officers as they became available. On the recommendation of WHO-SEARO experts, the MoH expanded the existing surveillance system to include disease cases reported in outpatient facilities, rather than continue the pre-tsunami surveillance system of reporting only on disease cases presented by inpatients. Once expanded, the surveillance system provided more complete disease case notification. To further strengthen Sri Lanka’s ability to detect communicable diseases, WHO-SEARO provided seven public health and 18 clinical laboratories with essential supplies and reagents to support laboratory operations for up to 12 months.
In addition to strong surveillance, vaccinations also offered a potential tool to prevent outbreaks in the aftermath of the tsunami. But, because Sri Lanka already had high vaccination rates when the tsunami occurred, the MoH, WHO, and UNICEF agreed that routine vaccinations did not need to be supplemented with an additional vaccination campaign. On the other hand, the infrastructure for the delivery of routine vaccinations needed a boost. Thus, WHO-SEARO, UNICEF and Pfizer Inc. conducted an assessment of the cold chain and identified areas where the system either needed repairs or had to be improved to sustain the existing strong delivery of routine vaccinations. Outside of the MoH, UNICEF contributed the most to meeting these needs following the tsunami. UNICEF printed and distributed 100000 Child Health Development Cards for recording immunization data, and supported a major programme for re-establishing and improving Sri Lanka's cold chain.

Finally, while Sri Lanka had high immunization rates to help protect it from vaccine-preventable diseases, UN agencies decided that extra measures were needed to ensure the containment of dengue and malaria, which cannot be prevented through vaccinations. National and international efforts to prevent the development of malaria following the tsunami focused primarily on the supply of anti-malarial drugs, distribution of impregnated mosquito nets, and increased monitoring in affected areas. By November 2005, UN agencies had provided 100000 Malaria Rapid Diagnostic Kits and 100000 anti-malaria tablets. UNICEF, WHO-SEARO, the Red Cross, and other humanitarian organizations delivered hundreds of thousands of bed nets to the tsunami-impacted areas. Although humanitarian organizations provided tsunami survivors with plenty of mosquito nets, survivors living in camps were not always able to use the mosquito nets because the tents and other temporary shelters sometimes were too crowded or made it difficult to properly place the nets. Insecticides also were used to prevent the development of malaria, but chemical preventive measures were used conservatively. For example, WHO distributed 50 pesticide fogging machines (Figure 7.7), but spent nearly eight times the amount of resources on bed nets as it did on insecticides.

In one study published a little over a year after the tsunami, researchers reported that because the number of cases of malaria in 2005 was considerably lower than anticipated by the government and responders had prepared for (only 1628 cases reported), many of the 100000 UN-supplied anti-malaria tablets and 50000 tablets per district the government warehoused would likely expire before being used.

Recovery responses and development in public health
As the relief phase transitioned into the recovery phase, the government, donors, and humanitarian agencies turned their attention to restoring the damaged public health infrastructure and to development. Nongovernmental organizations (NGOs) and other humanitarian agencies played a major role in funding reconstruction. For example, AmeriCare funded the construction and furnishing of two Gramodaya Health Centres in the Ampara district. The Gramodaya Health Centres were built by the International Medical Corps, and were located so as to be able to serve tsunami-impacted populations. One was located near the coast in a tsunami-impacted area and the second was located further inland, near an area where IDPs had been permanently resettled. The incidence of diarrhoeal diseases in the IDP camps declined from 17.6% in February to 11.1% in May.

Medical (curative) care system
Pre-event
Similar to its public health system, Sri Lanka's medical care system had achieved substantial gains with minimal resources, and had provided a model for countries with similar economic backgrounds. Most of the population—with
the exception of those living in the north and east—lived within 5 km of a public medical care facility. Ninety-five percent of births were attended by skilled attendants. Sri Lanka had 3.7 physicians/10000 people and 11.6 health workers/10000 population.

The public sector and private sector both provided health services that included modern medicine and Ayurvedic medicine. Most of the country’s hospitals were public, with the public sector providing for 70% of all medical care needs and approximately 90% of registered live births. Private sector services, generally, were concentrated in Colombo and Kandy.

Sri Lanka’s public medical care facilities can be segregated into two basic levels of care, primary and secondary (Table 7.7). The secondary level consisted of larger hospitals that provided specialized services, and included teaching hospitals, provincial hospitals, and base hospitals. At the primary level, healthcare facilities generally were small and provided basic, non-specialized services, and included district hospitals, peripheral units, and rural hospitals. Among the primary care facilities, the number of available beds ranged from 20 at peripheral units and rural hospitals to 200 beds at the district level. The larger secondary care hospitals had from 200 beds at a base hospital to 1000 beds at a teaching hospital or provincial hospital.

While Sri Lanka’s medical care system had much to boast about, there remained room for improvement. Medical care services imbalances within the medical care system hierarchy and geographic distribution of services created inefficiencies and inequalities in the availability of services. Within the medical care system hierarchy, use patterns involving secondary and primary hospitals resulted in inefficient delivery of services. While hospital services at the primary levels were under-utilized, secondary level hospitals were over-stretched to meet demands.

Occupancy rates at secondary level hospitals were >100%, while occupancy at the primary care level was barely 30%. People with medical problems that normally could be addressed by a primary caretaker, were bypassing primary level services for secondary level services because of staff shortages and poor quality services at the primary level. Also, inadequate laboratory facilities at the primary level resulted in a greater frequency of referrals to secondary level hospitals.

Furthermore, the availability of medical care services tended to be much weaker in the conflict-burdened northeast districts than in other coastal districts (Table 7.8, Figure 7.8). A survey that provided a detailed examination of intensive care units (ICU) indicated that ICU availability was much greater in the west and south than in the conflict-burdened northeast provinces (Table 7.9). The population/ICU ratio of the Eastern Province (708000:1) was more than three times higher than was the population/ICU ratio in the Western Province (206000:1). Similarly, an ICU in the Northern Province served an average population of 520481.

In addition to highlighting imbalances in the geographic distribution of medical care services, the survey also provided a broad picture of the capacity of Sri Lanka’s ICUs to treat critically ill patients (Table 7.9). The survey identified 52 ICUs in the country. Of the 49 ICUs that participated in the study, 28 (57.1%) were located in teaching hospitals, 13 (26.5%) in base hospitals, six (12.2%) were in provincial hospitals, and two in specialty hospitals (4.1%). In addition, 25 (51%) of the ICUs were multidisciplinary, four (8.2%) were general surgical, and three (6.1%) were general medical units. The remaining units were of medical surgical and pediatric sub specialties.

With respect to the equipment available in the ICUs, 26 (53%) had a ventilator: bed ratio of 1:1 or more, 35 (71%) had a blood gas analysis.*only 40 ICUs listed
available, and 45 (92%) had a defibrillator. With respect to the ICU staffing, 37 (75.5%) had a nurse: bed ratio of 1:1 or more, 24 hours/day, seven days/week, and 46 (93.9%) had a 24-hour resident medical officer.

In addition to the availability of hospitals and healthcare workers, good medical care also relies on the availability of medicines and essential supplies. Unlike the Maldives, which had to rely on imports for all of its pharmaceutical needs, Sri Lanka supplied a portion of its own pharmaceutical drug needs. Its pharmaceutical industry included large domestic drug manufacturers, such as the Stet Pharmaceutical Manufacturing Corporation, although it still imported a large portion of its drugs from abroad; imports from India accounted for approximately 45% of Sri Lanka’s pharmaceutical supply.

As for the distribution of pharmaceuticals, all of Sri Lanka’s public medicine supplies were managed by the Medical Supplies Division under the jurisdiction of the Ministry of Health. The Medical Supplies Division’s main office in Colombo distributed drugs and medical supplies to the country’s 19 largest hospitals and its regional branch offices. In turn, the regional branches distributed the supplies to local dispensaries and hospitals.  

Finally, it is important to highlight one additional feature of Sri Lanka’s Medical Care System, the capacity of hospitals to manage dead bodies. In Sri Lanka, forensic pathologists staffed the larger provincial hospitals, and consequently, Sri Lankans customarily took all dead bodies to hospitals. However, a typical hospital morgue was equipped to manage only 5 to 10 bodies.

**Damage to the medical care system**

After the tsunami, victims who suffered injuries needed medical care, and bodies found lying on a beach had to be taken to facilities where relatives were likely to find and identify them, namely the healthcare facilities. Unfortunately, managing the corpses in the healthcare facilities that were closest hampered their ability to deliver treatment. Of the 92 healthcare facilities that the tsunami damaged or destroyed, 35 were medical care facilities. Of the US$ 60 million in damages sustained to the public health and medical care systems, the medical care system accounted for US $49 million. The repair of damages to the medical care system was estimated at US $84 million. In addition, an estimated 54 medical care system vehicles were damaged.

At the district level, Galle suffered the greatest medical care system damage. However, at the provincial level, medical care system damages were greatest in the conflict-burdened northern and eastern provinces in which medical care resources already were scarce relative to the rest of the country. Of the US$ 60 million in healthcare facility damages, more than US$ 40 million occurred in the northern and eastern provinces (Table 7.10). In the Karaithheevu and Ninthavur divisions of Ampara district, the tsunami left two hospitals seriously damaged. Damages to healthcare infrastructure also included buildings used to store medical drugs and supplies. Three regional medical supplies divisions in Ampara, Matara, and Galle were destroyed or damaged, and consequently, a portion of Sri Lanka’s stored medical drugs and supplies were lost. In addition, drugs and medical supplies were also lost in damaged hospitals. Even when the tsunami did not directly damage hospital stores of drugs, medications that required refrigeration sometimes were lost due to tsunami-related power outages.

Other facilities damaged included administrative healthcare structures. In Matara, the tsunami reduced the Deputy Provisional Health Director’s main office building to rubble. Unfortunately, damage to Sri Lanka’s medical care system was not limited to buildings and supplies. Thirty-five healthcare workers lost their lives, including medical officers, technical staff, non-technical staff, and others.

**Changes in medical care functions**

Even when hospitals were available, equipment and supplies did not always match the needs
of the injured being brought to hospitals. For example, the Jaffna hospital in Sri Lanka’s northern province, did not suffer damages due to the tsunami, but when patients from nearby areas arrived for treatment, the hospital did not have enough ventilators available to treat patients who had suffered near-drowning and aspiration pneumonia.

Damages to medical care infrastructure, supplies, and equipment severely compromised the abilities of the facilities to provide even routine care, much less meet the demands created by the surge of injured victims. The provision of services were compromised further by the inability of some medical staff to immediately report for duty because they had suffered injuries or were searching for loved ones. Five days after the tsunami had badly damaged the Mahamodara Teaching Hospital in the district of Galle, only 25% of the hospital’s staff had reported for duty.56

Thus, with drug storage units, drugs, hospitals, and equipment damaged and destroyed, some hospitals located in regions hardest hit by the tsunami could not meet the demands for care. Some of these hospitals were damaged, yet faced a demand for medical care that well exceeded normal demands. The challenge of providing medical care to survivors was complicated further by the displacement of large numbers of people. Migrating populations of tsunami-displaced victims created new concentrations of people in places not necessarily equipped to provide medical care for such a large number of people. Additionally, many displaced people ended up living in camps in which poor sanitation and crowding put them at greater risk for contracting illnesses that required medical care. Consequently, in the first few days following the tsunami, access to primary healthcare for IDPs living in temporary shelters was difficult.56 Access to medical care became particularly difficult in areas in which the provision of medical care services had already been limited before the tsunami and where the tsunami had struck particularly hard; this included the districts of Ampara, Trincomalee, and Kilinochchi.57

**Relief responses in the medical care system**

The first to respond to the medical care needs of victims in the tsunami-impacted areas was the local medical care system. Where the local medical care system had been crippled by damages or overwhelmed by the sudden influx of injured victims, medical care facilities in neighbouring areas mobilized medical care workers and resources to fill in the gaps in the tsunami impacted areas. Local medical responses were followed quickly by national medical care responses that imported doctors from areas that had suffered little damage, into areas that had been hard hit by the tsunami. International medical support also arrived, but much later than local and national support, and did not play a role in the immediate lifesaving relief phase of the disaster, despite the expectations of many international medical care teams that arrived to treat tsunami victims. Foreign medical personnel began arriving in tsunami-impacted regions as early as 28 December, and were accompanied by medical supply shipments from international donors. The number of foreign personnel and the quantity and type of medical supplies that arrived from abroad, however, often did not match the immediate, medical care needs—and sometimes created new burdens on the local medical care system. Within the first five days following the tsunami, at least 158 medical team personnel comprising 15 foreign medical teams arrived in Sri Lanka. Foreign medical teams were directed to the Sri Lanka WHO office, which, in collaboration with the Ministry of Health, arranged for the deployment of each arriving medical team.57

International medical personnel arrived expecting to find understaffed hospitals overwhelmed by large numbers of injured victims. But, by the time that international medical care teams arrived, the number of injured victims presenting to local medical care facilities had slowed to a trickle, and local and national doctors from non-impacted areas had filled the staffing gaps. Before the end of December, in some settings, the logistical burdens and coordination challenges that accompanied the foreign medical assistance had
begun to outweigh the benefits. For example, the administration of immunizations and medications was sometimes duplicated when survivors were treated by multiple medical care providers.50

On 29 December, the Sri Lankan government announced that it had 700 national medical volunteers and did not need more foreign volunteer doctors.58 This attempt by the Sri Lankan government to discourage the arrival of foreign medical personnel, however, was ineffective. By 12 January 2005, more than 600 foreign medical personnel comprising approximately 70 medical teams had arrived in Sri Lanka. Additionally, some foreign medical teams avoided national regulations put in place to ensure only credentialed medical personnel provided medical care treatment. None of the 70 medical teams had registered with the Sri Lanka Medical Council, despite a law requiring them to do so.59

The medical relief responses to the tsunami disaster included the provision of temporary medical care facilities and medical supplies where needed. To ensure the delivery of medical care services, the government authorized the Ministry of Health to requisition any building within or close to tsunami-impacted regions for use as a hospital facility.56 In a few instances, medical care services were moved into other structures. In the Trincomalee district, an outpatient department and a delivery room were established in the Trincomalee Library after the district’s Kinniya Hospital was destroyed.57 In Kilinochchi, where the district hospital was not directly impacted by the tsunami, but was inundated with patients after nearby coastal medical care facilities were damaged or destroyed,60 the Department of Health used the Kilinochchi Transit Centre to accommodate the overflow of patients from the Kilinochchi hospital.56 WHO-SEARO rented temporary quarters for the Deputy Provincial Director of Health Services in Matara and Port Health Office in Galle, after the tsunami destroyed the buildings in which they had been operating. Also, WHO-SEARO subsidized the temporary relocation and re-equipping of the Regional Medical Supplies Divisions in Matara and Kalmunai, and helped to set up temporary drug facilities in other locations such as hospitals.38

Similarly, Sri Lanka met the immediate needs for medical supplies in tsunami-impacted areas with its own resources. In most cases, medication shortages in hospitals treating tsunami victims were quickly filled by pharmacies and other medical stores. The national government also delivered medications and medical supplies to the impacted areas, although the deployment of national emergency supplies of medicines was delayed due to logistical problems. Because of the long holiday weekend and disruptions to communications systems, Sri Lanka’s main medications distributor, the Medical Supplies Division, had difficulty obtaining needed staff and receiving accurate information about where and what types of medicines were most needed. The distribution of national medical supplies began on the day following the tsunami, with the Sri Lanka Air Force distributing them to areas that could not be reached by road such as Batticaloa and Trincomalee.49

Although local and national medicine supplies were adequate to meet the disaster-related medical care needs, international donors were eager to donate medications to tsunami-impacted areas. Consequently, the Medical Supplies Division compiled a list of useful drugs that donors could send. The first version of the list was created on the day following the tsunami; subsequently, it was updated every week, published on government websites and in the media, and distributed to NGOs and others upon request.25 The list reflected drug needs that had existed prior to the tsunami rather than those drug needs that had resulted due to the tsunami. Consequently, Sri Lanka was able to use the tsunami disaster relief response to fill chronic gaps in its national drug supplies.60-61

Nevertheless, most of the drugs donated to Sri Lanka did not match the country’s needs, and quickly consumed valuable warehouse space such that the Division rented additional space to store...
them. Two weeks after the tsunami, Sri Lankan authorities asked Pharmaciens Sans Frontières, Germany and Pharmaciens Sans Frontières, France to inform donors that Sri Lanka no longer wished to receive drug donations; however, the message had little impact. In the five months following the tsunami, the Medical Supplies Division received 3500 truckloads of donated drugs. Approximately 50% of the donated drugs had no expiration date listed on the packaging, and 5% either were expired on arrival or within a few days of arrival. Some drugs even had expiration dates of 2001. Of the drugs that did have expiration dates noted, only 67% had a shelf-life of a year or more. Some of the drugs received were neither on the MoH’s list of requested drugs nor appropriate for use during disaster circumstances, for example, six packages of Viagra were included in donated boxes of medicines. The Medical Supply Division was forced to destroy approximately 150 tons of donations at a cost to the Division of US$ 24096.

The drugs typically arrived in unsorted boxes. During the five months following the tsunami, the Medical Supply Division had staff busy sorting medicines 24 hours each day. Sorting was complicated by the fact that many of the drugs did not have generic names or were labelled in a language other than the local language or English, which many Sri Lankans can understand.

In an effort to curb the delivery of inappropriate drugs and medical equipment, the Sri Lanka government required all donors supplying medical supplies to gain approval from the Bio- Medical Engineering Services Unit of the Ministry. WHO-SEARO, helped the Ministry of Health establish a 24-hour tsunami operation cell in each impacted district to help oversee medical responses to the disaster. Further, reconstruction efforts and the supply of medical equipment were monitored by Provincial Health Directors and a committee of officials with project monitoring experience. The monitoring committee operated under the direction of the National Health Development Committee, and was appointed by the Ministry of Health. The monitoring committee reported to the Minister of Health on a regular basis.

Recovery responses and development in the medical care system

As the relief phase of the disaster transitioned to the recovery phase, humanitarian agencies turned their attention to rebuilding healthcare facilities, and in some cases, development of medical care services, including staff training. In July 2005, the Canadian Red Cross sent a medical team to Kilinochchi Hospital to provide treatment to patients and to train local doctors and nurses. The team included a surgeon, anaesthetist, operating theatre nurse, teaching nurse, administrative nurse, and a programme manager. The NGO also supplied the Kilinochchi Hospital with operating theatre equipment. Within about a year of the tsunami, negotiations with various donors had produced memorandums of understanding for the repair and rebuilding of most impacted medical care facilities and also for the renovation of several medical care facilities that had not been damaged.

Water and sanitation system

Pre-event

Sri Lanka is characterized in part by its many waterfalls, the results of heavy rainfall combined with high runoff and mountains. The country receives an average rainfall of 1861 mm/year. In its coastal districts, rainfall ranges from 1131 mm/year in the district of Hambantota to 3980 mm/year in the district of Kalutara; the greatest rainfall occurs in the southwest. In the northern and eastern provinces rainfall ranges from 1238 mm/year in the district of Jaffna to 1643 mm/year in the district of Batticaloa. Due to large runoff, a high proportion of Sri Lanka’s rainfall gathers in surface bodies or runs into the ocean rather than seeping into ground aquifers; groundwater sources in Sri Lanka are considered minor compared with its surface water sources (Figure 7.9). Although, in general, only a small proportion of rain seeps into aquifers, some coastal areas are exceptions This is particularly the case along the easterly coast, where rainwater quickly percolates through sandy soils.
to form what is known as sandy coastal aquifers (Figure 7.9). These aquifers extend anywhere from 2–8 km inland, and often are located on strips of land confined by the sea on one side and a brackish water lagoon on the other. Sandy coastal aquifers provide a source of freshwater that is more reliable, abundant, and of a higher quality than groundwater aquifers found further inland. However, sandy groundwater aquifers are also vulnerable to contamination from pollutants and salination due to over exploitation.68

Generally, access to clean water was not a problem in Sri Lanka before the tsunami (Table 7.11). Approximately 82% of Sri Lankans had access to an improved water source, and in the coastal district of Batticaloa, access to an improved water source was 96.6%.69 However, access varied from district to district, and some of the districts with less access to clean water also were among those that were hit hardest by the tsunami, namely the eastern and northern districts of Trincomalee, Killinochchi, and Mullaitivu. Prior to the tsunami, only 74.1% of Trincomalee residents had access to an improved water source.68 Although reliable estimates for pre-tsunami access to water in Killinochchi and Mullaitivu are not available, access in these two districts is believed to have been among the worst in the region,70 in part, due to the political conflict, which damaged water infrastructure.73

In urban and rural areas, Sri Lanka’s population relied on different water sources. Urban populations tended to rely on surface water supplies from higher elevations, while rural areas tended to rely on groundwater and wells. Additionally, urban residents were far more likely to receive piped water services than were the rural populations. Piped water served 75% of urban residents, but only 14% of rural residents.69

With respect to access to safe sanitation, 2002 statistics indicate that Sri Lanka ranked above the global averages; 93% of Sri Lanka households had access to safe sanitation, compared to 61% worldwide. However, access to sanitation varied anywhere from 96.6% of households in the southern district of Matara to 57% in the eastern district of Batticaloa.69 Sri Lanka has only one centralized wastewater system, which is located in Colombo.71

At the national level, the Ministry of Urban Development and Water Supply (MUDWS) was responsible for Sri Lanka’s Water and Sanitation BSF system, while Local Government Acts required local authorities to ensure that all citizens have access to adequate and safe water and sanitation facilities. The MUDWS agency’s key to addressing its water supply and sanitation responsibilities was the National Water Supply and Drainage Board and its six regional offices, each covering from one to three provinces. Additionally, an oversight and monitoring unit, known as the Rural Water Supply and Sanitation Unit also operated under the Ministry in carrying out water supply and sanitation responsibilities.70

**Damage to the water and sanitation system**

Damage to the water and sanitation system occurred in 13 districts. The heaviest damage occurred in the areas that were heavily reliant on wells. An estimated 62000 wells were contaminated or abandoned due to salinity or seawater contamination; 12000 wells required cleaning. However, in some areas, aquifers were contaminated, wells could not be restored, and the residents had to find new sources of water.

The National Water Supply and Drainage Board (NWSDB) estimated replacement costs and indirect losses in the Water and Sanitation BSF System due to the tsunami totaled US$ 41.9 million. Damage to pipe-supplied water systems was reported in six districts, while damages to wells were reported in at least 13 districts. Damages to pipe-distributed water systems totalled approximately US $3 million while damages to wells, totalled approximately US $18.1 million. Replacement costs for damaged sanitation infrastructure was US $11.6 million.51 In the sanitation sub-system, the tsunami damaged one sewage pump system located at...
Mt. Lavinia that served the Colombo sewage system. Other damaged sewage facilities consisted of individual household systems; only a few households had their own sewage treatment systems.49

The greatest water and sanitation system damages occurred in the eastern province district of Ampara, where there was an estimated US $12 million in replacement costs and indirect losses. At the provincial level, the majority of the damages were in the northern and eastern provinces, which accounted for US $35.4 million of the US $41.9 million in total water and sanitation system damage costs respectively.71

Changes in water and sanitation functions

The greatest challenges for the water and sanitation system occurred in the displacement camps, where many people suddenly congregated in places in which available water and sanitation were insufficient. Immediately after the tsunami, sanitation in some camps was poor due to inadequate toilet facilities, waste disposal, and distribution of safe water. The number of latrines available was alarmingly low in many camps. In one of the worst cases, 1135 people had access to only three latrines in a camp in the district of Batticaloa. This was contrary to the Sphere standards.73 That same camp had only one water tank.74

Clogged drains also posed a problem. In Galle district, WHO water and sanitation team reported that water distribution systems needed improvement and that open drains in urban areas clogged with debris urgently needed to be cleaned.69

Relief responses in the water and sanitation system

The immediate relief responses to the tsunami focused on providing a supply of water and the availability of latrines; later interventions included addressing water quality. Ensuring that tsunami-impacted populations had enough water was addressed faster than were sanitation and water quality checks. Impacted populations generally migrated away from areas in which piped water and wells had been damaged. Away from shore, migrating populations, in most cases, could rely on water sources that had not been impacted. However, in some cases, this was not sustainable—particularly in the camps. Consequently, the government and humanitarian agencies delivered bottled water and tanker water to the impacted populations until more sustainable water sources could be established.

Tanker water soon became the main source of potable water in those areas in which local sources could not be relied upon to provide adequate supplies. However, in a few cases, displaced populations relied on bottled water. For example, in the Hettigoda camp in Galle district, IDPs only had access to bottled water as a potable water source for six days following the tsunami.51

The risk that tsunami survivors would become ill from drinking salt water was low since people can taste and will refuse to drink water that is too saline. Protecting survivors from accidentally drinking water contaminated with pathogens posed a greater challenge. In the initial aftermath of the tsunami, coordination was poor for ensuring water quality, and in some cases, people likely became ill as a result of drinking contaminated water. On 8 January, an outbreak of diarrhoea was reported in the Batticaloa district. However, when relief workers distributed chlorine for treating the water, the incidence of diarrhoea dropped and the outbreak was controlled within two days.76–79

Humanitarian agencies widely distributed supplies to survivors and relief workers to prevent the transmission of water-borne diseases. The Canadian Red Cross provided 80000 hygiene kits (each can provide for the hygiene needs of a family of up to six people), 37440 water containers, and 770000 water purification sachets (enough to treat 15-million litres of water).80 By November 2005, UN agencies had provided 100000 chlorine tablets, 500 chlorine testing kits, 30 bacteria testing kits, and 900 sanitation kits.41,81
At the request of the National Water Supply and Drainage Board, WHO developed a one-page, good practice sheet that was distributed to agencies that were transporting water to IDP camps. The sheet instructed agencies on the appropriate levels of chlorine in distributed water supplies. Other WHO-SEARO water safety educational activities included hygiene promotion campaigns and training programme organized at national, regional, and district levels. Training programme were conducted through the Health Education Bureau of MoH and included education and training on water quality surveillance, water testing, and hand hygiene. The national programme was attended by 49 participants, most of whom were health education officers representing districts from all over the country.74

By 15 January, relief camps had sufficient water supplies, but a lack of coordination among relief organizations complicated efforts to provide good sanitation. Many relief organizations operated independently and failed to consolidate their efforts with other organizations and agencies working to improve sanitation in the camps to acceptable levels.75 As a result, many camps had too few latrines. For example, one camp with 1135 IDPs at one point had only three latrines. Until a sufficient number of latrines could be provided, the camp’s IDPs were provided with 3000 squatting plates and 300 shovels.74 And while NGOs and other humanitarian agencies built a large number of camp latrines to meet the needs, their efforts often were complicated by logistical problems. UNICEF, which had been designated as the lead UN agency for the water and sanitation responses, installed 50 latrines in a camp in Hambantota. In addition, in coordination with the Department of Health and several NGOs, UNICEF provided 125 latrines in three camps in Ampara. However, in Ampara, high groundwater levels complicated latrine building efforts and slowed the construction.76

Even when sufficient latrines had been built, persons in the camps still faced sanitation issues because the agencies that built them failed to properly maintain them.71 Latrines filled quickly and needed to be emptied in order to remain functional. As the disaster continued, an increasing number of gully emptiers were used to suction out and remove human wastes.71 However, finding a place to dispose of the human wastes proved difficult, and gully trucks did not always dispose of the waste properly. In response to these issues, the Sri Lanka government, UNICEF, and NGOs developed guidelines for the safe disposal of human waste.72

Recovery responses in water and sanitation system

Early in the responses to the disaster, many humanitarian agencies were looking beyond the relief phase to recovery, particularly with respect to water. Efforts to restore sustainable water sources focused largely on the restoration of wells. Hence, UNICEF and WHO-SEARO conducted a rapid assessment of the extent of the tsunami damages to wells, and with the help of NGOs and several UN agencies, they mobilized teams to clean contaminated wells.38 In the district of Jaffna, 715 of its 2000 contaminated wells were cleaned by 28 January 2005.77 A contaminated well typically was cleaned by emptying the well of contaminated water either by using a pump or manual methods, or with bleaching powder.79 However, cleaning the wells proved to be a more complicated task than some had anticipated, and not all well-cleaning efforts were successful. Many of the humanitarian workers who attempted to clean the wells did not have the required skills, and wells remained salinated even after having been repeatedly emptied and cleaned. In some cases, the cleaning process did more damage than good; wells collapsed or new contamination problems were introduced.68 In the areas hardest hit by the tsunami, wells drew primarily from sandy coastal aquifers, which easily become saline when over-extracted. Consequently, heavy pumping of the wells sometimes made wells even more saline and slowed their natural recovery process. In the first months following the tsunami, there was little expert oversight of well-water restoration efforts, and heavy pumping procedures commonly
were used to clean wells. However, about 10
week following the tsunami, researchers with
greater water expertise became involved, and,
in May, they issued new guidelines for cleaning
the contaminated wells. These new guidelines
recommended that heavy pumping be avoided,
that water quality be closely monitored, and that
rainwater be allowed to flush saltwater out of
impacted wells. It was believed that the impacted
wells would return to their pre-event status
within about two years.68

Seven months after the tsunami, the salinity levels
in tsunami-inundated wells monitored along the
east coast had declined, but remained higher than
non-inundated wells. Researchers monitoring the
condition of the wells anticipated that tsunami-
impacted wells would require at least one more
monsoon season before the salinity levels in
the wells would begin to return to pre-tsunami
levels.68

Development of the water and
sanitation system
Aside from restoring freshwater wells, attempts
to provide a sustainable source of freshwater
was made through the provision of desalinization
plants. However, this approach generally proved
to be unsustainable, since local communities
could not provide long-term maintenance
without outside assistance.73

In ensuring safe water supplies, WHO-SEARO
also provided water pumps, chlorine tablets,
water storage tanks, and chloroscopes that
are used for testing chlorine levels in water.
Additionally, the water board and provincial
health department supplied water testing
laboratories with WHO-purchased
equipment. WHO provided sanitation kits to
help camp managers keep public latrines
serviceable and water testing kits that allowed
local water authorities to spot-check
water quality.

