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-II
## Contents

### Part IV - Analysis

#### Chapter 9: Events and Framework
- Introduction 1
- Events 3
- Summary 4
- References 6

#### Chapter 10: Public Health
- Introduction 9
- Pre-events 11
- Damage 15
- Changes in function 20
- Relief responses 23
- Recovery responses 24
- Developments 25
- Summary 25
- References 26

#### Chapter 11: Medical Care System
- Introduction 39
- Pre-events 41
- Healthcare providers 42
- Damage 44
- Changes in functions 45
- Relief response 47
- Recovery responses 53
- Development 54
Chapter 17: Social Systems

Introduction
Pre-events
Damages
Changes in functions
Relief responses
Recovery responses
Developments
Summary
Reference

Chapter 18: Education Systems

Introduction
Pre-events
Damages
Changes in functions
Recovery responses
Developments
Summary

Chapter 19: Transportation and Logistics Systems

Introduction
Pre-events
Damage
Changes in functions
Relief responses
Recovery responses
Development
Summary

Chapter 20: Economy Systems

Introduction
Pre-events
Damage
Changes in functions
Relief responses
Recovery responses
Development
Summary
References

Chapter 21: Communications Systems

Introduction
Pre-events
Damage
### Chapter 27: Putting It Together—2

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Introduction</td>
<td>217</td>
</tr>
<tr>
<td>Functional changes in medical facilities</td>
<td>232</td>
</tr>
<tr>
<td>Role of the military</td>
<td>237</td>
</tr>
<tr>
<td>Social structures</td>
<td>238</td>
</tr>
<tr>
<td>Summary</td>
<td>240</td>
</tr>
<tr>
<td>References</td>
<td>240</td>
</tr>
</tbody>
</table>

### Chapter 28: Conclusions and Recommendations

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Introduction</td>
<td>247</td>
</tr>
<tr>
<td>Data, information, indicators, and reporting</td>
<td>247</td>
</tr>
<tr>
<td>Events</td>
<td>251</td>
</tr>
<tr>
<td>Damage</td>
<td>252</td>
</tr>
<tr>
<td>Burdens</td>
<td>254</td>
</tr>
<tr>
<td>Assessments</td>
<td>255</td>
</tr>
<tr>
<td>Evaluations of interventions/responses</td>
<td>255</td>
</tr>
<tr>
<td>Public health Systems</td>
<td>256</td>
</tr>
<tr>
<td>Medical care Systems</td>
<td>256</td>
</tr>
<tr>
<td>Mental health</td>
<td>261</td>
</tr>
<tr>
<td>Coordination and Control</td>
<td>263</td>
</tr>
<tr>
<td>Communication systems</td>
<td>264</td>
</tr>
<tr>
<td>Impact of civil conflict</td>
<td>266</td>
</tr>
<tr>
<td>Water and Sanitation Systems</td>
<td>267</td>
</tr>
<tr>
<td>Food and Nutrition Systems</td>
<td>267</td>
</tr>
<tr>
<td>Transportation and Logistics Systems</td>
<td>269</td>
</tr>
<tr>
<td>Public Works and Engineering Systems</td>
<td>269</td>
</tr>
<tr>
<td>Security Systems</td>
<td>269</td>
</tr>
<tr>
<td>Energy Supply Systems</td>
<td>269</td>
</tr>
<tr>
<td>Education Systems</td>
<td>270</td>
</tr>
<tr>
<td>Social Systems</td>
<td>271</td>
</tr>
<tr>
<td>Interventions/responses</td>
<td>272</td>
</tr>
<tr>
<td>Other Societal functional systems</td>
<td>273</td>
</tr>
<tr>
<td>Shelter and Clothing Systems</td>
<td>274</td>
</tr>
<tr>
<td>Economy Systems</td>
<td>275</td>
</tr>
<tr>
<td>Preparedness and planning</td>
<td>275</td>
</tr>
<tr>
<td>Military</td>
<td>276</td>
</tr>
<tr>
<td>References</td>
<td>277</td>
</tr>
</tbody>
</table>

### Bibliography

<table>
<thead>
<tr>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>283</td>
</tr>
</tbody>
</table>

### Appendix

<table>
<thead>
<tr>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>319</td>
</tr>
</tbody>
</table>
Part IV
Analysis

Chapter 9
Events and Framework
Introduction

On 26 December 2004, two different events originated under and in the Indian Ocean in close proximity to the southwest shores of northern Indonesia. Both of these events were related to the rupture of the Sumatra-Andaman fault, which generated the largest earthquake in the world during the last 40 years. The fault ruptured for almost 1800 km and was measured at 9.3 on the Richter scale. This primary event generated the most destructive tsunami recorded in modern history. It impacted 10 of the 11 Member States of WHO’s South-East Asia Region. The effects on five of these countries (India, Indonesia, the Maldives, Sri Lanka, and Thailand) were the most severe. These five countries are the subject of this publication.

However, the nature and the scope of each of these events on each of the five countries differed substantially. They differed by: (1) the geography of the land and ocean; (2) the population densities; (3) the culture and livelihood of the inhabitants and tourists; (4) the types and locations of the built environment; (5) the presence of civil strife; and (6) the level of preparedness, development, and available resources.

Part IV of this book contains analyses of the information provided in the Country Reports. The analysis is structured using the Basic Societal Systems provided for each of the countries. The analyses combines the information from each of the five countries in order to identify: (1) similarities and differences in their pre-event status; (2) the characteristics of the events within the country; (3) the damage that resulted from the event(s); (4) the changes in functional states that resulted from the damage; (5) the responses that were directed to relief; (6) the responses that were directed to recovery; and (7) the development that occurred (where available). The descriptions follow the phases of a disaster as was used in the country descriptions. However, they are categorized by the Basic Societal Systems, each as a different chapter.

There are many gaps that could not be filled from the information obtained during three years of extensive investigations. Part IV also discusses the actions of the World Health Organization and its Regional Office for South-East Asia (WHO-SEARO). Delineation and definition of the barriers encountered in the development of this book also are discussed.

It is noted that material derived from the country chapters is not annotated again within Part IV which is a synthesis of the information provided in Part III. Only information referenced that is not annotated in the country chapters is included in Part III. For those references not included, the reader is advised to return to the annotations in the appropriate preceding chapters.
Part IV consists of examination of the Basic Societal Systems as they apply primarily either directly or indirectly to the Public Health and Medical Care Systems. Areas of dependency and interdependency between the other Basic Societal Systems and the public health and medical care systems are explored.

It is noted that there is much information in the country chapters that has not been included in the Analyses—this material should be addressed in future analyses.

Events
The two events responsible for the ensuing damage were: the earthquake that resulted from an extensive rupture along the Sumatra-Andaman fault—it was the primary (precipitating) event; and the tsunami was a secondary event that resulted from the earthquake and its associated underwater landslides.

Earthquake
The duration of the two ruptures along the Sumatra-Andaman fault line was eight minutes. The Indo-Australian plate slid further under the Eurasian plate, which it lifted about 10 metres. The energy released has been equated to that of an explosion of 10,000 atomic bombs.1 The records of the duration and intensity of the shaking are sketchy; there were no uniform reports of the amplitude, duration, direction, and severity of the shaking. The intensity of the earthquake and its many, many aftershocks (some estimates as many as 5000 were greatest in Sumatra, Indonesia and in the Indian territories of the Andaman and Nicobar islands. The seismic waves traveled almost concurrently to each of the countries. In concordance with analyses of previous earthquakes, the energy released by the rupture along the fault line dissipated as the distance from the epicentre increased. Inhabitants in some of the countries noted minimal shaking while those in closest proximity to the epicentre (Aceh, Indonesia, and the off-shore islands of Nias and the Andaman and Nicobar Islands) felt intense shaking. In the remainder of the countries, the shaking was not sufficiently severe to cause major damage to the natural or built environments. The interval between the earthquake and the arrival of the tsunami in these areas was very short (only 15–20 minutes), and it has been difficult to differentiate the damages that were related to the earthquake from those related to the tsunami. Collapse of school buildings in the Andaman and Nicobar islands were reported before the tsunami struck the shore. There were no reports of damage due to the earthquake in any of the other countries where the shaking was rated at only II–IV using the Mercalli scale.

The earthquake changed the landscape in the northwestern provinces of Indonesia, Nias, and the Andaman and Nicobar islands. Severe subsidence occurred in many areas along the coasts. In some areas, the shoreline disappeared into the ocean while in others, coral was pushed up out of the sea. There are no reports of landmass changes from the earthquake and its aftershocks in any of the other countries studied. This is further testimony to the dissipation of the propagation of the energy of the earthquake that had not been transferred to the tsunami.

The varied assessments and record-keeping that were used in documenting and judging the scope of the earthquake rendered this analysis difficult and much important data and information were not accessible. No standard reporting terminology, methods, or scales were used, and much of the data that had been acquired had perished before the initiation of this project. It would have been valuable for this analysis to have had data on the damage and dysfunction that occurred in areas that experienced heavy shaking, but that the tsunami did not directly impact. But, such data are not available even for those areas in which the shaking was most severe and prolonged, i.e., Aceh province. In the future, characteristics of each earthquake should be recorded using standard terminology and indicators of the amplitude, duration, intensity, scale, and magnitude of the shaking and the characteristics of the earth in those areas impacted by the seismic waves. It also
would be helpful if the impacted areas were evaluated using cluster techniques. In this way, a single earthquake could be subdivided into multiple events of different scopes that could be correlated with the amount and types of damage produced (absorbing capacity). The use of these methods would be helpful in facilitating integration of the findings into preparedness efforts for future earthquakes.

**Tsunami**

The origin of the tsunami was an upward thrust of the sea floor of an estimated 5 metres that was related to the rupture of the fault. This thrust initiated a series of waves, each of which travelled at very high speed. The graph in Figure 9.1 indicates that the average speed of the first wave was about 700 km/hour. However, it took approximately the same amount of time for the initial wave to reach Thailand and Sri Lanka although the distance between the epicentre and Thailand and Sri Lanka differ by nearly 1000 km. Thus, the average velocity of the first wave toward Thailand was approximately 320 km/hour while that towards Sri Lanka was about 830 km/hour. These differences may be related to the impact of the first wave on Indonesia and the Andaman and Nicobar islands which slowed its progression towards Thailand. However, it is more likely that the differences in the sea floor and run-up to the shorelines contributed to the loss of energy and slowing of the velocity of the tsunami towards Thailand. The ocean depth is more shallow between Indonesia and Thailand than it is between Indonesia and the Nicobar and Andaman Islands. Tsunamis travel more slowly in shallow water than in the deep; the friction created between the sea floor and the wave absorbs some of the energy of the tsunami and may have contributed to the lower run-up and height of the tsunami waves in Thailand (maximum 10-11 metres compared to 30 metres in Aceh province).

Regardless of the cause, it is important to note that at least two hours elapsed from the initiation of the earthquake to the appearance of the initial wave of the tsunami in each of the countries other than Indonesia, Nias, and the Nicobar and Andaman Islands. Had warnings that a huge tsunami had occurred been sent to other countries potentially in harm’s way, and if such a message was received, recognized, passed on, and warnings and instructions issued using the media and other forms of communication, and had the populations-at-risk been able to respond appropriately, many of the subsequent injuries and deaths from the injuries in the other countries probably could have been avoided. However, a communications network for such circumstance either did not exist or was not utilized.

An important observation is that for several of the countries studied, the first wave was preceded by the withdrawal of the sea from the shore as the water was sucked up into the forthcoming tsunami wave. In fact, the occurrence of this phenomenon drew many people to the seashore instead of scaring them so that they would run in the opposite direction, and thus, placed many people in harm’s way for what was to follow.

However, the withdrawal of the sea prior to the approach of tsunami waves did not occur in the Maldives. Instead, water welled-up from the ground, from wells, and even as what appeared to be volcanic eruptions of mud were observed prior to the arrival of the tsunami—a phenomenon not previously reported regarding an impending tsunami. This most probably was related to the abrupt shoreline characteristics of the porous coral atolls that comprise the Maldives.

Tsunamis generally consist of multiple waves as was apparent for the Andaman-Sumatra tsunami.\(^1\) The numbers of waves ranged from 3–5 in Indonesia and the Andaman and Nicobar islands, 2–3 in Sri Lanka, Thailand, and India, and 1–3 in the Maldives (Table 9.1). Furthermore, the first wave to arrive not always was the largest and most destructive. Many reported that the second wave to strike was the largest, highest, and most destructive. Thus, when the first wave strikes, it should not be assumed that it will be the only

---

\(^1\) An important observation is that for several of the countries studied, the first wave was preceded by the withdrawal of the sea from the shore as the water was sucked up into the forthcoming tsunami wave.
one; furthermore, subsequent waves may be even more destructive than the first.

Reported estimates of the amount of time that elapsed between the waves varied between 3–5 minutes in Indonesia and the Andaman and Nicobar islands and 10–15 minutes (2 and 20 minutes in the Maldives) (Table 9.1). In most instances (except in the Maldives), significant withdrawal of the sea from the shore preceded each of the subsequent waves. The withdrawal reportedly was the greatest between the first and second waves, but this has been difficult to substantiate. Regardless of the magnitude of the withdrawal, retreat of the sea from the shore generally indicates that another tsunami wave will follow in relatively short order.

Wave heights reportedly ranged from 2.5 to 31 metres (8–100 ft) above sea level. The amount of potential energy stored in a wave 100 ft high is enormous. Furthermore, this enormous mass of water was moving towards the shore at an extraordinary velocity. Thus, the energy transferred to the environment when the wave approached and eventually reached the shore, was so great that only very few human-built structures could absorb it without sustaining profound damage. It moved objects of huge mass far inland. The velocity and force of a tsunami wave was modified by the nature of the sea floor, the shoreline, and other structures such as mangroves that absorbed some of the energy as it came ashore.

The water from the tsunami moved onto the land for a variable distance from the shoreline with estimates ranging from 500 metres to 5 km inland. This distance varied not only with the energy impacted on the shore, but the nature of the shoreline. Many of the atolls that comprise the Maldives were completely run over by the waves as the highest points were not equal to the height of the surge of water.

In addition, for several of the countries in the areas impacted, the population was concentrated along the shores. Thus, the energy imparted together with population densities and the poor absorbing capacities of the human-built structures combined to injure and kill so many, many people and cause the massive destruction of the environment.

Lastly, although some reports exist about the change in animal behaviours preceding the earthquake and tsunami, such reports could not be substantiated during this study.

Summary
The two events of 26 December 2004 witnessed unprecedented energy released by a natural hazard in the last century. The massive destruction caused by the earthquake of this magnitude has not been well-documented, and most of the observations have been attributed to the tsunami. The tsunami waves were multiple, travelled across the open waters of the Indian Ocean at an average velocity of 700 km/hour. However, the shallow water between the epicentre and Thailand slowed the speed to about 50% of the velocity as compared to the other countries impacted. As best can be determined, there were no warnings issued between the areas initially impacted to those that were about to be impacted.

References
Figure 9.1: Distance and time for the first tsunami wave to reach each of the five countries (average $\approx 700 \text{ km/hr}$) ($\text{km/hr} = \text{kilometres/hour}$)
### Table 9.1: Characteristics of earthquake and tsunami (h = hours)

<table>
<thead>
<tr>
<th>Indicator</th>
<th>India</th>
<th>Indonesia</th>
<th>Maldives</th>
<th>Sri Lanka</th>
<th>Thailand</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time start (h) UTC</td>
<td>0100</td>
<td>0058</td>
<td>0100</td>
<td>0100</td>
<td>0100</td>
</tr>
<tr>
<td>Distance from Epicenter (km)</td>
<td>1,900</td>
<td>100</td>
<td>2,500</td>
<td>1,600</td>
<td>600</td>
</tr>
<tr>
<td>Mercalli Scale</td>
<td>unknown</td>
<td>IX</td>
<td>IV</td>
<td>II-IV</td>
<td>II-IV</td>
</tr>
<tr>
<td>Arrival 1st wave (h/min)</td>
<td>09:35/156</td>
<td>08:14/15</td>
<td>11:15/196</td>
<td>08:55/116</td>
<td>10:05/107</td>
</tr>
<tr>
<td>Number of waves</td>
<td>≥2</td>
<td>3–5</td>
<td>1–3</td>
<td>2–3</td>
<td>3–5</td>
</tr>
<tr>
<td>Time between waves (min)</td>
<td>unknown</td>
<td>unknown</td>
<td>2–20</td>
<td>10–15</td>
<td>&gt;15</td>
</tr>
<tr>
<td>Wave Height Range (m)</td>
<td>1.5–2.5</td>
<td>5–31</td>
<td>1.6–2.0</td>
<td>2.4–7.5</td>
<td>4.0–10.6</td>
</tr>
<tr>
<td>Maximum Penetration from shore (km)</td>
<td>0.5</td>
<td>5</td>
<td>**</td>
<td>2</td>
<td>3</td>
</tr>
</tbody>
</table>

**Over-ran some islands

Source: [http://www.tsunami.htm](http://www.tsunami.htm)
Part IV
Analysis

Chapter 10
Public Health
Introduction

The Public Health Basic Societal System is responsible for the health of the society in which it functions. Some prefer to call the system “preventive” health, others call it “societal” health, and still others refer to it as “population” health. Regardless of what the system is called, its primary role is to protect the population by preventing disease and injury from developing. In general, Public Health Systems are not fully appreciated since their successful operation means that nothing bad happens to the health of the society—recognition comes only when an outbreak of a disease or injuries occurs in the population. The Public Health System plays a major role not only in the protection of the community, but in the development of preparedness measures and the ability of the public health system to respond during a crisis or an emergency. Recognition of the hazards and risks to which the population is exposed is a key element to public health activities.

Unfortunately, much of the public health information for this review consisted of data for each of the countries as a whole—very little information pertaining to public health was available for the areas directly impacted. The most complete information obtained was abstracted from documents of the World Health Organization (WHO), and the International Federation of the Red Cross and Red Crescent Societies (IFRC).1–3.