Shelter and clothing system
Pre-events
Along Sri Lanka’s coastal areas, the annual
average temperature is about 27.5ºC. From the
warmest months, April and May, to its coolest
months, November and February, the average
temperatures vary by about 2.4ºC.76 Unlike
the temperature, the rainfall in Sri Lanka varies
considerably throughout the year. Two primary
monsoon seasons occur each year: the first from
May through July bringing rain primarily to the
western, southern and central regions of the
country; the second occurs during December
and January and brings rain primarily to the
eastern and northern regions. These two
monsoon periods are responsible for 55% of
the country’s rainfall. At the time of the tsunami,
the areas impacted were in the midst of their
monsoon season. Throughout the country, the
average annual rainfall varies from <1 000 mm/
year to >3 000 mm/year. However, the highest
amount of rainfall occur in the central highlands
away from the tsunami-impacted coasts.81

In the coastal regions, a typical house had only
one storey walls of cement or burnt brick,
wooden supports underlying a roof of tiles or
cement-asbestos roof sheets and a shallow
foundation. More modest dwellings with walls of
wattle and daub,* plank or palm leaf walls, and
unfinished floors, also were common.66 Among
the 5.4 million building units in Sri Lanka as of
2001, 4.6 million (87%) were housing units.82
Housing quality varied from district to district
with the greatest proportion of the population
living in higher quality housing in Colombo and
neighbouring districts (Table 7.12). In Colombo,
86.8% of the population had permanent housing,
1 1.2% lived in semi-permanent houses and
0.3% in improvised houses. However, in the
coastal districts of Ampara, Hambantota, and
Puttalam, the proportion of the population living
in permanent houses was 67.5% or less. In
Hambantota, only 58.8% of the population lived

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*Wattle refers to the wooden planks and daub to the clay and sand or animal dung mixture sometimes used to build walls in
houses. The wattles are woven into a lattice work and the daub is used to cover and fill gaps in the latticework.
in permanent houses, 40.1% lived in semi-permanent houses, and 0.4% lived in improvised houses. Pre-event district-level statistics on housing quality in the tsunami-impacted districts of Batticaloa, Trincomalee, Mullativu, Kilinochchi, and Jaffna were not available. However, the proportion of housing that was semi-permanent or improvised in these districts was likely to be high since these districts had suffered great infrastructure damage due to two decades of political conflict.

Before the tsunami, laws regulating coastal construction were not strongly enforced and many communities settled near shorelines without government oversight. The law regulating coastal development was established under the Coastal Conservation Act of 1981. Under the law, the Coastal Conservation Department granted case-by-case approval for construction projects based on vulnerability to known hazards and other criteria.

**Damage to the shelter and clothing system**

In Sri Lanka, the tsunami destroyed and damaged 88544 housing units; 49983 (56%) of these were either destroyed or too damaged to be inhabited. Together, destroyed and damaged housing represented an estimated 13% of the housing stock in Sri Lanka’s coastal administrative districts. A financial institute assessment estimated damaged housing costs between US $306 m and $344 with a cost between US $306 m and $344 to repair or rebuild. At the district level, the tsunami damaged and destroyed the greatest number of housing units in Ampara and Batticaloa, where 18810 and 17405 units were damaged or destroyed respectively (Table 7.13). At the provincial level, the tsunami damaged and destroyed the greatest number of housing units (65240) in the conflict-burdened northern and eastern provinces.

A post-tsunami study examining housing destruction in two Sri Lanka cities, Galle and Batticaloa, determined that single-storey buildings were more likely than were multi-storey structures to be damaged or destroyed by the tsunami (Figure 7.10). Additionally, buildings within 100 metres of the ocean were more likely to be destroyed than were buildings located 100 metres to 200 metres from the ocean.

**Changes in shelter and clothing functions**

In the first few days after the tsunami, nearly 900000 people in Sri Lanka were displaced from their homes. Within two weeks, however, the number of IDPs in camps decreased by at least 300000, as families moved in with relatives or found other alternative shelter. As of 10 January, 545492 displaced people remained in camps, down from >850000 on 29 December. In areas of ongoing conflict, the tsunami compounded existing displacement issues. As of March, of the 73000 tsunami displaced people still living in camps or with relatives or friends in the northern province, approximately 90% already had been previously displaced at least once due to the ongoing political conflict.

**Relief responses in the shelter and clothing system**

In the early aftermath of the tsunami, host families and public buildings played a major role in providing shelter to those evacuating the coast. Families and friends of the displaced, schools, mosques, temples, kovils, and other public buildings opened their doors to accommodate tsunami survivors. Those survivors not fortunate enough to find shelter with a host family or in a public building established makeshift camps.

To meet immediate shelter needs, humanitarian and government agencies quickly organized relief camps and delivered tents. By 18 January, the government had distributed 2300 tents. Nongovernmental agencies and organizations that provided tents included UNHCR, UNICEF, IOM, ICRC, and IFRC. As an emergency shelter, tents were easy to transport to the tsunami-impacted areas, although some of the displaced complained that the tents were ill-suited for the humid climate, making conditions inside the tents unbearable.
By 7 January 2005, government had placed camp management teams within all IDP camps. Management teams included security personnel, medical personnel, and a manager. The number of camps was greatest during the first few days following the tsunami, on 29 December, an estimated 850,000 IDPs were living in about 750 camps. In January, the number of camps declined as displaced people found shelter outside the camps and as camps were consolidated to facilitate the delivery of relief goods. By 5 January, there were 57,257 IDPs living in 637 camps, and by 30 January, there were 208,498 IDPs in 319 camps.

Although the number of people living in camps fell quickly during the weeks following the tsunami, this did not necessarily reflect a corresponding drop in the need for housing assistance. Some of those who left camps may have found shelter that better suited their needs than was available in the camps, but did not necessarily provide them with a permanent housing solution. Some are believed to have found host families or to have returned to homes that remained damaged.

The need for organized camps that could provide for the needs of the displaced survivors was pressing. Public buildings had insufficient sanitary facilities and public services such as education could not be carried out as long as displaced tsunami survivors occupied the buildings needed to provide those services. In the homes of host families, the burdens of sheltering displaced survivors in some cases became too great to continue for more than a few days. And, in makeshift camps that had been erected after the tsunami, survivors had to rely on whatever they could find locally to provide for themselves and their families.

Recovery Responses in the Shelter and Clothing System

Unfortunately, it took many months, and in some cases, years before displaced survivors would receive permanent housing. In the interim, survivors required shelter that could meet their needs more appropriately than tents or host families. To help ensure that both temporary and long-term housing needs were met, the government established a Task Force for Rebuilding the Nation to coordinate rebuilding efforts, the Transitional Accommodation Project to ensure the provision of transitional shelter, and the Tsunami Housing Reconstruction Unit to help move people from transitional shelters into permanent housing.

The Sri Lankan government requested that UNHCR take the lead in coordinating NGO efforts to build transitional shelters. Although UNHCR usually does not respond to disasters due to natural hazards, due to the scale of the disaster, it accepted a short-term role in responding to the tsunami in Sri Lanka. The effort to build transitional shelters started slowly, but by the end of 2005, the number of shelters required to move tsunami-displaced populations out of tents was substantial: as of 21 March 2005, just 4,000 transitional housing units had been built. But, by 22 November, 58,000 transitional shelters had been built by more than 100 NGOs under the coordination of UNHCR.

While the transitional shelter building effort successfully met its goal, the provision of permanent housing proved to be more elusive. Efforts to rebuild permanent housing were complicated by regulations on where and how housing could be built, and by shortages of staff needed to approve building projects. The location of permanent shelters became a major issue for many of those who had lived near the coast before the tsunami. Immediately after the tsunami, the government announced that it would enforce a coastal buffer zone of 200 metres in the north and east, and 100 metres elsewhere, where house rebuilding would be prohibited. The government held that the buffer zone was needed to protect citizens from future tsunamis, and that a larger buffer zone was required in the north and the east due to greater vulnerability to natural hazards. People whose homes were in the buffer zone, but that had not been damaged, however,
would be allowed to continue to live in their homes. For people whose homes had been damaged or destroyed by the tsunami, two programmes were established to meet their permanent housing needs. For people who owned damaged or destroyed homes within the buffer zone, the government promised that they would receive a 46-square-metre house within reasonable proximity to their former homes under the Relocation Housing Programme. For people who owned damaged or destroyed homes outside the buffer zone, the government agreed to provide donor-funded rebuilding grants through the Owner Driven Programme. Owner Driven Programme grants for homes outside of the buffer zone offered $2500 to owners of houses that had been ≥40%, and $1000 to owners of houses that had been less than 40% damaged.

However, despite the offer of a new home free of charge, many people were unhappy with the announced buffer zone, which had broad implications, particularly in areas where land is scarce, such as in the densely populated areas in Colombo, Jaffna, and Ampara. Complying with the policy would require the relocation of tens of thousands of families and prevent the displaced survivors from returning to their communities. Besides increasing the distance from their work location, there were social and cultural reasons for the reluctance to accept alternative housing sites. Additionally, the buffer zone created delays in construction by donors who had to delay construction until alternative locations for the reconstruction of destroyed houses were identified.

The issue became increasingly contentious and pressure to change the buffer zone regulations mounted. By November 2005, the policy to enforce the buffer zone was reviewed and subsequently replaced with a considerably less stringent and limited policy known as the “no build category one zone”. Under the new policy, building was restricted an average of 35 metres from the coastline.

The issue of relocating people who previously had lived in the buffer zone combined with supply and labour shortages slowed efforts to rebuild housing. During the first phase of house rebuilding, the construction of 43000 houses was required under the Relocation Housing Programme, and 55525 houses needed to be repaired or rebuilt under the Owner Driven Programme. Progress was slow, particularly within the Relocation Housing Programme. Although the Tsunami Housing Reconstruction Unit had signed memoranda of understanding with donors for the construction of 36126 houses, only 1271 houses had been built by August 2005. The relaxation of the buffer zone near the end of 2005 decreased the number of houses required under the Relocation Housing Programme from 43000 to 29830, and increased the number of houses that needed to be repaired or rebuilt under the Owner Driven Programme from 55525 to 79184. During the second year following the tsunami, the pace of house rebuilding picked up, and by December 2006, 14488 houses had been rebuilt under the Housing Relocation Programme, and 46531 houses had been rebuilt under the Owner Driven Programme. Even with improved progress achieved during the second year following the tsunami, permanent house rebuilding and repairs still had met only about 50% of needed housing construction.

Following the earthquake and tsunami, donors also sent large quantities of clothing to Sri Lanka. But, in some cases, the incoming shipments of clothing donations were inappropriate, did not fill a need, and became more of a burden than an asset. Donors from around the world appeared to have emptied closets and garages of used clothing and shoes to send to Sri Lanka without consideration of the appropriateness or usefulness of the items. For example, stiletto shoes, thong panties, Father Christmas costumes, and winter coats arrived along with many other unneeded clothing items. Consequently, donated clothing filled valuable government warehouse space.
Development of the shelter and clothing system
No specific information was found relative to development of the shelter and clothing system as pertaining to the public health and medical care systems.

Food and nutrition system
Pre-event
Nutritional indicators point to a weakness in Sri Lanka’s population health. When the tsunami occurred, Sri Lanka had improved many population (public) health indicators beyond what would be expected of a country with a per capita GDP of just US $1,031/year. But the nutritional indicators remained unacceptably poor and the percentage of Sri Lankan children who were underweight was particularly high (Table 7.14). As of 2000, 30% of children five years of age and under were underweight, 14% were wasted, and 14% were stunted.94 These and other nutritional indicators did not fall into line with Sri Lanka’s other more positive population health indicators.95,96 Nutritional indicators also were poor among pregnant Sri Lankan women; 37% of pregnant women were anaemic.97

The highest rates of under-nutrition occurred among the poor in the conflict region. Nutritional indicators for districts in the conflict region were less reliable than in other parts of the country. In some cases, under-nutrition was estimated to have been almost twice as high in the conflict region as in the rest of the country.96 A large portion of Sri Lanka’s conflict region was considered the country’s bread basket, particularly with respect to rice production. But, the conflict resulted in high poverty levels and disrupted markets, thus limiting access to food and food diversity. In an effort to improve access to food among the disadvantaged, national and international programmes extended food assistance to the poor and to those living in conflict affected areas.92 Sri Lanka’s primary social programme, Samurdhi, earmarked 80% of its budget for supporting food assistance to the poor. Unfortunately, Samurdhi was inefficient at reaching those most in need; 40% of the programme food aid went to the richest 60% of the population, and 36% of the country’s poorest households did not benefit from the programme. Additionally, Samurdhi benefited ethnic minorities, including Tamils and Moors, less than the majority Sinhalese, and distributed little aid within conflict areas.97 However, the population in the conflict region was also supported by the World Food Programme, which had increased its presence in Sri Lanka to provide aid to the conflict-affected population. The WFP had established a strong relationship with the government by which it provided food and the government assisted with the distribution. When the tsunami occurred, WFP had approximately 4000 tons of food aid warehoused in Colombo.70,98,99

Food availability in Sri Lanka relied heavily on rice. In 2004, Sri Lanka produced 2.6 million tons of cereals,94 of which 1.5 million tons was rice.95,99 Of Sri Lanka’s average 2405 calorie/capita daily calorie intake, 899 calories came from rice.94 Unfortunately, the distribution of rice from Sri Lanka’s productive areas to non-productive areas sometimes was limited due to the fact that a large portion of the country’s rice production occurred in the conflict region. The eastern province alone accounted for approximately one-third of the country’s rice production. In addition to 2.6 million tons of cereals, in 2004 Sri Lanka also produced 3 million tons of other food crops. Nationwide, Sri Lanka had approximately 1.9 million hectares of land under cultivation,99 of which nearly 500000 hectares consisted of rice paddies.99

Another important source of domestically produced food came from the ocean and freshwater bodies. Sri Lankans consumed an average of 22.4 kg of fish/year. Fish comprised 55% of the population’s animal protein intake.101 Sri Lankan fishermen had a fishing fleet of 31619 boats and harvested approximately 250000 ton(s of fish/year.102 In comparison, Sri Lankan livestock produced 130000 tons of meat/year.

Domestic food production met the bulk of the food needs, but Sri Lanka also relied on imported...
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food. For example, Sri Lanka relied heavily on imports of wheat, which was a major component of the diet, but could not be produced domestically. Even for food that could be produced domestically, the country often relied on imports to supplement domestic production. Sri Lanka imported 1.4 million tons of cereals of which wheat accounted for approximately 67% and rice for 17%. Although Sri Lanka harvested 250,000 tons of fish per year domestically, it required an import of approximately 130,000 tons of fish/year to supplement domestic harvests.

Although the quantity of food available is an important factor in determining a population’s nutritional health, in Sri Lanka, other factors may have been as or even more important in determining its population’s nutritional health. Some believe that Sri Lanka’s malnutrition issues are the result of poor food quality rather than food quantity. Other factors believed to have contributed to high malnutrition include poor sanitation in some areas, which can result in illnesses caused by parasites that reduce the body’s ability to absorb nutrients, and poor public education on good nutritional practices.

**Changes in food and nutrition functions**

After the tsunami, the availability of fish and Sri Lankan’s fish consumption patterns changed considerably. In 2005, the fisheries catch declined by 50% to 130,000 tons compared to 250,000 tons in 2004. During the first few months following the tsunami, fears about the safety of eating fish also impacted fish consumption in Sri Lanka, and fishermen struggled to sell what little they did catch. Fearful that locally caught fish had fed on human corpses and would transmit diseases to consumers, many Sri Lankans refused to eat freshly caught local fish, and instead turned to canned and dried fish; the price of fresh fish plummeted while the price of dried and canned fish climbed.

The impact of the damages on other domestic food supplies were minor. In fact, favourable weather conditions actually enabled Sri Lanka to increase rice harvests in 2005 compared with 2004 harvests. However, aside from its impact on domestic food production, tsunami damages also impacted the supply of food to tsunami-impacted populations by ruining markets and food distribution infrastructure, and by increasing the extent of poverty. Although there is little information on how ruined markets, distribution infrastructure, and personal assets affected access to food among tsunami-impacted populations, these damages are likely to have had the most immediate impact on food availability.

Little has been documented on whether tsunami-impacted populations suffered food shortages in the immediate aftermath of the tsunami. Most of the affected communities generally received food...
from neighbouring communities, thus avoiding serious shortages before food aid deliveries arrived. However, fewer resources were available in communities in conflict areas, where access to food already had been more limited. Even without major shortfalls in the quantity of foods available or consumed, the tsunami is likely to have caused problems in the quality of foods consumed.

**Relief responses in the food and nutrition system**

As noted, Sri Lankan residents were the first to respond to the food needs of the tsunami survivors. The communities into which tsunami survivors fled offered food from their own pantries, and Sri Lankans living in communities far from the most impacted areas collected and sent food to populations devastated by the tsunami. This response helped buffer the immediate disruptions to the food supply until national and international relief efforts could organize a more systematic and organized distribution of food.

For years, the World Food Programme had been providing food within the areas where the tsunami hit the hardest, and consequently, was in the best position to provide tsunami survivors with food aid. However, while WFP had 4000 tons of emergency food aid warehoused in Colombo, finding enough trucks to deliver the food from Colombo to the impacted areas became an obstacle. Rental vehicles had been quickly booked by Sri Lankans wanting to deliver their own donations to the tsunami-impacted populations. However, with the support of several private companies, including Unilever and TNT, that donated the use of trucks, truck drivers, and even trains to deliver food aid to tsunami-impacted populations, WFP overcame these transportation difficulties.

Between 28 December and 14 January, WFP sent 6872 tons of food to tsunami-impacted populations and would acquire and send many more tons in the following weeks and months. In providing food donations, WFP worked closely with the government, which took responsibility for distributing food aid within the tsunami-impacted areas. Even at the local level, WFP worked alongside the government to help ensure that food aid was well-targeted.

Although the areas that required the greatest food assistance were located within conflict areas, WFP faced few major obstacles in their efforts to deliver food to these locations. In the conflict areas, the Liberation Tigers of Tamil Eelam (LTTE) helped WFP reach remote villages and even allowed WFP to establish a field office in the Mullaitivu area, an area in which the LTTE previously had prohibited UN agencies from establishing an office.

In the aftermath of the tsunami, determining how many people would need food aid and for how long, proved difficult, and WFP’s earliest estimates proved to be optimistic. Initially, WFP estimated that 750000 Sri Lankans would require emergency food aid for three months. However, as the third month of the disaster approached, and it became clear that recovery was occurring slower than anticipated, WFP extended general food aid distribution to tsunami survivors for a longer period of time. Estimates of the number of people who would need emergency food aid also were low. At the height of its operations, WFP provided food aid to more than 900000 Sri Lankans in impacted areas.

Food donors and humanitarian agencies had elected WFP to lead the effort to provide survivors with emergency food aid. Thus, following the tsunami, WFP was the only major emergency food aid provider in Sri Lanka. Tsunami donations to WFP had been generous and sufficient to fully fund WFP is emergency food aid in Sri Lanka. Strong donor support enabled WFP to provide approximately 84000 tons of food to tsunami-impacted areas by the end of 2005.

In the aftermath of the tsunami, ensuring the nutritional well-being of the tsunami-impacted populations required not only ensuring that survivors received enough food, but that they were receiving food that met their nutritional
needs. An early nutritional assessment of survivors living in camps indicated that while the survivors were receiving enough food, the nutritional needs of many were not being met. The assessment conducted by the Medical Research Institute of the Ministry of Health, Nutrition and Uva Wellassa Development, UNICEF, and WFP, between 17 and 28 January, found that the nutritional needs of 70.9% of the children studied were not being met, and that although vitamin A capsules were readily available, only 23% of the children had received them.\textsuperscript{109,110} The nutritional assessment also found that children in the tsunami-impacted areas had a higher prevalence of being underweight, when compared to the pre-event national averages (30%); of the 905 children surveyed, 20.2% were stunted, and 16.1% were wasted.\textsuperscript{111} The high underweight prevalence among children in the camps was likely the product of several factors that may or may not include the quality or quantity of food served in camps. For example, children in the camps were more likely to have come from the poorer sections of society.\textsuperscript{111}

Efforts to meet the nutritional needs of the survivors appear to have been more successful in the months following this initial nutritional assessment. By November 2005, 384885 children had received supplemental doses of vitamin A.\textsuperscript{42} A nutritional surveillance system established in nine tsunami-impacted districts found that from January 2005 to February 2006, the prevalence of wasting had decreased from 16.1% to 10.8%. However, there was no major change in the stunting or underweight rates in the children.\textsuperscript{87}

**Recovery responses in the food and nutrition system**

Although the number of people who required food aid declined after the first three months, the need for assistance remained substantial. Consequently, WFP extended general food aid support to tsunami survivors first by an additional two months, and then, until September 2005. After September, WFP continued food aid distributions until 2007, although it limited distribution to 350000 people who were considered particularly vulnerable.\textsuperscript{108}

During the second half of 2005, WFP launched a pilot programme that provided some tsunami survivors with cash vouchers rather than food; survivors who lived in communities where food markets were stable and where they could easily cash vouchers, preferred the vouchers to food donations. However, in places where food markets were volatile and vouchers could not be easily cashed, recipients preferred to receive food donations.\textsuperscript{109}

In Sri Lanka, the cash vouchers were believed to support long-term food security recovery, and possibly, also improve nutrition among the households receiving them. Imported emergency food aid often had been criticized for undermining the market for domestically produced food, and consequently, slowing food security recovery. The provision of cash vouchers enabled beneficiaries to purchase their food from local vendors rather than rely on imported aid. In addition, there has been a push among food aid donors, including WFP, to purchase food aid supplies from within the beneficiary country when available. In the year following the tsunami, Sri Lanka was in a good position to supply food to donors purchasing food to be distributed to tsunami-impacted populations. Generally speaking, Sri Lanka produced enough food to meet the bulk of its food requirements, and in 2005, crop harvests were good. The WFP signed an agreement with the Ministry of Agriculture to buy 18000 tons of rice from Sri Lankan farmers to help to support WFP’s food-aid operations within the country.\textsuperscript{110} In addition to supporting local food producers, cash vouchers appeared to enable beneficiaries to consume healthier diets consisting of more diversity and more fresh produce than available in food aid rations.\textsuperscript{109}

Finally, responses to the tsunami disaster included addressing the restoration of Sri Lanka’s capacity to produce and distribute its own food. As noted, tsunami damages to the fisheries had the greatest impact on food availability and food consumption.
in Sri Lanka. While the tsunami had also damaged agricultural areas near the coast and had undermined the livelihoods of many farmers, Sri Lanka’s overall crop production actually was greater in 2005 than in 2004. Tsunami damages, however, had certainly taken a toll on domestic harvests and the marketing of fish as did false fears that local fish were no longer safe to eat. International and national relief efforts worked quickly to counter these setbacks and restore the Sri Lankan fishery’s important role in the Sri Lankan diet. When Sri Lankans stopped eating local fish after the tsunami, WHO officials and other health authorities confronted false concerns that the fish were unsafe, and urged Sri Lankans to resume eating locally caught fish.  

Donors generously funded the restoration and replacement of boats, and within approximately one year after the event, had replaced all of the boats that the tsunami had destroyed. With strong donor support, Sri Lanka’s fisheries slowly improved from a low catch of 130000 tons in 2005 to 215000 tons in 2006.76

**Development in the food and nutrition system**

Responses to the nutritional needs included efforts to prepare for future nutritional needs. The government developed a National Policy on Nutrition to address nutrition-related responses during a disaster within the country’s overall nutritional strategy.  

**Energy system**

**Pre-event**

Two-thirds of the electricity in Sri Lanka was supplied by hydroelectric plants, and one-third by thermal plants using oil and/or natural gas. All the generation plants were located inland and service was provided by the Ceylon Electricity Board (CEB) and the Lanka Electricity Company (LECO). The CEB is a governmental institution involved in the generation, transmission, and distribution of energy, serving 3567000 customers across Sri Lanka. The LECO provided distribution services and served a total of 391000 customers in limited areas north and south of Colombo.71 In the areas impacted by the tsunami, distribution lines and substations provided electricity to local residents. The major transmission lines, grid sub-stations, and power plants that served these areas were located further inland and were not in the tsunami-impacted areas.70

In coastal regions, distribution rates varied with greater availability of electricity in the southern and eastern provinces than in the north. In the southern province districts, electrification rates were 57% in Hambantota, 74% in Matara, and 85% in Galle (Table 7.15). In the northern region it is estimated to be around 30–40%. Electrification rates in the eastern province districts are 46% in Tricomalee, 44% in Batticaloa and 57% in Ampara.70

Electricity was the major source of light in 52–87% of the household in the impacted areas. Kerosene provided light in nearly 50% of the households in Ampara, Hambantota, and Puttalam (Table 7.15). Except for Colombo, firewood provided most of the energy used for cooking.

**Damage to the energy system**

Because electricity-generating facilities were located inland, they did not sustain damages due to the tsunami. However, near the seashore, the tsunami damaged the electricity distribution infrastructure and disrupted supplies. The tsunami damaged 88 substations and approximately 450 km of medium- and high-voltage powered distribution lines. Additionally, although the tsunami did not damage generation facilities, it did damage the Ceylon Electricity Board Complex in Hambantota.

Damages to the electricity subsystem cost an estimated of US $14.4 million with the greatest damages occurring in the south and southeastern districts of the country. Electricity asset damages were greatest in Galle district, at an estimated US $3.3 million, followed by Ampara, at US $ 2.4 million, and Hambantota at US $1.8 million.
No information was identified relative to other damages in the energy system as related to the medical care and public health systems.

Changes in energy system functions
The greatest number of customers that lost service were in Galle where nearly 20,000 households lost service followed by Ampara where 14,000 households lost service. All told, the tsunami disrupted service to approximately 63,000 households. Of all of CEB and LECO’s household customers, approximately 2% lost service due to the tsunami. It was not possible to identify the impact of losses of electricity and fuels on the health facilities.

Relief responses in the energy system
In the immediate aftermath of the tsunami, some donors responded to energy shortages with the provision of electrical generators; WHO-SEARO provided generators to those hospitals that lost power due to the tsunami.112

Recovery responses and development in the energy system
Recovery of the electricity component of the Energy BSF System in communities served by the Ceylon Electricity Board took approximately two months. However, the Energy Board’s recovery work continued much longer as newly rebuilt homes would require new connections.114

Public works and engineering system
Pre-event
Sri Lanka had an extensive road network system, consisting of 1.53 km/km². However, the road system was unevenly distributed, and some of the areas that were least accessible were also among those hardest hit by the tsunami.134 Sri Lanka had only one international airport, Bandaranaike International Airport, located approximately 35 km north of Colombo.

Generally, waste was managed poorly prior to the tsunami; wastes frequently piled up in residential areas along streets and in clogged gutters. Local governments in the country removed a total of 26.58 million tons of waste from residential, commercial, and industrial areas; most was dumped along the outskirts of cities and towns.136 However, collected wastes represented only about 40% of the total generated waste, which was estimated at approximately 64,000 tons per day.

Damage to the public works and engineering system and changes in its function
Many of the roads in areas directly impacted by the tsunami were badly damaged and in some cases unusable.134 However, for the most part, tsunami damages were limited to areas close to the shore, and most impacted communities could be accessed from roads further inland when the coastal roads had been damaged. The tsunami damaged a total of 1,700 km of roads, 900 km of which were national roads, and 800 km of provincial roads.113

The tsunami scattered an estimated 900,000 metric tons of debris along the Sri Lanka coastlines. In impacted areas, an already weak waste management system collapsed, and waste was dumped indiscriminately, thereby compounding environmental health hazards.114 Tsunami-scattered debris, such as tires, pans, and plastic water bottles left many new places for rain to collect, and hence, increased the potential for an increase in the number of mosquitoes transmitting malaria and dengue fever.111 Additionally, scattered debris, including broken glass and scattered bits of sharp metal, posed new injury hazards, and health wastes became a problem.

Relief and recovery responses in the public works and engineering system
Efforts to rapidly clear rubble, waste, and other tsunami-scattered debris early in the disaster resulted in the haphazard disposal of debris onto beaches, in fields, along roads, and other areas turned into makeshift dumpsites (Figure 7.11). In
In some cases, people attempted to clear debris by burning it causing air quality to become a concern and the Central Environmental Authority ordered that the practice be stopped.\textsuperscript{66}

In an effort to restore the transportation infrastructure, the Sri Lanka Road Development Authority was given responsibility for coordinating road recovery. Recovery in the road rebuilding subfunction of the Public Works and Engineering System was credited with being the most efficient among recovery efforts. Donors quickly committed funds for road and bridge reconstruction, and within two years of the tsunami, the construction/repair of five bridges had been completed.\textsuperscript{115–116}

**Development**

The Sri Lankan government established an expert team to investigate issues related to coastal planning in light of the risks posed by tsunamis, cyclones, and sea erosion.\textsuperscript{115–116}

**Social systems**

**Pre-event**

In Sri Lanka, two opposing forces pulled social and mental health indicators in opposite directions. A long smouldering conflict weakened many of the indicators that define social and mental health, while strong social services, such as public health and education, helped improve them. Sri Lanka’s conflict was rooted in ethnic tensions. Differences in language, religion, and origins separated Sri Lanka’s population into three primary ethnic groups that represented more than 99% of Sri Lanka’s population. According to a 2001 government census, 74% of the population were Sinhalese, 9.4% of the population were Tamils, and 7.9% were Moors.\textsuperscript{87} The Sinhalese are mostly Buddhist, speak Sinhalese, and have a history in Sri Lanka dating back to 500 BC. The Tamils are more recent arrivals that migrated from India’s Tamil coast, and are divided into two groups: the Sri Lankan Tamils; and the Indian Tamils. Both speak Tamil and most are Hindu, but the Sri Lankan Tamils live primarily in the north and the east while the Indian Tamils live mostly in the central highlands. The Moors are the descendants of Arab traders who settled in Sri Lanka between the 15th and 18th centuries; most are Islamic, primarily speak Tamil, and many are multi-lingual.

The geographic distribution of Sri Lanka’s ethnic groups also polarized them, with the Sinhalese concentrated in the south and southwest and Tamils and Moors concentrated in the central highlands, north and northeast.

Sri Lanka’s civil conflict had persisted for approximately 20 years, and was aggravated primarily by tensions between the Sri Lankan Tamils and Sinhalese. In the regions most affected, the north and northeast, the conflict increased poverty rates, disrupted livelihoods, and broke apart families with deaths and displacements; this resulted in grim mental health and psychosocial consequences. Alcoholism, drug use, and suicide rates were high in Sri Lanka, particularly in regions heavily affected by the conflict. Sri Lanka’s suicide rate was among the highest in the world; official figures indicate that the suicide rate of 33 suicides/100000 people in 1986, with rates remaining at or close to that rate through the rest of the century.\textsuperscript{117} Some reports suggest that these official estimates were low and that the suicide rate may have reached as high as 47 suicides/100000 people in the nation as a whole, and as high as 53.5 suicides/100000 people in the heavily conflict-burdened district of Jaffna.\textsuperscript{82} Other factors thought to have contributed to Sri Lanka’s suicide rates were high levels of alcohol use and drug addiction, and high poverty levels. Between 1980 and 2003, the per capita consumption of alcohol increased nearly four-fold, and Sri Lanka’s alcoholism levels were among the highest in the world.\textsuperscript{118}

While the conflict and its consequences pulled many of the indicators of social well-being downward, Sri Lanka’s strong educational...
system and medical care and public health systems tended to improve some indicators of social well-being, particularly with respect to women's rights and empowerment. For many years preceding the tsunami, Sri Lanka made free and equal access to education and health care a high priority, which facilitated improvements in women's status and reduced reproductive rates. Consequently, Sri Lanka had achieved a greater degree of gender equality than many other developing countries. By 2004, Sri Lanka's gender development index had risen to 0.74, above the average for countries of a similar level of development. Under Sri Lanka's system of General Law, women had equal rights. However, despite these achievements, Sri Lankan women's equality and empowerment still faced several challenges. For example, with respect to the law, not all Sri Lankan women enjoyed the same freedoms and rights. In addition to the General Law, Sri Lanka had three parallel systems of law—Islamic Law, Kandyan Law, and Tamil Thesavalmai Law—which were applied according to cultural identity and governed by customary practices and religion. Under these parallel systems of law, some discriminatory provisions continued to persist regarding marriage, divorce, property, and financial transactions. Under the General Law, women may marry once they reach 18 years of age, except for those marrying under Islamic Law, which does not recognize a minimum age for marriage.

The ongoing civil conflict also undermined women's equality and empowerment. While Sri Lankan women are legally entitled to freedom of movement, security issues in conflict areas sometimes limited women's ability to travel without jeopardizing their safety. These problems were accentuated in the IDP camps.

Although Sri Lanka provided strong educational and public health services, it provided conspicuously little support for psychosocial and psychiatric services. Although conflict-related traumas, high levels of alcoholism, drug use, and suicide suggest many Sri Lankans would have benefited from strong psychosocial and psychiatric services, psychosocial and psychiatric services were limited. For its population of 19.4 million people, Sri Lanka had only 30 psychiatrists and three clinical psychologists. Sri Lanka also had eight psychiatric social workers and 55 medical officers of mental health, who essentially were general physicians with three months of mental health training. Except for a few communities, the country did not have trained mental health workers at the community level.

Outside of Colombo, very few hospitals had separate acute mental healthcare wards—more than 90% of Sri Lanka's mental health resources were concentrated in Colombo and in few other major cities. Three long-stay hospitals for individuals with mental illnesses were located in Colombo and had approximately 3000 patients, 1700 of which were long-stay patients. Approximately 80% of resources devoted to mental healthcare were consumed in the care of long-stay patients. WHO-SEARO estimated that continuing care could be provided in their respective communities; 90% of the hospitals' long-stay patients could be discharged. People located outside the few areas in which mental health services could be accessed had to travel long distances to reach them. In addition, patients had to obtain prescribed psychiatric medications from the hospital that treated them, requiring repeated trips.

Some of the regions that needed mental health services the most had the poorest access. In the conflict districts, there were only two psychiatrists, four medical officers of mental health, and no clinical psychologists. Only two places within the conflict region provided reasonable access to mental healthcare services. In Jaffna and Batticaloa, community-based mental healthcare services had been established despite limited resources. Jaffna was one of the few districts to have a hospital with a separate acute care ward for mental health patients. The ward hosted a multi-disciplinary team that included volunteers that worked within the community. Despite the apparent increased need for
psychosocial support for persons in the conflict areas, few services were available.

Finally, in addition to the inequitable distribution of scarce psychosocial health resources, Sri Lanka’s mental health legislation was based on an 1873 British law that promoted stigmatization, discrimination, and isolation of people with mental illnesses. The law on which Sri Lanka legislation was based, the British Lunacy Act, was created at a time when people with mental illnesses were incarcerated in large institutions. This law was partially revised in 1956.

In some cases, NGOs stepped in to fill in gaps in local mental health services for minorities and others vulnerable to the impact of the conflict. In June 1998, the local NGO, Eastern Self Reliant Community Awakening Organization, was established in Batticaloa, with a primary goal of supporting children who had lost one or two parents due to the conflict.111

**Damage to the social system**

Tsunami-related traumas were similar to those inflicted by the conflict, i.e., the tsunami destroyed livelihoods, displaced families, and injured/killed loved ones. Some of the greatest tsunami devastation occurred in the same regions of the country in which the conflict had been most active. The tsunami fatalities differed from conflict fatalities in that they comprised mostly women and children. Several factors are believed to have contributed to the high female fatality rates; Sri Lankan women’s typical wrap-around clothing would have made it difficult for them to run to safety; and women are believed to have had greater difficulty running to safety because they were more likely to be carrying children.123 In the village of Dutchbar in the district of Batticaloa, the tsunami struck at the time when the women bathed in the sea.124 Similarly, children would have had difficulty running to safety and would have been more likely to have drowned if caught by the tsunami. Out of 35000 fatalities, as many as 12000 (34%) were estimated to have been children.122,125,126 Relative to the number of fatalities, the tsunami seemingly resulted in few orphans. For example, in the southern province, the tsunami killed approximately 10000 people, and the Sri Lanka Child Protection Authority identified 672 surviving children who lost one parent, and 84 surviving children who lost both parents due to the tsunami, with slightly more losing mothers rather than fathers.81

Survivors often not only suffered more due to the deaths of family members, but also their grief was compounded when the remains of loved ones were not found and identified. In order to initiate the grieving process, survivors needed to be certain that their loved ones had died. Additionally, cultural rituals central to the healing process could not be performed. Many of those who died due to the tsunami remained unidentifed and the unresolved loss of their friends and relatives likely contributed to greater psychosocial and psychiatric health issues.

The tsunami damaged and destroyed churches, mosques, and temples standing within its reach. In the district of Ampara, 81 religious buildings were destroyed.126

**Changes in social system functions**

With respect to damaged social infrastructure, damage to schools, homes, and workplaces delayed survivors’ ability to resume their normal day-to-day lives. There was little mental health infrastructure pre-event and what little there was, was generally located outside the tsunami’s reach.

Women who survived and were widowed by the tsunami sometimes faced challenges as ethnic customs and laws required women to rely heavily on men. In cases in which families were registered under the man’s name for governmental and insurance purposes, widowed women sometimes struggled to access benefits such as cash and rations after the tsunami.124

While not often discussed as an aspect of the mental health response to the disaster, the identification of the deceased provided an effective means for assisting the traumatized to resume their normal lives. Unfortunately, the
opportunity to relieve bereaved survivors of the anxiety of not knowing for certain whether or not their loved ones had died was largely missing. There were no plans in Sri Lanka for managing a mass-casualty event as large as the one that followed the tsunami, and administrative, health, and judicial services were overwhelmed by the number of bodies that required attention after the tsunami.

**Relief responses in the social system**

In the immediate aftermath of the tsunami, Sri Lankans with mental health training and who were available to support tsunami survivors were in short supply. Hundreds of international NGOs attempted to fill gaps in mental health services, but international NGO relief workers often did not have the appropriate psychosocial training and had a limited understanding of the local culture.

Early during the disaster, Sri Lanka created the National Psychosocial and Mental Health Committee, and completed the National Action Plan for the Management and Delivery of Psychosocial and Mental Health Services. The plan, completed on 10 January, outlined the activities required to meet the short- and mid-term mental health needs of survivors and designated national and local authorities to lead them. Activities outlined in the plan emphasized the normalization of survivors’ lives, improving the capacities of existing institutions to detect survivors in need of care, and to provide them with services and coordination of activities between states, local, and international actors.

The tsunami provided a renewed focus on Sri Lanka’s mental health services and an opportunity to improve them. In developing the National Action Plan for the Management and Advisory of Psychosocial and Mental Health Plan, Sri Lanka’s Department of Mental Health Services consulted with a number of mental health stakeholders including WHO-SEARO. WHO-SEARO also helped health officials identify appropriate psychosocial responses, manage resources, address staffing shortages, and helped the Directorate of Mental Health Services of the Ministry of Health coordinate the NGO psychosocial response.

Coordination presented a formidable challenge; hundreds of NGO workers offered mental health interventions, and there was no strong mechanism in place to manage and direct their activities. Communities and camps in tsunami-impacted areas sometimes were barraged with inappropriate mental health interventions. For example, in a community of mostly Muslim survivors in Kalmunai, Ampara, a foreign psychosocial relief team upset community leaders when the workers encouraged children and youth to express themselves through Western dance and song. Camp administrators and primary healthcare workers had little experience with psychosocial interventions as a disaster response, and did little to regulate psychosocial activities of NGOs among survivors.

The negative impact of the influx of personnel from outside the area was substantial. At this time, the need was not so much for specialist interventions (except for a small proportion with major psychiatric illnesses) nor was there a great need for widespread use of psychotropic substances.

In Sri Lanka, bodies were recovered almost exclusively by the communities themselves. On the day of the tsunami, recovered bodies were taken to hospital morgues, which were filled within a matter of hours. And on the second day, the unceremonious disposal of bodies into mass graves began (Figure 7.12). Following the tsunami, WHO tried to discourage the hasty disposal of unidentified fatalities by issuing guidelines on disposal of dead bodies, while also indicating that dead bodies do not pose an epidemic risk.

In some cases, the bereaved found and identified the remains of loved ones before they were buried or rendered unidentifiable due to decomposition. The Sri Lankan Centre for National Operations mandated local authorities to collect fingerprints and take photographs of...
all the deceased, but the instructions did not reach the relevant authorities until several days after the tsunami. Also, even when photographs were taken, they could not always be used because there was no money to develop the film or, in cases in which photos were taken by private individuals, there was insufficient money to pay the photographer. However, there were exceptions; the handling of bodies at a hospital in Matara illustrates that even when resources are scarce, careful records can improve fatality identification considerably. At the Matara hospital, digital photographs and the recording of basic profile information, such as sex, height, and personal effects, resulted in identification of >87% of the 547 bodies that arrived at the hospital.133

While most Sri Lankans had to rely on early identification of fatalities by friends and relatives or photos and recorded profile data, the identification of foreigners garnered greater attention and resources. Foreign victims were sent to an Identification Centre in Colombo. And for foreign victims who somehow did not make it to Colombo, the Centre supervised six major exhumations. In the process, Sri Lankan victims also were exhumed, but not targeted for identification.133

In some cases, the loss of family members left remaining family members vulnerable. This was true particularly for children who had lost parents. In its response to meet the needs of children who had been orphaned by the tsunami, Sri Lanka sought to minimize the trauma of their losses by keeping them within familiar surroundings and encouraged extended family to care for orphans.114

**Recovery responses in the social system**

While the mental health responses to the tsunami disaster in many ways were chaotic and sometimes inappropriate, it also included some innovative services that responded to the local realities of the tsunami aftermath. For example, recovery services included support groups for widowers, for survivors suffering from alcoholism,133 and for survivors who preferred to receive support through temples and other religious institutions. One innovative programme provided psychosocial support training to approximately 100 monks.130

**Development of the social system**

Short-term mental health activities took centrestage in the first weeks and months of the disaster. At the same time, the Ministry of Health’s Mental Health Director, WHO-SEARO, and the College of Psychiatrists pushed for changes in mental health services that would reach beyond the needs created by the tsunami. Their efforts resulted in three major successes; changes in Sri Lanka’s mental health policy; greater provision of local mental health facilities; and extension of mental health care into communities provided by trained community-level workers.

Following the tsunami, the MoH and WHO-SEARO placed high priority on drafting and enacting new mental health policies, and by October, a new National Mental Health Policy was finalized. The new policy shifted the course of mental health services away from institutional and centralized services toward decentralization and community-based care. In the policy, the Sri Lankan government committed to a considerable increase in mental health infrastructure resources. Newly committed resources included the appointment of additional nurses to work in new mental health wards, the appointment of medical officers of health in each of the country’s 276 medical officer health districts, and the training of new mental health professionals. Implementation of the new mental health policy represented a major advance for Sri Lanka’s mental health infrastructure, but also required major resources. Early implementation received support from Finland and Victoria State in Australia.122 As a result of the new policy towards decentralization, many more districts now have acute mental health care wards, enabling more patients to receive care locally rather than having to travel to hospitals in Colombo.
WHO-SEARO developed a strategy to train community-level workers, known as Community Support Officers (CSOs), to provide basic psychosocial support. Using this strategy, community-level workers were selected and trained in mental health and psychosocial work to address the basic psychosocial needs of tsunami survivors. In addition, they were able to refer survivors who they believe require greater care. Within a year of the tsunami, 500 people had been recruited to complete training to become CSOs. The CSO strategy was developed in response to the tsunami, but its success has had a lasting legacy in tsunami-impacted areas.

In addition to the CSO strategy, an International Medical Corps (IMC) programme was initiated that educated and trained primary healthcare workers in mental health, did not require great resources, was sustainable, and was integrated. However, unlike the CSOs programme which rapidly saw case detection rates climb, it did not result in greater case detection rates. Despite their apparent success, the future of CSOs is uncertain. By the end of 2008, Sri Lanka remained reluctant to integrate CSOs into the national system, and the donations that WHO relied on to support the CSOs had begun to dry up.

Transport and logistics system
Pre-event
The geographical location of Sri Lanka places it in a strategic position as a crossroads of many Asian trading routes. The transport and logistics system in Sri Lanka consisted of road, railway, and sea elements. The system contributes about 8% to Sri Lanka’s GDP.

Roads were the primary means used for 70% of transportation traffic. Except for Thailand, the road densities were high relative to the other countries discussed in this book. However, outside Colombo, in general (50%), they were neglected and speeds and services tended to be slow. In addition, the traffic on the roads tended to be congested. And, the use of the roads was essential for the rural population (65%) to access essential services. Road travel was compromised further because fuel prices were increasing steadily, which, in turn, caused increases in prices of tickets for public transportation.

There were 2073869 registered vehicles in Sri Lanka in 2003 and 2297711 in 2004. Of these, 18% were automobiles, 12% were 3-wheelers, and 70% were motorcycles. In 2004, there were 54000 road crashes in which some 20000 persons were injured while 1700 ambulances/hearses were registered; there was no operational EMS system and no information could be found as to how the ambulances were staffed or the equipment and supplies carried in the ambulances.

The use of the railroads for passenger and freight traffic had declined progressively before the earthquake and tsunami so that it carried only 5%–8% of the total transportation traffic. There was 1500 km of railroad track and 150 locomotives. Furthermore, the rolling stock, communications, and rail beds were old and in disrepair. This was the case particularly in the northeast areas that fell victim to the tsunami. Moreover, the southern rail corridor carries 78000 passengers/day (mostly commuters) and freight from the Port of Galle.

There are international sea ports in Colombo, Trincomalee, and Kankasanthurai. The premier port was in Colombo.

Damage to the transport and logistics system
For the most part, there was little damage to the transportation and logistics system related to the tsunami. The total number of registered vehicles continued to increase at a rate of 12%/year from 2003 through 2007 with motorcycles continuing to provide 69% of the vehicles, but with a slight increase in the proportion of 3-wheelers.

The tsunami did take a toll on public transportation, flooding and ruining buses and trains. In Peraliya, Galle, the tsunami threw a train
off of its tracks, killing more than 1000 people (Figures 7.13 and 7.14).\textsuperscript{136,137} Twenty kilometers of the Southern corridor suffered major damage involving embankments, track, bridges, culverts, signaling and communication systems, buildings, and rolling stock. Minor damage was sustained by the northeastern and eastern rail corridors.\textsuperscript{135}

**Changes in transport and logistics functions**

Transportation difficulties that occurred following the tsunami were caused not only by damages to the transportation infrastructure, but also by a sudden increase in demand for transportation to and from the impacted areas. Due to the increased transportation demand, rental vehicles were quickly booked and fuel availability became problematic. The limited availability of fuel and damages to roads and vehicles, including buses and ambulances resulted in an inability of some of the injured to access medical facilities. Additionally, damage to the hospitals near coastal areas sometimes meant victims had to travel further inland to receive treatment.\textsuperscript{138}

Rail services along the southern, northeastern, and eastern corridors were interrupted for several days and part of the southern corridor for several months. This resulted in an inability of commuters to reach their areas of employment and compromised the freight traffic along the key routes. Some communities were temporarily isolated due to the damages, and in some instances, impacted communities could only be reached by boat.\textsuperscript{83}

**Relief responses in the transportation and logistics system**

Early efforts to improve transportation included donations for improving vehicular availability, particularly in areas that were central to disaster relief efforts. For example, in the medical care BSF system, WHO provided healthcare volunteers with 66 bicycles, midwives with 260 mopeds, and public health inspectors with 100 motorcycles. Similarly, UNICEF provided the Ministry of Health with 34 ambulances and other vehicles, and 124 motorcycles for public health inspectors.\textsuperscript{81} Additionally, the Saudi Red Crescent Society donated 19 ambulances to Sri Lanka, 15 of which were given to government hospitals.\textsuperscript{38} Repairs were made within days to most of the railroad beds, but the speeds attainable remained compromised for months.

Coordination between the MoH and UN helped ensure the proper documentation and storage of medical supplies received through the Bandaranaike International Airport. The inventory and storage of medical supplies destined for Sri Lanka and UN agencies were handled by the World Food Programme (WFP) and the MoH. Incoming medical supplies initially were received by the WFP Logistics Centre, and then, immediately transferred to the Medical Supply Centre that was established and manned by the Medical Supply Unit of Ministry of Health. Additionally, medical supplies destined for other agencies, but not picked up from the airport within a designated period of time were stored at the Medical Supply Centre.\textsuperscript{131}

**Recovery responses in the transportation and logistics system**

With respect to the railways, responsibility for recovery coordination was given to the Department of Railways.\textsuperscript{113} Train services between Colombo and Matara resumed on 20 February 2005.\textsuperscript{136}

**Development of the transportation and logistics system**

The only information relative to development of the transportation and logistics system was that resources were placed into the development of a major port in Hambantota. No other information on the development of the transportation and logistic system was relevant to the public health and medical care systems in Sri Lanka.

**Security System**

**Pre-event**

Like the Acehnese in Indonesia, Sri Lankans had endured the burdens of conflict for many years. The conflict had begun in the early 1980s in Sri
Lanka’s northeast province, as the Liberation Tigers of Tamil Eelam (LTTE) began fighting the Sinhalese for an independent Tamil state in the region. Conflict in the region impeded development in the north and the east on many levels; poverty rates were higher and the indicators that reflected the health status, nutritional status, and education generally were at lower values than for the nation as a whole. Shortly before the tsunami, however, it seemed as if diplomacy might relieve Sri Lanka of the conflict. In February 2002, the LTTE and the government signed a Memorandum of Understanding—fighting simmered down and life in the north and east showed signs of improvement.

However, even with a lull in fighting, safety remained a major concern in the conflict areas. Landmines planted during the conflict still posed a hazard, even though mines had been marked, fenced, and their locations recorded by a global positioning system.140

### Damage to the security system

The immediate impact of the tsunami on the security system was mixed. On the one hand, the tsunami forced displaced people into vulnerable circumstances and included areas contaminated with land mines. Fortunately, disturbances to areas that were known to contain landmines by the tsunami were limited. Fences and other markers indicating landmine locations were damaged or destroyed in many areas along the northeast coast, but for the most part, the landmines moved little, and those that had moved remained within close proximity to areas already declared to be dangerous.

### Changes in the security system functions

The disaster, at least temporarily, improved security in the conflict areas by urging conflicting groups to work together in an effort to rebuild tsunami-impacted areas. The LTTE told the government and international agencies that it would coordinate with them in the regions under its control.140 and on 30 December, the LTTE held a coordination meeting with relief workers in Kilinochi. Representatives of UNDP, UNICEF, and UNHCR participated in the meeting. At this point during the disaster, coordination between LTTE, district authorities, and the armed forces was reportedly smooth in Jaffna, Kilinochi and Mullativu, but not in Batticaloa.50,132

### Relief and recovery responses in the security system

The cited UN coordination meeting immediately raised concerns about landmines, and a UNDP de-mining project representative investigated concerns, found no floating mines, and found that some landmine markers had shifted.132 Assessments were conducted by UNDP, the Mines Advisory Group, Danish Demining Group, Norwegian People’s Aid, Humanitarian Demining Unit, and the Halo Trust in the districts of Batticaloa, Jaffna, Kilinochchi, Mallativu, and Trincomalee to determine how the tsunami had impacted landmines and unexploded ordnance in those areas. No evidence was found to support media stories reporting that the tsunami had displaced mines floating off the coast and heading toward shorelines. Additionally, the assessments did not find evidence of post-tsunami mine victims in Kilinochchi, Jaffna, and Mallativu, which also had been reported by the media. Approximately 43 foreign military forces responded to the tsunami disaster in Sri Lanka.50

Assistance transcended religious and ethnic boundaries. Buddhists and relief workers traveled to the Tamil-controlled northeast from the government-controlled south to help victims. However, as the disaster wore on, reconstruction continued at a slow pace and refugees in the Tamil north accused the government of unequal distribution of resources.50

### Development in the security system

The civil war between the government and the LTTE waxed and waned for several years following the tsunami. Numerous attempts were made to resolve the conflict. The last truce
agreement between the warring parties was signed on 17 May 2009.