Pre-events status

Overall

Some of the overall public health indicators in 2003–2004 for the South-East Asia Region (SEAR) and each of the five countries included in this publication are listed in Table 10.1. Overall, using the indicators in Table 10.1 with the exception of India, the health status of the five countries generally was better than for the SEAR as a whole. The average life expectancies were 5–6 years longer than was the average for the South-East Asia Region. The average mortality rates were approximately half those for the region—the maternal mortality rate was only one-third of those for the region). The health status indicators in the Maldives and Sri Lanka were far better than they were for the region as a whole.

All of the health indicators for India were worse than for the other countries in this study, and, except for the maternal mortality rate, were poorer than for the SEAR as a whole. As noted in the previous chapters, generally, each of these countries had been making progress towards better health status prior to the earthquake and tsunami. This development had occurred even in Sri Lanka and Aceh, Indonesia, despite ongoing internal conflicts.

Similar health indicators for Aceh province, Nias Island, and all of Indonesia are listed in Table
10.2. For Aceh province and Nias island, life expectancies were the same as for Indonesia as a whole, but the neonatal mortality rate was 75% higher, the under-five mortality rate was 43% higher, and the maternal mortality was 62.5%–347% higher than for all of Indonesia and 50%-400% greater than for the rest of the countries except India. These differences have been attributed to the ongoing conflict within Aceh province at the time of the earthquake and tsunami. Importantly, Nias island and Aceh province were the areas hardest hit by the earthquake and tsunami.

These data indicate that the overall health status of the countries impacted (Maldives, Sri Lanka, and Thailand) was better than for the rest of the region. As an indicator of vulnerability; the pre-event health status of the population of Aceh province and India caused them to be more vulnerable than were the other countries. But, this does not reflect the overall performance of the respective healthcare systems when stressed by the events.

Causes of death
The most prominent causes of death in the five countries before the events of 26 December were communicable, maternal, perinatal, nutritional (mean = 29.2 ± 9.8%) and cardiovascular (mean = 28.0 ± 5.1%) diseases (Table 10.3). It is noteworthy that prior to the earthquake and tsunami, Sri Lanka had by far the lowest proportion of deaths due to communicable, maternal, perinatal, and nutritional diseases (13%), and the highest proportion related to cardiovascular diseases (34%)—both of these proportions are more than one standard deviation from the mean values for the five countries. On the other hand, Thailand had the lowest proportion of deaths due to cardiovascular diseases (20%). The other three countries were close to the overall averages in all of the other disease-related deaths. Some might infer that shifts from communicable diseases and perinatal, neonatal, and maternal mortality to cardiovascular diseases are a product of the development of the country.

It is of further interest that Sri Lanka had good public health indicators despite a relatively low Gross Domestic Product (GDP), while Thailand had generally good public health indicators and a relatively high GDP in comparison to other countries in the region. The indicators utilized for those areas directly impacted by the earthquake and tsunami could not be isolated from those for the countries as a whole. Although the indicators might be similar in the areas affected as compared to the national data, it may be inappropriate to extrapolate these numbers directly to the areas impacted by the tsunami.

Disease surveillance
The disease surveillance programmes and capabilities in the five countries differed substantially. Public health surveillance was robust in Thailand where, since 2000, 68 diseases were followed and reported at regular intervals. The education and training of the senior managers were accomplished through a field epidemiology training programme. By 2000, the public health programme in Thailand was staffed with epidemiologists, surveillance and rapid response teams. Private health care providers were required to participate in the surveillance system. This programme facilitated the public health surge capacity.

A relatively strong disease surveillance programme was also present in the Maldives and Sri Lanka. In Sri Lanka, there existed a long-standing surveillance and reporting system that was supported by strong legislation and staff, including 276 personnel in the health units. However, in contrast to Thailand and the Maldives, which required weekly reporting of diseases from all healthcare settings, Sri Lanka did not require reporting of morbidity from outpatient services. Furthermore, surveillance activities were not evenly distributed across Sri Lanka. This was largely due to the ongoing conflict in the northeastern part of the country, which had disrupted reporting and resulted in less staff assigned to and resident within the conflict area. It seems that the public health infrastructure was less robust in the provinces directly impacted by the tsunami than in the areas not directly impacted.
Surveillance activities were poor in both India and Indonesia. India did not require private entities to report infectious diseases. The Public Health System was plagued by fragmented efforts to collect data, and, at the time of the tsunami, India had just begun to implement an Integrated Disease Surveillance Project. However, India had a strong capacity to respond, once a disease outbreak was detected. Surveillance activities in India were very unevenly distributed and seem to have been better in the areas impacted by the tsunami than for most of the other parts of the country.

Indonesia had the least effective surveillance system of the five countries studied. Indonesia required reporting from surveillance activities only annually, and the reporting was not comprehensive. The country was pursuing a policy of decentralization; this may be one reason that the surveillance data from the districts and provinces was not easily accessible at the national level. In Aceh province, data collection was incomplete. As in Sri Lanka, ongoing conflict contributed to this poor system. In addition, surveillance activities in Aceh province were hampered because of the lack of public health regulations and incomplete planning.

**Infectious Diseases**

**Incidence**

The presence of chronic diseases may have had an impact on the survivability of the victims to the forces brought by the earthquake and tsunami. Other than for Aceh province, data were not available for those areas hardest hit by the earthquake and tsunami. The incidence (where data were available) of infectious diseases in the five countries is listed in Table 10.4; accurate data were not available for all the countries. Diseases with the highest incidences included acute respiratory infections, viral infections, and diarrhoea.

Pre-events, the highest incidence of malaria was in Indonesia, where 53.7 persons/10,000 population were infected annually. India ranked second with 17.7 new cases of malaria/10,000 population. In 2004, Thailand had only 3.0 new cases of malaria/10,000 population, and Sri Lanka had 1.9 new cases/10,000 population. While Indonesia had the highest incidence of malaria, the incidence in Aceh province was almost five times lower than was the incidence at the national level despite the ongoing conflict. However, of the five countries studied, Aceh province had the highest incidence of shigellosis and typhoid fever. This may have been related to the civil strife, although this was not evident in Sri Lanka. The Maldives had eradicated malaria, and it no longer was endemic.

**Prevalence**

Tuberculosis was a major problem in each of the countries; the highest incidence of 24.5 new cases/10,000 population occurred in Indonesia, followed by India, Sri Lanka, the Maldives, and lastly, Thailand. Resistant forms of the disease were manifest in each of the countries. It is important to note that the pre-event incidence of tetanus was low with only a few cases reported in India, Indonesia, and Sri Lanka. Thailand had an excellent surveillance system and reported no new cases of tetanus. Importantly, Aceh province reported an incidence of 0.09 cases of tetanus/10,000 population prior to the earthquake and tsunami. Data on the incidence of tetanus were not available for the Maldives. Lastly, dengue is endemic in each of the countries, and had the highest reported incidence in Thailand and Sri Lanka and the lowest incidence in Aceh province. The reasons for these differences are not clear.
of these countries for malaria, HIV/AIDS, and tuberculosis are listed in Table 10.5.

Malaria—The total number of reported cases of malaria for the five countries in 2004 was 105,635,628. The number of cases in India comprised 78.4% of the total number of cases. However, when adjusted for population, the prevalence of malaria in India (7780.7 cases/100,000 population) was slightly less than that for Indonesia (7934.1 cases/100,000 population). Whereas, 7.9% of the Indonesia population was infected with malaria, 7.7% of the population was infected in India. The Maldives had eradicated malaria and Sri Lanka had the lowest prevalence of malaria of the remaining four countries (1727.1 cases/100,000 population; 3.6% of its population).

HIV/AIDS—Not surprising, the number of documented cases of HIV/AIDS in India (3,870,000) was nearly six times greater than in any of the other countries. However, due to its huge population relative to the other countries, it had a burden (prevalence) of 363.4 cases/100,000 population, one-third the prevalence of HIV/AIDS in Thailand. The proportion of the population infected with HIV/AIDS in Thailand was 2.5 times greater than in any of the other countries.

Tuberculosis—The prevalence of infection with the tuberculosis bacteria was greatest in India with 300 persons infected/100,000 population. This was followed closely by Indonesia with 280 cases/100,000 population.

Vaccination status
The pre-events immunization status of children in each of the five countries is listed in Table 10.6. Overall coverage was excellent in the Maldives, Sri Lanka, and Thailand; coverage was poorest in India and Indonesia. Of special note is the relatively low BCG coverage of children in these two countries that also report the highest incidence and prevalence of tuberculosis. Also of significance is that one-third of the one-year-old children in India and Indonesia were not covered with DPT immunizations. Furthermore, DPT coverage in Aceh province was the second lowest in Indonesia and was half that of the levels of DPT immunization status in any of the five countries.

While the level of preventive health infrastructure and population health in each country before the tsunami was unique, it is essential that some of the information provided in the above discussion be viewed with caution. Prior to the events, there were no standard recording or reporting mechanisms for public/population health indicators. Thus, it is not clear that all of the indicators reported herein accurately reflect the true health status. Further, the picture provided for the countries as a whole may not reflect the status of the coastline areas actually impacted by the tsunami. Thus, it is recognized that the inter-country comparisons might not be appropriate because of the unique situation in each of the affected countries.

Mental health
Although it may not be the best indicator of available psychosocial support, the existence of psychosocial support before the events was meagre in each of the countries except Thailand. This is reflected in the number of psychiatrists available in the respective countries (Table 10.7). However, the number of psychiatrists may not be the best indicator of the mental health and psychosocial support before the occurrence of the event. For example, the number of psychiatrists available per 10,000 population of the Maldives (0.067) is deceiving, as, at the time of the tsunami, there were only two psychiatrists in the country, both practicing in the national hospital in Malé. Thailand had some 400 psychiatrists on 26 December 2004. From all available indications, Thailand’s psychosocial support programme was well developed and it was coordinated by the Department of Mental Health. The programme consisted of thousands of trained personnel working at the community level.

Another indicator of mental health services is the number of suicides (Table 10.7). The
overall suicide rate for the world is 16/100,000 population.5 The reported suicide rates before the earthquake and tsunami were highest in Sri Lanka.6 Thailand and India had the lowest overall rates, but much has been published about the extraordinary suicide rates of the young in India, especially in the South. Rates in the early adult group in 2002 were reported as high as 148/100,000 for women and 38/100,000 for young adult men.7 Where the data were available, in general, the suicide rates were higher in males than in females.

Other than in Thailand, the professional mental health services available were quite sparse, especially in the rural areas. Although Indonesia had mental health treatment and substance abuse policies in place, they were difficult to implement—1% of the national budget was directed to mental health services, and there was no specific legislation dealing with mental disease. In Aceh province, there was one psychiatric hospital staffed with three psychiatrists, three psychologists, and 252 paramedics. Some patients who could be discharged refused to return to their homes because of fear for their lives due to the ongoing civil conflict. The hospital was overcrowded and difficult to access. The psychosocial support that was available was provided at the provincial hospital—virtually no services were available at the community level.

In Sri Lanka, professional psychosocial services were also sparse, especially in the rural areas. Ninety percent of the services that were available were located in the capital city of Colombo. Psychotropic agents were available only by prescription that had to be obtained directly from the hospital. The three psychiatric hospitals were overcrowded; local NGOs provided some mental health support.

Similarly, access to psychosocial services was difficult in the Maldives prior to the tsunami. The problems not only were that there were only two psychiatrists (both located in Malé), but logistics made the availability of services impossible for some. There was no legislation dealing with mental diseases except for the confinement of those persons deemed dangerous to society. In addition, there were no policies for the use/distribution of psychotropic agents.

Thus, overall, the region was devoid of services to cope with the psychosocial disabilities and problems that would become associated with the horrific visions of the deaths of family members and friends, the massive destruction of their homes and all of their worldly possessions, and the loss of livelihoods that followed the earthquake and tsunami of 26 December.

Generally speaking, population health indicators and the preventive health infrastructure were particularly strong in Thailand and Sri Lanka, and weakest in India. In Sri Lanka, communicable diseases, reproductive health, and nutritional health deficiencies were responsible for just 13% of all deaths compared to 29% to 38% of all deaths in Thailand, the Maldives, India, and Indonesia.8 But, it is not enough to understand national population health and preventive health statistics, since there were great variations within each country and impacted regions sometimes sharply contrasted with national averages.

Although India’s overall pre-event population health indicators and preventive health infrastructure were weak, the tsunami impacted a region of India where population health indicators and preventive health infrastructure were among the country’s strongest. In contrast, Sri Lanka’s national population health indicators and pre-event preventive health indicators were quite strong, but the tsunami impacted a region of the country in which population health and the preventive health infrastructure were weakest. In Indonesia, the tsunami also struck a region in which the population health and preventive health infrastructure were among the country’s weakest. In regions where preventive health infrastructure was weak, pre-event surveillance and vaccination rates were also often poor.

**Damage**

The damage resulting from the earthquake and tsunami is presented as the number of persons
injured and the types and severity of injuries, the number and causes of deaths, the number of internally displaced persons (IDPs), and the damage to public health facilities and personnel. The damage to the population is described for the entire region followed by comparisons of the damage sustained by each of the five countries.

For the five countries combined, there was a reported total of 422,750 persons injured by the events of 26 December. Of these, 53.2% succumbed to their injuries (46.8% survived) (Table 10.8). The crude mortality rate (CMR) for the five countries increased 270-fold during the first three days following the events. Thus, for the five countries, the overall ratio of the number of injured survivors to the number of injured that died was 0.88. Overall, there were 1,534 injured survivors/10,000 population. This translates to a medical care burden of 1,534 plus those who immediately survived their injury but subsequently succumbed. It has not been possible to find support for these numbers. The dead should not have been burdens on the Medical Care System.

Dead and missing
Care must be exercised in interpretation of the numbers of dead and injured as the information reported was not always consistent. For example, some of those counted as missing also may have been counted as dead. Further, calculations based on total populations may not provide the best picture; in Indonesia, most of the population in areas impacted by the tsunami was concentrated along the shore and only a relatively small portion of Indonesia, (in particular Aceh province in Sumatra) experienced the severe and prolonged shaking associated with the earthquake. The same is true for the other countries, as the populations affected lined the coasts, and thus, the burden of death is likely to be much greater in those specific areas than are reflected by calculations using the total populations for the respective countries. However, the burdens are astounding even when calculated using total populations.

Of the total number of injured in the five countries, 224,983 persons lost their lives secondary to the earthquake and tsunami (Table 10.8). It is estimated that almost all of these deaths occurred on the day of the earthquake and tsunami and that 99% occurred within three days of the events. By far the greatest loss of life (74.5% of the total deaths) occurred in Indonesia. However, it is not clear how many of the deaths can be attributed directly to either the earthquake or tsunami.

Of the total number of lives lost, Sri Lanka ranked second with 36,603 deaths (16.3% of the total number of deaths recorded). However, of all of the countries studied, Sri Lanka reported the highest crude mortality rate of 6.32 deaths/10,000 population/day (almost three times the CMR of Indonesia). Few, if any of the deaths that occurred in Sri Lanka can be attributed to the earthquake as the shaking in Sri Lanka were barely perceptible. Therefore, the deaths in Sri Lanka are attributed to the tsunami. Sri Lanka experienced the greatest loss of life relative to its total population (0.18% of its total population compared to 0.07% of the Indonesian population). Thus, Sri Lanka had to cope with the highest burden of deaths due to the tsunami.

The implications of such burdens become clearer when considering the number of deaths encountered in the Aceh province of Indonesia and the Andaman and Nicobar Islands of India. Both of these areas were impacted by severe shaking, subsidence, uplifting, and other effects of the earthquake in addition to experiencing the greatest forces associated with the tsunami. Unfortunately, for both of these areas, it is not possible to separate the number of deaths related to the earthquake from those related to the tsunami. The number of deaths in Aceh province accounted for 73.2% of the 167,540 deaths reported for all of Indonesia and 54.6% of the total number of deaths for the five countries. The burden of deaths in the province, as reflected by the number of deaths/10,000 population was 314.7 deaths/10,000 population (Table 10.9)! This was more than 200 times that of the five
countries and nearly 50 times greater than that for all of Indonesia. The number of deaths in Aceh province accounted for more than 85% of the total deaths sustained by all of Indonesia. Similarly, although the 3513 deaths reported for the Andaman and Nicobar islands of India represented only 28.3% of the total number of deaths reported for India; the burden for these islands was 98.7 deaths/10,000 population. Recall that these islands are more than 1000 km from the India mainland, and, like Aceh province, experienced severe shaking related to the earthquake as well as the brunt of the tsunami.

It was not possible to obtain accurate population densities for all of the areas impacted by the earthquake and tsunami. However, it is known that the populations in the coastal areas were most severely impacted. Attempts to correlate the number of deaths with country population densities were not fruitful. Comparison of the population densities of coastal provinces yielded some information of the relationship between the population density and the number of persons killed. For example, Banda Aceh had the highest population density of the areas of Indonesia affected by the events. However, the greatest number of dead and missing did not occur in Banda Aceh, but rather in Aceh Besar (Figure 10.1). Therefore, the number of persons killed did not relate entirely to the population density of the areas impacted. The same was true for the coastal provinces in India and Sri Lanka.

The major causes of death were drowning, blunt injuries from impact by debris, and being crushed against or under objects. Descriptive statistics delineating the distribution of these causes could not be found. It is known that most of the deaths occurred immediately, but it could not be determined how many of the deaths occurred among the injured who were alive when they reached a medical facility as compared to the injured who never reached a medical facility. For the most part, autopsies were delayed and decomposition of the remains prevented determining the exact causes of death. Furthermore, many of the victims were buried in mass graves, which that prevented identification of the exact causes of death (drowning, multiple injuries, crush, etc.).

Of substantial significance are the profound differences in the proportions of injured persons who succumbed to their injuries. In each of the countries except the Maldives, the ratio of dead to the total number of injured was 50% or greater (Table 10.8). Despite the huge limitations created by its geography, only 12% of those injured in the Maldives succumbed to their injuries (Table 10.8). This profound difference could have been related to better pre-hospital care and life-supporting first aid education and training of the lay public or could have been related to differences in the nature of the tsunami in this area. Further, this occurred despite the injured imposing a huge burden of 88.1/10,000 population on the Maldives compared to the other countries (Table 10.8). There were no differences in preparation of the lay public or in pre-hospital care. However, the Maldives did have the highest density of physicians and nurses of any of the countries studied. No evidence has been found relative to the enhanced life-supporting care provided by medical personnel. It seems cogent that the nature of the event in the Maldives was very different from that in the other countries. The waves that arrived at the Maldives were much lower than in the other countries and hence, the forces were much less. No data were uncovered that compared the nature of the injuries sustained in the Maldives to the other countries.