Communication system

Pre-event

Prior to the earthquake and tsunami, Sri Lanka had an extensive telephone system consisting of 883,000 fixed lines and 931,000 cellular lines. However, this represented a fixed line density of only 4.7/100 population and cellular density of 4.92/100 population. Two-thirds of the fixed-line services were in the Colombo area. Only 11% of the villages had telephone service in 2001. In 2003–2004, the computer availability density was 1.3/100 population and 1.0 Internet users/100 population.

Media outlets were separated by the languages used and were operated either by the government or private companies. The state owned two major television stations, operated a radio network (Sri Lanka Broadcasting Corporation), and published newspapers in Sinhala, Tamil, and English. The private sector owned and operated at least one dozen radio stations and eight television stations. These stations were allowed to broadcast programmes debating government policies. Of the eight newspapers published, six were privately owned.

No tsunami warning system was in place prior to the tsunami.

Damage to the communication system

Sri Lanka Telephone sustained an estimated US $100 million in damages, especially to transmission line poles and local switching equipment inundated by the water. Additional information specific to damage sustained by the communication system was not found.

Changes in communication system functions

For the most part, telephone and cell phone communications were transiently inoperative. Other than the fact that there was no warning of the approaching tsunami, no information could be found of failures of the communication system.

Relief responses in the communication system

Relief efforts in the communications system focused on enabling those for whom services were needed most. For example, in the medical care BSF system, WHO provided responders in the public health and medical care systems in affected areas with 20 sets of telecommunications equipment.

Additionally, WHO-SEARO installed local area networks, servers, and work stations in the offices of the Deputy Provincial Director of Health Services and the main hospitals in the districts of Ampara, Hambantota, Matara, and Jaffna. WHO also installed smaller systems with stand-alone computers in the Ministry of Health offices in those four districts.

In the aftermath of the tsunami, the International Water Management Institute’s remote sensing and geographic information systems unit and MapAction facilitated coordination among relief workers by providing interactive maps using up-to-date information on occurrences in specific areas. The maps, known as geographic information system (GIS) maps, displayed complex information about tsunami-impacted areas that allowed relief workers to better assess damages and gauge the needs. Additionally, GIS maps were frequently updated to display the most current information available.

Recovery responses in the communication system

The Family Health Bureau of the central Ministry of Health sent supplies of printed forms to primary health centres, so that health centres could reconstruct health records that were damaged/destroyed.

Development of the communication system

WHO-SEARO provided telecommunications equipment to link medical facilities. Other information specific to the communication system...
Economic system

Pre-event

In 2004, Sri Lanka had a GDP of US $1031 per capita and its economy was shifting from reliance on the agricultural sector to greater reliance on the service and industrial sectors. In 2004, services and industry contributed to 56% and 26% of Sri Lanka’s GDP, respectively, compared with an 18% contribution from agriculture including fishing. Fishing, hotels, and tourism together contributed 3% to the GNP including 100000 jobs in the fishing industry and 27000 jobs in tourism. Employment numbers in the industrial sector grew by more than 600000 to 1.7 million, while employment numbers in the services sector nearly doubled from 1.7 million in 1990 to 3.2 million in 2004. In 2004, the total number of people employed in all sectors was 7.4 million.

Unemployment rates were in a steady decline from a high of 15.9% in 1990 to a low of 7.6% in 2000, but rose to 8.3% in 2004. During the same period, unemployment rates generally were twice as high among women as for men. In 2004, 6% of the male labour force was unemployed, whereas 12.8% of the female labour force was unemployed. The provinces impacted by the tsunami did not provide a large portion of the GNP, the south and northeast provinces made up 26% of the total population of Sri Lanka, but they contributed only 17.5% of the GNP; the south and northeast provinces made up 26% of the total population of Sri Lanka, but they contributed only 17.5% of the GNP; one-quarter to one-third of the population in these provinces were below the poverty line, which contributed to increased vulnerability to the forces brought by the tsunami.

Damage to the economic system

Approximately 5000 small businesses and 200000 jobs are estimated to have been lost due to the tsunami. A survey of livelihoods consisting of interviews of 1627 people in tsunami-impacted areas in January and February 2005 found that 30% of the Sri Lankan households in impacted areas had been poor before the tsunami. The districts of Hambantota and Batticaloa had the highest incidence of tsunami-impacted households that had been poor before the tsunami.

Preliminary estimates indicated that damages inflicted totaled about US$1.5 billion (7% of the GNP). Two-thirds of the fishing industry was destroyed or damaged, and 5000 village industries were decimated. Damage to agriculture and livestock cost some $3 million.

Changes in economic system functions

Damages to the fishing industry cost nearly 100000 jobs, and tourism lost 14000 jobs and indirectly negatively impacted more than 65000 jobs. The salinity added to the soil rendered the land non-productive for three to four years.

Relief and recovery responses in the economic system

The largest sum of money for relief and recovery from a disaster caused by a natural hazard was pledged during the earthquake-tsunami disaster; by the end of 2005, it totaled US$ 13.6 billion with donations from 92 countries. However, more than for any of the other countries in this study, the distribution of the funds allocated to Sri Lanka for relief and recovery have been most difficult to identify and track. It seems that the economic issues basically mimicked those of Indonesia.

Development of the economic system

Since the tsunami, despite the tsunami and the civil war, the Sri Lankan economy has grown by an average of 8%/year driven primarily by strong agriculture and services industries, expanding...
industrial production, and a huge growth in tourism. Peace and expectation have attracted investments and return of land from the LTTE has boosted cultivation in the northeast province. Sri Lanka has invested in development of a major port in Hambantota which will produce thousands of new jobs and should attract foreign investments. In 2010, its GDP had increased to US$ 42 billion with a per capita income of US$ 2014. Exports accounted for 20% of its GDP\textsuperscript{152,153}

Educational system

Pre-event

As far back as the 1940s, Sri Lanka has implemented forward-looking policies that approached education as an investment in its future. These policies prioritized free and equal access to education and resulted in high literacy rates. Between 1987 and 1990, Sri Lanka had the highest literacy rates relative to per capita income.\textsuperscript{154} After 1990, Sri Lanka lost this lead as other countries increased investments in education, but it continued to enjoy high literacy rates relative to its per capita income. As of 2003, Sri Lanka had a literacy rate of 92.3\%.\textsuperscript{155}

As of 2003, Sri Lanka also had 185036 teachers in 9790 government schools attended by 3941685 pupils. This included 1667994 primary school students, 1032371 junior high school students (grades 6–8), 954541 senior school students (grades 9–11), and 286779 collegiate students (grades 12–13).\textsuperscript{156}

Damage to the educational system

A total of 190 schools, including 168 public schools, 18 vocational schools/industrial training centres, and four universities in Sri Lanka were damaged by the tsunami. The districts that suffered the greatest damage were Ampara (38 schools), Batticaloa (33 schools), and Trincomalee (27 schools). Of the schools damaged, 90% were primary and secondary schools. Damages to schools included damage to the buildings, equipment, books, and other school supplies. Educational system damages were estimated to cost US$ 45 million.\textsuperscript{81}

Changes in the educational system functions

Although damages to schools were small relative to the total number of schools in the country, the educational system faced the double burden of disruptions due to damages and disruptions due to IDPs using schools as temporary shelters. In addition to the schools that had been damaged or destroyed, 444 schools were used as IDP camps and needed to be vacated and rehabilitated before they could be used as schools again.\textsuperscript{157} Consequently, the education of approximately 38862 students was disrupted as a result of the tsunami.\textsuperscript{158}

Relief responses in the educational system

Restoration of the educational BSF system was prioritized as an important step in helping tsunami-impacted families regain normalcy in their lives. Internally displaced persons living in schools were provided with alternative shelter to free-up occupied schools and in places where school buildings had been damaged or destroyed. Some NGOs, such as the IOM and UNICEF, erected temporary schools. Sri Lankan students whose schooling had been disrupted by the tsunami, slowly began returning to classrooms approximately two weeks following the tsunami.\textsuperscript{157}

Recovery responses in the educational system

The restoration of damaged and destroyed schools progressed slowly. Rebuilding efforts were complicated by security issues due to the conflict, the shortage of technical staff to monitor rebuilding, and other issues. By the end of April 2006, only 11 schools had been rebuilt, and nine schools for the IDPs had been restored. Major donors in the rebuilding of schools included Rotary International, the Italian Civil Protection Mission, the Norwegian Refugee Council, and UNICEF.\textsuperscript{157,158}

Development of the educational system

In addition to recovery, some donors focused on developing the educational system. At the
university level, the University of Peradeniya, Kandy collaborated with WHO to establish a disaster medicine training programme targeting the needs of different levels of managers of the medical care BSF system. The training programme, Public Health and Emergency Management in Asia and the Pacific, was scheduled to begin offering post-graduate degrees as of 2007.159

Coordination and control

Pre-event

Prior to the tsunami, Sri Lanka had no national disaster management plan in place,160 and no holistic approach to managing disasters. Mechanisms for disaster management were fragmented and focused on reacting to rather than anticipating them. Several government structures, such as the National Disaster Management Centre, supported national disaster response capacities, but none had a comprehensive disaster management plan, and for the most part, there were no specialists in the field.160,161

The National Disaster Management Centre (NDMC) was among Sri Lanka’s leading disaster capacity support mechanisms, but had little authority (power) and weak institutional capacity. The NDMC was established by the Ministry of Women’s Empowerment and Social Welfare in 1996, to carry out post-disaster relief activities at the district and divisional levels. But the NDMC had no legal powers, and was not structured to coordinate relief efforts during a disaster. Its main role was limited to reporting official figures on the numbers of injured persons, fatalities, and damaged housing. Earlier in 2004, a proposal to strengthen disaster management in Sri Lanka came before the Sri Lanka Parliament, but it failed to pass. Had it passed, the Disaster Management Act would have created an institutionalized system for disaster management and strengthened the capacities of the NDMC.161

Despite its loose structure for managing disasters, Sri Lanka was not a stranger to disasters. Heavy flooding along river basins as well as 20 years of conflict frequently had generated regional disasters resulting in deaths, displacements, and losses of infrastructure. Consequently, some regions had experience with responding to disaster conditions similar to those that resulted from the tsunami. Nowhere in Sri Lanka, however, was there any disaster preparation that specifically addressed tsunami hazards; no tsunamis had been reported in Sri Lanka since a minor tsunami in 1883. As a result, there was little public or government risk awareness related specifically to tsunamis.162

Damage and changes in coordination and control functions

No reports of damage to the minimal disaster response infrastructure were found. However, the scale of the disaster required greater disaster coordination capacity than was available in Sri Lanka at the time, and there were few trained specialists to fill the gaps. Additionally, what coordination capacity Sri Lanka did have was inhibited by breakdowns in the communication and transportation and logistics systems.

Relief responses in the coordination and control system

Following the tsunami, Sri Lanka quickly realized the disaster required strong national and international support, and major changes in disaster response coordination. Sri Lanka declared a State of Disaster, requested international support, and on the day following the tsunami, released 93 million LKR (US$ 840 million) from the National Treasury to support relief operations in 10 tsunami-impacted districts. However, in order for relief responses to be effective, Sri Lanka also required strong coordination. The tsunami revealed serious weaknesses in Sri Lanka’s capacity to coordinate the many ministries, NGOs, and UN agencies that attempted to support the responses. The National Disaster Management Centre and other existing disaster management institutions had the advantage of institutional memory, but had few resources, little access to the central government, and no legal mandate. So rather than rely on existing disaster management institutions, Sri Lanka decided to create new ones.163
By 29 December, the government had established the Centre for National Operations (CNO) to monitor and coordinate all post-tsunami initiatives undertaken by government ministries, agencies, and other institutions. The CNO became fully functional within two days of its establishment. In addition to the CNO, the government established three senior-level task forces: Rescue and Relief (TAFRER), Logistics, Law, and Order (TAFLOL), and Rebuilding of the Nation (TAFREN).

The TAFRER assessed the needs of all the BSF systems, coordinated and facilitated rescue and rehabilitation activities, and coordinated international donor assistance while consulting with the Ministry of Finance and Planning, Ministry of Foreign Affairs, other relevant line ministries, and the Centre for National Operations. The TAFREN began work in mid-January and was responsible for leading the reconstruction effort and all coordinating reconstruction aid activities. Finally, the TAFLOL coordinated with customs and immigration authorities to ensure that donated items were stored securely and distributed to disaster victims.

In an effort to coordinate the relief responders pouring into the country and direct them to where they were most needed, the UN stationed a logistics team at the international airport to list and document NGOs and other responders who arrived to provide relief assistance. For example, the relief workers who had arrived to provide medical care- or public health-related assistance were contacted by WHO-SEARO, which issued recommendations to the Ministry of Health on where to send the relief workers. The UN agencies also helped to coordinate and list out donations arriving at the airport. On behalf of the United Nations Country Team, the World Food Programme established a Logistics Centre at the airport, which received all incoming relief supplies, inventoried them, and provided storage. The World Food Programme then contacted each of the agencies for which supplies had been sent and asked them to pick up the supplies within three days.

Recovery responses in the coordination and control system

In the year following the tsunami, Sri Lanka struggled to achieve continuity within its disaster coordination infrastructure and maintain institutional memory. The CNO and each of the three task forces eventually either were replaced or merged to become parts of yet another task force. The TAFRER and TAFLOL merged to create the Task Force for Relief (TAFOR), which replaced the CNO. And, in January 2006, the TAFREN was replaced by the Reconstruction and Redevelopment Agency (RADA). In addition to a lack of continuity, institutions created to respond to tsunami disaster coordination needs did not always have the legal support they needed to fulfill their responsibilities. For example, TAFREN had no legal means by which it could compel donors and humanitarian aid agencies to be transparent and accountable. The successor to TAFREN, the RADA, was similarly limited. Consequently, data on tsunami-related pledges, commitments, and expenditures were inadequate.

Development of the coordination and control system

The shuffle to create new coordination institutions to respond to the tsunami also revealed a broader need to improve coordination capacity not only to respond to the tsunami disaster, but to all future disasters. The government began making a serious effort to address this broader need in February when it created the Parliamentary Select Committee to investigate and offer recommendations on how Sri Lanka’s disaster management could be improved. These recommendations helped to shape subsequent policies and legislation addressing Sri Lanka’s disaster management capacity including the Disaster Management Act of May 2005.

The Disaster Management Act supported the establishment of a Disaster Risk Management System and established the National Council for Disaster Management charged with providing the system with direction. The new Council’s
responsibilities included forming the national policy and programme on the management of disasters, creating plans for national disaster management and national emergency operation, recommending allocation of funds, promoting awareness campaigns, and initiating prevention and mitigation programme. Under the National Council for Disaster Management, the Disaster Management Act also created the Disaster Management Centre. Later in the year, Sri Lanka also established a ministry to address disaster management issues. The Ministry of Disaster Management took responsibility for leading the effort to plan disaster responses, risk mitigation and reduction, and preparedness.

In its efforts to expand coordination efforts to respond to the tsunami disaster and future disasters, Sri Lanka was not alone. In particular, many UN agencies helped the government develop greater capacity in both its overall coordination and at the societal function system level. For example, WHO-SEARO helped the Ministry of Health better coordinate the responses of the medical care and public health systems. Following the tsunami, the MoH and WHO-SEARO initiated two weekly health coordination meetings: one convened by the MoH, and a second convened by the WHO. The MoH hosted meetings that began on 28 December and continued weekly for the next four months. The WHO meetings began on 3 January 2005 and continued on a weekly basis. All agencies and organizations responding to health needs during the disaster were encouraged to attend both meetings. Meeting participants included representatives of the Task Force for Rebuilding the Nation, UNICEF, IOM, UNFPA, UNHCR, and Red Cross Societies. In addition to these two weekly health systems meetings, WHO-SEARO and UNICEF also convened district-level health systems coordination meetings in each of the affected districts, except in Mullaitivu and Kilinochchi which were under the exclusive control of the LTTE.

The UN helped provide coordination between general and individual basic societal systems. The UN assisted the Sri Lanka government with general coordination early during the disaster by holding meetings that were convened on the UN campus every Monday and Thursday until 15 January 2005, when the meetings were hosted by the Sri Lanka government and convened every week for approximately six months following the tsunami. The overall UN response to the disaster in Sri Lanka was coordinated by the United Nations Disaster Assessment and Coordination (UNDAC) Team. Basic societal systems coordination provided by UN agencies included WHO coordination in the medical care and public health BSF systems and UNICEF coordination in the education, water and sanitation, and public works and engineering BSF systems, WFP coordination in the food and nutrition system, UNDP coordination in the shelter and clothing BSF system and the International Labor Organization (ILO) coordination of the Economic (livelihood and employment) system.

The levels of Sri Lanka in relation to the 12 SEARO Benchmarks are summarized in Table 7.14.

**Summary**

Although hours elapsed from the onset of the earthquake until the arrival of the first wave of the tsunami at its shores, Sri Lanka had no warning of the possibility that a tsunami would strike. There had not been a tsunami recorded in Sri Lanka for more than a century. Although the government had begun with the development of a national Disaster Management Plan, this was not finalized before the tsunami struck. Moreover, there did not exist any agency within the government that was endowed with the mandate, authority, and resources to prepare the country to cope with the damage and related collapse of functions that resulted from the tsunami. Furthermore, the country has an ongoing conflict for 20 years preceding the events of 26 December. Basically, it’s capacities were overwhelmed by the devastation brought forth by the tsunami, and so assistance from the international community was also needed.
Prior to the tsunami, Sri Lanka had a relatively robust public health system with outstanding immunization coverage and a functioning disease surveillance system that only required some support from the WHO-SEARO. This was evidenced by the fact that there was no need for any mass immunization campaigns after the event but more of a focus of restoring the cold chain systems rapidly to cover for routine immunization services. For the most part, as evidenced by the fact that no epidemics or major outbreaks occurred, despite nearly 1 million persons being displaced from their homes into camps or with relatives and friends. It is important to recognize that an estimated 400,000 persons were also impacted by an ongoing civil unrest. Compared to the other countries in this study, Sri Lanka was also fortunate to have abundant fresh water supplies thus problems in availability of safe water availability was not one that was not an insurmountable challenge. Despite, the security issues due to the ongoing conflict, these were overcome by cooperation from opposite sides of the conflicting groups in certain health services that were to be delivered. A highlight of the response is the psychosocial support and mental health services with the scaling up of skills of health workers especially those community based. It also lead to the improvement of mental health legislation and policy, a clear example of a response contributing to better development.

As mentioned, the country had good systems in place prior to the even and although there was a massive increase in need to deliver these essential services, assistance was also available from national and international partners. With the assistance of the WHO-SEARO and hundreds of NGOs, the gaps in medical care, public health and management of the displaced were all covered. The story of the tsunami response and recovery in Sri Lanka is one that also lead to better disaster risk management in the health sector thereafter.

List of people interviewed

Sriyani De Silva, tsunami witness of the tsunami in the district of Matara

Krisantha Weerasuriya, the former Professor and Head of the Department of Pharmacology, Faculty of Medicine, Colombo

Thushara Fernando, HRH Focal Point, Department of Health Systems Development, WHO-SEARO

Kanapathipillai Umapathy, orthopedic surgeon at Jaffna Teaching Hospital

Bipin Verma, formerly the Emergency Preparedness and Response Focal Point for WHO Representative’s Office Colombo

Herbert Raajmakers, Emergency Health Management technical officer for the World Health Organization, Sri Lanka

Jeff Taft-Dick, former country director for the World Food Programme in Sri Lanka

Kolitha Wickramage, Mental Health & Violence Prevention Project, WHO Sri Lanka
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159. WHO Sri Lanka. Sri Lanka hazard profile. ?????


Earthquake Shaking in Sri Lanka

Before the Sumatra-Andaman earthquake had even finished rupturing, seismic waves from the earthquake traveled 1,700 kilometers northwest to Sri Lanka, arriving just four minutes after rupture onset. Although the earthquake passed through Sri Lanka largely unnoticed, 15 Sri Lankans responding to a USGS survey reported having felt some shaking. The Sri Lankan responses to the survey were rated according to the Mercalli Intensity Scale, a scale used to assess earthquake intensity on a scale of I to X, with I indicating no shaking was felt and X indicating extreme shaking and damage. Of the 15 Sri Lankan respondents who felt shaking, 14 indicated very weak shaking for a score of II on the scale and one indicated having felt weak shaking for a score of III on the scale.

Figure 7.2: Tsunami run-up and elevation measurements as reported by the International Tsunami Survey Team. Run-up heights are indicated by the blue bar in the graphs and the tsunami elevations are indicated by the black bars.

http://www.sciencemag.org/cgi/content/full/308/5728/1595?ijkey=U3bZlpRHLQd6

Figure 7.3: Two boats, approximately 100 metres inland in the municipality of Kalmunai, where the tsunami deposited them on Sri Lanka’s eastern coast. Photo: USGS

http://walrus.wr.usgs.gov/tsunami/srilanka05/photos.html
Figure 7.4: Population densities in the tsunami-impacted areas of Sri Lanka.

Source: CNO
http://csi.cgiar.org/tsunami_maps/tsunami_map8.html

Figure 7.5: CNO maps indicating how many and where in Sri Lanka lives were lost. These maps were published on 27 January 2005. The map on the left shows the number of people missing and the map on the right the number of people who died. Since the publication of these maps, official reports have aggregated the two. The same has been done in this book, including numbers reported in Table 7.5.

Source: CNO http://csi.cgiar.org/tsunami_maps/tsunami_map8.html
Figure 7.6: Tsunami victims lay half buried in a mass grave in Mullaitivu district. A disproportionately large number of fatalities in Mullaitivu and Jaffna districts were fishermen comprising more than one out of every four deaths in these districts.

http://www.fisheriesdept.gov.lk/tsunami/deaths.html

Photo source: http://www.tamilnet.com/art.html?catid=13&artid=13762

Figure 7.7: A member of the Korea Emergency Rescue Foundation fumigates piles of debris along the shoreline to kill mosquitoes on 03 January 2005 to help to prevent the spread of malaria and dengue.


Figure 7.8: A Galle delivery ward damaged by the tsunami.

Photo by: Kelly Darnell.
Source: Direct Relief International
http://www.directrelief.org/PressCenter/Commentary/NotesFromTheField/AsiaPacific.aspx?blogmonth=6&blogyear=2007&blogid=432
Figure 7.9: Location and extent of sandy aquifers in Sri Lanka

Figure 7.10: In some areas of Kalmunai in the district of Ampara, nearly all the buildings within 500 metres of the shore were destroyed
Photo: Phillip Liu, Cornell University. Found on USGS
Web: http://walrus.wr.usgs.gov/tsunami/srilanka05/kk2loc.html

Figure 7.11: This beach in Matara became a dump site for the quick disposal of tsunami debris
Photo: USGS http://walrus.wr.usgs.gov/tsunami/srilanka05/mataraloc.html
Figure 7.12: A mass grave beside a crematorium in Matara provides a resting place for some of the victims who died during the tsunami. Photo taken on 29 December 2004 by Krisantha Weerasuriya.


Figure 7.14: Train coaches lay scattered near the southwest coast of Sri Lanka among debris after the tsunami threw them off their tracks and killed many of the passengers who were trapped inside. Source: photo by Shahidul Alam/DRIK and found at http://www.andaman.org/BOOK/denis_pics/denis.htm
Table 7.1: Estimated population of 13 tsunami-impacted districts in 2004.

<table>
<thead>
<tr>
<th>Province</th>
<th>District</th>
<th>Population</th>
<th>People/km²</th>
<th>Coastline length (km)</th>
</tr>
</thead>
<tbody>
<tr>
<td>North</td>
<td>Jaffna</td>
<td>596,000</td>
<td>642</td>
<td>336.6*</td>
</tr>
<tr>
<td></td>
<td>Kilinochchi</td>
<td>143,000</td>
<td>119</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Mullaitivu</td>
<td>144,000</td>
<td>60</td>
<td>66.8</td>
</tr>
<tr>
<td>East</td>
<td>Trincomalee</td>
<td>383,000</td>
<td>151</td>
<td>83.9</td>
</tr>
<tr>
<td></td>
<td>Batticaloa</td>
<td>544,000</td>
<td>208</td>
<td>120.6</td>
</tr>
<tr>
<td></td>
<td>Ampara</td>
<td>613,000</td>
<td>145</td>
<td>118.0</td>
</tr>
<tr>
<td>South</td>
<td>Hambantota</td>
<td>538,000</td>
<td>216</td>
<td>145.5</td>
</tr>
<tr>
<td></td>
<td>Matara</td>
<td>788,000</td>
<td>620</td>
<td>51.2</td>
</tr>
<tr>
<td></td>
<td>Galle</td>
<td>1,020,000</td>
<td>631</td>
<td>79.3</td>
</tr>
<tr>
<td>Western</td>
<td>Kalutara</td>
<td>1,085,000</td>
<td>688</td>
<td>34.3</td>
</tr>
<tr>
<td></td>
<td>Colombo</td>
<td>2,342,000</td>
<td>3,464</td>
<td>31.2</td>
</tr>
<tr>
<td></td>
<td>Gampaha</td>
<td>2,099,000</td>
<td>1,565</td>
<td>34.6</td>
</tr>
<tr>
<td>North Western</td>
<td>Puttalam</td>
<td>728,000</td>
<td>253</td>
<td>241.3</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td><strong>11,023,000</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>


<table>
<thead>
<tr>
<th>Population health indicators</th>
<th>Sri Lanka</th>
</tr>
</thead>
<tbody>
<tr>
<td>indicator</td>
<td>year(source)</td>
</tr>
<tr>
<td>Life expectancy (years)</td>
<td>73</td>
</tr>
<tr>
<td>Crude mortality/1,000/day</td>
<td>5.9</td>
</tr>
<tr>
<td>Infant mortality/1,000/day</td>
<td>11.2</td>
</tr>
<tr>
<td>Maternal mortality/100,000 live births</td>
<td>47</td>
</tr>
</tbody>
</table>

### Table 7.3: Percentage of one-year-old Sri Lankan children vaccinated in 2004

<table>
<thead>
<tr>
<th>Vaccine</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Measles</td>
<td>96</td>
</tr>
<tr>
<td>Three doses of DTP (diphtheria, tetanus, pertussis)</td>
<td>97</td>
</tr>
<tr>
<td>Three doses of Hepatitis B</td>
<td>79</td>
</tr>
<tr>
<td>BCG</td>
<td>99</td>
</tr>
<tr>
<td>Poliomyelitis</td>
<td>97</td>
</tr>
</tbody>
</table>


### Table 7.4: Disease incidence in Sri Lanka and the tsunami-impacted districts in 2004.

<table>
<thead>
<tr>
<th>Disease incidence / 10,000 population</th>
<th>Incidence</th>
<th>year(source)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Vector-borne</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Malaria</td>
<td>1.91</td>
<td>2004(4)</td>
</tr>
<tr>
<td>Dengue</td>
<td>7.85</td>
<td>2004(4)</td>
</tr>
<tr>
<td><strong>Water-borne</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bacillary dysentery</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shigellosis</td>
<td>5.24</td>
<td>2004(4)</td>
</tr>
<tr>
<td>Cholera</td>
<td>0.00</td>
<td>2004(1)</td>
</tr>
<tr>
<td>Typhoid fever</td>
<td>1.55</td>
<td>2004(4)</td>
</tr>
<tr>
<td>Leptospirosis</td>
<td>0.58</td>
<td>2004(1)</td>
</tr>
<tr>
<td>Hepatitis</td>
<td>1.15</td>
<td>2004(4)</td>
</tr>
<tr>
<td><strong>Direct contact</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Measles</td>
<td>0.04</td>
<td>2004(4)</td>
</tr>
<tr>
<td>Mumps</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tetanus</td>
<td>0.03</td>
<td>2004(4)</td>
</tr>
<tr>
<td>Petrusis</td>
<td>0.02</td>
<td>2004(2)</td>
</tr>
<tr>
<td>Diphtheria</td>
<td>0.00</td>
<td>2004(2)</td>
</tr>
<tr>
<td>Tuberculosis</td>
<td>6.00</td>
<td>2004(5)</td>
</tr>
<tr>
<td><strong>Other</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Acute Respiratory Infections</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Diarrhea</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Enteric fever</td>
<td>1.55</td>
<td>2004(4)</td>
</tr>
<tr>
<td>Viral fever</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 7.5: Deaths due to the tsunami by district and crude mortality rates before and after the tsunami.