Of further note is that the proportion of the injured that died in Aceh province (44.1%) was lower than that for Indonesia as a whole, or for the other countries except for the Maldives (Table 10.9). The reasons for this are not clear. It may have been related to the presence of military resources or to the more rapid influx of outside assistance.

Lastly, almost three-quarters (71.9%) of the injured in the Indian state of Tamil Nadu succumbed to their injuries. This
occurred despite the relatively rapid influx of reinforcements into Tamil Nadu from neighbouring Indian states, and the fact that the hospitals dispatched medical personnel into the field to perform triage, and the remarkably low burden of injured/10 000 population (0.448). The reasons for these observations are not clear. Perhaps the surge of the number of injured was greater in Tamil Nadu than elsewhere.

The injured survivors
As with quantifying the numbers of dead and missing, care must be exercised in interpreting the data regarding the numbers and types of injuries caused by the earthquake and tsunami (Figure 10.2). Some of the countries only reported persons with injuries who sought medical care at hospitals and did not include those who presented to hospitals as outpatients, to clinics, to health centres, and/or to private offices. Therefore, it must be assumed that the numbers reported, at best, are quite conservative. On the other hand, due to the confusion created by multiple responding agencies working in the same areas, some of the injured may have been reported more than once. Furthermore, it can be assumed that some of the victims who sought care were not accounted for during the surge and that the demands for medical care following the earthquake and tsunami were greater than are reflected by the data. No standardized reporting systems and sets of indicators were used, and the diagnoses and treatments of similar conditions may have been labeled differently. Thus, the data and information presented only are estimates.

Overall, of the total of 422,750 people injured in the five countries, 197,767 persons (46.8%) were reported to have survived their injuries (Table 10.8). This equates to approximately 88 injured survivors/100 deaths. However, the relationship between the numbers of injured who survived and the numbers of dead was not consistent between the five countries. A major outlier was noted in the Maldives where 7.4 persons survived their injuries for each life lost. Recall that the tsunami that inundated the Maldives was distinctly less powerful than that which impacted the other countries. However, the burden of injured survivors for the Maldives was 26.3 injured survivors/10 000 population; the numbers of injured survivors that presented for health care created a huge relative burden on the healthcare facilities of the Maldives, which also faced additional obstacles due to its unusual geography.

Overall, the burden of injured survivors was the greatest in the Maldives where there were 23.3 injured survivors/10 000 population; the burdens on the Maldives and Sri Lanka were greater than that for Indonesia (6.54/10 000 population) and Thailand (1.30/10 000 population) Table 10.8). Given its extraordinarily large population, the burden of the injured for India (0.07/10 000 population) was far less than that of any of the other countries.

Of great interest is the huge burden created by the numbers of injured survivors in Aceh province and in the Andaman and Nicobar Islands, where the impact of the earthquake and the tsunami was most intense (Table 10.9, Figure 10.3). Given the destruction of Aceh, the number of injured survivors per 10,000 of population of Aceh province was profound (405.8/10 000 population, or 3.9% of its population survived their injuries). But, surprisingly, 56% of those injured in Aceh, survived. This same burden sustained by the population of the Andaman and Nicobar Islands was 40.1 persons injured/10 000 population. Furthermore, the Andaman and Nicobar Islands had the smallest proportion of the total numbers of injured who survived their injuries. This could be related to the severity of the injuries and/or to the inability to access medical care for their injuries, and/or the combination of the earthquake and tsunami. The former two possibilities were also true for the areas of the Indian mainland impacted, as well as for Sri Lanka.

Injuries
Living beings do not have a robust absorbing capacity for physical forces that impact their body. Hence, the humans impacted by the forces of
the earthquake and tsunami were extremely vulnerable to the forces involved. Indeed, almost all of those who lost their lives succumbed to their injuries without receiving any medical care.

The injuries described are those that occurred immediately or shortly following the events. The complications associated with the injuries are described later. The mechanisms responsible for the immediate injuries seem fairly clear regardless of the country, except perhaps, for Aceh and the Andaman and Nicobar islands, where some of the injuries may have been caused by the collapse of structures due to the earthquake. However, no data have been found to document the types and numbers of injuries that were caused by the earthquake. It is not likely that other areas impacted by the tsunami sustained earthquake damage sufficient to generate a substantial number of injured. There is no reason to believe that the mechanisms of injury and deaths associated with this earthquake would be different from those produced by other major earthquakes. Even though the most intense damage from the earthquake was sustained in Aceh province and the Andaman and Nicobar islands, it is not possible to separate the injuries due to the two events in these areas. Currently, the number of persons killed or non-fatally injured as a result of the earthquake alone could not be determined.

It is known that of the 958 victims evaluated in a hospital in Phuket, 328 (34.2%) were admitted to the hospital. Thailand reported 419 cases of diarrhoea, 287 with viral fever, and a five-fold increase of acute respiratory infections in Phuket during the week following the tsunami.

Little descriptive data could be found that categorized the types of injuries encountered. The reasons for this are not clear, but could be related to poor record-keeping, diverse sets of indicators, poor accessibility to the records, or failure to seek such records. This lack of data/information impairs the ability to project the types of injuries to anticipate with the next tsunami. In addition, it has not been possible to access the findings of the autopsies conducted on the victims or to access the forensic reports from the autopsies performed. By the time most of the autopsies were conducted, it was not possible to identify the causes of death and the examinations were done primarily for the purposes of identification of the deceased.9

The data captured in the foregoing chapters of descriptions of each country do give some clues that may be useful in preparing for the next tsunami. The principal causes of injuries (both fatal and non-fatal) associated with the tsunami were related to being transported by the water (often smashing into stationary objects), being submerged in the water, or being impacted by the debris in the water. Additionally, some of the injuries were acquired during the clean-up after the water had withdrawn into the sea. Major causes of injuries that were not immediately fatal, were related to inhalation of filthy, contaminated sea water and near-drowning, crush injuries as a result of being pinned by massive elements of debris or collapsed structures, and/or blunt and/or penetrating injuries created by being struck by or colliding with fixed structures or floating debris. Reports from hospitals in Banda Aceh, a Galle hospital in Sri Lanka, and from the Maldives on victims who presented to the hospitals within hours or days of the events, infer that the major injuries in survivors able to reach a hospital consisted of airway and pulmonary injuries from aspiration of heavily contaminated sea water (near drowning), multiple traumatic injuries, fractures, and lacerations (many deep and contaminated). In the data that were accessed, pulmonary injuries were present in 30%–40% of the immediate survivors (Table 10.10). From the data available, between 11% and 38% of those injured who presented to the medical facilities suffered extremity fractures and other musculoskeletal injuries. Skin injuries (lacerations of the skin and underlying tissues) were present in 12%–21% of the injured survivors who sought assistance. Surprisingly, the data from Banda Aceh indicate that about 11% of the victims sustained crush injuries, while the reports from the Galle hospital reported that only 2% of the victims who
The Public Health infrastructure in the Maldives was not damaged, the places of residence and work were flattened or rendered uninhabitable.

The Public Health infrastructure in the Maldives was not damaged, the places of residence and work were flattened or rendered uninhabitable.

The Public Health infrastructure in the Maldives was not damaged, the places of residence and work were flattened or rendered uninhabitable.

The Public Health infrastructure in the Maldives was not damaged, the places of residence and work were flattened or rendered uninhabitable.

The Public Health infrastructure in the Maldives was not damaged, the places of residence and work were flattened or rendered uninhabitable.

The Public Health infrastructure in the Maldives was not damaged, the places of residence and work were flattened or rendered uninhabitable.

The Public Health infrastructure in the Maldives was not damaged, the places of residence and work were flattened or rendered uninhabitable.

The Public Health infrastructure in the Maldives was not damaged, the places of residence and work were flattened or rendered uninhabitable.

The Public Health infrastructure in the Maldives was not damaged, the places of residence and work were flattened or rendered uninhabitable.

The Public Health infrastructure in the Maldives was not damaged, the places of residence and work were flattened or rendered uninhabitable.

The Public Health infrastructure in the Maldives was not damaged, the places of residence and work were flattened or rendered uninhabitable.

The Public Health infrastructure in the Maldives was not damaged, the places of residence and work were flattened or rendered uninhabitable.

The Public Health infrastructure in the Maldives was not damaged, the places of residence and work were flattened or rendered uninhabitable.

The Public Health infrastructure in the Maldives was not damaged, the places of residence and work were flattened or rendered uninhabitable.

The Public Health infrastructure in the Maldives was not damaged, the places of residence and work were flattened or rendered uninhabitable.

The Public Health infrastructure in the Maldives was not damaged, the places of residence and work were flattened or rendered uninhabitable.

The Public Health infrastructure in the Maldives was not damaged, the places of residence and work were flattened or rendered uninhabitable.

The Public Health infrastructure in the Maldives was not damaged, the places of residence and work were flattened or rendered uninhabitable.

The Public Health infrastructure in the Maldives was not damaged, the places of residence and work were flattened or rendered uninhabitable.

The Public Health infrastructure in the Maldives was not damaged, the places of residence and work were flattened or rendered uninhabitable.

The Public Health infrastructure in the Maldives was not damaged, the places of residence and work were flattened or rendered uninhabitable.

The Public Health infrastructure in the Maldives was not damaged, the places of residence and work were flattened or rendered uninhabitable.

The Public Health infrastructure in the Maldives was not damaged, the places of residence and work were flattened or rendered uninhabitable.

The Public Health infrastructure in the Maldives was not damaged, the places of residence and work were flattened or rendered uninhabitable.

The Public Health infrastructure in the Maldives was not damaged, the places of residence and work were flattened or rendered uninhabitable.

The Public Health infrastructure in the Maldives was not damaged, the places of residence and work were flattened or rendered uninhabitable.

The Public Health infrastructure in the Maldives was not damaged, the places of residence and work were flattened or rendered uninhabitable.

The Public Health infrastructure in the Maldives was not damaged, the places of residence and work were flattened or rendered uninhabitable.

The Public Health infrastructure in the Maldives was not damaged, the places of residence and work were flattened or rendered uninhabitable.

The Public Health infrastructure in the Maldives was not damaged, the places of residence and work were flattened or rendered uninhabitable.

The Public Health infrastructure in the Maldives was not damaged, the places of residence and work were flattened or rendered uninhabitable.

The Public Health infrastructure in the Maldives was not damaged, the places of residence and work were flattened or rendered uninhabitable.

The Public Health infrastructure in the Maldives was not damaged, the places of residence and work were flattened or rendered uninhabitable.

The Public Health infrastructure in the Maldives was not damaged, the places of residence and work were flattened or rendered uninhabitable.

The Public Health infrastructure in the Maldives was not damaged, the places of residence and work were flattened or rendered uninhabitable.

The Public Health infrastructure in the Maldives was not damaged, the places of residence and work were flattened or rendered uninhabitable.

The Public Health infrastructure in the Maldives was not damaged, the places of residence and work were flattened or rendered uninhabitable.

The Public Health infrastructure in the Maldives was not damaged, the places of residence and work were flattened or rendered uninhabitable.

The Public Health infrastructure in the Maldives was not damaged, the places of residence and work were flattened or rendered uninhabitable.

The Public Health infrastructure in the Maldives was not damaged, the places of residence and work were flattened or rendered uninhabitable.

The Public Health infrastructure in the Maldives was not damaged, the places of residence and work were flattened or rendered uninhabitable.

The Public Health infrastructure in the Maldives was not damaged, the places of residence and work were flattened or rendered uninhabitable.

The Public Health infrastructure in the Maldives was not damaged, the places of residence and work were flattened or rendered uninhabitable.

The Public Health infrastructure in the Maldives was not damaged, the places of residence and work were flattened or rendered uninhabitable.

The Public Health infrastructure in the Maldives was not damaged, the places of residence and work were flattened or rendered uninhabitable.

The Public Health infrastructure in the Maldives was not damaged, the places of residence and work were flattened or rendered uninhabitable.

The Public Health infrastructure in the Maldives was not damaged, the places of residence and work were flattened or rendered uninhabitable.

The Public Health infrastructure in the Maldives was not damaged, the places of residence and work were flattened or rendered uninhabitable.

The Public Health infrastructure in the Maldives was not damaged, the places of residence and work were flattened or rendered uninhabitable.

The Public Health infrastructure in the Maldives was not damaged, the places of residence and work were flattened or rendered uninhabitable.

The Public Health infrastructure in the Maldives was not damaged, the places of residence and work were flattened or rendered uninhabitable.

The Public Health infrastructure in the Maldives was not damaged, the places of residence and work were flattened or rendered uninhabitable.

The Public Health infrastructure in the Maldives was not damaged, the places of residence and work were flattened or rendered uninhabitable.

The Public Health infrastructure in the Maldives was not damaged, the places of residence and work were flattened or rendered uninhabitable.

The Public Health infrastructure in the Maldives was not damaged, the places of residence and work were flattened or rendered uninhabitable.

The Public Health infrastructure in the Maldives was not damaged, the places of residence and work were flattened or rendered uninhabitable.

The Public Health infrastructure in the Maldives was not damaged, the places of residence and work were flattened or rendered uninhabitable.

The Public Health infrastructure in the Maldives was not damaged, the places of residence and work were flattened or rendered uninhabitable.

The Public Health infrastructure in the Maldives was not damaged, the places of residence and work were flattened or rendered uninhabitable.

The Public Health infrastructure in the Maldives was not damaged, the places of residence and work were flattened or rendered uninhabitable.

The Public Health infrastructure in the Maldives was not damaged, the places of residence and work were flattened or rendered uninhabitable.

The Public Health infrastructure in the Maldives was not damaged, the places of residence and work were flattened or rendered uninhabitabilit
arrangements, storage of the remains until appropriate burials and/or autopsies can be arranged, transportation of the remains, and the financial, opportunity, and emotional costs associated with each of these components. However, it also includes the anxiety fueled by the media of the dangers that dead bodies will spread disease, the stench of rotting flesh, and the psychosocial effects of the deaths (losses) on the families and on the affected population. These latter effects are discussed in detail in Chapter 17. Suffice it to say that the psycho-social burden was immense for each of the countries.

The burdens created by the number of dead could not be met in any of the countries by their traditional means of managing the dead. The surge created by the burden resulted in a need to manage a massive numbers of bodies. This included the collection, storage, identification of the corpses, as well as notification of the families, arrangements for burial, legal issues of ownership and payments of obligations (insurance, etc.), loss of livelihood and its economic consequences, provision of psychological and social support, restructuring of the family units, and last but not least, the compromise of vital societal services that could not be provided due to the loss of personnel. The normal ability to provide these functions at a local level was overwhelmed in each of these countries and required outside assistance (Chapter 17, Social Structures).

Special note must be taken of the burdens created by the tourists who were injured/killed in the Maldives and Thailand. Of the total number of persons killed in Thailand (8327), a total of 2400 were tourists and approximately 2392 were injured survivors. For Thailand, this represented a huge burden as a substantial proportion of its economy was tourist based. The challenge was to repatriate as many of the injured survivors as possible and to exert substantial efforts in identifying the remains using forensic methods. Thus, forensic pathologists were recruited from outside Thailand to assist with this effort. The absolute number of tourists in the Maldives who succumbed was not found.

**The surge of injured survivors**

The burdens created by the number of injured survivors per unit of population are reflected in the surge of patients who presented or were presented to the medical facilities. These numbers of injured in excess of the numbers generally managed by the medical facilities in normal times tested the surge capacity of the institutions impacted. In each of the areas directly impacted by the tsunami and earthquake, the surge exceeded the capacity of local systems to manage the burden (see Chapter 11: Medical Care System). Given the resources and organization of the healthcare systems in India and Thailand, the needs created by the surge were managed more easily with the relatively large amount of resources that could be brought to bear within these countries. But, what resources were available to meet the profound needs in Aceh, the Andaman and Nicobar islands, and the Maldives? An additional consideration was the need for referral services for many patients who could not be managed locally due to the problems imposed by disruption of the physical infrastructure, e.g., hospitals, roads, and communication.

**Displaced populations**

As noted, the destruction/damage to places of residence and employment including fishing boats and processing facilities as well as the fear that another event was imminent resulted in survivors fleeing from the areas impacted by the events of 26 December 2004 (Table 10.11). The displaced populations placed an additional burden on the public health capabilities and capacities of each of the countries. From available information, more than 2 million accounted IDPs went to camps, shelters, and other public buildings, or to the residences of family or friends. The exact number of IDPs cannot be defined as the number who moved in with family or friends could not be accounted. Initially, a large proportion of the IDPs migrated into camps either already operational or spontaneously formed camps — 850 000–900 000 IDPs in 750 camps in Sri Lanka. The greatest immediate burden was experienced in Sri Lanka where 4663 persons were displaced.
from their homes/10 000 population—4.7% of the population of Sri Lanka. The Sri Lankan government had to support approximately 900 000 persons displaced, of which 94.4% initially were gathered in camps. On 26 January, 417 124 IDPs were resident in 66 camps in Indonesia. Only four camps were opened to shelter the nearly 30 000 IDPs in the Maldives.

As indicated in Table 10.11, more than 90% of the IDPs in India went into camps. India ranked second to Sri Lanka in the total number of persons (637 119) displaced from their homes, which actually was only 0.06% of its total population. Initially, there were 572 378 IDPs in India in 644 rapidly organized camps.

Approximately 450 000 persons were displaced in Indonesia of which 400 000 were from Aceh province (89%). Maldivians experienced a burden of 986 displaced persons/10 000 of its population (almost 10%) of its population. Similarly, 10% of the population in Aceh province was displaced. Other than in Thailand, with only 6000 IDPs following the tsunami, the displaced populations placed an extraordinary burden on the resources of the affected countries. It is not known how many persons fled to the undamaged homes of their families or friends. Thus, the above numbers are quite conservative. The migrants imposed a burden, and this group generally did not get the benefits of relief measures. These migrants also increased the risks for the development and spread of infectious diseases in their supposedly temporary places of residence. Given the previously identified public health capacities of each of the countries, the challenges posed were enormous. The Public Health System had to oversee the provision of essential supplies and shelter, which are summarized in the chapters that follow. Of substantial importance was the need for surveillance for infectious disease outbreaks.