<table>
<thead>
<tr>
<th>Province</th>
<th>District</th>
<th>Fatalities and missing</th>
<th>Total</th>
<th>/ 10,000 pop.</th>
<th>/ km of coastline</th>
</tr>
</thead>
<tbody>
<tr>
<td>North</td>
<td>Jaffna</td>
<td>3,180</td>
<td>53.00</td>
<td></td>
<td>11.11</td>
</tr>
<tr>
<td></td>
<td>Kilinochchi</td>
<td>561</td>
<td>39.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Mullaitivu</td>
<td>3,552</td>
<td>247.00</td>
<td></td>
<td>53.17</td>
</tr>
<tr>
<td>East</td>
<td>Trincomalee</td>
<td>1,415</td>
<td>36.90</td>
<td></td>
<td>16.87</td>
</tr>
<tr>
<td></td>
<td>Batticaloa</td>
<td>3,873</td>
<td>71.00</td>
<td></td>
<td>32.27</td>
</tr>
<tr>
<td></td>
<td>Ampara</td>
<td>11,312</td>
<td>185.00</td>
<td></td>
<td>95.86</td>
</tr>
<tr>
<td>South</td>
<td>Hambantota</td>
<td>5,463</td>
<td>102.00</td>
<td></td>
<td>37.54</td>
</tr>
<tr>
<td></td>
<td>Matara</td>
<td>1,955</td>
<td>25.00</td>
<td></td>
<td>38.18</td>
</tr>
<tr>
<td></td>
<td>Galle</td>
<td>4,772</td>
<td>47.00</td>
<td></td>
<td>60.18</td>
</tr>
<tr>
<td>Western</td>
<td>Kalutara</td>
<td>411</td>
<td>4.00</td>
<td></td>
<td>11.98</td>
</tr>
<tr>
<td></td>
<td>Colombo</td>
<td>91</td>
<td>0.40</td>
<td></td>
<td>2.92</td>
</tr>
<tr>
<td></td>
<td>Gampaha</td>
<td>11</td>
<td>0.10</td>
<td></td>
<td>0.32</td>
</tr>
<tr>
<td>North Western</td>
<td>Puttalam</td>
<td>7</td>
<td>0.10</td>
<td></td>
<td>0.03</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td><strong>36,603</strong></td>
<td><strong>33.20</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Sources: Population, and crude mortality rates were taken from Ministry of Health 2005 Annual Health Bulletin. The estimated number of victims who died or disappeared due to the tsunami were taken from the Centre for National Operations map found in this chapter.

Table 7.6: Disease cases and rates/10000 population for 2004 and 2005

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>year</td>
<td>cases</td>
<td>rate</td>
<td>cases</td>
<td>rate</td>
</tr>
<tr>
<td>Shigellous</td>
<td>2004</td>
<td>1,357</td>
<td>0.70</td>
<td>2,477</td>
<td>1.27</td>
</tr>
<tr>
<td></td>
<td>2005</td>
<td>1,508</td>
<td>0.77</td>
<td>1,632</td>
<td>0.83</td>
</tr>
<tr>
<td>Dengue</td>
<td>2004</td>
<td>2,129</td>
<td>1.09</td>
<td>5,711</td>
<td>2.93</td>
</tr>
<tr>
<td></td>
<td>2005</td>
<td>862</td>
<td>0.44</td>
<td>891</td>
<td>0.46</td>
</tr>
<tr>
<td>Malaria</td>
<td>2004</td>
<td>1,350</td>
<td>0.69</td>
<td>788</td>
<td>0.40</td>
</tr>
<tr>
<td></td>
<td>2005</td>
<td>739</td>
<td>0.38</td>
<td>261</td>
<td>0.13</td>
</tr>
</tbody>
</table>

1In each district, the tsunami-impacted area is small relative to district size. Consequently, using district populations to calculate the fatality rates among Sri Lanka’s tsunami-impacted populations, underestimates the true fatality rates.
### Table 7.7: Medical care facilities in Sri Lanka before the tsunami

<table>
<thead>
<tr>
<th>Facility</th>
<th>Facility description</th>
<th>Average Capacity (beds)</th>
<th>n</th>
</tr>
</thead>
<tbody>
<tr>
<td>Provincial Hospitals</td>
<td>Tertiary facilities with specialized services including general medicine, surgery, obstetrics, gynaecology, paediatrics, orthopaedic, ophthalmology, psychiatric, oncology, otolaryngology, radiology, and well-equipped pathology laboratories.</td>
<td>70</td>
<td>6</td>
</tr>
<tr>
<td>Teaching Hospitals</td>
<td>Tertiary facilities with essentially the same services as provincial hospitals, but also used to train new healthcare professionals (Average capacity of 963 beds).</td>
<td>963</td>
<td>16</td>
</tr>
<tr>
<td>Base Hospitals/ General Hospitals</td>
<td>Basic specialties including general medicine, paediatrics, obstetrics-gynaecology and surgery, but specialties offered by each varied widely. A few also offered non-basic specialties, such as dermatology and cardiology.</td>
<td>269</td>
<td>38</td>
</tr>
<tr>
<td>District Hospitals</td>
<td>Most managed by medical officers (range = 29–298 beds).</td>
<td>90</td>
<td>159</td>
</tr>
<tr>
<td>Peripheral Units</td>
<td>Managed by medical officers.</td>
<td>48</td>
<td>98</td>
</tr>
<tr>
<td>Rural Hospitals</td>
<td>Similar to Peripheral Units, but without separate maternity wards. Administered by assistant medical officers. Average capacity of 25 beds.</td>
<td>25</td>
<td>183</td>
</tr>
<tr>
<td>Central Dispensaries and Maternity Homes</td>
<td>Outpatient treatment and inpatient maternity care. Administered by assistant medical care officers—smallest medical facility to provide inpatient services.</td>
<td>11</td>
<td>80</td>
</tr>
<tr>
<td>Central Dispensaries</td>
<td>Smallest outpatient unit; administered by assistant medical officers; no staff.</td>
<td>0</td>
<td>400</td>
</tr>
</tbody>
</table>

**Source:** Ministry of Health & Nutrition Website[^4] and 2003 Annual Health Bulletin.[^14] (*n* = number of each type of facility)
Table 7.8: Medical care personnel and beds available/10000 population, and percentage of births attended by skilled birth personnel in Sri Lanka by percent. n = number

<table>
<thead>
<tr>
<th>Medical care indicators</th>
<th>Sri Lanka</th>
<th>yr(source)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Physicians</td>
<td>5.0</td>
<td>2002(2)</td>
</tr>
<tr>
<td>Nurses</td>
<td>8.9</td>
<td>2002(2)</td>
</tr>
<tr>
<td>Midwives</td>
<td>4.1</td>
<td>2002(2)</td>
</tr>
<tr>
<td>Dentists</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Health workers</td>
<td>11.6</td>
<td>2002(1)</td>
</tr>
<tr>
<td>Hospital beds</td>
<td>31.0</td>
<td>2003(2)</td>
</tr>
<tr>
<td>Births attended by skilled personnel</td>
<td>97%</td>
<td>2000(1)</td>
</tr>
</tbody>
</table>

Sources: (1) WHO;43 and (2) Annual Health Bulletin, 2003.13

Table 7.9: Number of intensive care units (ICUs) per province in Sri Lanka as identified by a 2002 survey, and the reported numbers of tsunami-related injured and fatalities in each province47,48 (n = number)

<table>
<thead>
<tr>
<th>Province</th>
<th>Population</th>
<th>ICUs n</th>
<th>Population/ICU ratio</th>
<th>Tsunami fatalities</th>
<th>Tsunami injuries</th>
</tr>
</thead>
<tbody>
<tr>
<td>Western</td>
<td>5,361,185</td>
<td>26</td>
<td>206,199</td>
<td>343</td>
<td>467</td>
</tr>
<tr>
<td>North Western</td>
<td>2,157,711</td>
<td>5</td>
<td>431,542</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>Southern</td>
<td>2,277,145</td>
<td>5</td>
<td>455,429</td>
<td>10,060</td>
<td>7,326</td>
</tr>
<tr>
<td>Northern</td>
<td>1,040,963</td>
<td>2</td>
<td>520,481</td>
<td>6,200</td>
<td>4,907</td>
</tr>
<tr>
<td>Eastern</td>
<td>1,415,949</td>
<td>2</td>
<td>707,974</td>
<td>14,354</td>
<td>2,495</td>
</tr>
</tbody>
</table>

Table 7.10: Number of healthcare facilities damaged by district and the degree of damage, and estimated cost of damages in US$ millions. Sources: (1) ADB, JBIC and World Bank Sri Lanka assessment;51 and (2) unpublished Ministry of Health document36

<table>
<thead>
<tr>
<th>District</th>
<th>Damaged facilities (1)</th>
<th>Teaching Hospitals</th>
<th>General Hospitals</th>
<th>District Hospitals</th>
<th>Peripheral Units</th>
<th>Rural Hospitals</th>
<th>CD/PHC/GHC</th>
<th>MOH</th>
<th>Other</th>
<th>Damage in million US$ ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Galle</td>
<td>10 fully 8 partially</td>
<td>1</td>
<td></td>
<td>1</td>
<td>1</td>
<td>14</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>18.78</td>
</tr>
<tr>
<td>Batticaloa</td>
<td>9 10</td>
<td>5</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>11</td>
<td>4</td>
<td>4</td>
<td>1</td>
<td>12.17</td>
</tr>
<tr>
<td>Ampara</td>
<td>11 fully 2 partially</td>
<td>4</td>
<td>2</td>
<td></td>
<td>2</td>
<td>2</td>
<td>4</td>
<td>1</td>
<td>1</td>
<td>11.35</td>
</tr>
<tr>
<td>Trincomalee</td>
<td>3 6</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>4</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td>10.16</td>
</tr>
<tr>
<td>Mullativu</td>
<td>6 0</td>
<td>1</td>
<td></td>
<td>1</td>
<td></td>
<td>2</td>
<td>1</td>
<td>2</td>
<td>4</td>
<td>4.43</td>
</tr>
</tbody>
</table>
### Damaged facilities by type

<table>
<thead>
<tr>
<th>District</th>
<th>Teaching Hospitals</th>
<th>General Hospitals</th>
<th>District Hospitals</th>
<th>Peripheral Units</th>
<th>Rural Hospitals</th>
<th>CD/PHC/GHC</th>
<th>MOH</th>
<th>Other</th>
<th>Damage in million US$ (1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Matara</td>
<td>2</td>
<td>5</td>
<td>1</td>
<td></td>
<td></td>
<td>3</td>
<td>1</td>
<td>2</td>
<td>2.21</td>
</tr>
<tr>
<td>Kalutara</td>
<td>2</td>
<td>3</td>
<td>1</td>
<td></td>
<td></td>
<td>3</td>
<td>2</td>
<td></td>
<td>0.27</td>
</tr>
<tr>
<td>Hambantota</td>
<td>0</td>
<td>5</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.22</td>
<td></td>
</tr>
<tr>
<td>Columbo</td>
<td>0</td>
<td>5</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.22</td>
<td></td>
</tr>
<tr>
<td>Jaffna</td>
<td>0</td>
<td>4</td>
<td>1</td>
<td></td>
<td></td>
<td>2</td>
<td>1</td>
<td></td>
<td>0.16</td>
</tr>
<tr>
<td>Kilonochchi</td>
<td>1</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.06</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>44</td>
<td>48</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>60.05</td>
<td></td>
</tr>
</tbody>
</table>

*Note: sources differed slightly on the number of facilities damaged. Consequently, totals under “Damaged facilities” and “Damaged facilities by type” are also slightly different. (CD = central dispensaries; PHC = Primary Health Care; GHC = General Health Care)

### Table 7.11: Population percentages with access to water and sanitation in the tsunami-impacted districts of Sri Lanka.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Columbo</td>
<td>95.8</td>
<td>96.2</td>
</tr>
<tr>
<td>Gampaha</td>
<td>90.9</td>
<td>96.5</td>
</tr>
<tr>
<td>Kalutara</td>
<td>84.1</td>
<td>95.3</td>
</tr>
<tr>
<td>Galle</td>
<td>81.8</td>
<td>94.5</td>
</tr>
<tr>
<td>Matara</td>
<td>78.2</td>
<td>96.6</td>
</tr>
<tr>
<td>Hambantota</td>
<td>85.8</td>
<td>95.1</td>
</tr>
<tr>
<td>Puttalam</td>
<td>92.5</td>
<td>80.8</td>
</tr>
<tr>
<td>Jaffna</td>
<td>94.1</td>
<td>81.0</td>
</tr>
<tr>
<td>Killinchchi</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Mullaitivu</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Ampara</td>
<td>85.5</td>
<td>75.1</td>
</tr>
<tr>
<td>Batticaloa</td>
<td>96.6</td>
<td>57.0</td>
</tr>
<tr>
<td>Trincomalee</td>
<td>74.1</td>
<td>72.0</td>
</tr>
</tbody>
</table>

*Source: Millennium Development Goals, 2005.*
### Table 7.12: Number and type.quality of housing units in eight of 13 tsunami-impacted districts.

Information for the tsunami-impacted districts of Mannar, Kilinochchi, Jaffna, Mullaitivu, Trincomalee, and Batticaloa was not available.

<table>
<thead>
<tr>
<th>District</th>
<th># of housing units</th>
<th>Permanent (%)</th>
<th>Semi-permanent (%)</th>
<th>Improved (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ampara</td>
<td>145,184</td>
<td>67.5</td>
<td>28.7</td>
<td>3.1</td>
</tr>
<tr>
<td>Hambantota</td>
<td>148,516</td>
<td>58.8</td>
<td>40.1</td>
<td>0.4</td>
</tr>
<tr>
<td>Matara</td>
<td>197,552</td>
<td>71.7</td>
<td>27.3</td>
<td>0.6</td>
</tr>
<tr>
<td>Galle</td>
<td>253,697</td>
<td>72.3</td>
<td>26.3</td>
<td>0.9</td>
</tr>
<tr>
<td>Kalutara</td>
<td>270,147</td>
<td>78.5</td>
<td>20.1</td>
<td>0.4</td>
</tr>
<tr>
<td>Colombo</td>
<td>507,678</td>
<td>86.8</td>
<td>11.2</td>
<td>0.3</td>
</tr>
<tr>
<td>Gampaha</td>
<td>511,621</td>
<td>80.0</td>
<td>17.7</td>
<td>1.1</td>
</tr>
<tr>
<td>Puttalam</td>
<td>192,295</td>
<td>61.1</td>
<td>31.9</td>
<td>6.2</td>
</tr>
</tbody>
</table>

### Table 7.14: Pre-event nutritional indicators for Sri Lanka

<table>
<thead>
<tr>
<th>Nutritional status indicators</th>
<th>Sri Lanka</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>indicator</td>
</tr>
<tr>
<td>Stunted children &lt;5 years</td>
<td>14%</td>
</tr>
<tr>
<td>Underweight children &lt;5 years</td>
<td>30%</td>
</tr>
<tr>
<td>Wasted children &lt;5 years</td>
<td>14%</td>
</tr>
<tr>
<td>Low birth weight newborns</td>
<td>22%</td>
</tr>
<tr>
<td>Pregnant women with anemia</td>
<td>37%</td>
</tr>
<tr>
<td>Per capita energy supply (calories/day)</td>
<td>2,405</td>
</tr>
<tr>
<td>Per capita protein supply (grams/day)</td>
<td>54.1</td>
</tr>
<tr>
<td>Per capita fat supply (grams/day)</td>
<td>46.3</td>
</tr>
<tr>
<td>Calories from cereal</td>
<td>53%</td>
</tr>
</tbody>
</table>

**Sources:** (1) Department of Census and Statistics; (2) WFP; (3) SEARO Member Countries nutritional profiles; and (4) UNICEF.
Table 7.15: Household energy and fuel sources used in households in eight of the 13 tsunami-impacted districts in Sri Lanka prior to the tsunami by percent of. Information for the Mannar, Kilinochchi, Jaffna, Mullaitivu, Trincomalee, and Batticaloa districts was not available.

<table>
<thead>
<tr>
<th>Household Energy and Fuel Uses</th>
<th>Ampara</th>
<th>Hambantota</th>
<th>Matara</th>
<th>Galle</th>
<th>Kalutara</th>
<th>Colombo</th>
<th>Gampaha</th>
<th>Puttalam</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Principal source of light</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kerosene</td>
<td>46.6</td>
<td>53.5</td>
<td>27.8</td>
<td>25.0</td>
<td>25.8</td>
<td>10.4</td>
<td>14.7</td>
<td>46.0</td>
</tr>
<tr>
<td>Electricity</td>
<td>51.7</td>
<td>45.2</td>
<td>71.2</td>
<td>74.2</td>
<td>72.5</td>
<td>86.9</td>
<td>83.4</td>
<td>52.7</td>
</tr>
<tr>
<td>Solar</td>
<td>0.5</td>
<td>0.4</td>
<td>0.0</td>
<td>0.1</td>
<td>0.1</td>
<td>0.0</td>
<td>0.0</td>
<td>0.1</td>
</tr>
<tr>
<td><strong>Principal source of cooking fuel</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fire wood</td>
<td>85.6</td>
<td>94.9</td>
<td>89.0</td>
<td>85.6</td>
<td>81.5</td>
<td>32.0</td>
<td>65.7</td>
<td>88.3</td>
</tr>
<tr>
<td>Gas</td>
<td>8.4</td>
<td>3.8</td>
<td>8.9</td>
<td>12.5</td>
<td>15.0</td>
<td>49.3</td>
<td>24.4</td>
<td>8.2</td>
</tr>
<tr>
<td>Kerosene</td>
<td>2.0</td>
<td>0.3</td>
<td>0.6</td>
<td>0.7</td>
<td>1.5</td>
<td>14.4</td>
<td>6.8</td>
<td>1.8</td>
</tr>
<tr>
<td>Electricity</td>
<td>0.9</td>
<td>0.1</td>
<td>0.1</td>
<td>0.1</td>
<td>0.2</td>
<td>0.4</td>
<td>0.2</td>
<td>0.2</td>
</tr>
<tr>
<td>Saw dust/Paddy husk</td>
<td>1.8</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.1</td>
<td>0.1</td>
<td>0.0</td>
</tr>
</tbody>
</table>

Table 7.16: Status of Sri Lanka relative to the 12 SEARO preparedness benchmarks as of May 2005 (SOP = standard operating procedure)

<table>
<thead>
<tr>
<th>Benchmark Number</th>
<th>Benchmark</th>
<th>Sri Lanka Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Legal framework and functioning mechanism and organizational structure in place for health at all levels involving stakeholders</td>
<td>Disaster Management Act No. 13, approved May 2005</td>
</tr>
<tr>
<td>2</td>
<td>Regularly updated disaster preparedness and emergency management plan for health sector and SOPs (emergency directory, national coordination focal point) in place. It must include: (1) standard operating procedures; (2) memoranda of understanding; (3) mechanisms for coordination and control; (4) responses; and (5) all-hazards and a hazard-specific approaches.</td>
<td>To be finalized</td>
</tr>
<tr>
<td>3</td>
<td>Countries have a line item in their budget and system to assure financial resources are accessible to meet the immediate needs in case of a catastrophic event. Essential personnel, equipment, and supplies also are available in quantities necessary to cope with the damage created by an event for which it is at risk. Accounting procedures for the use of such resources are in place. Emergency financial (including national budget), physical and regular human resource allocation and accountability procedures have been established.</td>
<td>Available in a patchy manner</td>
</tr>
<tr>
<td>4</td>
<td>Rules of engagement exist for the management of external actors.</td>
<td>Must develop and address ethical issues</td>
</tr>
<tr>
<td>5</td>
<td>Capacity to identify risks and assess vulnerability levels has been established. Appropriate measures have been implemented to reduce the vulnerabilities.</td>
<td>Done through universities</td>
</tr>
<tr>
<td>Benchmark Number</td>
<td>Benchmark</td>
<td>Sri Lanka Status</td>
</tr>
<tr>
<td>------------------</td>
<td>---------------------------------------------------------------------------</td>
<td>-------------------------------------------------------</td>
</tr>
<tr>
<td>6</td>
<td>Community-based response and preparedness capacities have been developed, and are supported with training and regular simulations and/or mock trials.</td>
<td>Comprehensive plan must be developed</td>
</tr>
<tr>
<td>7</td>
<td>Local capacity for emergency provision of essential services and supplies (shelters, safe drinking water, food, communication) is developed.</td>
<td>Currently ad hoc; must be systematic</td>
</tr>
<tr>
<td>8</td>
<td>Advocacy and awareness has been developed through education, information management, and communication (pre-, during-, and post-event).</td>
<td>Needs strengthening, but more organized for northeast conflict</td>
</tr>
<tr>
<td>9</td>
<td>A community plan for mitigation, preparedness, and response that is based on risk identification and participatory vulnerability assessments, and backed by a higher level of capacity has been developed.</td>
<td>To be finalized</td>
</tr>
<tr>
<td>10</td>
<td>Human resources capabilities are updated and maintained continuously. Appropriate programs to educate and train people to cope with events and disasters have been implemented. Adequate numbers of people are being trained, and trained experts are on-call in case of a disaster.</td>
<td>Formal courses have begun</td>
</tr>
<tr>
<td>11</td>
<td>Health facilities are built/modified to withstand expected risks and to able to continue to provide the required medical care during events and disasters.</td>
<td>Must incorporate plans</td>
</tr>
<tr>
<td>12</td>
<td>Early warning and surveillance systems for identifying health concerns are established.</td>
<td>Exists for health sector</td>
</tr>
</tbody>
</table>

Part III
Country Reports
Chapter 8
Thailand
In December 2004, Mark Oberle and his family decided to arrange a last-minute vacation to Patong Beach on southern Thailand’s Phuket island. However, it was peak tourism season, and the family had to choose from a limited number of available hotel rooms and flights. The family had hoped to stay in a waterfront hotel with a view of the ocean, but instead would have to stay in a hotel behind the waterfront hotels. And they had hoped to book a daytime flight, get a good night’s rest, and wake up early the next morning to board a dive boat. However, the daytime flights were fully booked, and the family had to book a night flight. After spending one night in Phuket, Oberle and his family would be grateful that they had failed to book the hotel and flight they originally wanted.

Having arrived late on 25 December, Oberle, who is an American physician, his wife, and their son were in no hurry to wake up the next morning. However, at about 08:00 hours (h), their sleep was interrupted when an earthquake shook their room for two to three minutes and jolted them awake. Oberle thought a small local earthquake had caused the shaking, and had no way of knowing that the shaking actually had been caused by a massive 9.3 magnitude, tsunami-generating earthquake centred more than 500 km away. At about 10:00 h, Oberle and his family had finished breakfast and were preparing to leave the hotel for the beach. Some people speaking Thai ran into the lobby in a panic. Although the people were clearly distraught, Oberle could not understand what they were saying or identify their concern (Figure 8.1).

Shortly thereafter, Oberle and his family stepped outside the Duangjitt Hotel and heard what sounded like explosions. When they looked around for the source of the noise, they were surprised to see a three-storey jet of water blast through a road-gap bisecting a row of waterfront hotels. A metre-high wave followed, spilling out from the road-gap between the hotels and across the approximately 90-metre wide lawn and garden separating the waterfront hotels from the Duangjitt Hotel. People began shouting, urging everyone to escape into the upstairs floors of their hotels. Oberle, his wife, and their son headed to their room just above the ground floor. A few minutes later a second wave arrived. The second wave was bigger than the first and flooded the Duangjitt Hotel’s ground floor rooms. Luckily, the waterfront hotels had shielded the Duangjitt Hotel from the worst. On the beach side of the waterfront hotels, the tsunami swept up cars, tuk-tuks, taxis, and people located along the beach road and smashed them against the waterfront hotels.

After the first two waves subsided, injured victims fled the shore and began arriving at the Duangjitt Hotel where Oberle’s wife heard their calls for help. Oberle and his wife descended to the hotel
lobby, which was a little over one meter higher than the ground floor rooms and had not been flooded. Several injured people had gathered there, including a Thai woman with a broken arm and contaminated wounds and a young Thai man who had inhaled sand-laden seawater and lay frothing on the floor. The couple quickly began treating the injured people with what was available, using sheets to stop bleeding, broken furniture to splint broken bones, and bottled water to clean contaminated wounds.

On the sea side of the waterfront hotels, the tsunami slammed beaches with waves as high as five metres above sea level. Unaware of what was happening on the other side of the waterfront hotels, Oberle and his wife continued to treat injured victims at the Duangjitt Hotel; after about 20 minutes, a Norwegian man told them an injured woman in one of the waterfront hotels urgently needed help. Oberle checked to see if he had treated the most seriously injured victims in the Duangjitt Hotel, and then, followed the Norwegian man to the waterfront hotel, wading across the Duangjitt Hotel lawn and garden through 60 centimetres of dark, debris-laden water. Oberle moved quickly but carefully, fighting the mud as it sucked at his flip flops and cautiously navigating around sharp debris. At the hotel, Oberle and the Norwegian man climbed four flights of stairs, slick with mud and blood, to a room where a woman with multiple lacerations lay pale and shivering. As he treated the woman’s wounds, Oberle caught his first glimpse of the sea from the room’s window. In front of the waterfront hotels, the sea continued to surge around mud-slicked piles of cars and debris (Figure 8.2).

On the balcony of a neighbouring hotel, an English man with multiple wounds, including a severe wound deeply penetrating one of his legs, lay bleeding. Climbing onto a Toyota truck wedged against the hotel, Oberle inched his way towards the victim. After treating this man, Oberle was led to more injured victims in the hotel and other waterfront hotels. Most suffered contaminated wounds, but some also suffered skeletal injuries, including a German man who had suffered a back injury when he was pinned by a tsunami-propelled car.

Oberle treated victims in the waterfront hotels for more than an hour, while tsunami waves continued to surge into the hotels. A raft of cars and other debris loudly groaned and screeched as the churning water ground away at what was left of the lower floors of the hotels. As he treated injuries, Oberle kept track of the victims who were too injured to evacuate themselves. When he returned to the Duangjitt Hotel, he found volunteers to help evacuate injured victims from the waterfront hotels to the Duangjitt Hotel using beach chairs. About two hours after the first wave, the tsunami had subsided and enough water had drained away to enable a large delivery truck to approach the Duangjitt Hotel and evacuate injured victims to hospitals. Soon thereafter, the first ambulances arrived and also evacuated injured victims that had gathered at the Duangjitt Hotel.