The reasons for and the locations to which victims migrated are described in the discussions of the Shelter and Clothing System (Chapter 13).

However, it is important to note here that many of the displaced persons initially congregated in makeshift camps. Thus, they were tightly packed into relatively small areas in which sanitation and the availability of potable water and food were quite limited. Consequently, there was a high likelihood that outbreaks or even epidemics of infectious diseases could easily have been propagated.

Mental health

The emotional trauma associated with the earthquake and tsunami was immense. Furthermore, traditional support structures, such as religion and traditions were severely compromised due to loss of support personnel and a disbelief that this could happen to them. (see Chapter 17—Social Systems).

At a time when the social structures operating within the community should have provided support, little, if any, was available. Some felt that the events were punishment for previous immoral behaviours. People experienced grief for their losses and often, guilt for their survival. The generally meagre support systems available pre-event, collapsed. Although many religious buildings survived the onslaught of nature, many of the trappings of the religions were swept away. Religious institutions lost leaders and the trappings within the mosques. Thus, the survivors also lost the emotional support usually available from their respective religions. For many, there were no explanations and they had nowhere to turn for help. Most became displaced from their homes and wound up in camps with poor living conditions and with persons they had not known. The emotional suffering was overwhelming. Hope was all that many had left, but most felt a sense of hopelessness.

Other

It is important to note that vaccine supplies were interrupted by disruption of the cold chain due to loss of electrical power and the inundation by sea water of many of the storage and supply facilities. This resulted in the transient interruption of ongoing immunization programmes. Similar
interruptions were encountered in the delivery of drugs for treatment of chronic diseases, such as tuberculosis, diabetes, heart failure, asthma, hypertension, coronary artery disease, HIV/AIDS, etc. In addition, the loss of transportation capabilities impaired the delivery of vaccines, essential medications, and health personnel.

**Relief responses**

As outlined in the pre-events health status section, many infectious diseases were endemic or occurred as local outbreaks in the region prior to the earthquake and tsunami. Thus, there was concern regarding the potential for development of outbreaks or even, epidemics, following the tsunami. This concern was fueled further by the fact that immunization rates were low in some of the countries, particularly in India and Indonesia (Table 10.6). There was the augmented potential for outbreaks of measles, DPT, hepatitis, and tuberculosis, particularly in areas in which the respective pre-event immunization rates were low. The potential for outbreaks of measles, tetanus, and pertussis was exceptionally great in Banda Aceh, in which only one-third of the children had received the full 3-doses for tetanus and pertussis, and only 31% had been immunized against measles. In addition, following the tsunami, conditions seemed ripe for the development of outbreaks or even epidemics of cholera, even though cholera was not a public health problem in any of the countries before the tsunami. However, non-cholera diarrhoea was common in each of the countries, and, given the conditions in the areas most severely impacted, the increase in the incidence of diarrhoea was anticipated during the post-tsunami period.

Thus, it seemed essential that rigorous surveillance efforts would be necessary to detect and respond to any outbreaks of infectious diseases and/or tetanus. However, only Thailand and, to some extent, the Maldives had rigorous, operational surveillance programmes for the anticipated outbreaks at the time of the tsunami. Sri Lanka had a good surveillance system, but seemingly did not have the expertise to adequately deal with the information generated. Furthermore, Sri Lanka was collecting data only from in-patient facilities. India professed good surveillance capabilities and did not request any outside assistance. However, surveillance activities were augmented in each of the countries, except Thailand, by United Nations agencies (WHO, UNICEF) and, possibly by some NGOs through the provision of supplemental personnel including epidemiologists, supplies, equipment, and information processing.

The diseases for which surveillance activities were mounted differed by country (Table 10.12). Surveillance activities for dengue, measles, and acute respiratory infections were in place or augmented in each of the countries impacted. India, Indonesia, and the Maldives experienced minor outbreaks of measles, especially in the IDP camps. A possible isolated outbreak of cholera occurred in Indonesia, but this could not be verified. Limited outbreaks of mumps occurred in the Maldives and in Sri Lanka. An unexpected rash of cases of tetanus occurred in Indonesia, where at least 106 cases were detected with a reported mortality rate of 18.9%. Of significance, only 65% of the children in Indonesia had received the full three doses of DPT vaccine prior to the tsunami, and only 31% of the population in Aceh province had been fully immunized against tetanus. No increase in the number of cases of tetanus was reported in any of the other countries, including India, in which only 64% of the children had received DPT. However, the immunization rates in those areas of India impacted by the tsunami could not be assessed.

Several other preventive measures were implemented to increase the absorbing and buffering capacities of the affected populations: India, Indonesia, and Thailand implemented measles vaccination programmes. The measles vaccination programme in the affected areas of India increased immunization coverage in the camps to nearly 100%. Despite its pre-event 96% coverage, Thailand initiated a vaccination programme for measles immunization. Indonesia implemented a measles vaccination campaign that was supplemented by personnel, equipment,
and supplies from the Ministry of Health, WHO, UNICEF, and the American Red Cross, and was able to achieve immunization coverage for 93% of the population in the affected areas. However, it was reported that the distribution of the vaccination programme was uneven across the country. An immunization campaign against cholera was implemented in Indonesia against the advice of WHO. This effort was not necessary and was a high-cost, low-impact intervention. Sri Lanka had achieved very high immunization coverage before the tsunami struck. Consequently, it did not request outside assistance with an immunization programme. Of the supplies of vaccine sent to Sri Lanka, at least 12% was wasted and had to be discarded. Both Sri Lanka and the Maldives initiated a mumps vaccination programme following a limited outbreak. The impact of this intervention is not clear as there are no data to support this effort, except that there were outbreaks of mumps following the tsunami.

Several additional measures were taken to minimize the risks for the development of infectious disease outbreaks (i.e., to increase the absorbing and buffering capacities of the affected societies). These included the provision of additional supplies of mosquito netting and plastic sheeting impregnated with insecticides to decrease the risks for the development of outbreaks of malaria and dengue. Often, the supply was in excess of what was needed. This particularly was true in Indonesia, India, and Sri Lanka, where many reports indicate that there was a marked oversupply of these materials. Fogging with insecticides also was initiated in the affected provinces of India, Indonesia and Sri Lanka. Fogging supplies and equipment were provided by WHO-SEARO. In some of the impacted areas in India, ponds and lakes were stocked with mosquito larvae-eating fish.

In addition, some chemical disinfectants were used widely, particularly in India and the Maldives. India dispensed and applied bleach, lime, chlorine, and phenyls in the affected areas to control possible infections arising from the dead bodies and from animal carcasses. These chemicals also were applied to beaches and areas that had been inundated by the tsunami. Similarly, chlorine was applied to carcasses in the Maldives.

**Recovery responses**

As noted, several problems were encountered with the preservation of the cold chain, which was interrupted in the countries due to power failures in the storage facilities and limitations in the Transport and Logistics Systems. However, inundation of supplies and equipment by water from the tsunami also compromised their utility. Limitations in the availability of transport vehicles and of skilled personnel contributed to the problems encountered. Such losses were key in Aceh province where the injury and death burdens were extreme. Within days of the events, WHO-SEARO, UNICEF, the American Red Cross, and Pfizer Pharmaceuticals provided supplies, equipment, and personnel to assist the ministries of health of the affected countries with the restoration of the cold chain. In addition, supplies and equipment were obtained from regional stores. Clearly, the functional status of the cold chain also was dependent upon the functional status of the Energy supply and Transportation and Logistics Systems. These responses are described elsewhere in this document.

It is not clear whether the increases noted in the incidence of infectious diseases were real or whether they were due to the increased surveillance. Importantly, no epidemics or even major outbreaks occurred in any of the countries. Minor outbreaks were controlled quickly through preventive public health interventions. Thus, whatever the reasons, there were no outbreaks of infectious diseases despite the crowding of people into IDP camps or into the homes of their families and friends. This was remarkable regardless of the reasons and is an area that needs further investigations.

The public health burden created by IDPs was complex and was dependent upon and interdependent with many of the other Basic
Societal Systems (BSS), including Water and Sanitation, Shelter and Clothing, Food and Nutrition, Public Works and Engineering, Security, Social Systems, and others. These relationships and responses are covered under the discussions appropriate to the specific BSS.

It is believed that pre-events, public health systems in India were better developed in the areas impacted by the tsunami, while just the opposite was true in Sri Lanka. There were 900,000 IDPs in Sri Lanka and Aceh province had the second highest number of IDPs/10,000 population with some 400,000 IDPs.

Conditions in the camps varied, and it was not possible to determine whether the conditions in these camps met the Sphere standards. The camps were crowded and the situations were ripe for the rapid spread of infectious diseases. However, this did not occur. WHO-SEARO and UNICEF augmented the public health personnel in India, Indonesia, and the Maldives in an effort to detect and contain any outbreaks. It is not clear whether the absence of outbreaks, much less epidemics, was related to public health oversight of the camps. Importantly, many humanitarian organizations played a significant role in the containment of diseases. Some of these contributions are highlighted in the following chapters.

In general, it is not known whether the IDPs that left the camps returned home, moved in with family or friends whose homes remained functional, or moved into temporary (public buildings left standing) or permanent shelters. Perhaps, the clearest picture of this process is based on data from Sri Lanka. Initially, Sri Lanka had the highest numbers of IDPs of all the countries studied. During the first month following the tsunami, both the numbers of IDPs and the numbers of IDP camps decreased progressively (Figures 10.4 and 10.5). By 30 January, the number of IDPs dropped to 25% of the original IDP burden and the number of IDP camps decreased from 750 to 319 (a decrease of 57.5%). However, at that time, more than 200,000 IDPs remained in the camps and continued to pose a public health threat for the development and spread of infectious diseases. Thus, the surveillance of the camps continued with the bolstered staff and augmented reporting procedures noted above.

Further, it is not known why some persons remained in camps and did not move into temporary or permanent quarters when such facilities became available. Some may have felt more secure in the camps than elsewhere. It may have seemed that they would have been safe from attacks by the insurgents. Some may have believed that it was more likely that their needs could be met better in the camps than if they were out on their own. The actual reasons need further study.

**Developments**

Many aspects of Public Health responses left the affected countries in a better state than they were prior to the events of 26 December 2004. In each of the countries, surveillance was strengthened and the sub-function of the Public Health System has been sustained in each of the countries. Laboratory facilities were improved. Personnel were trained in the monitoring of the quality of the water.

**Summary**

Despite the lack of a comprehensive public health infrastructure prior to the earthquake and tsunami, there were no major outbreaks of diseases in any of the countries. This is testimony to the successful operations of public health services in the response. However, the reasons for its success cannot be attributed to a specific intervention. In addition, the augmented public health capabilities and capacities of each of the countries have been sustained.
References

1. WHO: See appropriate section in Part III: Country Reports


Figure 10.1: Distribution of dead and missing within Aceh province.

Figure 10.2: Societal burdens for the five countries created by the injured, dead, and injured survivors related to the earthquake and tsunami.

Figure 10.3: Societal burdens related to the earthquake and tsunami in the areas directly impacted.
Figure 10.4: Number of IDPs living in camps in Sri Lanka vs. days after the tsunami (slope = 25,000/day).

Figure 10.5: Number of IDP camps in Sri Lanka vs. days after the tsunami (slope = -13/day).
Table 10.1: Overall indicators of health for each of the five countries included in this study and comparisons with SEAR as a whole. Indicators that indicate a lower health status than the region as a whole are denoted in italics. Bold values are the best in the Region (U5MR = under 5 year old mortality rate; CMR = crude mortality rate; sd = standard deviation; yrs = years).

<table>
<thead>
<tr>
<th>Indicator</th>
<th>India</th>
<th>Indonesia</th>
<th>Maldives</th>
<th>Sri Lanka</th>
<th>Thailand</th>
<th>Mean</th>
<th>sd</th>
<th>Sear</th>
</tr>
</thead>
<tbody>
<tr>
<td>Life Expectancy Total (Yrs)</td>
<td>62.5</td>
<td>67</td>
<td>71</td>
<td>71.5</td>
<td>69.1</td>
<td>68.2</td>
<td>3.7</td>
<td>63.7</td>
</tr>
<tr>
<td>Male (yrs)</td>
<td>60</td>
<td>65</td>
<td>70</td>
<td>68</td>
<td>67.9</td>
<td>66.2</td>
<td>3.9</td>
<td>61</td>
</tr>
<tr>
<td>Female (yrs)</td>
<td>62</td>
<td>68</td>
<td>71</td>
<td>75</td>
<td>74.9</td>
<td>70.2</td>
<td>5.4</td>
<td>64</td>
</tr>
<tr>
<td>Mortality Rates CMR/1000 population</td>
<td>7.5</td>
<td>10.0</td>
<td>3.0</td>
<td>5.9</td>
<td>8.0</td>
<td>6.7</td>
<td>3.0</td>
<td>64</td>
</tr>
<tr>
<td>Neonatal deaths/1000 live births</td>
<td>39</td>
<td>20</td>
<td>10</td>
<td>11</td>
<td>9</td>
<td>17.8</td>
<td>12.6</td>
<td>38</td>
</tr>
<tr>
<td>Infant mortality/1000 live births</td>
<td>58</td>
<td>35</td>
<td>14</td>
<td>11</td>
<td>24</td>
<td>28.4</td>
<td>19</td>
<td>53</td>
</tr>
<tr>
<td>U5MR/1000 live births</td>
<td>89</td>
<td>41</td>
<td>18</td>
<td>15</td>
<td>12</td>
<td>35</td>
<td>32.3</td>
<td>78</td>
</tr>
<tr>
<td>Maternal/mortality 100 000 live births</td>
<td>301</td>
<td>230</td>
<td>78</td>
<td>92</td>
<td>24</td>
<td>145</td>
<td>51.7</td>
<td>460</td>
</tr>
</tbody>
</table>

Table 10.2: Public health indicators for Indonesia and Aceh province.

<table>
<thead>
<tr>
<th>Population health</th>
<th>Indonesia indicator</th>
<th>Indonesia year (source)</th>
<th>Aceh Indicator</th>
<th>Aceh year (source)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Life expectancy (yrs)</td>
<td>67</td>
<td></td>
<td>67.6</td>
<td>2002&lt;sup&gt;14&lt;/sup&gt;</td>
</tr>
<tr>
<td>Life expectancy at birth for males</td>
<td>65</td>
<td>2003&lt;sup&gt;15&lt;/sup&gt;</td>
<td>65.7</td>
<td>2002</td>
</tr>
<tr>
<td>Life expectancy at birth for women</td>
<td>68</td>
<td>2003&lt;sup&gt;14&lt;/sup&gt;</td>
<td>69.6</td>
<td>2002</td>
</tr>
<tr>
<td>Crude mortality rate/1000 population</td>
<td>7</td>
<td>2002&lt;sup&gt;16&lt;/sup&gt;</td>
<td>7</td>
<td>2002</td>
</tr>
<tr>
<td>Neonatal mortality rate/1000 live births</td>
<td>20</td>
<td>2002</td>
<td>35</td>
<td>2004&lt;sup&gt;17&lt;/sup&gt;</td>
</tr>
<tr>
<td>Infant mortality/1000 live births</td>
<td>35</td>
<td>2002</td>
<td>36.1</td>
<td>2003&lt;sup&gt;18&lt;/sup&gt;</td>
</tr>
<tr>
<td>Under-five mortality/1000 live births</td>
<td>41</td>
<td>2003</td>
<td>58.6</td>
<td>1997&lt;sup&gt;19&lt;/sup&gt;</td>
</tr>
<tr>
<td>Maternal mortality/100 000 live births</td>
<td>230</td>
<td>2000</td>
<td>373-800</td>
<td>2004</td>
</tr>
</tbody>
</table>
Table 10.3: Pre-events (2003–2004) causes of death in the five countries most affected by the earthquake and tsunami (SD = standard deviation)

<table>
<thead>
<tr>
<th>Disease</th>
<th>Indonesia (%)</th>
<th>India (%)</th>
<th>Maldives (%)</th>
<th>Sri Lanka (%)</th>
<th>Thailand (%)</th>
<th>Mean (%)</th>
<th>SD (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cardiovascular</td>
<td>28</td>
<td>28</td>
<td>30</td>
<td>34</td>
<td>20</td>
<td>28.0</td>
<td>5.1</td>
</tr>
<tr>
<td>Communicable, maternal, perinatal, nutritional</td>
<td>29</td>
<td>36</td>
<td>38</td>
<td>13</td>
<td>30</td>
<td>29.2</td>
<td>9.8</td>
</tr>
<tr>
<td>Diabetes</td>
<td>3</td>
<td>2</td>
<td>2</td>
<td>4</td>
<td>5</td>
<td>3.2</td>
<td>1.3</td>
</tr>
<tr>
<td>Other chronic diseases</td>
<td>11</td>
<td>8</td>
<td>9</td>
<td>15</td>
<td>13</td>
<td>11.2</td>
<td>2.9</td>
</tr>
<tr>
<td>Injuries</td>
<td>10</td>
<td>11</td>
<td>7</td>
<td>10</td>
<td>11</td>
<td>9.8</td>
<td>1.6</td>
</tr>
<tr>
<td>Cancer</td>
<td>12</td>
<td>8</td>
<td>8</td>
<td>13</td>
<td>14</td>
<td>11.0</td>
<td>2.8</td>
</tr>
<tr>
<td>Chronic respiratory diseases</td>
<td>7</td>
<td>7</td>
<td>6</td>
<td>11</td>
<td>7</td>
<td>7.6</td>
<td>1.95</td>
</tr>
<tr>
<td>Total</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
</tbody>
</table>

Figure 10.4: Incidence of infectious diseases/10 000 population in 2004 in India, Indonesia, Maldives, Sri Lanka, Thailand, Aceh Province

<table>
<thead>
<tr>
<th>Mechanism of transmission</th>
<th>Disease</th>
<th>India</th>
<th>Indonesia</th>
<th>Maldives</th>
<th>Sri Lanka</th>
<th>Thailand</th>
<th>Aceh province</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vector-borne</td>
<td>Malaria</td>
<td>17.70</td>
<td>53.7</td>
<td>0.0</td>
<td>1.91</td>
<td>3.00</td>
<td>9.85</td>
</tr>
<tr>
<td></td>
<td>Dengue</td>
<td>3.07</td>
<td>3.65</td>
<td>2.75</td>
<td>7.85</td>
<td>9.96</td>
<td>0.54</td>
</tr>
<tr>
<td></td>
<td>Scrub typhus</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Waterborne</td>
<td>Bacillary dysentery</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Shigellosis</td>
<td>4.10</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>16.83</td>
</tr>
<tr>
<td></td>
<td>Cholera</td>
<td>0.04</td>
<td></td>
<td></td>
<td>0.00</td>
<td></td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Typhoid fever</td>
<td>1.19</td>
<td></td>
<td>3.04</td>
<td>1.55</td>
<td>11.97</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Leptospirosis</td>
<td></td>
<td>2.75</td>
<td>0.58</td>
<td>0.78</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Hepatitis</td>
<td>1.88</td>
<td></td>
<td></td>
<td>3.68</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Direct contact</td>
<td>Measles</td>
<td>0.48/</td>
<td>1.35</td>
<td>2.80</td>
<td>0.04</td>
<td>0.72</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Mumps</td>
<td></td>
<td>1.52</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Tetanus</td>
<td>0.03</td>
<td>0.08</td>
<td>0.03</td>
<td>0</td>
<td>0.09</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Pertussis</td>
<td>0.30</td>
<td>0.07</td>
<td>0</td>
<td>0.02</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Mechanism of transmission</td>
<td>Disease</td>
<td>India</td>
<td>Indonesia</td>
<td>Maldives</td>
<td>Sri Lanka</td>
<td>Thailand</td>
<td>Aceh province</td>
</tr>
<tr>
<td>----------------------------</td>
<td>----------------------------------</td>
<td>-------</td>
<td>-----------</td>
<td>----------</td>
<td>-----------</td>
<td>----------</td>
<td>--------------</td>
</tr>
<tr>
<td></td>
<td>Diphtheria</td>
<td>0.08</td>
<td>0.01</td>
<td>0</td>
<td>0.00</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Tuberculosis</td>
<td>16.8</td>
<td>24.5</td>
<td>5.08</td>
<td>6.00</td>
<td>1.42</td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td>Acute respiratory infection</td>
<td>235.74</td>
<td>1955.9</td>
<td></td>
<td></td>
<td></td>
<td>91.85</td>
</tr>
<tr>
<td></td>
<td>Diarrhoea</td>
<td>95.39</td>
<td>513.3</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Enteric fever</td>
<td>6.07</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Viral fever</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1476.9</td>
</tr>
</tbody>
</table>

**Table 10.5: Prevalence of chronic diseases in the five countries**

<table>
<thead>
<tr>
<th>Disease</th>
<th>India</th>
<th>Indonesia</th>
<th>Maldives</th>
<th>Sri Lanka</th>
<th>Thailand</th>
</tr>
</thead>
<tbody>
<tr>
<td>Population (million)</td>
<td>1065</td>
<td>242</td>
<td>0.3</td>
<td>19.3</td>
<td>64.9</td>
</tr>
<tr>
<td>Malaria</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cases*</td>
<td>82 864 215</td>
<td>19 200 504</td>
<td>0</td>
<td>333 335</td>
<td>3 237 574</td>
</tr>
<tr>
<td>Prevalence/100 000 population</td>
<td>7780.7</td>
<td>7934.1</td>
<td>0</td>
<td>1727.1</td>
<td>4988.6</td>
</tr>
<tr>
<td>(% population)</td>
<td>7.7</td>
<td>7.9</td>
<td>0</td>
<td>3.6</td>
<td>4.9</td>
</tr>
<tr>
<td>HIV/AIDS</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cases**</td>
<td>3 870 000</td>
<td>100 000</td>
<td>&lt;100</td>
<td>8500</td>
<td>671 000</td>
</tr>
<tr>
<td>Prevalence/100 000 population</td>
<td>363.4</td>
<td>41.3</td>
<td>33.3</td>
<td>44.0</td>
<td>1033.9</td>
</tr>
<tr>
<td>(% population)</td>
<td>0.4</td>
<td>0.4</td>
<td>0.3</td>
<td>0.4</td>
<td>1.0</td>
</tr>
<tr>
<td>Tuberculosis</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cases***</td>
<td>3 195 000</td>
<td>677 600</td>
<td>180</td>
<td>19 300</td>
<td>136 290</td>
</tr>
<tr>
<td>Prevalence/100 000 population***</td>
<td>300</td>
<td>280</td>
<td>60</td>
<td>100</td>
<td>210</td>
</tr>
<tr>
<td>(% population)</td>
<td>0.3</td>
<td>0.3</td>
<td>0.02</td>
<td>0.01</td>
<td>0.2</td>
</tr>
</tbody>
</table>

* bde%201[1][1].pdf
** http://www.searo.who.int/LinkFiles/Publications-aids-135.pdf
*** http://www.searo.int/LinkFiles/Events_03_Narain_who_searo.pdf
Table 10.6: National immunization status of children in each of the five countries (DPT = diphtheria, tetanus, pertussis; HepB = hepatitis B; BCG = Bacillus Calmette-Guérin, a vaccine for tuberculosis)

<table>
<thead>
<tr>
<th>Indicator</th>
<th>India</th>
<th>Indonesia</th>
<th>Maldives</th>
<th>Sri Lanka</th>
<th>Thailand</th>
<th>Aceh</th>
</tr>
</thead>
<tbody>
<tr>
<td>One-year-olds with one dose of measles (%)</td>
<td>56</td>
<td>78</td>
<td>96</td>
<td>96</td>
<td>96</td>
<td>31</td>
</tr>
<tr>
<td>One-year-olds with third dose of DPT* (%)</td>
<td>64</td>
<td>66</td>
<td>97</td>
<td>97</td>
<td>99</td>
<td>35</td>
</tr>
<tr>
<td>One-year-olds with third dose of HepB (%)</td>
<td>79</td>
<td>51</td>
<td>97</td>
<td>79</td>
<td>96</td>
<td></td>
</tr>
<tr>
<td>One-year-olds with BCG (%)</td>
<td>73</td>
<td>88</td>
<td>98</td>
<td>99</td>
<td>99</td>
<td></td>
</tr>
<tr>
<td>One-year-olds immunized with third dose of polio (%)</td>
<td>70</td>
<td>72</td>
<td>91</td>
<td>97</td>
<td>98</td>
<td>6</td>
</tr>
</tbody>
</table>

Table 10.7: Number of psychiatrists/100,000 population and suicide rates by country in 2004 (pop = population)

<table>
<thead>
<tr>
<th>Mental Health Workers/10,000 population</th>
<th>India</th>
<th>Indonesia</th>
<th>Banda Aceh</th>
<th>Maldives</th>
<th>Sri Lanka</th>
<th>Thailand</th>
</tr>
</thead>
<tbody>
<tr>
<td>Psychiatrists</td>
<td>0.027</td>
<td>0.016</td>
<td>0.013</td>
<td>0.067</td>
<td>0.005</td>
<td>0.064</td>
</tr>
<tr>
<td>Suicide rates/100,000 pop</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>24*</td>
<td>NA</td>
<td>NA</td>
<td>0.7</td>
<td>44.6</td>
<td>12.0</td>
</tr>
<tr>
<td>Female</td>
<td>12.2</td>
<td>NA</td>
<td>NA</td>
<td>0.0</td>
<td>16.8</td>
<td>3.8</td>
</tr>
</tbody>
</table>

Sources: *adnkronosinternational: Indonesia: Suicide rate at 1500 a day due to poverty. Available at: http://www.adnkronos.com/AKI/English/CultureAndMedia?id=10.0.1404242294. Accessed 23 September 2010.: pop = population; NA = not available
Table 10.8: Public health indicators of damage from the earthquake and tsunami (\# = number; CMR = crude mortality rate)

<table>
<thead>
<tr>
<th>Indicator</th>
<th>India</th>
<th>Indonesia</th>
<th>Maldives</th>
<th>Sri Lanka</th>
<th>Thailand</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Population (mil) (estimates 2004)</td>
<td>1065</td>
<td>242</td>
<td>0.30</td>
<td>19.3</td>
<td>64.865</td>
<td>1289.6</td>
</tr>
<tr>
<td>Total number Injured (% total)</td>
<td>19.592 (4.6)</td>
<td>325.805 (77.1)</td>
<td>907 (0.2)</td>
<td>59.662 (14.1)</td>
<td>16.784 (4.0)</td>
<td>422.750 (100)</td>
</tr>
<tr>
<td>Killed/missing (% total deaths)</td>
<td>12.405 (5.5)</td>
<td>167.540 (74.5)</td>
<td>108 (0.04)</td>
<td>36.603 (16.3)</td>
<td>83.27 (4.0)</td>
<td>224.983 (100.4)</td>
</tr>
<tr>
<td>% injured killed</td>
<td>63.3</td>
<td>51.4</td>
<td>11.9</td>
<td>61.4</td>
<td>49.6</td>
<td>53.2</td>
</tr>
<tr>
<td>CMR/10 000/ day Pre-events</td>
<td>0.002</td>
<td>0.003</td>
<td>0.0008</td>
<td>0.002</td>
<td>0.002</td>
<td>0.002</td>
</tr>
<tr>
<td>CMR/10 000/ day for 1st 3 days</td>
<td>0.03</td>
<td>2.30</td>
<td>1.20</td>
<td>6.32</td>
<td>0.48</td>
<td>0.54</td>
</tr>
<tr>
<td>Deaths/total population (%)</td>
<td>0.001</td>
<td>0.07</td>
<td>0.04</td>
<td>0.18</td>
<td>0.01</td>
<td>0.01-</td>
</tr>
<tr>
<td>Deaths/10 000 population</td>
<td>0.1</td>
<td>6.9</td>
<td>4.0</td>
<td>18</td>
<td>1.0</td>
<td>1.74</td>
</tr>
<tr>
<td>#Injuries/# deaths-missing</td>
<td>0.58</td>
<td>0.44</td>
<td>7.4</td>
<td>0.63</td>
<td>1.02</td>
<td>0.88</td>
</tr>
<tr>
<td>Survivors injured (%)</td>
<td>7.187 (3.6)</td>
<td>158.265 (80.0)</td>
<td>799 (0.4)</td>
<td>23.059 (11.7)</td>
<td>845.7 (4.2)</td>
<td>197.767 (99.9)</td>
</tr>
<tr>
<td>% Injured who survived</td>
<td>36.7</td>
<td>48.6</td>
<td>88.1</td>
<td>38.6</td>
<td>50.4</td>
<td>46.8</td>
</tr>
<tr>
<td>#Injured/10 000 population</td>
<td>0.068</td>
<td>6.540</td>
<td>26.333</td>
<td>11.940</td>
<td>1.304</td>
<td>1.534</td>
</tr>
<tr>
<td>Population/km2</td>
<td>329</td>
<td>126</td>
<td>1068</td>
<td>306</td>
<td>764</td>
<td></td>
</tr>
</tbody>
</table>

Sri Lanka: 99% fatalities within 3 days (most on day 1)
Causes of deaths (drowning, blunt injuries/penetrating wounds/crush)
No deaths attributed to events 2 Jan-3rd week Jun
Thailand: Range of injuries 15-5597
Indonesia: Collapse of communication system isolated Aceh and Nias
Drowning vs. struck by debris, crush, limitation of clothing
Table 10.9: Number of injuries and deaths in Aceh province compared to all of Indonesia and in the Andaman and Nicobar Islands and the state of Tamil Nadu of India. (# = number; CMR = crude mortality rate for the first three days following the tsunami)

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Indonesia</th>
<th>Aceh province</th>
<th>India</th>
<th>Andaman &amp; Nicobar islands</th>
<th>Tamil Nadu</th>
</tr>
</thead>
<tbody>
<tr>
<td>Population (mil) (estimates 2004)</td>
<td>242</td>
<td>3.9</td>
<td>1065</td>
<td>0.356</td>
<td>64 279</td>
</tr>
<tr>
<td>Total number Injured</td>
<td>325 805</td>
<td>278 051</td>
<td>19 592</td>
<td>5002</td>
<td>11 145</td>
</tr>
<tr>
<td>Killed/missing (% total deaths)</td>
<td>167 540 (74.5)</td>
<td>122 736 (73.2)</td>
<td>12 405 (5.5)</td>
<td>3513 (28.3)</td>
<td>8009 (64.5)</td>
</tr>
<tr>
<td>% injured killed</td>
<td>51.4</td>
<td>44.1</td>
<td>63.3</td>
<td>63.0</td>
<td>71.9</td>
</tr>
<tr>
<td>CMR/10 000/day for 1st 3 days</td>
<td>2.30</td>
<td>104.90</td>
<td>0.03</td>
<td>32.87</td>
<td>0.41</td>
</tr>
<tr>
<td>Deaths/total population (%)</td>
<td>0.07</td>
<td>3.1</td>
<td>0.001</td>
<td>0.010</td>
<td>0.0001</td>
</tr>
<tr>
<td>Deaths/10 000 population</td>
<td>6.9</td>
<td>314.7</td>
<td>0.1</td>
<td>98.7</td>
<td>1.2</td>
</tr>
<tr>
<td>#Injures/#deaths-missing</td>
<td>0.44</td>
<td>1.26</td>
<td>0.58</td>
<td>0.30</td>
<td>0.39</td>
</tr>
<tr>
<td>Survivors injured (%)</td>
<td>158 265</td>
<td>155 317</td>
<td>71 87</td>
<td>1489**</td>
<td>3136***</td>
</tr>
<tr>
<td>% Injured who survived</td>
<td>48.6</td>
<td>55.9</td>
<td>36.7</td>
<td>37.0</td>
<td>28.1</td>
</tr>
<tr>
<td>#Injured/10 000 population</td>
<td>6.540</td>
<td>405.8</td>
<td>0.068</td>
<td>40.1</td>
<td>0.448</td>
</tr>
</tbody>
</table>

*per 10 000/day during 1st 3 days
**http://www.ncpedp.org/policy/pol/res01.htm
***http://www.undp.org/tsunami/India.htm
****http://www.searo.int/EN/Section23/Section1108/Section1835/Section1851/Section086_8599.htm
Treated in Aceh province: Serious injuries = 6,884 (84.8%); Minor: 148,433 (98.9%)

Table 10.10: Conditions related to injuries from the earthquake and tsunami as reported by hospitals in Banda Aceh, the Maldives, and Galle Hospital in Sri Lanka

<table>
<thead>
<tr>
<th>Conditions</th>
<th>Banda Aceh (n (%))</th>
<th>Galle Hospital Early (n (%))</th>
<th>Galle Hospital Late (n (%))</th>
<th>Maldives (n (%))</th>
</tr>
</thead>
<tbody>
<tr>
<td>Respiratory</td>
<td>325 (36.5)</td>
<td></td>
<td>32</td>
<td>33% minor</td>
</tr>
<tr>
<td>Trauma</td>
<td>254 (28.6)</td>
<td></td>
<td>17</td>
<td></td>
</tr>
<tr>
<td>Musculoskeletal</td>
<td>111 (12.9)</td>
<td></td>
<td>11</td>
<td>10.1</td>
</tr>
<tr>
<td>Skin infections</td>
<td>105 (11.8)</td>
<td>15</td>
<td></td>
<td>20.6</td>
</tr>
<tr>
<td>Fractures</td>
<td></td>
<td>10</td>
<td></td>
<td>38</td>
</tr>
<tr>
<td>Near-drowning</td>
<td></td>
<td>43</td>
<td></td>
<td>1.1</td>
</tr>
<tr>
<td>Crush</td>
<td>94 (10.6)</td>
<td>1.8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Head injury</td>
<td></td>
<td></td>
<td></td>
<td>3.9</td>
</tr>
</tbody>
</table>
Table 10.11: Internally displaced persons following the tsunami (pop = population; term = temporary; # = number).