As the injured were carted away, rumour spread that another tsunami was due to arrive and non-injured tourists and Thais began to leave the Duangjitt Hotel and the surrounding Patong Beach area. The rumour turned out to be false, but even without a second tsunami, Thailand’s southwestern provinces had suffered an unprecedented level of destruction and loss of lives. On the day of the tsunami, no one fully understood the scope of the disaster in Thailand, and fatality reports grossly underestimated the human toll. On the day of the tsunami, 279 people were estimated to have died in Thailand. However, a total of 8327 people are believed to have died.

Along the Andaman coast, the tsunami couldn’t have occurred at a worse time. In December and January of each year, tourist season peaks at the coast and tourists and locals fill beaches.
In some cases, local infrastructure exacerbated the impact of the waves. For example, many of the 160 people the tsunami killed in Patong City, died when they could not escape from the basement floor of a shopping complex and garage. In the fishing village of Ban Nam Khem, where the tsunami killed 3000 people out of a population of 4800, buildings did not have sufficiently strong columns to keep them from collapsing, and its main roads ran parallel to the coast, making it difficult to escape inland. Additionally, mining ponds located near shore in Ban Nam Khem, may have prevented some people from escaping when the tsunami washed them into the ponds.4

Along Thailand’s 960 km of Andaman coast,5 wave heights were highest in three provinces, Phang Nga, Phuket, and Krabi, which also accounted for 8146 of the 8327 lives lost due to the tsunami (Figure 8.3). In Phang Nga province, the highest waves occurred in Khao Lak district, where tsunami waves reached more than 10 metres high and killed more people than in any other district.6 In the Khao Lak area, the tsunami killed about 3000 out of 15 000 people. In resorts and other buildings near the Khao Lak shore, the tsunami waves blew out walls on the first and second floors.4

In Phuket province, the highest wave heights (5–6 m) occurred along Patong Beach, the province’s most popular beach.6 In Krabi province, the tsunami most acutely impacted Phi Phi Don island where one area was hit by the tsunami from two directions (Figure 8.4). The island is shaped like the letter “H”, and when the tsunami arrived, it completely inundated the centre of the island from both the north and the south with waves 5.8 and 4.6 metres high.6

Several natural warnings preceded the tsunami in Thailand. Because Thailand is east of the tsunami-generating earthquake fault and was relatively close (500 km) to the earthquake epicentre, the first tsunami wave to arrive in Thailand was preceded by both the earth shaking and a large sea withdrawal. The tsunami reached most of the impacted coastlines in Thailand about two hours following the earthquake rupture. Within this two-hour period, tsunami witnesses observed shaking, sea withdrawal, and loud explosion-like sounds before the first destructive tsunami wave arrived. In a survey of 663 witnesses who were in the area at the time of the tsunami, 24% said they felt ground shaking, 21% observed strange animal behavior, 69% saw the sea behave unusually, and 55% heard something unusual. Witnesses observed unusual behaviour of the sea, estimated 3.5 minutes before the tsunami arrived. Witnesses who heard something unusual just moments before the tsunami, compared it with the sound of thunder, a jet, or a train.7 Of the 663 respondents, 81% said they had to evacuate to safety, and of those, 54% said they ran “as fast as possible”.5

Although most of the people in the disaster areas witnessed some sort of natural warning of the tsunami’s arrival, few understood the meaning and fled for safety. In fact, many of the people who witnessed the sudden sea withdrawal walked onto the exposed seafloor to explore coral outcroppings and stranded sea creatures (Figure 8.1). Of the 24% of surveyed witnesses who said they felt ground shaking during the earthquake, most had thought the shaking was due to some phenomena other than an earthquake such as passing automobiles.7

However, not all of the witnesses failed to recognize the tsunami’s natural warning signs. A group of indigenous people, the Mokens, living on one of Thailand’s Surin islands, understood that the earthquake shaking and sea withdrawal indicated danger and headed for higher ground. On this island, generations of Moken had passed along stories about a day when the sea once reared back into a giant wave and crashed violently inland. The stories refer to the tsunami as the laboon or the wave that “eats people”. The Mokens lived throughout the Surin islands as well as on the Thai mainland. But the lessons of the story of the laboon were best preserved among the Moken living on a secluded southern Surin island. On this island, the tsunami destroyed...
a village inhabited by about 200 Mokens, but killed only a previously disabled man who failed to escape to higher ground.8,9

Population impacted
In 2003, Thailand had a total population of 63.08 million,10,11 with approximately 1.8 million living in the six provinces impacted by the tsunami (Table 8.1). The impacted coast extended 954 km from north to south.12 In these provinces, population densities ranged from 56.1 people/km² in Phang Nga to 440.1 people/km² in Phuket.

Public (population, preventive) Health System
Pre-events
Before the tsunami, Thailand’s population health indicators had begun to look more and more like those of a developed country. Fewer and fewer deaths were occurring due to communicable diseases, reproductive health issues, and nutritional deficiencies, while the number of deaths due to diseases associated with longevity, such as cancer, had increased (Figure 8.4). In 2002, 30% of the deaths in Thailand resulted from communicable diseases, reproductive health issues, and nutritional deficiencies, while 59% of deaths were related to chronic diseases such as diabetes and cardiovascular diseases.13

Thailand also boasted high life expectancy rates, high vaccination coverage, and had made great strides in driving down the incidence of communicable diseases (Table 8.2). However, the country still faced a number of key communicable disease concerns including malaria, dengue, HIV/AIDS, tuberculosis, and the newly emerging avian influenza, particularly along borders with neighbouring countries such as Myanmar. But lingering communicable disease hurdles did not stop Thailand from achieving great improvements in its population’s overall health status.

In the years proceeding the tsunami, Thailand’s development indicators climbed rapidly, due largely to improvements in Thailand’s health indicators. For example, during the two decades leading up to the tsunami, Thailand’s life expectancy had increased to 69.1 years, thus exceeding the global average. Between 1990 and 2000, the maternal mortality rate declined by about two-thirds, and by 2002, Thailand reported a maternal mortality rate of 24 deaths/100,000, by far the lowest among the five countries analyzed in this book.14

Thailand had also reduced its population’s vulnerability to communicable diseases by achieving high immunization rates (Table 8.4).15,16 With immunization coverage among one-year-old children ranging from 96% to 99% for measles, DTP3, HepB3, BCG, and polio, Thailand had higher vaccination rates than did India, Indonesia, Sri Lanka and the Maldives.17

Despite strong population health indicators and high immunization rates, Thailand still contended with a few problematic communicable diseases. For example, as in India and Indonesia, Thailand’s population had one of the highest prevalence of tuberculosis. And although Thailand had reduced the number of new HIV infections from 143,000 to 19,500/year between 1991 and 2004, the country still had high prevalence of this disease. Thailand had a higher HIV and AIDS prevalence than did India, Indonesia, Sri Lanka, and the Maldives.18

With respect to vector-borne diseases, Thailand still contended with malaria and dengue. Although the incidence of malaria had declined, it remained an important disease control issue particularly in areas bordering Myanmar, which accounted for 70% of the country’s malaria disease burden.15 Dengue also posed a major communicable disease problem during the three decades leading up to the tsunami. Between 1997 and 2002, trends in dengue incidence rose with epidemics occurring about every two years. However, the case fatality rates due to dengue had declined.12,19

Finally, just before the tsunami, Thailand faced the emergence of two new diseases within its borders—avian influenza and the severe acute
respiratory syndrome (SARS). Fortunately, Thailand had a well-established disease surveillance system to confront communicable diseases. Using a passive surveillance system, the Ministry of Public Health had been with its surveillance system, tracking diseases since 1970 and by 2000, and kept watch over 68 diseases. Thailand’s strong surveillance capacity was due, in part, to a two-year training programme initiated in 1980 by the Ministry of Public Health, WHO, and the US Centers for Disease Control. The Field Epidemiology Training Programme (FETP) educated and trained Thai health professionals in field surveillance and established Surveillance and Rapid Response Teams. By 2003, the programme had graduated 118 Thai field epidemiologists and established more than 1000 Surveillance and Rapid Response teams, thus greatly expanding Thailand’s ability to respond to disease control issues. Thailand’s surveillance system also had been strengthened by the Ministry of Public Health through its experience with SARS and avian influenza. The experience with these two diseases shortly before the tsunami had triggered further expansion of the surveillance system to detect these diseases. Consequently, the surveillance system had good surge capacity in the form of surveillance and rapid response teams that could be mobilized immediately in the case of an emergency.

A national reference laboratory, 167 provincial laboratories, and 678 district laboratories provided diagnostic services. Thailand’s diagnostic laboratories were relatively well-equipped and maintained, but a shortage of adequately trained staff remained a problem.

**Damage**

In Thailand, almost all of the fatalities that occurred due to the tsunami occurred along the coasts of just three provinces, Phang Nga, Phuket, and Krabi. Together, these three provinces accounted for 97% of the 8327 lives lost (Figure 8.5, Tables 8.4 and 8.5). The greatest loss of life occurred in the district of Phang Nga, and in particular, the Khao Lak resort area and the fishing village of Baan Nam Kem. However, overall, fewer people died due to the tsunami in Thailand than in Indonesia, Sri Lanka, or India. And relative to the national population, fewer deaths occurred in Thailand than in the Maldives, Indonesia, or Sri Lanka. Nonetheless, the tsunami killed more people than any other single event in modern Thai history. Thailand had the largest proportion of international fatalities among the five countries (50.4%); thus, the management of casualties became complex in ways unique from any of the other tsunami-impacted countries.

A total of 16,784 persons were reported injured, of which 8,457 people reportedly survived. The number of injured survivors essentially was equal to the number of injured who died directly related to the tsunami. Of the 8,457 injured survivors, 2,392 were foreigners and 6,065 were Thai nationals. The number of injuries per province ranged from 5,597 in Phang Nga to 15 in Satun.

Medical reports following the tsunami suggest that most of the injured suffered open wounds and/or respiratory complications ranging from mild lung inflammation to serious infection caused by near-drowning. Of the 958 patients that arrived at Phuket’s largest public hospital, the majority had sustained open lacerations. A large number also presented with pneumonitis, and 326 victims were admitted to the hospital with severe aspiration pneumonia secondary to inhalation of contaminated sea water. Near-drowning tsunami victims presented unique complications when compared to usual near-drowning victims; the salt water inhaled by victims contained large quantities of mud, microorganisms, and other debris.

**Changes in functions**

Although the tsunami resulted in a sudden influx of victims with injuries, it appears to have triggered only a few changes in disease incidence; an increase in the incidence of a few communicable diseases occurred, but none resulted in an epidemic. The most common ailments encountered in the weeks following the tsunami were infected wounds and non-cholera...
diarrhoea. Between 26 December and 11 January, the reported incidence of diarrhoea was about 1.7 times higher than it was for the same period one year earlier, 2950 cases/100 000 compared to 1758 cases/100 000. Some of this increase may have been due to the fact that during this period, diarrhoea was under active surveillance, instead of the usual passive surveillance. During the same time period, impacted districts within the six provinces also reported 356 patients with wound infections, 177 with febrile illnesses, and 156 with pulmonary illnesses including six cases of pneumonia. The incidences of febrile illnesses and pneumonia were similar to the same period during the previous year.20 After the tsunami, an unusual number of dengue outbreaks was reported, but these were not believed to have been related to the tsunami.24,25

While the tsunami may have taken lives and affected the health of many among the impacted population, it did little damage to Thailand’s ability to monitor health. Unlike Aceh province in Indonesia, where the surveillance system had been weak before the tsunami and further weakened following the tsunami, Thailand’s surveillance system had been strong before the tsunami and suffered little loss of function due to the tsunami. Consequently, Thailand had a strong, functional surveillance system that it could employ following the tsunami and did not require the level of surveillance assistance required in the other countries.27,28

Relief responses
Because Thailand’s well-developed healthcare system, health responders swiftly brought disease and trauma problems under control. Of the more than 8000 victims who arrived at the hospitals following the tsunami, only 0.3% died.26 This low fatality rate has been attributed to Thailand’s quick and strong responses to the tsunami. Within 48 hours of the tsunami, Thailand had dispatched more than 200 medical staff from non-impacted areas including six teams tasked to conduct active surveillance and investigate potential disease outbreaks.20 Thus, Thailand increased surveillance capacity to closely track fluctuations in disease incidence rates.

The Ministry of Public Health created an Andaman coast surveillance hub in Phuket to take responsibility for epidemic surveillance and response in the six impacted provinces.29 On 26 December, the Ministry also set up a National Command Centre in Bangkok (the “Operation Centre for Handling Contagious Diseases and Natural Disasters”), which relied heavily upon infrastructure already in place for the surveillance of SARS and avian influenza.30

Following the tsunami, the Ministry implemented active surveillance in impacted areas for 20 of the 68 diseases it already had been tracking through passive surveillance. The impacted areas included 20 districts within the six provinces impacted and active surveillance efforts gathered information from 77 health centres, 22 public hospitals, four private hospitals, two shelters, and two Disaster Victim Identification (DVI) centres.20 Early during the disaster, Thailand also conducted a formal, rapid assessment and situation analysis of the surveillance system in the impacted region, but due to communications complications and focus on the effort to save lives in the immediate aftermath of the tsunami, the results consisted mostly of subjective observations.22

Recovery responses
Even without a robust assessment, it was clear that the Thai surveillance system remained strong and required only limited assistance. Although Thailand received support for surveillance activities from international responders such as [US] CDC, the Armed Forces Research Institute of Medical Sciences, and WHO-SEARO, Thailand continued to lead preventive communicable disease efforts.20 Also, Thailand produced some of the most complete post-tsunami surveillance reports and analysis.22

Aside from keeping a close watch over fluctuations in disease incidence rates, Thailand implemented several additional preventive measures including a supplemental measles
vaccination campaign and vector control measures. The supplemental measles campaign vaccinated children five-years of age and younger in 14 IDP camps and vector control measures included fogging impacted areas with insecticide and distributing bed nets (Figure 8.8).

**Development**

No records were identified in the further development of the public health system in Thailand following the earthquake and tsunami.

**Medical Care System**

**Pre-events**

Thailand had a strong medical care system when the tsunami struck, including a public medical care system that provided 90% of the nation’s healthcare. In an analysis of health systems in 191 countries, the World Health Organization has ranked Thailand’s health care system as the 47th most efficient. Also, Thailand had made great strides in ensuring equitable access to medical care for its population, both in financial and geographic terms. In Thailand, as in the other countries covered in this book, health professionals and health facilities have tended to concentrate in urban centres. However, strong efforts to make the distribution of medical care more equitable in Thailand had made impressive progress prior to the tsunami. Starting in the late 1970s, Thailand made a concerted effort to develop rural health centres that resulted in reversing trends in urban and rural outpatient visits. In 1977, 46% of outpatient visits occurred in urban provincial hospitals, while only 29% occurred in rural health centres. But by 2000, the opposite was true—46% of outpatient visits were occurring in rural health centres and only 18% were occurring in urban provincial hospitals.

In 2001, Thailand took a bold step toward the goal of providing health care for all by introducing a universal healthcare scheme known as the “30-Baht” scheme. Before the introduction of this scheme, many Thais were covered by several other publicly funded systems, but the 30-Baht scheme sought to extend coverage to all Thais. Under the 30-Baht scheme, Thais not covered by other health plans could receive an insurance card for free and for 30 Baht (US$ 0.75), they could make an outpatient visit or be admitted to the hospital. During its first two years, the system showed great progress in expanding public medical care coverage to a greater proportion of the population. By the end of 2003, the 30-Baht scheme combined with already existing public healthcare schemes, had expanded coverage to more than 90% of the Thai population.

Thailand’s highest levels of medical care were centred in Bangkok. Outside of Bangkok, medical care services were provided by a hierarchy of medical care facilities managed by 75 Provincial Health Offices. Each of Thailand’s 75 Provincial Health Offices is headed by a provincial Chief Medical Officer, who manages one or two regional/general hospitals and several smaller district-level hospitals called Community Hospitals (Table 8.6). Provincial-level hospitals offer tertiary care, while district-level hospitals, comprised mostly of Community Hospitals, but also some extended-level hospitals and Municipal Health Centres, offer secondary care. Below the district-level facilities are the sub-district- and village-level facilities that offer primary care. Health Centres form the backbone of the primary care system below the district level. Each supports the primary care needs of a population of 1000–5000 people.

In addition to the public healthcare sector, Thailand also had a substantial private healthcare sector consisting of approximately 346 hospitals and 14 953 clinics. The private sector accounted for 34 863 hospital beds (about 25% of
Thailand’s hospital bed capacity); approximately 21% of Thailand’s doctors worked in the private sector. However, the Thai population served by the private healthcare sector was limited to patients who could afford to pay for private services.

In the southwestern region of the country, where the tsunami struck ashore, the availability of medical care infrastructure and personnel was about the same or greater than in the nation as a whole. Access to medical care was particularly strong in the two provinces hit hardest by the tsunami, Phang Nga and Phuket, since they were prime tourist destinations. For example, compared to the national average of 3 doctors/10 000 population, Phuket had nearly five doctors/10 000 population. The main general hospital in Phang Nga, Takuapa hospital, had one ambulance, 177 beds, a six-bed intensive care unit, four operating suites, an emergency department, and medical, surgical, and paediatric wards. The hospital also had a staff of 118 nurses, five junior doctors, one general surgeon, two orthopaedic surgeons, two general physicians, three paediatricians, and one ophthalmologist. Phuket island had three general hospitals, the largest of which was Vachira Phuket Hospital.

Overall, the communities hardest hit by the tsunami had access to strong medical care services with the capacity to respond to a large-scale emergency. There was one glaring exception: Phi Phi Island, a remote tourist island in Krabi Province, had just one medical care facility, a primary care centre with only 15 staff including one physician and four nurses, and five observation beds. Although small, the primary health centre was the only medical care facility on the entire island, and its medical director was the island’s only doctor. When the tsunami hit, it heavily inundated the centre killing an assistant pharmacist and injuring a nurse. The remaining team members in the centre, the physician, two nurses, and two additional staff members could not continue to treat patients in the damaged facility and had to move to another building.

Changes in functions
Responses of the Medical Care System in Thailand were prompt. Medical facility damages affected healthcare delivery on the remote island of Phi Phi, and thus, victims could not be quickly transferred to other facilities. Although the tsunami resulted in compromised medical care in other districts along the Andaman coast, it generally did not do so in places as remote as Phi Phi Island, and consequently, did not seriously disrupt the delivery of healthcare services. Damages included the tsunami-inundated and damaged first floor of the Kamala Public Health Clinic, in the district of Kathu in Phuket province. Although the main hospital in Takuapa district did not suffer structural damages, it did

Damage to the medical care system
Compared with other countries hard-hit by the tsunami, Thailand’s medical care system suffered little damage and only a few healthcare workers were killed.

The tsunami destroyed one primary care centre and damaged or destroyed four health clinics. The destroyed primary care centre, located on Krabi province’s Phi Phi Island, had only 15 staff including one physician and four nurses, and five observation beds. Although small, the primary health centre was the only medical care facility on the entire island, and its medical director was the island’s only doctor. When the tsunami hit, it heavily inundated the centre killing an assistant pharmacist and injuring a nurse. The remaining team members in the centre, the physician, two nurses, and two additional staff members could not continue to treat patients in the damaged facility and had to move to another building.

Compared with other countries hard-hit by the tsunami, Thailand’s Medical Care System suffered little damage and only a few healthcare workers were killed.
lose staff. Three Takuapa hospital doctors were caught in the tsunami; one died and two survived, but were unable to join the hospital team until the day after the tsunami occurred. The hospital also lost an ambulance and a nurse and a librarian assistant who were killed by the tsunami.35

**Relief responses**

At 10:30 h on 26 December, the Takuapa hospital received a call from an unidentified caller reporting that a wave had swept through the fishing village of Ban Nam Khem injuring and killing a large number of people. The hospital sent an ambulance to investigate and found widespread flooding as well as dead bodies and injured victims. The community already had begun to help: able-bodied survivors gathered injured victims and brought them to the hospital.35

When hospital staff realized the scale of what had occurred, they quickly implemented the hospital’s Major Incident Policy. The hospital’s public address system was used to call nurses from their on-site residences to report to the hospital; hospital workers telephoned doctors and a team of nine doctors responded. As injured victims and fatalities began to arrive at the hospital, head nurses assumed the triage responsibilities. Victims with minor injuries received care wherever space was available in the hospital; the hospital’s four operating rooms were in use around the clock.35

The strong locally organized responses to the tsunami disaster at the Takuapa hospital were reflected by other medical care facilities in and around the tsunami-impacted area. Medical care facilities in the lowest and highest care levels responded quickly and worked together in close coordination, providing care to tsunami victims within a matter of hours. All the public medical care facilities in the impacted area had rehearsed mass-casualty plans that were implemented following the tsunami. Implementation of the plans was effective and did not require high level medical care authorities to intervene, which helped to avoid delays in the relief responses.37

However, on Phi Phi Island, the local medical care response faced steep challenges that were not addressed in any mass-casualty plan and required innovative measures on the part of the island’s small medical care staff. Because the island’s primary care centre and only medical care facility was destroyed, healthcare workers moved to a nearby hotel, where they treated victims injured by the tsunami for four hours before outside help arrived by helicopter. Approximately 600–700 people came to the hotel seeking medical attention approximately 100 of which had injuries so severe they could not walk. When the first helicopter arrived on Phi Phi Island, it brought an additional doctor and two nurses. With so few staff and so many victims in the immediate aftermath of the tsunami, the Phi Phi medical care workers focused attention on victims who were bleeding rather than on patients with breathing problems. There also was a shortage of medical supplies; medical care workers used bed sheets to help stop external bleeding.36

The overall response by medical facilities in impacted areas was strong. In the three provinces in which most of the injuries and fatalities occurred, different methods of primary triage and evacuation were used. In Phuket, nearly all victims were evacuated to hospitals, thus inundating hospitals. Additionally, in the first hours following the tsunami, there was little coordination between hospitals in order to redistribute patient loads from the most heavily burdened hospitals to the least burdened.38

In the province of Phang Nga, instead of waiting for the victims to come to the hospital, the Takuapa hospital director sent healthcare workers to victims in Ban Nam Khem for medical care and triage. As a consequence, the patient burden in that hospital was limited to those who needed the greatest care.38 Field triage also was performed in Krabi province; 70% of the victims either received treatment from medical care workers in the field or were triaged to primary health centres.38
Although hospitals in impacted areas were on their own during the first few hours following the tsunami, national medical support arrived quickly. The Ministry of Public Health mobilized medical teams, and supplies began arriving in impacted areas within six hours of the tsunami. Some of the earliest arriving support included more than 200 doctors sent to Phuket. Overall, the Ministry of Public Health deployed approximately 100 teams to provide emergency medical care and 12 teams to provide technical support and health education.

Recovery responses

As part of the national responses, some patients were transferred to other hospitals. By 28 December, most non-Thai and about half of the Thai patients in the Takua hospital area had been transferred to hospitals in Bangkok, or elsewhere. And approximately two weeks after the events, the tsunami patients either had been discharged or transferred to other hospitals, and the Takua hospital returned to normal operating levels.

By 9 January, more than 90,000 people in the tsunami-impacted areas had received healthcare. Approximately 80,000 of these had received care from mobile teams, 9798 had received outpatient healthcare services, and 2233 had received inpatient healthcare services. Of those who required inpatient services, 398 (17%) were in intensive care units, and 1254 (56.1%) had undergone major surgery. At Takua hospital alone, 683 surgical procedures were performed during the week following the tsunami.

As in other countries, tsunami survivors’ medical care needs extended beyond treatment for injuries suffered on the day of the tsunami. Following the tsunami, many people were at increased risk of contracting illnesses, particularly in areas where people had been displaced from their homes. To ensure that displaced populations had access to health care, Thai health officials established camp clinics. One camp that housed 390 families (1859 individuals) in Bangmuang, was served by a healthcare clinic 12 hours/day.

The clinic was staffed by a rotation of volunteer nurses throughout its operation in addition to a visiting physician six hours a day.

As Thailand’s Medical Care System’s response capacity to the disaster was able to cope with the circumstances, Thailand did not request medical help from outside of. Nonetheless, international teams did arrive uninvited on Thailand’s doorstep, sometimes insisting that the country accept their services even though their services were not needed or were likely to impede the response rather than improve it. Out-of-country medical response teams required translators, transportation, and lodging, distracting those working within the local Medical Care System from the task at hand. In at least one instance, Thailand received a formal complaint from an embassy after the Ministry of Public Health refused to accept a medical response team from the embassy’s country. However, while Thailand was the centre of a great deal of media attention and did receive unwanted help in the Medical Care System as well as in other Basic Societal Systems, the level of medical response was not as high as it was in Sri Lanka or Indonesia.

With respect to medical supplies, some hospitals in the impacted area ran short of blood, blood products, surgical tools, and antibiotics. However, national medical support filled gaps in medical supplies within two days. From 30 December to 6 January, three teams of Thai and US health professionals conducted a rapid health needs assessment to collect data on the hospitals in the impacted areas.

The Thai medical infrastructure required little rebuilding. Consequently, what rebuilding was required was completed quickly. For example, the Phi Phi Primary Care Centre was repaired and reopened by 15 February 2005.

Development

No records were identified in the further development of the Medical Care System in Thailand following the earthquake and tsunami.
Water and Sanitation System

Pre-events

Thailand had high levels of access to safe drinking water and improved sanitation prior to the tsunami, and the disparities between rural and urban access were small. As of 2000, 91% to 97% of the population had access to sustainable, improved water sources, with greater access among urban populations than rural populations. Access by the population to improved sanitation was even higher in urban areas with 99.5% and 97% in rural areas.14

Ample rainfall helped to ensure access to fresh water sources in Thailand’s southern provinces, including provinces along the Andaman coast. Overall, the average annual rainfall is about 1700 mm. However, rainfall is much heavier in the south, where an average of about 2400 mm of rain falls each year. Most of Thailand’s rain arrives during two monsoon periods: the south-west monsoon period from mid-May to mid-October, and the north-west monsoon period from mid-October to mid-February.12 When the tsunami struck in 2004, most of southern Thailand was relying primarily on shallow wells and man-made ponds for fresh water.39

Damage

The damages to the freshwater and sanitation infrastructure in Thailand were not as great as they were in Indonesia or as disruptive as they were in the Maldives. But, damages did result in acute water and sanitation problems in a few localized areas, including villages in Phang Nga’s Takua Pa district. Overall, the tsunami disrupted water supply and sanitation for an estimated 50,000 people in Thailand. The force of the tsunami damaged water distribution systems to houses and other buildings, and saltwater inundation contaminated surface and underground fresh water sources.40

The tsunami damaged 19 water supply systems, costing an estimated US$ 61,586,000 in direct damages.41 In Khao Lak, the tsunami flooded the Phang Nga navy base water treatment plant damaging electrical controls and the emergency generator, which was rendered useless.42 In the Kamala Beach area of Phuket, tsunami damage disrupted water services for nearly three weeks.42 Although the tsunami damaged seaside pumping stations, pipes, and sanitation infrastructure that was located near the shore, core water distribution systems and waste water treatment plants remained largely intact.43

Determining the amount of damage to groundwater and surface water sources proved difficult, since there was little information on the quality of these freshwater sources before the tsunami. However, a survey of groundwater and surface water quality in villages in the Takua Pa district found that bacterial and saltwater contamination were considerably higher in those areas inundated by the tsunami than in non-inundated areas. The survey measured high contamination levels even after two months following the tsunami, by which time most of the sampled wells had been cleaned and chlorinated at least once.39 Similarly, a Ministry of Public Health analysis of well water in Thailand’s six impacted provinces found evidence of both saltwater and bacterial contamination, including significant groundwater contamination in Phang Nga. Of the 530 wells that the Ministry sampled for bacterial contamination, 187 (35.3%) were found to be unsafe due to high coliform bacteria levels. Of the 534 wells sampled for saltwater content, 32 (6.0%) were found to be unsafe.44

In addition to damage to freshwater supplies and infrastructure distribution, the tsunami also resulted in damages to sanitation infrastructure. In Phuket, the tsunami damaged two municipal wastewater treatment plants.40

Changes in functions

The tsunami is believed to have contaminated an estimated 2324 shallow wells, 737 groundwater wells or ponds, and 102 surface water ponds in the tsunami-impacted areas.40 In most cases, the contamination was minor. In some cases, however, tsunami contamination was so great
that local water sources could not even be used for washing or other household needs. Low availability of water for washing reportedly led to skin problems in some areas impacted by the tsunami. No reports were identified indicating that survivors did not have access to clean drinking water for any sustained period of time or that they became ill from drinking contaminated water. However, an increase in reported cases of diarrhoea in the tsunami-impacted regions was reported, but this may have been due partly to the strong surveillance system.