<table>
<thead>
<tr>
<th>Indicator</th>
<th>India</th>
<th>Andaman &amp; Nicobar islands</th>
<th>Indonesia</th>
<th>Banda Aceh</th>
<th>Maldives</th>
<th>Sri Lanka</th>
<th>Thailand</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td># Pre-events</td>
<td></td>
<td></td>
<td></td>
<td>1000-38 000*</td>
<td>73 000***</td>
<td>???</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Population (mili)</td>
<td>1065</td>
<td>0.356</td>
<td>242</td>
<td>3.9</td>
<td>0.30</td>
<td>1.93</td>
<td>64.865</td>
<td></td>
</tr>
<tr>
<td>Total # Displaced</td>
<td>627 119</td>
<td>1346 in small area+</td>
<td>450 000</td>
<td>400 000</td>
<td>29,577++</td>
<td>900 000**</td>
<td>6 000</td>
<td>2010,696</td>
</tr>
<tr>
<td>% pop displaced</td>
<td>0.06</td>
<td>0.21</td>
<td>10.26</td>
<td>9.86</td>
<td>46.63</td>
<td>0.009</td>
<td></td>
<td></td>
</tr>
<tr>
<td># Displaced/10 000 pop</td>
<td>5.89</td>
<td>20.66</td>
<td>1025.64</td>
<td>985.90</td>
<td>4663.21</td>
<td>0.92</td>
<td></td>
<td></td>
</tr>
<tr>
<td># in Camps</td>
<td>572 578****</td>
<td>43 332</td>
<td>450 000</td>
<td></td>
<td></td>
<td>850 000</td>
<td></td>
<td></td>
</tr>
<tr>
<td># Camps</td>
<td>644****</td>
<td>169</td>
<td>66+++</td>
<td>4+ +++</td>
<td>750</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>% in camps</td>
<td>91.3</td>
<td>50.0</td>
<td></td>
<td></td>
<td></td>
<td>94.4</td>
<td></td>
<td></td>
</tr>
<tr>
<td># in Residences</td>
<td></td>
<td></td>
<td>250 000</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td># in Shelters</td>
<td></td>
<td></td>
<td>Schools &gt;2000</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>End of 2005</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td># in temp shelters</td>
<td></td>
<td></td>
<td>70 000</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td># tents</td>
<td></td>
<td></td>
<td>67 000</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Increase 2 months following Declaration of Marshall Law 2002–then to 14 950 pre-event
** 10 Jan, 545 492 in camps; 05 Jan 572 578 in 637 camps; 30 Jan 208; 498 in 319 camps
*** in conflict areas
++++ end of Dec, +3 wks— 100 000 in 256 camps; Tamil Nadu: 43 332 in 169 camps
+ football field
+ + + On 26 January, 417 124 IDPs were resident in 66 camps in Indonesia. (http://www.searo.who.int/EN/section1108/Section1835/Section1851/Section1867_8643.htm)
Table 10.12: Outbreaks of infectious diseases and some of the measures used to control outbreaks and epidemics (X = present, but quantity or description not available)

<table>
<thead>
<tr>
<th>Outbreaks</th>
<th>India</th>
<th>Indonesia</th>
<th>Maldives</th>
<th>Sri Lanka</th>
<th>Thailand</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cholera</td>
<td></td>
<td>? increase</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Malaria</td>
<td></td>
<td>Decreased</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Measles</td>
<td>Tamil Nadu</td>
<td>Increased in IDP camp</td>
<td>Increased</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tetanus</td>
<td></td>
<td>106 cases with 18.9% mortality</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TBC</td>
<td></td>
<td>Rx stopped for 3-4 days</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dengue</td>
<td></td>
<td>Decreased</td>
<td>Increased late</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Resp Infect</td>
<td></td>
<td>Increased 8x</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mumps</td>
<td></td>
<td>Increase ? due to tsunami</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Diarrhoea</td>
<td></td>
<td>2x for 3 mo</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| Epidemics                 | None  | None      | None      | None      | None      | None      |

<table>
<thead>
<tr>
<th>Interventions</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th>Previous experience with SARS and Avian Flu</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mosquito netting</td>
<td>×</td>
<td>'TOO MANY'</td>
<td>UNICEF to 66K families</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Impregnated Plastic Sheets</td>
<td>×</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chemical disinfectants</td>
<td>Bleach, lime, phenyls</td>
<td>Chlorine to carcasses</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Burial of remains</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fogging with insecticides</td>
<td>×</td>
<td>×</td>
<td>WHO x 50</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Weekly briefing</td>
<td>×</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mosquito eating fishes</td>
<td>×</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>India</td>
<td>Indonesia</td>
<td>Maldives</td>
<td>Sri Lanka</td>
<td>Thailand</td>
</tr>
<tr>
<td>--------------------------</td>
<td>-------</td>
<td>-----------</td>
<td>----------</td>
<td>-----------</td>
<td>----------</td>
</tr>
<tr>
<td>Clean water</td>
<td>×</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cholera detect kits</td>
<td>×</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Personnel-Teams Dispatched</td>
<td>×</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Supplies + equipment for isolation in schools</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>WHO</td>
<td>×</td>
<td>Training</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>UNICEF</td>
<td>×</td>
<td>×</td>
<td>Vaccinations + repair of cold chain</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Introduction

As outlined in the previous chapter, the injured and dead body burdens presented a huge challenge to the countries and added to the routine medical care problems managed by them. The Basic Medical Care System for each of the countries was at a different phase of development at the time of the earthquake and tsunami, and thus, the relative burdens were managed differently by each of the countries.

As has been documented in studies, the deaths of victims of acute traumatic injuries followed the previously described trimodal temporal distribution. Most of those who died during or shortly following the events did not receive medical aid before their death, since access to emergency medical services was not possible. It is not clear how many of those who died had life-threatening injuries, and therefore, potentially could have survived had they received adequate medical care in time. However, given the huge numbers of injured, it is not likely that even those victims who were able to reach a medical facility, would have survived. The immediate damage caused by the event(s) presented a surge of injured victims and dead bodies to the often damaged and crippled medical facilities that, in many locations, had lost a substantial number of their staff. Generally, this immediate surge lasted less than one week (actually only a few days). As noted, the major injuries included aspiration of filthy water, extremity fractures, and deep wounds. This acute period was followed by a period that required treatment of complications from the initial injuries and containment of limited outbreaks of infectious diseases. Aspiration pneumonia, infected wounds, and psychosocial problems followed the injuries produced by the sudden-onset event(s). In addition, there was a substantial increase in the incidence of acute pulmonary infections and diarrhoea.

The bodies of many of the victims were transported to medical facilities that did not have sufficient cold storage facilities in which to keep the bodies until identification procedures could be completed. Overall, the number of forensic pathologists was inadequate to perform the autopsies.

Caution is suggested with the interpretation of some of the data collected, since the recording and reporting structure was poor in all countries except Thailand. For the most part, the numbers of healthcare issues reported were those of victims who had received care at hospitals or some other medical facility. Data from victims that were evaluated and treated at clinics and outposts generally were the most difficult to obtain. This included the inability to access reports of the patient loads evaluated and treated by many of the non-governmental organizations (NGOs) that responded. In addition, it was not possible to capture the numbers of injured/ill that cared for

Medical Care System
themselves or who were treated using traditional medicine techniques. Also, it is not evident how many of those reported as dead were alive when they reached one of the medical facilities, but who ultimately succumbed to their injuries or the complications thereof. Generally, information relative to the private sector medical care provided was not available.

Some of the analyses are based on professional projections of experiences from other tragedies. Where tables are incomplete, the data could not be obtained despite extensive searches.

The material that follows consists of an assembly of information provided in the preceding country descriptions. Some of the findings essentially were identical for all the countries, but there were some profound differences as well.

Pre-Events status

Healthcare facilities

The Medical Care Systems in the five countries differed. As depicted in Table 11.1, the hierarchy of the levels of governmental subdivisions of Indonesia, Sri Lanka, and Thailand are quite similar, moving from the central national governments down to the community level. The countries are subdivided into provinces which, in turn, are subdivided into districts. For these countries, the Medical Care Systems infrastructures are assigned into subdivisions (derived from the respective country descriptions) (Table 11.2): the main tertiary care facilities (including medical schools) and large, tertiary care hospitals were located at the national and provincial levels, and secondary care was provided at the regional level. Some was provided at the provincial levels, as well as at the national levels. Primary health care was delivered at all levels. The major subunits that provide primary care have different labels, but fit into this hierarchy.

The Maldives had one tertiary-care facility located in Malé, with secondary care provided in regional and atoll hospitals. Primary care was provided in the atoll health centres, island health posts, and family health sections (in decreasing order of medical capabilities and capacities).

Because of its large size, India is subdivided into states, and the states are subdivided into districts. The Andaman and Nicobar Islands are Union territories. Tertiary care facilities exist in the major cities and secondary care is provided in regional hospitals and in district hospitals within the states. Health care below the district hospital is provided through a network of Primary Health Centres. Primary health care services are provided in descending order of complexity in the Primary Health Centres, family, community and welfare centres (predominantly in urban areas), and sub-centres. Medical doctors are available up to the level of Primary Health Centres. These respective organizational differences had significant implications on the ability of the countries to respond to the losses of function that resulted from the damages incurred from the earthquake and tsunami.

The above information applies primarily to the public facilities. Information related to the contributions of the private sector in times of emergency and its respective organization, control, and cooperation for most of the countries has been difficult to identify.

Healthcare providers

The number of medical personnel in each of the countries provides important baseline information as to the ability of a country to mobilize resources during an emergency (response capacity). The relative numbers of medical personnel/10,000 population for each of the countries is listed in Table 11.3. The Maldives had the highest number of physicians and nurses per unit of population, but suffered from chronic shortages of health professionals. This may well have been a geographical imperative caused by the wide distribution of the islands and atolls and the difficulty in moving ill or injured patients over long distances. Interestingly, 95% of the physicians in the public sector and 71% in the private sector were expatriates. In addition, 35% of the nurses in the public sector and 82% in the

The Maldives had the highest number of physicians and nurses per unit of population, but suffered from chronic shortages of health professionals
private sector personnel serving the Maldives were expatriates.

Of the five countries studied, Indonesia had the lowest density of physicians and nurses. However, in the hardest hit province of Aceh, the density of physicians was slightly higher (1.9/10 000) than for the country as a whole, and the density of nurses was more than three-fold greater than for the country as a whole.

Although Thailand had the second lowest density of physicians, it had the second highest ratio of nurses/unit of population (second to the Maldives). But Thailand’s geography differs profoundly from that of the Maldives. This factor played heavily in the ability of Thailand to meet the needs for medical care that resulted from the tsunami; the healthcare system in Thailand was the best organized of any of the countries, and this organizational structure played a major role in the relief responses generated following the tsunami.

Sri Lanka had the highest number of hospital beds per capita (31.0/100 000 population) followed by Thailand with 21.3 beds/100 000 population, and the Maldives (18.6/100 000). In 2003 in the Maldives, there were two hospitals in Malé, six regional hospitals, eight atoll hospitals, 63 health centres (with beds) and 52 health posts in atolls. The total number of hospital beds (2002) was 558, with a population to bed ratio of 503. In addition, there were 30 private clinics in Malé and 17 in the atolls (2000). The existing health infrastructure development suffers from a lack of attention given to human resource needs and support services at the planning stage. An acute shortage of biomedical expertise has created major problems with regard to the maintenance and repair of equipment.

India, by far, had the lowest number of hospital beds /10 000 population (1.3/100 000 population). Indonesia had less than one-third the number of hospital beds/capita (6.2/100 000 population) than did Sri Lanka; Thailand and Aceh province were similar to Indonesia as a whole with 21.3 beds/100 000 population. Utilization rates were not available.

Another indicator of the level of development of the Medical Care System in place before the earthquake/tsunami is reflected by the number of births attended by skilled personnel (Table 11.4). Almost all the births in Thailand and Sri Lanka were attended by skilled healthcare personnel. This factor correlates with the reported pre-event rates of maternal and neonatal mortality for each of the country’s Medical Care Systems ($r = -0.87; r = -0.87$, respectively) (Figures 11.1 and 11.2).

**Emergency medical services (EMS)**

For the most part, emergency medical services (EMS) were poorly developed in each of the countries affected by the earthquake and tsunami. Beginning in 2002, Indonesia started to develop a prehospital EMS system. It identified a universal emergency call number (1-1-8) and began the education and training of individuals to perform at levels equivalent to those of emergency medical technicians in the USA (including paramedic level). When the tsunami struck, 1-1-8 was operational in at least 18 of the largest cities in Indonesia. However, there was no such system operating in Banda Aceh. At the time of the earthquake and tsunami, there were 15 ambulances available in Banda Aceh. Ambulance services in each of the other countries were weak, and for the most part, were used primarily for patient transport and not for emergency responses. For example, Phuket had 10 ambulances available most times; they were operated by the government hospitals and staffed with nurses aides trained in first aid. Their activities were confined mostly to the urban areas where they served 270 000 residents and 40 000 tourists. Few of them were staffed 24/7—they only responded to emergencies when requested to do so by the police. In each of the countries, victims or their families were transported to medical facilities using taxis or private vehicles.
Similarly, in 2004, there was no defined EMS system in the parts of India impacted by the tsunami. The ambulances that were available were operated by hospitals, police, fire brigade, the government, or as private businesses.\textsuperscript{1,2} There was no tested organizational model. Further, no such services were available in the Indian territories of the Andaman and Nicobar Islands. The same was true for the Maldives; at the time that the tsunami struck, there were only seven ambulances in all of the Maldives, and five were stationed in Malé. No water ambulances were available either in the Maldives or in the Andaman and Nicobar Islands. In the islands, when medical care was not available, people seeking medical care had to be transported by boat (or air when available) to other medical facilities. Formal travel between the islands and medical facilities in the atolls and between the atoll hospitals and the national hospital in Malé was rare, often available only 2–3 times per month. Of note, some of the waters between islands are quite shallow and are not accessible by large ships. Inter-island transport is provided by dhori boats capable of carrying up to 100 persons. Access to health care in the islands often required the use of boats. In none of the five countries studied would even the best EMS system have impacted victim survival given the magnitude of the earthquake and tsunami and the number of injured victims.

**Damage**

In general, the absorbing capacity of the Medical Care Systems was inadequate to prevent damage to the medical facilities and resources in the regions impacted by the earthquake and tsunami. The Medical Care System in all the countries, except Thailand, sustained substantial damage to infrastructure, healthcare personnel, equipment, and supplies (Table 11.5). Hundreds of healthcare facilities were damaged or destroyed. For the most part, it has not been possible to separate the damage due to the earthquake from that produced by the tsunami. However, it is clear that two hospitals in Banda Aceh sustained considerable damage from the earthquake. Even though, in the Andaman and Nicobar islands, subsidence of the earth was a prominent feature of the damage due to the earthquake, it is not clear how much damage to the medical infrastructure in the islands was related to the earthquake. There is substantial evidence that the tsunami resulted in damage associated with the waves as well as damage created by the subsequent flooding. This was most apparent in the Maldives and for at least one provincial hospital in Banda Aceh that was inundated with water and mud that not only destroyed supplies and equipment, but drowned many of the patients and possibly staff in the facility.

The greatest number of medical care facilities damaged or destroyed were in Indonesia, which also encountered the greatest forces associated with earthquake and tsunami events. For example, 33 (86.6%) of the health facilities were damaged or destroyed in Banda Aceh (Figure 11.3).\textsuperscript{3} A total of 103 (36%) of the health facilities in the four districts analyzed were damaged or destroyed. The greatest number of facilities damaged or destroyed were in Aceh Jaya district, which also had the highest burden of damaged or destroyed medical facilities per unit of population (5.17 facilities/10 000 population). Overall, the damage sustained by the medical facilities was variable and did not correlate to the number of facilities in the area pre-events.

In Sri Lanka, the greatest damage to medical care facilities occurred in the districts with the greatest exposure to the tsunami. Importantly, the greatest damage in Sri Lanka was sustained in the northeast districts that had been subject to political unrest and that also had the poorest pre-event health status. In the Galle and Batticaloa districts, a total of 27 healthcare facilities were destroyed or damaged: 19 destroyed and 18 damaged.

In addition, storage facilities for drugs and other medical supplies and equipment also sustained damage. Damage to storage facilities was severe in Indonesia (particularly in Banda Aceh) and in Sri Lanka. Fourteen of the 15 ambulances
operating in Banda Aceh were destroyed! In contrast, Thailand, which also experienced huge forces from the tsunami, sustained relatively little damage to its medical care infrastructure.

The bulk of the damage occurred in healthcare facilities whose mission was to provide primary care. However, the main tertiary facility in Banda Aceh was severely damaged, as were three of its smaller hospitals, while the tertiary care hospital in the Maldives was only minimally damaged. Even the minimally damaged facilities at least temporarily lost access to electrical power and potable water.

Indonesia, in general, and Aceh province in particular, experienced the greatest loss of healthcare personnel (208) including 97 nurses/midwives and seven physicians killed as a result of the events. Thailand reported that one physician and one nurse were killed by the tsunami. Sri Lanka reported only the total number of healthcare personnel (n=35) who were injured and survived. No data could be found on how many medical care professionals were injured and unable to work in their respective roles. Data regarding damage to the Medical Care System in India could not be accessed.

There is abundant evidence that the trimodal distribution of deaths from traumatic injuries occurred in each of the five countries.4,5 Evidence supports the fact that many of the persons who died as a result of the events, did so immediately (Phase I of the distribution of deaths related to trauma) and did not present to a medical facility for care only to succumb after reaching the medical facility (Phase 2). However, given the reports of the number of injured that constituted the injury burden on the medical facilities, an unknown number of persons who were severely injured were transported to medical facilities and died following their arrival. In Phase 2, required supplies and personnel were limited and the victims’ injuries were severe. And, after a gap of a few days, many complications developed from these injuries (Phase 3), such as aspiration pneumonia (“tsunami lung”) and massive, heavily infected wounds. In addition, there occurred an increase in the number and severity of acute pulmonary infections and non-cholera diarrhoea, and in Aceh, an outbreak of tetanus. In the hospital that sustained the least damage in Meulaboh, Indonesia, mattresses were stolen from the hospital wards.

Economic estimates of the damages were in the millions of US dollars with Indonesia approaching US$ 100 million, more than double that of Sri Lanka (US$ 40 million). The amount of money pledged and donated far exceeded the estimated costs of the damage. These estimates do not include those costs encumbered by the need to educate and train healthcare staff to replace the personnel killed, incapacitated, or who did not return to service for other reasons.

Changes in functions
As is apparent from the previous discussion of the pre-event status, the baseline Medical Care Systems in Indonesia, Sri Lanka, and the Maldives were only marginally able to provide routine care to their respective populations during normal times. This particularly was the case in the northeastern districts of Sri Lanka and in Aceh province of Indonesia, which witnessed inter-human violence prior to the earthquake and tsunami.

Many of the healthcare facilities, including their equipment, and supplies were damaged or destroyed (Table 11.5). Personnel were killed or injured, and/or survivors needed to search for missing loved ones, and/or attempt to deal with the grief of the loss of loved ones, and/or needed to tend to family and friends. These needs severely compromised the ability of the healthcare system to provide healthcare services to the stricken population. For example, only 25% of the staff in hospitals and facilities in Sri Lanka that remained structurally able to function at some level, reported for work during the first five days following the earthquake and tsunami. In the Meulaboh hospital in Aceh province, only four of 14 doctors and 18 of 120 nurses reported for duty. Together with the looting of equipment, such as mattresses, only
15 of its 100-bed complement could be staffed, and thus, it only was possible to operate three of its eight wards. Such was not the case in Thailand, where sufficient staff was available not only to staff the hospital, but also to form teams that were deployed into the field.

The normal levels of function of the Medical Care System were compromised further by the loss of electrical power and consequently, the loss of refrigeration, which have been well-documented for Indonesia and Sri Lanka. In addition, supplies of clean and potable water were limited, especially in Indonesia, in general, and Aceh province, in particular. The inadequate supplies of medications and other medical supplies to meet the medical needs of the victims were accentuated by the damage to the storage facilities and their contents.

Thus, in all the areas impacted by events (except Thailand), the sustained damage compromised their buffering capacity, i.e., the ability of the Medical Care System to provide routine, day-to-day care of the sick and injured. Even if the events had not created a huge surge in injured, ill, and dead, the Medical Care System would have faltered, and assistance from outside the areas impacted would have been required, whether from neighbouring provinces, the central government, or the international community.

The additional burdens imposed by the injured, ill, and dead that resulted from the tsunami (Phase 2) further overwhelmed what remained of the medical systems. These burdens have been compared in the preceding chapter and are summarized in Tables II.6. The numbers provided by country are indicative of the respective burdens placed on the Medical Care Systems of the countries as a whole. Thus, the greatest burdens of the injured on the respective countries were in the Maldives and Sri Lanka. Given the geography of the Maldives, the distribution of the persons with injuries presented a special challenge of access. Yet, the number who succumbed to their injuries is remarkably small given the number of persons who sustained injuries and survived. In the Maldives, the number of survivors/10 000 population who had sustained injuries outnumbered the dead by 6.5 times. This ratio was reversed for India, Indonesia, and Sri Lanka.

However, the injury burdens noted for the specific areas, provinces, or territories were enormous when compared to the total population of each country. The injury burden for Aceh province was 60 times greater than for Indonesia as a whole. And, the death burden was 45 times greater for Aceh than for all of Indonesia. Moreover, the injury burden for the Andaman and Nicobar islands was almost 600 times that for India, and was the second highest amongst the countries (second only to Aceh); the injury burden for the Tamil Nadu state of India was seven times that of the entire country.

In addition to being overwhelmed with injured victims, it was customary for the rescue workers, relatives, and neighbours to bring the dead victims to the hospitals. Thus, the burden of the dead also had to be managed at the medical facilities, which diverted very scarce resources from other, more medically appropriate tasks.

Furthermore, the numbers of internally displaced persons (IDPs) and IDP camps that were established suddenly placed an additional strain on the profoundly compromised Medical Care Systems. At some time following the events, up to 900 000 persons (4.5% of the total population of Sri Lanka) were in IDP camps or with relatives or friends. For Aceh province and for the Maldives, the IDPs comprised one-tenth of their total population. This represented a huge shift in the location of patients and represented another challenge for both the Medical Care and Public Health Systems. Additionally, crowds accumulated at the medical facilities demanding information on their missing loved ones. And, many flocked to the medical facilities as they were considered to be safe havens.

All of these factors were compounded further by failures in the other basic societal systems upon
which the Medical Care System is dependent and/or interdependent. Available inventoried supplies could not be transported because Transport and Logistics Systems initially were paralyzed and later inadequate. Food and potable water were difficult to obtain, and so on. Each of these factors/systems that apply to the Medical Care Systems is discussed in their respective chapters.

As a result of damage to storage facilities and the huge surge of injured and ill, there was an acute shortage of medical supplies, e.g., medications for the chronically ill, antibiotics, and for Indonesia, tetanus immunoglobulin. The numbers of mechanical ventilators were critically inadequate and were unavailable for many victims suffering with tetanus or tsunami lung. It is not known how many victims perished because they could not be provided with essential ventilatory support.

It must also be noted that the reported numbers of injured do not include the numbers and severity of those who suffered/developed psychosocial problems. This additional burden is discussed in Chapter 17 (Social Systems).

In terms of available buffering capacity of the Medical Care System, Thailand differed from the other countries. Thailand’s burden of injuries (8457 persons) was the second lowest for the countries. The exception to this was on Phi Phi island where 600–700 persons were injured and the hospital was destroyed. Overall, it appears that the Medical Care System in Thailand was able to buffer the burden created by the thousands of persons injured. But, this must be viewed in the light of the fact that Thailand had, by far, the lowest burden of injured of the five countries.

Given all of these factors, there undoubtedly occurred many potentially preventable deaths due to failures of the Medical Care System. However, it has not been possible to sort the unpreventable deaths that occurred from those that potentially could have been prevented if adequate medical care had been provided earlier, or if augmented response capacities had been implemented as part of disaster preparedness at all levels.

The numbers of mechanical ventilators were critically inadequate and were unavailable for many victims suffering with tetanus or tsunami lung.

Given the damage sustained from the tsunami and where appropriate, from the earthquake, it is clear that the ability of the areas impacted to absorb the substantial surge in the burdens created by the injured, by the huge population displacements into crowded settlements, and by the arrival of dead bodies at the hospitals was severely limited. Generally, there was little available buffering capacity of the Medical Care System to the damage sustained from the events and almost no response capacity was available to successfully mitigate any surge. The damage sustained compromised the ability of the Medical Care System in each of the countries to provide medical care even at pre-event levels.

Relief responses

The relief phase of the disasters will be compared using the following sub-phases: (1) Immediate (first week); (2) Intermediate (1 week to 1 month); and (3) Late (≥ 1 month). Recovery interventions will be discussed in the next section of the Medical Care Systems. These are sub-phases are not intended to coincide with the trimodal distribution of deaths due to trauma-induced injuries.

It is important to note that neither the Indian nor the Thai governments requested outside (international) assistance for medical care relief activities. These countries believed that their resources were adequate to manage the medical care aspects of the disaster. Eventually, India accepted assistance in the Recovery phase. As best it could, Thailand rigidly limited services and goods offered only to what it really needed. It must be noted that although a host of interventions were provided, there is very little information available relative to the impacts of specific interventions on the affected populations.

Immediate relief responses (< 1 week)

The immediate relief sub-phase lasted for the first week after the events. The primary injuries that presented for care were near-drowning and deep, contaminated wounds often with substantial haemorrhage, fractures, crush injuries, and injuries due to blunt trauma (see Table 10.9).
Life-saving activities were provided by local medical care professionals and the lay public on the day of the events. This is consistent with most of the reports from other disasters. Except for Thailand, no outside assistance was provided in any of the countries during the first day. Thailand responded in accordance with its national Disaster Mass-Casualty Plan with responding professionals from areas immediately reaching the area impacted.

Both the injured and many of the dead were transported to the medical care facilities by any available means of transport. Thus, the severely compromised Medical Care System was overwhelmed by the surge of the injured victims, the dead, and the families/friends of the missing, as well as by onlookers.

Every available effort was made to care for the victims in very austere circumstances. On Phi Phi Island, where the hospital was badly damaged, the remaining hospital staff set up evaluation and treatment facilities in a nearby hotel. The staff concentrated on caring for those who were bleeding, but did not have the resources to treat the victims of near-drowning who presented to the makeshift facility. Actions such as these are likely to have occurred at all of the medical facilities directly impacted, and are representative of good triage practices given the severe limitations of staff, equipment, and supplies. Under different circumstances, many of the victims who were alive in the field or upon arrival at a medical facility possibly may not have died as a result of the events. Much of the life-saving that could be accomplished was completed during the day of the events or within a very few days after the events.

In the Thai provinces of Phang Nga and Krabi, the hospitals dispatched teams to the field to treat as many of the victims as possible on-site, and to triage the less severely injured to its primary health centres. This helped to relieve much of the rush at the hospitals. In addition, the head nurse in the primary hospital assumed the responsibility for triage. This response had been outlined in the hospital’s Mass-Casualty Plan and had been practiced within one month before the event.

The arrival dates of the first outside assistance in the form of personnel, equipment, and supplies, as best could be identified, are listed in Table 11.8. The earliest assistance to the areas impacted originated from the neighbouring area within the country and, generally, began during the 1st or 2nd days following the events. Many of the professionals who arrived were prepared to provide life-supporting interventions. However, in most circumstances, all that could be done for most of the life-threatened victims either had been accomplished already, or the victims had died. Most of the services provided by relief personnel consisted of supplementing the severely compromised routine care that no longer could be provided by the crippled local Medical Care System.

Unfortunately, it has not been possible to identify the number of injured victims who succumbed after reaching a medical facility or when they died or what medical interventions were administered. This would have been helpful to gain an understanding of the impact that medical relief and care may have had in the affected countries and would have provided clues to the number and types of patients who potentially could have been saved by provision of timely medical care.

As noted previously, the burden to the severely damaged healthcare system created by the injured was the greatest in Aceh province (Table 11.7). The burden on the hospitals and other medical facilities created by injured victims, was compounded by the burden of the dead as seemingly, many of those accounted as dead, died after they had made contact with the Medical Care System. On 27 December, the Indonesian government provided 4 tons of medical supplies that were used in the delivery of basic healthcare services. On 28 December, the government sent more than 100 nurses to supplement the remaining nursing staff in Banda Aceh. On 29 December, doctors from Jakarta were sent to the impacted area. The next day,
(four days after the events), six field hospitals were set-up in Aceh province: three provided routine medical care to bolster lost services in Banda Aceh; one provided care in Sgili; one provided care in Aceh Timor; and one provided some of the services lost with the destruction of the military hospital in Meulaboh. Also, on 30 December a medical team from Australia arrived in Aceh province. Throughout this period, the Indonesian military had been providing basic first-aid care, some medications, and wound dressings. It set up operations in one of the two damaged hospitals in Banda Aceh (and eventually the other as well) that had been damaged by the earthquake. The military added an electric generator and later repaired the defunct hospital generator and added a water purification system. On 31 December, a medical relief team from Singapore arrived in Aceh province. Records that could document the impact of these relief activities cannot be found.

In India, assistance from neighbouring states began to arrive in the impacted area on 28 and 29 December. Generally, this assistance arrived too late to provide life-saving care. Many survivors were evacuated to hospitals that were further inland and not damaged. The central government of India sent 278 medical teams into Tamil Nadu and helped to establish 96 relief camps.

The Andaman and Nicobar Islands experienced the second highest burden of injured and dead among the impacted countries. It seems apparent that the same observations noted above for Banda Aceh also occurred in these islands. Left on their own for 2–3 days with limited medical personnel and supplies, the islanders cared for as many of the victims as possible. Many of their facilities were damaged; the remaining healthcare personnel attempted to set up alternative treatment sites. Despite the arrival in Port Blair of a naval ship with supplies on 27 December, most of the supplies did not reach the heavily damaged areas for an additional 2–3 days. Some of the severely injured victims on the islands were evacuated to Port Blair when transportation facilities became available or on the return trip of a vehicle that was used for providing the supplies. Telemedicine services that were available to many of the islands before the events were re-established on 27–28 December.

The experiences in the Maldives were quite similar to those experienced in the Andaman and Nicobar islands with one notable difference: a very low mortality burden and a very high burden of injured survivors. Efforts in many of the atolls were directed to moving the injured by boat to areas in which medical care was available. Importantly, the only tertiary care hospital in the Maldives (in Malé) was only minimally damaged and continued to function. Also, many of the injured victims in the Maldives were tourists who generally sought medical care in the private hospitals in Malé. Some 80 injured tourists were registered in the private hospitals in Malé.

The Maldivian government began delivery of medical supplies to the atolls during the day of the precipitating events. These supplies were transported by the National Security Force (military). WHO-SEARO, UNFPA, and the ICRC provided additional supplies and volunteers.

Although the medical infrastructure of the impacted areas in each of the countries sustained severe damage, and many medical personnel either were killed or injured or did not report to work for personal reasons, the primary relief efforts were delivered by local medical personnel. Supplies were short. Assistance came from neighbouring districts, but generally arrived too late for life-saving interventions. The central government of Sri Lanka dispatched additional doctors from Colombo. The first foreign personnel did not arrive in Sri Lanka until 28 December. By 31 December, 158 foreign medical personnel within 15 medical support teams were on the ground in Sri Lanka. They brought with them additional supplies, some of which were not needed during the immediate sub-phase of the relief responses, as Sri Lanka was able to provide most of the medical supplies required during this sub-phase of relief.
Coordination of the activities of these teams and their dispatch presented substantial difficulties to the Sri Lankan government. Many of the severely injured victims and those that had developed complications had been transferred to the teaching hospitals outside of the area impacted by the tsunami.

In summary, in all instances, initial relief responses were provided by the locals. All of the early relief responses were impaired substantially by the gaps created in the ability of the Medical Care Systems to provide routine day-to-day care. Generally, outside assistance arrived too late to provide life-saving care, and primarily was used to fill the huge gaps left in the Medical Care Systems by the loss of infrastructure and personnel. Initially, all the countries (except Thailand) were short of supplies needed for the immediate care of the injured. Other than Aceh province, which bore the major brunt of the earthquake and tsunami, the populations on the islands experienced the greatest immediate problems due to logistical difficulties in providing assistance.

**Intermediate relief responses (1 week to 1 month)**

Essentially, the *intermediate* sub-phase of the relief responses to this disaster focused on the treatment of complications from the injuries sustained directly or indirectly from the events, and on restoration of the services that had been available before the events struck. Importantly, this sub-phase was marked by a huge influx of external relief responders and the delivery of massive quantities of supplies and equipment into the impacted areas.

Day-to-day medical care had to be provided by and for the personnel arriving from outside the affected areas as the basic Medical Care System was severely crippled by the loss of personnel and infrastructure. Information relative to patient loads and the care of patients with chronic diseases and acute emergencies has not been found. For example, it is not known if the incidence of acute coronary syndromes changed following the earthquake and tsunami. Further, it is not known whether the incidence of diabetic problems or the availability of essential drugs for those with chronic diseases, such as congestive heart failure, pulmonary failure, attacks of asthma, and other conditions routinely managed by the medical facilities compromised the health of patients following the events (indirect consequences). There is increasing evidence that the indirect toll following such events may exceed those related to the direct effects. Added to the usual patient loads were increases in the development of acute respiratory infections and non-cholera diarrhoea. The incidence of other infectious diseases following the earthquake and tsunami did not increase in any of the countries and no medical interventions were required for such problems (Chapter 10).

Major complications from the injuries sustained during the events included the development of aspiration pneumonia, pulmonary failure such as Adult Respiratory Distress Syndrome (ARDS), acute renal failure, severely infected wounds, and, in Indonesia, the presentation to the medical facilities of more than 100 victims who had developed tetanus. There was a shortage of mechanical ventilators and of tetanus immunoglobulin. In some instances, tetanus vaccinations were used in the treatment of tetanus victims. Nineteen percent of the patients that presented with tetanus succumbed to the disease. It is not known how many additional cases of tetanus were not able to get to the medical facilities for treatment, died due to the disease.

Antibiotics used for the treatment of aspiration pneumonia and infected wounds often were in short supply or were used inappropriately. Many of the infected wounds to extremities mandated amputations.

In general, the affected countries were inundated with responders, supplies, and equipment. Many of the responders arrived believing that they would be confronted with patients with severe traumatic injuries. However, this was not the case; the greatest need was for the provision of...
routine medical care. By 29 December, there were more than 700 volunteers attempting to work in the affected areas of Sri Lanka. And, by 12 January, there were at least 600 expatriates in at least 70 different teams trying to provide assistance. Many of these personnel did not register with the Sri Lanka Medical Council, as was required by the laws of Sri Lanka. Coordination of these relief responses became a major problem and much duplication of efforts occurred. Although a glut of drugs was donated and sent, many of them were not needed.

On 30 December, five emergency health kits arrived in the Maldives, supplemented by five more on 6 January. One hundred rehydration kits and 10 surgical kits arrived on 4 January. Japan supported the relief efforts by supplying an emergency hospital on Muli atoll. Canadian donors sent 605 drug and medical kits. The ongoing arrival of people and supplies often created a logistical nightmare including a glut of materials at airports without transport capabilities for distribution or disposal. In January, the government of the Maldives issued a statement that unneeded/unrequested supplies no longer were welcome. UNFPA sent supplies and equipment to be used for the transport of pregnant women to facilities to birth their babies. In January, the Maldivian Ministry of Health did request equipment and supplies for the treatment of acute pulmonary infections and failure including 80 oxygen concentrators, 120 mechanical ventilators, and 20 respiratory infection timers.

Three hospital ships (one from the US, one from India, and one from Germany) arrived off the shore of Aceh province. The first to arrive in January was the USS Lincoln—an aircraft carrier that had limited medical capabilities and capacity, but did provide helicopter transport for supplies and personnel. The 45-bed Indian hospital ship arrived on 4 January, and the 22-bed German ship arrived on 12 January with four surgeons, an anaesthetist, an operating theatre, and staffed intensive care beds. These facilities supported the routine care for the Aceh population and provided care for some victims suffering complications from the injuries sustained. Unfortunately, the ships were unable to dock and the patients had to be transported to and from the ships.

Although several field hospitals were set up in Indonesia and Sri Lanka, little has been found to demonstrate the utility and impact of these facilities. Indicators of the activities of the hospital ships off the coast of Sumatra primarily consist of indicators of achievement such as the number of cases seen, procedures accomplished, etc. No reports were found of the impact of the temporary medical facilities for relief for the affected population.

Hundreds of non-governmental, humanitarian organizations responded to Aceh. Basically, there was no attempt during the intermediate relief phase to check and verify the credentials of the persons or the organizations that arrived to provide support. Major problems were encountered with the coordination of their efforts. Consequently, despite the excellent services that most provided, there was substantial duplication; patients were shifted back and forth between facilities and tracking and medical records were incomplete.

Among the personnel who responded were many physicians—actually, too many physicians. For example, on 16 January, there were 21 surgeons in the Meubaloh Hospital compared to only two surgeons pre-event. However, there continued to be a shortage of nurses in this hospital; 120 nurses staffed the hospital pre-event, while only 70 nurses were available in the hospital on 16 January. Consequently, the hospital could not function at pre-event levels, even with the augmented physician staff. The discrepancy between the numbers of physicians and nurses was general throughout the impacted areas of Indonesia; there was a glut of doctors and a shortage of nurses. Many of the doctors and nurses who responded were tertiary-care oriented and were not trained as primary care staff.
Although the governments of India and Thailand did not request supplemental medical personnel, Thailand requested supplemental forensic pathologists to assist with the identification of the dead. Thailand’s relief responses also were different from those of the other countries. For one, all of its facilities had mass-casualty plans. Additionally, the areas of Thailand impacted by the tsunami were major tourist areas and more than half of those killed or injured were expatriates. By 28 January, most of the non-Thai, and 50% of all hospitalized victims, had been transferred to hospitals in Bangkok or other tertiary care facilities. Many of the foreign injured victims were transferred to their respective countries, generally using transportation provided by their countries. For example, the Norwegian military conducted five flights for the repatriation of Nordic citizens. Within two weeks of the events, all of the victims either were discharged from the hospitals or had been transferred to higher-level care hospitals. Although the coordination of national resources at times was weak, by 9 January, more than 90 000 patients had received medical and/or mental health care in Thailand: more than 80 000 were treated by mobile teams; 9798 were treated in outpatient facilities, and 2230 were treated as inpatients with 398 receiving intensive care and 1230 undergoing major surgical interventions. Although it was not possible to identify the burdens caused by IDPs in Thailand or even the number of camps, apparently clinics were established in each of the IDP camps in Thailand.