**Relief responses**

In regions in which water sources and water distribution systems were damaged, the immediate water needs of impacted communities were met by neighbouring communities and local stored water supplies, including a large supply of bottled water stored in the tourist areas. Soon after the tsunami, government authorities began trucking water into impacted areas including Phuket province’s Kamala Beach. Private water bottling companies also played a major role in providing water during the relief phase, delivering truckloads of bottled water to the tsunami-impacted areas.

Within the Thai government, several agencies were charged with assessing and monitoring water quality following the tsunami, including the Ministry of Public Health, the Ministry of Natural Resources, and the Department of Water Resources. These government agencies, researchers from Thai universities, and others, surveyed levels of contamination in both groundwater and surface water bodies in the regions impacted. Meanwhile, many locals were taking their own initiative to clean wells through the use of chlorination. Several UN agencies also stepped forward to help support the provision of clean drinking water and sanitation in impacted areas, including the UNICEF, WHO-SEARO, and UNFPA, as did several NGOs and donors, including the Danish Embassy and International Federation of the Red Cross.

**Recovery and development**

In addition to supporting relief supplies for tsunami survivors, some responders sought to help prepare for future water needs in emergency situations. For example, UNICEF provided the Bureau of Water Management Resources with 11 mobile drinking water treatment plants that could be used to respond to future emergencies.

**Shelter and Clothing System**

**Pre-events**

The warm temperatures and frequent rains in the Andaman coast of Thailand produce a tropical atmosphere with only minor swings in temperature. Consequently, life along the Andaman coast requires shelter from rain and mosquitoes, but little need for shelter from cold. The temperatures average 28°C throughout the year with the driest weather occurring in March and April. Although the people tended to live in non-engineered, single-storey homes made of reinforced concrete, the Andaman coast’s large tourist industry resulted in a mix of building infrastructure.

Among the coastlines that would be hardest hit by the tsunami, Thailand’s resort areas confronted the tsunami with the strongest building infrastructure. Along tourism-saturated areas of the Andaman coast, such as Phuket, tourist building infrastructure was modern and built to high standards compared to the coastal building infrastructure found along the coasts of other countries hit by the tsunami. For the most part, locals living along the Andaman coast lived in non-engineered, one-storey, reinforced concrete houses that were weak in the face of the tsunami.

In addition to the weak structures, many Thai communities also had a weak hold over possession of their land. In many sea gypsy and fishing communities, families living along coasts had lived on coastal lands for years or even centuries, but had never acquired land titles. While Thai law allows villagers to apply for title deeds after inhabiting public land for 10 years, the...
application process was slow. Additionally, many of the sea gypsies and fishermen living in small communities along the coast could not read. Consequently, it was difficult for many of these families to acquire titles for the land that they inhabited even if they had inhabited the land for many generations. In some cases, land disputes arose due to conflicting claims of various groups.46

**Damage**

The generally high standard building infrastructure along some of the hardest-hit regions of the Andaman coast most likely reduced the amount of damage created by the tsunami. Nonetheless, the tsunami destroyed 3578 houses and damaged an additional 2993 houses. The vast majority of the destroyed and damaged homes were located in the province of Phang Nga, where the tsunami hit the hardest, destroying 2563 houses and damaging 2052 others.3

Several construction features affected the damage sustained due to the tsunami (absorbing capacity). For example, buildings that were elevated and allowed water to pass below them were more likely to survive than were those with walls extending to the ground. Also, buildings constructed of reinforced concrete fared better than did masonry or wooden structures. Buildings that had strong foundations and features such as landscaping to prevent scouring around the foundation fared better than did those that did not. Finally, buildings that were not orientated perpendicular to the oncoming wave were less likely to sustain serious damage than those that were.47

**Changes in functions**

In some cases, government agencies and private businesses took advantage of coastal communities’ misfortunes when tsunami victims were displaced, bogging resettlement efforts with disputes. Sea gypsy and fishing villages near the shore were the worst affected. In some cases, the National Park or Forestry Departments told villagers that the land they had been living on belonged to the government. In other cases, private businesses moved in and posted “private property” signs, and claimed the land for future development. Generally, cases involving the National Park and Forestry Departments were settled with the inhabitants being allowed to return to the land that they had inhabited before the tsunami. Cases involving private businesses, however, were not easily settled and became major problems for a number of communities, including the Ban Nairai, Tubtawan, and Laem Pom communities in Phang Nga.48

Some of the land under dispute had been given on concession to tin mining companies under a certificate of land utilization in the first half of the 20th century. Once the mining contracts had expired, the communities that had moved there to work in the mines stayed.

**Relief responses**

In Thailand, the provision of temporary shelter and the eventual rebuilding of damaged and destroyed housing was more easily addressed than in Indonesia, Sri Lanka, India, or the Maldives. Also, considerably fewer people in Thailand had been displaced than in Indonesia, Sri Lanka, or India. And in Thailand, shelter relief and recovery efforts did not face the difficult transportation and logistical issues that complicated shelter relief and recovery in the Maldives and the Indian Andaman and Nicobar islands.

The government assigned the Interior Ministry the responsibility of overseeing the construction of temporary and permanent housing in cooperation with the Thai military and Ministry of Social Development and Human Security.40 But in the initial aftermath of the tsunami, displaced populations had to rely on what was immediately available including public buildings, the homes of friends and family, or, in some tourist areas, hotels that had temporarily offered to accommodate displaced survivors. Soon after the tsunami, displaced populations were moved into donated tents or, in the case of tourists, returned to their homes in other countries or other regions of the country. Soon tents were replaced with transitional shelters. On 18 January, World Vision
began building 475 temporary shelters.\textsuperscript{[1]} For the most part, few of the displaced would remain in temporary shelters beyond a year following the tsunami.

**Recovery responses and development**

National and local government authorities and NGOs built temporary shelters on vacant plots and in school yards using plywood and corrugated iron sheets.\textsuperscript{[49]} The government and NGOs quickly mobilized efforts to rebuild and move tsunami-impacted populations into permanent housing. Within the Thai government, the Ministry of Social Development and Human Security took primary responsibility for coordinating the effort to rebuild housing, and the Thai cabinet approved 506 million baht (US$126.5 million) for the construction of 3616 permanent houses.\textsuperscript{[3]} The Thai military played a key role in rebuilding houses, and by 15 February, more than 100 houses had been rebuilt.\textsuperscript{[49]} By the first anniversary of the tsunami, only 2900 people still were living in the temporary shelters, compared to 7000 in June 2005.\textsuperscript{[50]}

Although most of the displaced were offered homes within a year of the tsunami, some refused the houses built for them. Some were refused because the government used a cookie-cutter approach to building houses instead of consulting with the recipients about the location and types of houses being built for them.\textsuperscript{[50]} Some of the houses rebuilt by the military also were thought to be vulnerable to future disastrous events. For example, in Ban Nam Khem, the Thai army rebuilt houses said to be no more likely to keep residents safe from a future tsunami than the housing that the tsunami had just destroyed.\textsuperscript{[4]}

**Food and Nutrition System**

**Pre-events**

In the three decades leading up to the tsunami, Thailand had made a major nutritional transition. Under-nourishment plummeted and health issues associated with being overweight began to pose a new health concern. Under-nutrition indicators in Thailand dropped to among the lowest in South-East Asia. As of 2001, only 11.7% of children five years of age and under were stunted, 11.5% were underweight, and 3.9% were wasted (Table 8.8).\textsuperscript{[51]}

With respect to food safety, Thailand had two agencies charged with food monitoring responsibilities: the Ministry of Public Health’s Food and Drug Administration and the Ministry of Agriculture and Cooperatives’ Department of Livestock Development. Together, they conducted food safety surveillance from the farm level to the factory level and to the market and enforced food safety laws to prevent food contaminated with pathogens or dangerous chemicals from entering the market. Additionally, to enhance food safety monitoring, the Food and Drug Administration had established a 24-hour hotline where members of the public could report food safety concerns.\textsuperscript{[52]}

**Damage**

The tsunami caused approximately US$ 44 million in damages to the fishing industry, US$ 440 640 in livestock damages, and US$ 165 635 in agricultural damages.\textsuperscript{[24]}

**Changes in functions**

In addition to damages to the fishing industry, livestock, and agriculture, other damages, such as damages to food markets, had a greater impact on livelihoods than they did on access to food. Disruptions to access to food were minimal. Beyond the immediate aftermath of the tsunami, there was no need for large-scale food assistance in Thailand.\textsuperscript{[53]}

**Relief responses**

UNICEF and the World Food Programme (WFP) extended food assistance to tsunami-impacted populations. Food assistance for tsunami-impacted populations focused on the most vulnerable and generally concluded within a few months following the tsunami. For example, WFP provided the widowed, orphans, and tribal populations with food rations for three months, and supplemented a government school-lunch programme in impacted districts for six months following the tsunami.\textsuperscript{[54]}
Recovery responses
Recovery of the Food and Nutrition Basic Societal System was rapid as there was little disruption in availability. Thailand did not request any outside support.

Development
No records were identified in the further development of the food and nutrition system in Thailand following the earthquake and tsunami.

Energy Supply System
Pre-events
Thailand had achieved high electrification rates with little differences between rural and urban access. A rural electrification programme that began in the 1970s achieved great increases in rural electrification levels; and by 2000, rural electrification levels had reached 97% and 98.3% for the country as a whole. Access to electricity in the provinces along the Andaman coast ranged from a low of 89.5% in Ranong to 99.3% in Phuket, but was limited on the poor, remote islands. Electricity on these islands relied primarily on failure-prone solar systems or costly diesel generators. The vulnerability of the electrification system to a coastal flooding event along the Andaman coast generally was low, since most major electrical facilities were located inland.

The majority of the electricity supply in Thailand was derived from the burning of fossil fuels, especially crude oil and liquid natural gas. Pre-events, although Thailand possessed some oil and natural gas deposits, it still required a substantial amount of the fuel to be imported. In 2003, only 25% of the energy used was from domestic resources. At the time of the tsunami, 37% of the energy produced/imported was used by industry, 37% for transportation, 16% for residential, and 5% for commercial and public works.

Damage
For the most part, the tsunami did not result in major damages to the energy systems as most of the production was inland or in areas not impacted by the tsunami. The tsunami damaged 69 electrical subsystems, resulting in about US$ 4.4 million in direct damages. Disrupted systems were restored quickly. No reports of fuel shortages were identified.

Changes in functions
Compromise of the energy supplies, including electrical power to the medical facilities, was transient and caused no major interruptions in services.

Relief and recovery responses
For the most part, energy availability including electrical power was restored within a few days of the tsunami.

Development
Beyond repairing the damages caused by the tsunami, the disaster also drew attention to communities that had long-standing insufficient access to energy and spurred humanitarian efforts to improve access. Energy development efforts focused largely on poor remote islands and where access generally was the lowest, improved the reliability and affordability of islands’ energy supplies.

Public Works and Engineering System
Pre-events
Ground transportation along Thailand’s tsunami-impacted coast relied entirely on roadways. However, some of the Andaman coast was too rugged to build roads upon. On Phuket Island, for example, the coast is characterized by rugged cliffs interrupted by intermittent pocket beaches. Consequently, few roads abutted the sea other than within areas where the rugged cliffs were interrupted by beaches.

Thailand produced approximately 22 million tons of waste/year or about 0.65 kg of waste/person/day. Overall, waste generation was high in Bangkok, but per capita waste generation was greatest in tourist areas such as Patong Beach. Phuket, where 5 kg of waste was generated/
Collected waste was disposed of in one of Thailand’s 95 landfills or 330 open dumps, which lack precautionary environmental or health measures.

**Damage**

The tsunami washed out roads, weakened bridges, and deposited debris on roads along the Andaman coast. Along with weakened bridges and debris, other more common road damages included washed-out road shoulders and damaged railings. With respect to damages on various types of roadways, roads built on local sands suffered the heaviest tsunami erosion. With respect to the geographic distribution of damages to the Public Works and Engineering System, the greatest damage occurred in Khao Lak, where low elevation allowed the tsunami to travel far inland. The tsunami heavily eroded Khao Lak’s main road and entirely washed-out a lagoon bridge near the coast.

The tsunami left behind a massive quantity of debris along impacted coasts and in coastal reefs. Quite likely, no one will ever know the true quantity of debris the tsunami produced in tsunami-impacted regions of Thailand, but a post-tsunami field survey estimated that the tsunami produced more than 76,250 tons of debris on land. Tsunami debris dragged into the ocean was greatest in the waters surrounding the Phi Phi Islands where there was an estimated 1000 tons of debris. No specific reports on damages to the harbours were identified.

**Changes in functions**

Damage to the roads resulted only in transient obstruction to transportation and there was little apparent damage that obstructed access to the medical facilities. The tsunami also resulted in fluctuations in the local generation of municipal waste and hazardous infectious wastes. For example, in Phuket, a drop in tourism following the tsunami reduced the amount of municipal waste generated. But, the increased management of human remains and increased activity at hospitals increased biological hazardous wastes. Infectious waste received at the Phuket infectious incineration plant increased from 10–11 tons/month before the tsunami to 80 tons in January.

**Relief responses**

Following the tsunami, with the help of the Thai military, concerned national government, and administrative districts departments removed tsunami debris from the land and through a UNDP project removed debris from reefs. Additionally, the Ministry of the Interior provided US$ 887,500 to procure nine hazardous waste incinerators, six for Phang-Nga province and three for Krabi province. International assistance was not required. Essentially, no relief flights were required due to impaired access.

**Recovery responses**

A major obstacle facing clean-up efforts, was a shortage of land for the disposal of debris and wastes. In situations where in which tsunami debris was trucked to landfills, it quickly filled up the space. As a result, local authorities had to find ways to expand the landfills or create new ones to accommodate future waste. Some municipalities paid to have tsunami debris dumped on privately owned land. In the district of Bang Muang, a privately owned company, Waste Management Siam Co. helped to transport and dispose of tsunami debris in a non-hazardous industrial waste landfill in Chonburi province free of charge.

In Pang Nga, Phuket, and Phi Phi Island, authorities quickly collected and disposed of debris so that recovery could begin early. The quick removal of debris, however, pre-empted efforts to recycle tsunami debris, which would have reduced the pressure on limited disposal sites and provided materials for the rebuilding effort. Recycling debris after it already had been removed was difficult because removal tended to mix the debris with additional rubbish, soil, and other organic materials.
Development
No records were identified in the further development of the Public Works and Engineering System in Thailand following the earthquake and tsunami.

Social Systems
Pre-events
Thailand’s Andaman coast hosted several distinct populations; local Thais co-mingled with wealthy tourists and worked alongside poor migrant workers from Myanmar. Sri Lanka and the Maldives also hosted a large number of tourists, but nowhere else in the tsunami-impacted region, were there as many tourists as there were along Thailand’s Andaman coast. The Andaman’s migrant population also was unmatched among tsunami-impacted regions with respect to its migrant worker population. Before the tsunami, over 100,000 migrants had traversed the Myanmar border to try to make a living along the Andaman coast. In the four provinces that would be hardest hit by the tsunami and closest to the Myanmar border—Rangong, Phang Nga, Phuket, and Krabi—there was a total of 120,971 migrant workers, 91% of whom were Burmese. However, this likely is an underestimate of the true number of migrants in the area as many were undocumented.

Along the Andaman coast, the Burmese shared their minority status with a group of people known as the Mokens. Like the Burmese migrants, Mokens often work in the fringes of the economy, and frequently suffer exploitation even though many of them have lived in Thailand for generations. Many of the minorities living along the Andaman coast, including many Mokens and Burmese migrants, did not have Thai citizenship. Although unfavourable treatment of minorities created tensions along some areas of the Andaman coast, the region did not suffer from political conflict as did tsunami-impacted regions of Indonesia and Sri Lanka.

With respect to gender equality, Thailand had a strong record. Women had equal voting rights since 1932, the gap between the literacy rates of men and women was small, and women were more likely to attend higher levels of education and complete a Masters or PhD degree. However, Thai women still had fewer opportunities than men. Compared with men, they were socially, politically, and economically disadvantaged. But, when compared with women in neighbouring South-East Asian countries, Thai women were more likely to achieve levels of employment, promotion, and similar levels of wealth equal to those of their male counterparts.

The vast majority (94.2%) of Thailand’s population is Buddhist. The second and third largest religious groups are Muslims, who comprise 4.6% of the population, and Christians who comprise 0.8% of the population. Although most of the country is made up of Thai-speaking Buddhists, Pattani Malay-speaking Muslims make up the majority of the population in four southern provinces, one of which—Satun Province—was located along the Andaman coast.

With respect to the social support infrastructure, Thailand had a well-developed mental healthcare delivery system integrated within the healthcare system. The Mental Health Department was Thailand’s mental health authority, and there existed an extensive network of village health volunteers who were trained in basic mental health issues. In total, Thailand had 7.29 mental health personnel/100,000 population, and mental health services had been well-integrated into the primary healthcare system for many years. Thailand had a total of 122 outpatient service facilities for mental health and 17 mental health hospitals providing 13.8 beds/100,000 population. Additionally, Thailand also had a disaster/emergency preparedness plan for mental health. Thus, the country had both the capability and capacity for tackling mental health and psychosocial problems following an emergency.

In the years leading up to the tsunami, mental health issues were on the rise with the biggest
increases occurring around the time of the South-East Asian economic crisis in the 1990s. But, despite these increases, reported mental health issues and suicide rates generally remained low when compared with other South-East Asian countries.

**Damage**
The psychological damages from the tsunami were immediate. Those caught up in the waves who managed to survive quickly turned their attention to locating friends and family, and in some instances, found corpses. Even after the waves resumed their natural rhythms, never having seen anything like a tsunami, survivors remained uncertain—they feared proximity to the seashore. As the hours and days passed following the tsunami, the psychological trauma deepened for many as the reality of their new circumstances set in.

Some not only lost loved ones, but also homes and livelihoods. Those who lost homes were more likely to also have lost a loved one. A survey of displaced* and non-displaced survivors in the hardest-hit region found that 51% of displaced survivors lost a loved one compared to 13%–27% of non-displaced survivors. As if the trauma of losing loved ones, and in some instances, washed them out to sea further complicating the efforts of the survivors to find loved ones, homes, and livelihoods were not enough, survivors had to search among the many battered dead for the bodies of their loved ones. Crashing waves scattered bodies along many kilometres of coastline. Failure to locate a body complicated the grieving process among the survivors, as they would be unable to perform death rituals, reach a sense of closure, and move on with their lives.

**Changes in functions**
Tsunami fatalities disrupted the survivors’ most important source of social support, the family. The tsunami broke apart nuclear families, as it swept away the lives of husbands, wives, and children. For example, 1480 children who lost parents to the tsunami, would grow up with only one or possibly no parent to care for them. The remaining members of families that had lost members to the tsunami often were left more vulnerable. Sometimes, women widowed by the tsunami could not receive compensation when they could not provide a marriage certificate, even if they had several children with their deceased husbands.

The tsunami also resulted in heightened exploitation of several minority groups, including Burmese migrants and the Mokens. Generally, Mokens did not have papers to establish their legal rights to the land they had occupied for generations, and after the tsunami, they easily were marginalized by private companies trying to lay claim to the land. It wasn’t until an NGO recognized and fought against the mistreatment of Mokens, that they were able to return to their villages.

Migrants in Thailand faced some of the greatest difficulties following the tsunami. Prior to the tsunami, most had weak or no legal rights in Thailand and feared that they would face legal repercussions if they tried to seek assistance. Additionally, Burmese migrant workers were poorly documented. By May, 2000 bodies remained unidentified, most of which are thought to be those of migrants.

**Relief responses**
Thais benefited from an intensive forensics effort that greatly increased the number of fatalities identified that then could be returned to the bereaved. Due to the fact that tsunami victims included a large number of foreign tourists, Thailand faced greater pressure to identify dead bodies as compared to other impacted countries. Thailand recognized that a failure to identify large numbers of the foreign visitors would tarnish its image as a tourist destination. However,

*Of the displaced population interviewed for the survey, 98% had lost their property.
identifying so many fatalities required immense resources, particularly, since there was not nearly enough cold storage facilities available in which to preserve the remains.

In the aftermath of the tsunami, Thailand requested external assistance for identifying the corpses, and launched what would become the largest forensic operation in the history of the world. Forensics teams from more than 30 countries arrived, helping Thailand identify both foreign and Thai fatalities. The Wat Yan Yao temple in Phan Nga province became the primary hub for forensic work following the tsunami, and a Thai Tsunami Victim database was created to gather information about the missing and unidentified bodies. Of the victims identified using the Thai Tsunami Victim Identification database, more (46%) were identified using dental records than any other forensic technique. Most of those identified using dental records, were of European descent. Dental records were less useful in identifying Thai victims, since only 18% of missing Thais had dental records, and of those, more than 90% were inadequate for forensic identification. Forensic investigators mainly used fingerprints to identify bodies of victims from Thailand and other Asian countries. Of the Thai victims identified using forensic techniques rather than visual identification, 59.2% were identified using fingerprints, whereas only 2% were identified using dental records. Of the corpses identified using forensic methods, 18.6% were identified using DNA samples. The DNA samples were employed most heavily in identifying Thai victims, since they could not be as easily identified using dental records.

Eventually, forensics teams identified all but 422 of the nearly 3700 unidentified fatalities. Although the results of the forensic operation were impressive, it may have been even more successful had the morgues handling unidentified fatalities within the first days of the disaster been aware of the kinds of data needed for forensic identification. In these first few days, some morgues relied heavily on preserving DNA samples when photographs, finger prints, and dental examinations of the deceased would have been more effective and less expensive. But identification using DNA samples is costly and takes much longer than identification using dental records.

Thailand implemented strong and effective mental health responses following the tsunami, and did not require outside help to support these responses. The Thai government and local NGOs met survivors’ mental health needs so successfully that it was determined that international mental health responders were unnecessary. Thai mental health authorities and service providers exhibited exemplary coordination. The Department of Mental Health closely monitored all mental health response providers including NGOs, ensuring the consistency and quality of the services being delivered. Additionally, the availability of mental health services was widely publicized among the surviving population, and more than 700 000 village health volunteers were available for quick training and mobilization. Following the tsunami, mobile teams of mental health workers travelled to villages and rehabilitation centres to support the work of village health volunteers. A psychiatrist headed each team, which also included a counsellor, pharmacist, psychiatric social worker, and community health centre staff. The teams visited villages and rehabilitation centres on a fixed schedule.

**Recovery responses**

In contrast to the bereaved in Indonesia, Sri Lanka, and India, most of the bereaved in Thailand could confirm the deaths of their loved ones, execute death customs, complete the grieving process, and move on with their lives. This helped the pace of recovery, allowing Thais to regain a sense of normalcy in their lives and move on.

The Department of Mental Health monitoring detected sharp declines in mental health problems within the first month after the tsunami. The percentage of survivors with severe anxiety declined from 28% during the first week
following the tsunami, to 9.8% by the fourth week, and the survivors with depression declined from 35% during the first week, to 7.2% in the fourth week. Furthermore, Thailand’s mental health response ensured that those who would require ongoing care would not be ignored. As an example, at the Mental Health Recovery Centre in Phang Nga, the mental health plan for survivors not only addressed the immediate mental health support needs of survivors, but also prepared for their long-term support.

**Transportation and Logistics**

**Pre-event**

The number of ambulances in the provinces along Thailand’s Andaman coast was limited. In Phuket, where there are 270,000 local residents with as many as 40,000 tourists, there were 10 ambulances. Most ambulances were operated by government hospitals. All accredited Thai hospitals were required to maintain ambulances; typically the ambulances were equipped with flashing lights, sirens, a stretcher, first-aid kit, bag-valve-masks, oxygen, and intravenous infusion stands. Only a few large urban hospitals had ambulance drivers on duty 24 hours/day. There were no educational courses for driving ambulances in Thailand.

Ambulances were used primarily for non-emergency transport although most hospitals would send an ambulance to respond to police radio or telephone requests. Most hospitals did not offer pre-hospital emergency medical services nor did they employ emergency medical technicians. Instead, hospitals often sent ambulances staffed by nurse’s aids with basic life-support training. Availability of pre-hospital emergency medical services was limited particularly in rural areas. Consequently, Thai tended to assume responsibility for transporting patients to the hospitals using private cars or taxis rather than calling for ambulance services.

The airport in Phuket could accommodate most type of aircraft. The surge in flights delivering supplies were managed accordingly.

**Damage**

In Phuket, the primary roads suffered little damage and, in most cases, large debris blocking traffic were removed within a few hours of the tsunami. Although the Phuket International Airport is located near the coast with the western end located at the shoreline, the tsunami did not seriously damage that airport. A concrete wall located between the airport and the sea deflected tsunami wave energy. The tsunami did flood approximately 100 metres of the end of the runway.

Aside from the observation that the lagoon bridge in Khao Lak was damaged and some bridges were weakened by the forces of the tsunami, bridge infrastructure was not significantly disruptive. Overall, the tsunami resulted in 235.1 million Baht (US$ 7.2 million) in direct damages to Thailand’s Transportation and Logistics System.

**Changes in functions**

Thailand’s immediate responses to the tsunami were facilitated, in part, by the fact that the damages did not severely disrupt the transportation and logistics system along the Andaman coast. The flooding of the Phuket airport runway did not cause significant damage, and the airport was shut down for only two hours as a result. Flights were only minimally disrupted, and the airport otherwise was available to receive flights delivering assistance and transporting victims out.

Washed-out roads, weakened bridges, and debris on some roads made reaching victims more challenging, but did not seriously cripple relief efforts and assessments and identification of needs to the degree that they did in Indonesia and Sri Lanka.

Some bridges could not be used immediately following the tsunami, but in most instances, the damages did not compromise bridges’ load-carrying capacities.

Although damages and disruptions to transportation systems in the aftermath of the tsunami were moderate in Thailand when
compared with Indonesia or the Maldives, the sudden influx of victims requiring transport to hospitals overwhelmed hospital transport capacities. Where patient loads were the greatest, there was a severe shortage of emergency evacuation vehicles. Consequently, many patients were brought to hospitals via non-designated vehicles including private and police cars.\textsuperscript{38}

Relief and recovery
The Royal Thai Army and Ministry of Transport Department of Highways and Department of Rural Roads cleared roads of debris so rescue and relief teams could reach critical areas. As in Indonesia, elephants were used to help remove machinery from muddy areas that were difficult to access with equipment. Subsequent road repairs progressed quickly and transportation infrastructure was, for the most part, disrupted only for a few days.

Security System
Pre-events
There were really no tensions in security in the affected area. Issues with minorities and migrants sometimes created tensions and potential for unrest.\textsuperscript{63} But these did not escalate or turn into situations that compromised delivery of the health needs.

Damage and changes in functions
Relief workers became targets, when on 12 January, animosity towards Burmese migrants receiving aid boiled over. Six World Vision Thai and Burmese relief workers were kidnapped by villagers in Phang Nga for helping Burmese migrants. One of the relief workers was severely beaten and the relief workers were caged until they were handed over to the police who released them.\textsuperscript{65} Thousands of Burmese migrants went into hiding after the tsunami in fear of being arrested or harassed by Thai security forces.\textsuperscript{65}

Relief and recovery
Although it was anticipated that violence would occur, it did not, and therefore, violence did not adversely affect the relief and recovery efforts.

Communications System
Pre-event
One landline telephone company and at least three mobile phone companies provided telecommunication services in the Andaman coast region. Communication cables typically were hung from utility poles just below electrical lines and cell phone towers were located throughout the region.\textsuperscript{77}

Damage
Damage to the telecommunications system was estimated at 53.6 million baht (US$ 1.6 million).\textsuperscript{41} Damage to telecommunications systems was localized.

Changes in functions
For the most part, damages to the communications system created only minimal disruptions in services. Mobile phone services were not fully functional in tsunami-impacted areas for the first few days following the tsunami, and created some communication problems for the national disaster responses, which relied heavily on mobile phones.\textsuperscript{78} There was an overload of the mobile telephone system that resulted in failures of communication between coordination and responding organizations.

Relief responses
During the first few days following the tsunami, Thailand had the greatest capacity to convey the information about the disaster to the rest of the world and became a leading source of images and tsunami witness stories used in international newscasts. Tourists who had witnessed the tsunami relayed the tsunami tragedy to the rest of the world through film footage, photographs, and stories posted on-line.

Recovery responses
At the local level, communication services were quickly repaired and disruptions generally lasted only a few days.

The media played a strong role in keeping the public informed on relief efforts being conducted in the tsunami-impacted region. In
particular, the media played an important role in drawing attention to inequalities in beneficiary access to tsunami assistance and infringements upon the land rights of tsunami-impacted indigenous populations.76 There was no early tsunami warning system in place, and there was no warning issued to alert persons of the approaching tsunami that did not impact Thailand for hours after the tsunami impacted Indonesia.

Development

The tsunami led to the implementation of several development efforts to minimize the likelihood that communication failures that occurred during the tsunami would reoccur during future disasters. For example, the over-reliance on mobile phones for use in coordinating disaster efforts prompted Thailand’s leading disaster coordination agency to invest additional resources in radio equipment and to establish a Radio Network Centre.79 In addition, the failure of authorities to detect and warn people of the approaching tsunami prompted Thai officials to initiate efforts to develop a disaster communications system. The Ministry of Foreign Affairs and the Ministry of Information Technology began the effort by organizing a two-day ministerial-level meeting in Phuket to address the issue.80

Economy responses

Pre-events

Between 1986 and 1995, Thailand had traced a path of strong economic development. Thailand became a middle-income country; between 1990 and 2002, the number of people living below the poverty line decreased by almost two-thirds, from 27% to 9.8%.16 When the Asian economic crisis erupted in 1996, Thailand’s economy contracted, but by 2004, the country’s economy had recovered considerably.11

Tourism was an important part of Thailand’s economy. As one of the world’s top 20 tourist destinations, Thailand attracted more than 10 million tourists each year, many of whom flocked to beaches along the country’s Andaman pristine coast.81 In Phuket province, tourism accounted for 42% of the province’s GDP, higher than in any other province in the country. Tourism also had assumed increasing importance in the province north of Phuket—Phang Nga Province—where many new resorts recently had emerged along the Khao Lak Beach area.82

The Andaman coast also played an important role in Thailand’s fishing economy, providing 31.7% of Thailand’s marine catch.83 The fishing industry supported not only fishermen, but also employment in related activities such as processing and shipping. Among the six districts along the Andaman coast, the tourism and fishing industries employed more than 200 000 persons.84

In 2003, Thailand’s total expenditure on health comprised 3.5% of its national GDP.25

Damage

The economic impact of the tsunami on Thailand amounted to 1.4% of Thailand’s GDP.86 The tsunami smashed fishing boats, fishing equipment, docks, soiled beaches, ruined resorts, and scared away visitors, all of which cut deeply into two major income-generating industries along the Andaman coast—fishing and tourism (Figure 8.10). In all, more than 35 000 Thai families are believed to have lost their livelihoods due to the tsunami.76 In the fishing industry, the tsunami damaged an estimated 1559.9 million baht (US$ 48.4 million) in fishing boats and gear. However, this seems to be an underestimate, since not all of the fishermen reported their losses. Additionally, the time lost fishing due to destroyed boats and equipment has been estimated to have cost the industry an additional 3751.8 million baht (US$ 115.1 million).41

Similarly, the tsunami resulted in direct and indirect losses for the tourism industry. In the impacted area, the tsunami damaged or destroyed approximately 328 hotels that comprised 28% of the area’s room capacity. Additionally, many other tourism-related commercial facilities, such as restaurants and shops also were damaged or destroyed. Together, these damages are estimated to have
cost the Andaman coast 14,648.30 million baht (US$ 450 million).

Changes in functions
On top of the direct losses suffered from the tsunami, the tourism industry suffered a sharp drop in tourist visits at a time when the Andaman coast tourism industry should have been at its peak.41

While the tourism sector was not as large in Phang Nga province as it was in Phuket, the tsunami destroyed proportionately a greater share of Khao Lak Beach resorts than in Phuket. This large scale destruction smothered the Khao Lak tourism industry for the next season, hindering local recovery of livelihoods. However, the number of visiting tourists dropped significantly in both provinces. Hotel occupancy rates for 2005–2006 January through March tourism season dropped from the usual 57%–70% range to approximately 30% occupancy. This drop in occupancy rate occurred even as the number of rooms available had declined. After the tsunami, there were 25% fewer lodging establishments in Phuket1 and 61% fewer in Phang Nga. Consequently, the tsunami was a huge blow to tsunami-impacted Thais who relied on tourism for their livelihoods. In the first quarter of 2005, tourism-derived revenue declined almost 100%, and 82% in the second quarter.82

Although the tourism and fishing industries were among the hardest hit income generating industries along the coast, other industries also suffered. In the agriculture industry, for example, the tsunami flooded more than 225 hectares of productive agricultural land and killed 54,000 livestock.87

Relief responses
Thailand accepted technical support for managing the tsunami disaster, but in contrast to many other tsunami-impacted countries, it did not make an appeal for financial assistance from the international community. Thailand had a national relief and rehabilitation budget of US$ 1.7 billion.86

Recovery responses
With high losses in the tourism and fishing industries, Thailand put a high priority on restoring tourism levels to pre-tsunami levels and re-equipping those fishermen who had lost their livelihoods along with their equipment. The Thai government provided monetary compensation to fishermen who had lost boats and fishing equipment.

Thailand’s efforts to restore livelihoods and economic activity along the Andaman coast were aided by support from UNDP, the World Bank, and FAO. The UNDP set up income-generating activities in struggling tsunami-impacted villages, and supported debris clean-up from coral reefs, which were important to both the fisheries and tourism industry.

Education System
Pre-event
Thailand placed heavy emphasis on the education of its population. In 1997, it made six years of schooling compulsory, and in 1999, extended compulsory schooling to nine years. As of 2001, Thailand had a literacy rate of 95.7% and in 2002, enrolment in primary education was 86% and 55%, respectively.11 Thailand had 11 medical schools, 10 public and one private which admitted a total of 1374 students in 2003.11

Damage
The tsunami destroyed five schools and damaged an additional 51, resulting in 340.2 million baht (US$ 10.5 million) in damages to the Education Basic Societal System. The greatest damages occurred in Phang Nga and Phuket, which suffered losses of 123.8 million baht (US$ 3.8 million) and 110.7 million baht (US$ 3.4 million) in the education sector, respectively.41

*In Phuket, however, lodging establishments recovered quickly and within three weeks, 90% of the rooms open before the tsunami were again available.
Changes in functions
Although disruptions to classes due to tsunami damages was minimal, school attendance lagged behind. Even after all the schools had reopened, 25% of the students in tsunami-impacted areas were not attending, reportedly staying home from classes due to distress.89

Relief responses
In places where school buildings could not be used due to tsunami damages, classes were held in temporary schools or in neighbouring schools.88

Recovery responses
The effort to rebuild, repair, and re-open schools progressed quickly following the tsunami and disruptions were minimal. All schools re-opened by 10 January, and most actually had opened at the beginning of the school year on 4 January. UNICEF helped to support local efforts to reopen schools.76 The military also played an important role in reopening schools by rebuilding and, in some cases, relocating destroyed schools to safer locations. In Ban Nam Khem, for example, the Thai army built a new school on higher land further inland where it would be less vulnerable to coastal flooding events.4

Development
Humanitarian workers drawn to the Andaman coast by the tsunami disaster, also launched programmes to improve the school systems above pre-tsunami levels, and some used the schools as a tool to improve disaster awareness. Action Aid organized a school programme to develop a disaster curriculum to teach students to recognize disaster risks and how to protect themselves.90

Coordination and Control System
Pre-events
In Thailand, disaster management relied primarily on centralized capacities and focused on relief and response. Two specific provisions characterized Thailand’s disaster management system: (1) the Civil Defense Act of 1979; and (2) the Civil Defense Plan of 2002. The Civil Defense Act and Civil Defense Plan allowed the government to quickly release disaster funds and assigned the Prime Minister with the authority to direct disaster management. The Prime Minister directed disaster management via the Department for Disaster Prevention and Mitigation and National Civil Defense Council. The Department for Disaster Prevention and Mitigation, established in 2002 under the Ministry of Interior, was the government’s principal agency for coordinating disaster management. The National Civil Defense Council provided a link between Thailand’s armed forces and disaster responses. Thailand did not have a national plan for responding to disasters, but with the help of the Asian Disaster Preparedness Centre, was in the process of developing one.76

Damage
There was no formal coordination and control structure in place prior to the tsunami that could be damaged.

Changes in functions
Since there was no structure in place, the tsunami did not impair the function of coordination and control entity.

Relief responses
The government’s responses to the 2004 tsunami disaster were widely regarded to have been effective. Although Thailand did not have a national disaster management plan, its disaster management legal framework and structural arrangements were relatively clear. Additionally, Thailand’s decision to discourage unsolicited external assistance and not to rely on ad hoc response structures also contributed to effective, coordinated responses.

In an unusual move among tsunami-impacted countries, Thailand declined international financial assistance and welcomed technical assistance only in specified areas, such as donor coordination,
alternative livelihoods, disaster preparedness and forensic identification. A great deal of unsolicited assistance however, was received. By 29 December, more than 80 organizations either had arrived or had expanded to provide aid to tsunami victims. However, relative to other tsunami-impacted countries, such as Sri Lanka and Indonesia, external assistance in Thailand was kept to manageable levels.

Thailand’s limited external assistance reduced overlaps in the responses and confusion among responders. Responders in Thailand primarily were agencies present in Thailand long before the tsunami. These established relationships improved the efficiency of the responses and helped to ensure that the responses were appropriate given the local context. Also, agencies tended to focus on issues that were in line with their mission profiles, thus helping to ensure that responses were provided by responders skilled in the services being provided. Similarly, Thailand’s decision to rely on existing disaster management structures rather than on ad hoc agencies, also improved efficiency. Thailand activated the Civil Defense Act Emergency System that expanded national and local ministry capacities and froze resources. It did not create any major ad hoc structure to respond to the losses of function of the societal systems.

As in other tsunami-impacted countries, the earliest disaster responses, including search and rescue efforts were generated locally. However, in Thailand, local responses received international support within hours of the tsunami. On the day of the tsunami, Prime Minister Thaksin Shinawatra ordered disaster relief teams of military personnel, police officers, marine rescue workers, and public health officers into the devastated areas. The Thai armed forces and healthcare personnel were among the first to arrive. They assisted in search and rescue efforts and treatment of the injured. The government created a Crisis Coordination Centre in Phuket and similar Coordination Centres in city halls throughout the impacted region. These Centres provided assistance to survivors, helped repatriate foreigners, and coordinated and collected information on the missing/dead.

While Thailand’s overall relief response was strong, the tsunami disaster revealed some weaknesses. As in the other tsunami-impacted countries, Thailand failed to warn the population on the Andaman coast of the approaching tsunami. Furthermore, the concentration of the response capacity at the central level and the limited response capacity at the district level, is said to have resulted in some neglect of the needs of people in the poorer tsunami-impacted communities. Also, the Thai responses did not include strong mechanisms to ensure accountability. Clear information on private-sector donations was unavailable. Private donations not publicly accounted raised concerns that tsunami-aid was being diverted. Unregistered migrant workers impacted by the tsunami were not always able to access relief and recovery aid, since they were not entitled to official support.

Recovery responses
As relief efforts progressed toward recovery, Thailand also established a Sub-committee for the Coordination of International Assistance with three task forces focused on environmental restoration, geophysical hazard management, and livelihoods restoration. The sub-committee designated UNDP to lead environmental restoration, FAO to lead the geophysical hazard management, and UNDP and the World Bank to lead livelihood restoration.

Development
Following the tsunami disaster, Thailand took several steps to reconcile disaster management weakness in order to avoid repeating similar mistakes in the future. In May 2005, the government established the National Disaster Warning Centre. This Centre was created to detect earthquakes and assess the possibility that the earthquake might result in a tsunami and, if necessary, issue a warning through television stations, radio stations, and a SMS system to approximately 20 million mobile phones.
Thailand also installed 76 warning towers in disaster-prone areas, and was the first tsunami-impacted country to install the Deep-Ocean Assessment and Reporting of Tsunamis system in the Indian Ocean.90

Evaluations of the responses reported that if the Thai government had a national disaster management plan, some of the weaknesses exhibited during the relief and recovery efforts could have been avoided. Consequently, Thailand has created a National Disaster Management Plan. It has also ensured that planning occurs at the local levels. In December 2006, the Department for Disaster Prevention and Mitigation developed the Strategic National Action Plan for disaster risk reduction in collaboration with UNISDR. Below the national level, the Thai government assigned provincial authorities to prepare a Provincial Evacuation Plan and Drill for all 76 provinces and to practice the drills at least twice annually. These planning activities help to strengthen capacity at the local level and shift Thailand’s disaster management strategy from one focused on relief and response to one that also includes strong preventive measures. The provision of Community-Based Disaster Management training also boosts the local response capacities.

International efforts have also been made to improve Thailand’s disaster management capabilities. UNDP initiated a Development Assistance Database (DAD) to help improve accountability. Unfortunately, in the aftermath of the tsunami, the DAD system was not as effective as had been hoped. The system was not translated into Thai, failed to include government and private sector donations, and overall, did not meet expectations.76 In Phuket, the Phuket Provincial Employment Service required paid and unpaid foreign volunteer workers to acquire work permits.91

Summary
Overall, Thailand was the best prepared for the changes in functions created by the damage from the tsunami. Clearly, its health infrastructure and systems including other societal mechanisms were robust enough to address key problems promptly. In general, it met most of the challenges inflicted by the events. It also had the lowest number of injured and the injured that died. However, the tsunami struck into the heart of the country’s tourist area. Half of those injured and of those whose injuries were fatal were tourists which impacted its economy and the livelihoods of many of its people, especially the fishing industry. An extraordinary effort was directed towards disaster victim identification, especially of the expatriates. There were no epidemics or major disease outbreaks following the tsunami. Thailand did not request international assistance and internally managed its burdens quite well.

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90. Dimitrijevics A. Mainstreaming gender into disaster recovery and reconstruction. The World Bank Institute, 2007. Available at http://siteresources.worldbank.org/CMUDLP/Resources/Background.doc. Accessed 10 May 2012. (According to author’s remark on the title page of the publication…”This is a draft paper therefore it is not to be quoted without permission”)


Figure 8.1: A frame taken from an amateur video taken of the tsunami as it approached Khao Lak.

Source: http://www.asiansunamivideos.com/

Figure 8.2: Oberle treated injured victims in these two Patong Beach waterfront hotels during the tsunami. After treating a victim in the hotel on the right, Oberle walked across the brown truck wedged between the hotels to reach a victim in the hotel to the left.

Photo: Mark Oberle

Figure 8.3: The tsunami impacted six Thai provinces, Phang Nga, Phuket, Krabi, Trang and Satun. Phang Nga, Phuket and Krabi and accounted for 8146 of the 8327 lives lost.

Source: http://www.un.or.th/tsunamiinthailand/maps.html

Figure 8.4: The tsunami took a serious toll on the “H” shaped Phi Phi Don Island of Krabi Province.

Figure 8.5: Measures height of tsunami waves according to the geographic location.

Figure 8.6: Causes of death in Thailand.

Figure 8.7: Map of the tsunami-impacted provinces and the number of tsunami fatalities that occurred in each province.
Figure 8.8: Fumigators fog areas in Khao Lak with insecticide on January 4, to protect against the spread of malaria and dengue by mosquitoes.


Figure 8.9: A Thai mother holding her daughter walks in front of her tent after she lost her house in the tsunami in Takuapa district of Phang Nga Province, 6 Jan 2005. The Thai government eventually moved the families from the tents to temporary shelters built by the Thai army. Sukree Sukplang

Source: http://www.alertnet.org/thenews/photoalbum/1105621338.htm

Figure 8.10: A fishing boat perched on top of the piled remains of Ban Nam Khem, a fishing village devastated by the tsunami.

Table 8.1: Population, population densities and kilometres of coastline by state and territory in the tsunami-impacted areas.

<table>
<thead>
<tr>
<th>State/territory</th>
<th>population</th>
<th>people/km²(1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phang Nga</td>
<td>234,033</td>
<td>56.1</td>
</tr>
<tr>
<td>Krabi</td>
<td>334,410</td>
<td>71.0</td>
</tr>
<tr>
<td>Phuket</td>
<td>238,997</td>
<td>440.1</td>
</tr>
<tr>
<td>Ranong</td>
<td>160,960</td>
<td>48.8</td>
</tr>
<tr>
<td>Trang</td>
<td>593,743</td>
<td>120.7</td>
</tr>
<tr>
<td>Satun</td>
<td>247,327</td>
<td>99.8</td>
</tr>
<tr>
<td>Total</td>
<td>1,809,470</td>
<td></td>
</tr>
</tbody>
</table>

Source: (1) Thai National Statistics Organisation (10)

Table 8.2: Life expectancy in years, crude mortality rate per 1000 population, infant mortality rate per 1000 and maternal mortality rate 100,000 live births.

<table>
<thead>
<tr>
<th>Population health indicators</th>
<th>Thailand</th>
</tr>
</thead>
<tbody>
<tr>
<td>Indicator</td>
<td>Year(source)</td>
</tr>
<tr>
<td>Life expectancy</td>
<td>69.1</td>
</tr>
<tr>
<td>Crude mortality</td>
<td>8</td>
</tr>
<tr>
<td>Infant mortality</td>
<td>24</td>
</tr>
<tr>
<td>Maternal mortality</td>
<td>24</td>
</tr>
</tbody>
</table>

Sources: (1) Ministry of Public Health(11) (2) WHO(15) (3) WHO(16)

Table 8.3: Percentage of one-year-old Thai children vaccinated in 2004. (DPT = diphtheria, pertussis, tetanus)

<table>
<thead>
<tr>
<th>Vaccine</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Measles</td>
<td>96</td>
</tr>
<tr>
<td>Three doses of DPT</td>
<td>99</td>
</tr>
<tr>
<td>Three doses of HepB</td>
<td>96</td>
</tr>
<tr>
<td>BCG</td>
<td>99</td>
</tr>
<tr>
<td>Polio</td>
<td>98</td>
</tr>
</tbody>
</table>

Source: WHO-SEARO EPI fact sheet 2004(17)
Table 8.4: Communicable disease incidence rates in Thailand and tsunami-impacted states and territories.

<table>
<thead>
<tr>
<th>Disease incidence / 10 000 population</th>
<th>Thailand incidence</th>
<th>yr(source)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vector borne</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Malaria</td>
<td>3.00</td>
<td>2003(1)</td>
</tr>
<tr>
<td>Dengue</td>
<td>9.96</td>
<td>2003(1)</td>
</tr>
<tr>
<td>Scrub typhus</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Water borne</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shigellosis</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cholera</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Typhoid fever</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Leptospirosis</td>
<td>0.78</td>
<td>2003(1)</td>
</tr>
<tr>
<td>Hepatitis</td>
<td>3.68</td>
<td>2003(1)</td>
</tr>
<tr>
<td>Direct contact</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Measles</td>
<td>0.72</td>
<td>2003(1)</td>
</tr>
<tr>
<td>Tetanus</td>
<td>0.00</td>
<td>2003(1)</td>
</tr>
<tr>
<td>Pertussis</td>
<td>0.00</td>
<td>2003(1)</td>
</tr>
<tr>
<td>Diphtheria</td>
<td>0.00</td>
<td>2003(1)</td>
</tr>
<tr>
<td>Tuberculosis</td>
<td>14.2</td>
<td>2004(2)</td>
</tr>
<tr>
<td>Other</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ARI</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Diarrhea</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Enteric fever</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Viral fever</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Sources: (1) Thai Health Profile 2001-2004, Ministry of Public Health, Thailand (11) (2) World Health Organization, Tuberculosis database (19)

Table 8.5: Number of fatalities and missing due to the tsunami in impacted areas of Thailand.

<table>
<thead>
<tr>
<th>District</th>
<th>Total</th>
<th>per 1 0000</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phang Nga</td>
<td>5957</td>
<td>254.54</td>
</tr>
<tr>
<td>Krabi</td>
<td>1290</td>
<td>38.57</td>
</tr>
<tr>
<td>Phuket</td>
<td>899</td>
<td>37.61</td>
</tr>
<tr>
<td>Ranong</td>
<td>169</td>
<td>10.50</td>
</tr>
<tr>
<td>Trang</td>
<td>6</td>
<td>0.10</td>
</tr>
<tr>
<td>Satun</td>
<td>6</td>
<td>0.24</td>
</tr>
<tr>
<td>Total</td>
<td>8327</td>
<td>46.02</td>
</tr>
</tbody>
</table>

Source: Ministry of the Interior, Thailand (27)
### Table 8.6: Types of public medical care facilities available in Thailand

<table>
<thead>
<tr>
<th>Facility</th>
<th>Services and staff typically found at the facility</th>
<th>n</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bangkok hospitals</td>
<td>Of the 53 tertiary care hospitals in Bangkok, five were medical school hospitals, 29 were general hospitals, and 19 were specialized.</td>
<td>53</td>
</tr>
<tr>
<td>Regional-level hospitals</td>
<td>Of the 69 tertiary, regional-level hospitals, four were medical schools, 25 regional schools, and 40 specialized. Regional-level specialized hospitals included those specializing in maternal and child health (12), psychiatric services (1), neurological services (1), leprosy (1), communicable diseases (1), chest diseases (10), cancer control and prevention (6), drug dependence treatment (5), hearing (1), and elderly care (1).</td>
<td>69</td>
</tr>
<tr>
<td>Provincial-level hospitals</td>
<td>At the provincial level, 127 hospitals were providing tertiary care. Of the 127 provincial-level hospitals, 70 were general hospitals, and 57 were military hospitals.</td>
<td>127</td>
</tr>
<tr>
<td>10-bed hospitals in Bangkok</td>
<td>Provide secondary care in Bangkok.</td>
<td>5</td>
</tr>
<tr>
<td>District-level hospitals</td>
<td>District-level hospitals provide secondary care through 941 hospitals including 725 community hospitals, two extended hospitals, and 214 municipal hospitals.</td>
<td>941</td>
</tr>
<tr>
<td>Health centres</td>
<td>Provide primary care at the sub-district level</td>
<td>9765</td>
</tr>
<tr>
<td>Community health posts</td>
<td>Provide primary care at the village level</td>
<td>311</td>
</tr>
<tr>
<td>Community public health care centre</td>
<td>Provide primary care</td>
<td>69 331</td>
</tr>
<tr>
<td>Public health centres/branches</td>
<td>Provide primary care in Bangkok</td>
<td>61/82</td>
</tr>
</tbody>
</table>

**Sources:** World Health Organization Country Cooperation Strategy, Thailand 2008-2011(15) and Ministry of Public Health, Thailand Health Profile 2001–2004(11)

### Table 8.7: Medical care personnel and hospital beds available per 10 000 population and skilled birth attendance by skilled personnel percentage.

<table>
<thead>
<tr>
<th>Medical care indicators</th>
<th>Thailand indicator</th>
<th>yr(source)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Physicians</td>
<td>3.0</td>
<td>2004(2)</td>
</tr>
<tr>
<td>Nurses</td>
<td>15.34</td>
<td>2004(2)</td>
</tr>
<tr>
<td>Midwives</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dentists</td>
<td>1.24</td>
<td>2003(1)</td>
</tr>
<tr>
<td>Health workers</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hospital beds</td>
<td>21.32</td>
<td>2004(2)</td>
</tr>
<tr>
<td>Births attended by skilled personnel</td>
<td>98%</td>
<td>2004(2)</td>
</tr>
</tbody>
</table>

**Sources:** (1) Thailand Health Profile 2001-2004(11) (2) World Health Organization Country Cooperation Strategy, Thailand 2008-2011.(15)
Table 8.8: Nutritional status indicators for Thailand.

<table>
<thead>
<tr>
<th>Nutritional status indicator</th>
<th>Thailand</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>indicator</td>
</tr>
<tr>
<td>Stunted children &lt;5 years of age</td>
<td>11.7%</td>
</tr>
<tr>
<td>Underweight children &lt;5 years of age</td>
<td>11.5%</td>
</tr>
<tr>
<td>Wasted children &lt;5 years of age</td>
<td>3.9%</td>
</tr>
<tr>
<td>Newborns with low birth weight</td>
<td>8.9%</td>
</tr>
<tr>
<td>Pregnant women with anemia</td>
<td>12.0%</td>
</tr>
<tr>
<td>Per capita protein supply in grams per day</td>
<td>55.3</td>
</tr>
<tr>
<td>Per capita fat supply in grams per day</td>
<td>50.8</td>
</tr>
<tr>
<td>Per capita energy supply in calories per day</td>
<td>2,505</td>
</tr>
</tbody>
</table>

Sources: (1) Thai Health Profile 2001-2004, Ministry of Public Health, Thailand (2) SEARO nutritional profile
One of the lessons learnt from emergencies or disasters in the South-East Asia Region is that information and knowledge management is a weak area. The Indian Ocean tsunami of 26 December 2004 was no exception. In any emergency, no matter how difficult, information needs to be collected, stored, and retrieved systematically for analysis. This should be done before, during and after any event. By having a disciplined structure and practice around these activities, we can be more effective in turning information into knowledge and knowledge into action.

This was one of the goals of this book: the other was to take up the challenge of documenting a mega-event. This way one can review what happened on 26 December 2004 by correlating diverse information from various sources and how this impacted health. This book, in two volumes, serves as a reference textbook for the event itself as it happened in each country of study and provides a method for documenting emergencies in the larger discipline of emergency risk management in health. Populations will always live with risks and managing them better can only come with well-informed, evidence-based action, especially those that have a bearing on health. The book contributes to this practice—the information is relevant for future events and contributes to better public health practice in emergencies.