In summary, although the injury burden was not as great in Thailand as it was in the other countries, relative to the other countries, its Medical Care System performed well. There were mass-casualty plans in place and they had been exercised. Furthermore, the record-keeping and availability of records were far superior to those available from the other countries. However, it must be remembered that the burdens were not as great in Thailand, and it only can be guessed as to how well the Thai Medical Care System would have performed had the burdens been greater.

**Late relief responses (≥ 1 month)**

Following the intermediate sub-phase of the disaster, the influx of personnel, supplies, and equipment continued. The Aceh provincial government requested that WHO-SEARO assist with the coordination of all of the humanitarian health-related NGOs and their personnel, equipment, and supplies. The level of supplies reached extraordinary levels. Ultimately, Indonesia received 400 tons of supplies that were provided by at least 140 different donors. Of the drugs received, the majority were not on the national needs list and three-quarters of them were labeled in languages not familiar to those sorting the supplies. In addition, one-quarter of the donated medications already had expired before they arrived. The disposal of this material cost the Indonesian government at least US$ 3.2 million. In addition, storage of the donated supplies overwhelmed the storage facilities of the government and of the hospitals. Hospitals had to close offices and other areas to accommodate the donated materials. In Aceh, the medical relief teams tended to station themselves in the more populated areas and little medical assistance reached the rural areas. Most of the patients evaluated and treated by the medical relief teams were suffering from non-tsunami-related maladies. Furthermore, the country’s overall standard of routine medical care was pushed to a level beyond that which had existed pre-event making it difficult, if not impossible, to sustain after these teams departed.

The USS Mercy hospital ship provided medical support off the coast of Aceh province from 2 February through 16 March 2005. Despite the fact that patients had to be transported to and from the ship, which could not dock, the well-equipped and staffed floating hospital provided more than 19 000 procedures on more than 9500 patients. Of these, less than 10% of the chief complaints were related to the tsunami. However, the ship did provide some of the medical care that could not be provided by the decimated Aceh Medical Care System. Similarly, this standard of care provided by the staffed and
equipped hospital ship could not be sustained by the province following its departure.

Overall, the medical relief teams brought too many physicians and too few nurses. Often, the expatriate staff displaced surviving local healthcare staff.

Similar scenarios occurred in Sri Lanka. Within five months of the tsunami, 3500 truckloads of medications were received, much of which neither was needed nor requested by the Sri Lanka government. Again, most of the drugs received were unusable, required sorting, were labeled in foreign languages, and two-thirds were more than one year past their expiration date. The government had to spend a considerable amount for safe disposal of 150 tons of unneeded, unusable drugs. Thus, the amounts of medical equipment and supplies placed an additional burden on the medical facilities for storage, sorting, re-labeling, and disposal. As with the other countries, the Maldives also experienced relief overload. Staff and supplies were provided by UNFPA and donor governments. Late relief interventions in Thailand and India were managed internally. No information has been retrieved about the contributions and on the expatriates who came to either country.

In summary, the late sub-phase of the relief responses was marked by the provision of large quantities of equipment and abundant (maybe excessive) supplies of personnel. Some of the medical care provided by these resources attempted to fill the gaps in primary and secondary care that could not be provided by the remaining local staff and facilities. Some of the care provided was at a level that could not be sustained once the expatriates departed. Some of the excessive and inappropriate and often expired supplies had to be disposed by the local/national governments at considerable expense. Eventually, each of the countries limited further external “assistance” only to that required to meet the needs that could not be met locally.

Recovery responses

The transition from relief to recovery from the ravages of the earthquake and tsunami has been difficult to define. Much of the recovery effort was provided by NGOs, and it has been difficult to access and evaluate their respective contributions to recovery (i.e., return to the pre-event status). During the first 2–3 years following the tsunami, only a few details of recovery efforts have been published. This is unfortunate as rebuilding a stricken society is of prime importance. In fact, the hope as expressed by the former US President Clinton, was that “we should build it back better”.9

Recovery has consisted not only of restoring or replacing the physical structures, but also restoring the functional capabilities and capacities of the Medical Care System. Such capacities include recruiting, educating, and training medical care personnel to assume the roles of those killed or injured. Each of the countries has sponsored education and training programmes in an effort to restore the medical care workforce. The extent and success of these programmes could not be assessed in this review. The Maldives recruited 23 expatriate physicians during the relief period and encouraged them to remain for a period of at least one year; at least 15 of these physicians remained in the Maldives past the one year period. This retention contributed to the development of the medical care system of the Maldives.

Germany donated US$ 6.5 million to the Maldives to be used for recovery. By 2007, German resources were responsible for the building or repairing of 24 damaged or destroyed medical care facilities in the country.

As noted in the preceding chapter, the number of IDPs in camps and the number of IDP camps declined progressively following the tsunami. People left the camps to return to their previous habitats or to other locations, and some may have moved to other occupations. This is discussed further in the shelter and clothing sections.
One major issue occurred in Indonesia and in Sri Lanka. When the relief responses were concluded and many of the NGOs had departed, the levels of care that had been available during the relief phases could not be sustained by the locals. As world interest dissipated after the acute emergency was managed, it became difficult to get personnel to remain. More financial resources were donated to support the relief and recovery efforts than ever had been accumulated for disaster relief and recovery. Data about personnel educated and trained to assist in the return of the affected societies to the pre-event state are not available, and recovery of the Medical Care Systems has not been complete at the time of this writing.

**Development**

A major advance for disaster preparedness in the South-East Asia Region was accomplished through initiatives developed by WHO-SEARO. During the first of two meetings following the earthquake and tsunami, a set of 12 standards to be achieved by each of the countries in the Region were developed and mutually endorsed by the participants from the 11 countries impacted by the events. These standards are provided in Chapter 22, Coordination and Control. During this meeting, each of the countries identified its current status relative to each of these standards. At a subsequent meeting convened by WHO-SEARO, each country reported on progress towards each of the defined standards. Substantial progress was documented by each of the countries in at least some of the established benchmarks.

In a subsequent initiative, WHO-SEARO was able to obtain consensus on the development of an Emergency Relief Fund. The funds are kept in reserve and are to be made available to an affected country for use in purchasing medical and public health emergency relief supplies. Each of Member State has contributed to this Fund. Portions of these funds were used following the Bangladesh floods and the cyclone that devastated parts of Myanmar.

Also, for the record, the WHO donated two ambulance boats to serve the islands in the Maldives. In each of the countries, resources have been invested in the development of EMS systems.

**Summary**

The Medical Care System in each of the affected areas of the countries (except Thailand) was severely damaged and the ability to provide even routine medical care was compromised. Outside assistance served primarily to fill gaps in the delivery of routine, daily care. In some instances, the level of care provided could not be sustained when the assisting agencies departed. Some of the supplies donated were not useful, and had to be managed and disposed by the host countries.
References


10. World Health Organization: Regional Office for South East Asia: Regional Meeting on Health Aspects of Disaster Preparedness and Response. Prehosp Disaster Med 2006;21(5);s62-s78.

**Figure 11.1:** Neonatal mortality rates as a function of the proportion of births attended by skilled personnel.

**Figure 11.2:** Maternal mortality rates as a function of proportion of births attended by skilled personnel.

**Figure 11.3:** Numbers of health facilities in Aceh province of Indonesia damaged/destroyed by the earthquake and tsunami of 26 December 2004.

**Table 11.1**: Healthcare facilities damaged or destroyed in four districts in Aceh province.

<table>
<thead>
<tr>
<th>India</th>
<th>Indonesia</th>
<th>Maldives</th>
<th>Sri Lanka</th>
<th>Thailand</th>
</tr>
</thead>
<tbody>
<tr>
<td>National States (28) and Territories (7)</td>
<td>National Provinces (27)</td>
<td>Atolls</td>
<td>Provinces (8)</td>
<td>Provinces (75)</td>
</tr>
<tr>
<td>Districts</td>
<td>Districts</td>
<td>Districts</td>
<td>Districts</td>
<td>Districts</td>
</tr>
<tr>
<td>Sub-Districts</td>
<td>Sub-Districts</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Municipalities</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cities/Villages</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Data from 2005;


**Table 11.2**: Medical facilities in descending order of capabilities in each of the five countries

<table>
<thead>
<tr>
<th>Level of Care</th>
<th>India</th>
<th>Indonesia</th>
<th>Maldives</th>
<th>Sri Lanka</th>
<th>Thailand</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tertiary</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Urban hospitals</td>
<td>Hospitals</td>
<td>Central hospital</td>
<td>Provincial hospitals</td>
<td>Bangkok hospitals</td>
<td></td>
</tr>
<tr>
<td>District Hospitals (some attached to medical colleges or located in large cities)</td>
<td>Teaching Hospitals</td>
<td>Regional Hospitals</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Military Hospitals</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Provincial Hospitals</td>
</tr>
<tr>
<td>Secondary</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>District hospitals</td>
<td>District hospitals</td>
<td>Regional hospitals</td>
<td>District hospitals</td>
<td>Provincial hospitals</td>
<td></td>
</tr>
<tr>
<td>Community Health centres</td>
<td>Primary Health centres</td>
<td>Atoll Hospitals</td>
<td>General Hospitals</td>
<td>10-bed Hospitals-Bangkok</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Rural Hospitals</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>District level Hospitals</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Peripheral Units</td>
</tr>
</tbody>
</table>
## Table 11.3: Pre-event status of healthcare personnel and hospital beds

<table>
<thead>
<tr>
<th>Indicator</th>
<th>India</th>
<th>Indonesia</th>
<th>Maldives</th>
<th>Sri Lanka</th>
<th>Thailand</th>
</tr>
</thead>
<tbody>
<tr>
<td>Physicians/10 000 population</td>
<td>5.9</td>
<td>1.1</td>
<td>9.2</td>
<td>5</td>
<td>3.0</td>
</tr>
<tr>
<td>Nurses/10 000 population</td>
<td>8.0</td>
<td>6.5</td>
<td>27.0</td>
<td>8.9</td>
<td>15.3</td>
</tr>
<tr>
<td>Midwives/10 000 population</td>
<td>N/A</td>
<td>2.9</td>
<td>4.1</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>Dentists/10 000 population</td>
<td>0.6****</td>
<td>0.3</td>
<td>0.4***</td>
<td>0.8***</td>
<td>1.2</td>
</tr>
<tr>
<td>Health workers/10 000 population</td>
<td>?</td>
<td>13.8</td>
<td>?</td>
<td>11.6</td>
<td></td>
</tr>
<tr>
<td>Hospital beds/100 000 population</td>
<td>1.3</td>
<td>6.2</td>
<td>18.6*</td>
<td>31.0</td>
<td>21.3</td>
</tr>
<tr>
<td>Births attended by skilled personnel (%)</td>
<td>42</td>
<td>68</td>
<td>7011</td>
<td>97</td>
<td>98</td>
</tr>
</tbody>
</table>

**Sources:**
**2001 data (http://globalis.gvu.unu.edu/indicator_detail.cfm?IndicatorID=139&Country=MV)
***www.colombopage.com/archive_07February620939SL.html
****2004 http://who.int/globalatlas/dataQuery/reportData.asp?rpt/rptType=1
(N/A = not available)

## Table 11.4: Proportion of births attended by skilled personnel and maternal and infant mortality rates for each of the five countries prior to the events

<table>
<thead>
<tr>
<th>Indicator</th>
<th>India</th>
<th>Indonesia</th>
<th>Maldives</th>
<th>Sri Lanka</th>
<th>Thailand</th>
</tr>
</thead>
<tbody>
<tr>
<td>% Births attended by skilled personnel</td>
<td>42</td>
<td>68</td>
<td>70</td>
<td>97</td>
<td>98</td>
</tr>
<tr>
<td>Maternal mortality rate/100 000 live births</td>
<td>301</td>
<td>230</td>
<td>78</td>
<td>92</td>
<td>24</td>
</tr>
<tr>
<td>Neonatal mortality rate/1000 live births</td>
<td>39</td>
<td>20</td>
<td>10</td>
<td>11</td>
<td>9</td>
</tr>
</tbody>
</table>
Table 11.5: Damages sustained from the earthquake and tsunami (A+N=Andaman and Nicobar Islands; empty cells—not available; *=Banda Aceh only)

<table>
<thead>
<tr>
<th></th>
<th>India</th>
<th>A+N Islands</th>
<th>Indonesia</th>
<th>Banda Aceh</th>
<th>Maldives</th>
<th>Sri Lanka</th>
<th>Thailand</th>
</tr>
</thead>
<tbody>
<tr>
<td>Healthcare facilities damaged or destroyed</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tertiary</td>
<td>6*</td>
<td>1</td>
<td>1</td>
<td>4</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Secondary</td>
<td>7</td>
<td>2</td>
<td>31*</td>
<td>3</td>
<td>2</td>
<td>15</td>
<td>0</td>
</tr>
<tr>
<td>Primary</td>
<td>93</td>
<td>33</td>
<td>90*</td>
<td>29</td>
<td>73</td>
<td>58</td>
<td>4</td>
</tr>
<tr>
<td>Total</td>
<td>100</td>
<td>35</td>
<td>554</td>
<td>33</td>
<td>76</td>
<td>92</td>
<td></td>
</tr>
<tr>
<td>Number healthcare personnel killed</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>208</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>35</td>
<td>2</td>
</tr>
<tr>
<td>Physicians</td>
<td>7</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Nurses</td>
<td>48</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Midwives</td>
<td>49</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Support</td>
<td>104</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Injured</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>35</td>
<td></td>
</tr>
<tr>
<td>Loss of potable water</td>
<td>Yes</td>
<td></td>
<td></td>
<td></td>
<td>Yes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Loss of electrical power</td>
<td>Yes</td>
<td></td>
<td></td>
<td></td>
<td>Yes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Loss of storage facilities</td>
<td>Yes</td>
<td></td>
<td></td>
<td>Yes</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Monetary losses (US$ millions)</td>
<td>US$ 92.4</td>
<td>US$ 12.2</td>
<td>US$ 60.5</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 11.6: Burden of killed, injured, and displaced by country and areas impacted

<table>
<thead>
<tr>
<th></th>
<th>India</th>
<th>A+N Islands</th>
<th>Tamil Nadu</th>
<th>Indonesia</th>
<th>Aceh province</th>
<th>Maldives</th>
<th>Sri Lanka</th>
<th>Thailand</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number injured survivors/10 000 population</td>
<td>0.07</td>
<td>41.80</td>
<td>0.49</td>
<td>6.54</td>
<td>393.12</td>
<td>26.33</td>
<td>11.94</td>
<td>1.53</td>
</tr>
<tr>
<td>Number killed/10 000 population</td>
<td>0.10</td>
<td>98.67</td>
<td>1.25</td>
<td>6.9</td>
<td>314.71</td>
<td>4.0</td>
<td>18.0</td>
<td>1.0</td>
</tr>
<tr>
<td>Number displaced/10 000 population</td>
<td>5.89</td>
<td>20.66</td>
<td>1025.64*</td>
<td>985.90</td>
<td>4663.21</td>
<td>4.0</td>
<td>18.0</td>
<td>1.0</td>
</tr>
</tbody>
</table>

*Banda Aceh only
Table 11.7: Arrival dates of outside assistance

<table>
<thead>
<tr>
<th>Early relief interventions</th>
<th>India</th>
<th>A+N Islands</th>
<th>Indonesia</th>
<th>Aceh</th>
<th>Maldives</th>
<th>Sri Lanka</th>
<th>Thailand</th>
<th>Phi Phi Island</th>
</tr>
</thead>
<tbody>
<tr>
<td>Day of the event – by local citizens and professionals</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Arrival of 1st medical support from within the country</td>
<td>28-29 Dec</td>
<td>27 Dec</td>
<td>27 Dec</td>
<td>29 Dec</td>
<td>26 Dec</td>
<td>27 Dec</td>
<td>26 Dec</td>
<td></td>
</tr>
<tr>
<td>Arrival of 1st medical support from outside the country</td>
<td>None</td>
<td>29 Dec</td>
<td>29 Dec</td>
<td>30 Dec</td>
<td>30 Dec</td>
<td>28 Dec</td>
<td>None</td>
<td></td>
</tr>
</tbody>
</table>
Part IV
Analysis
Chapter 12
Water and Sanitation (WATSAN)
Introduction

Water and sanitation are basic needs in all societies. Water and sanitation are tightly intertwined and can be considered as subsystems of the overarching Water and Sanitation System. This basic societal system is also heavily inter-dependent upon many of the other Basic Societal Systems, including: (1) Public Health; (2) Transportation and Logistics; (3) Food and Nutrition; (4) Energy Supply; and several others.

Water is essential for life. The supply of water has a critical threshold below which survival is not possible. This critical threshold varies by location; for example, the need for water in the Sahara desert will be greater that in Alaska. Furthermore, the functional thresholds vary across the globe. In some areas, the functional threshold and critical threshold nearly are superimposed, while in other areas, the functional threshold may be substantially higher than the critical threshold.

Highly developed societies have a very high functional threshold as societal services provide sufficient water for many functions that are not common in developing societies. The functional threshold for water also is related to the culture, traditions, and climate of the area.

The Water and Sanitation Systems are linked closely with the Public Health System, and often, water and sanitation functions are considered as sub-functions of public health. Whereas public health is charged with monitoring the quality (content) of the water provided and assuring that the basic needs of a population are being met, it does not have the responsibility for the actual provision of the water—the supply actually is an output of the Water and Sanitation System. The Public Health System has the responsibility for assuring that the sanitary conditions of society are being met and that any impaired functions of the sanitary subsystem do not affect the health of members of society. Public health can negotiate with the Water and Sanitation System on how sanitation should be maintained and/or improved, but is not responsible for making it happen—it does not dig the latrines or empty the septic systems. Sanitary engineering is not part of public health, but the outcomes of sanitary sub-systems must meet the criteria established by Public Health. Contaminated water supplies and/or mishandled sanitary conditions can produce serious diseases and even death. It is important to note that lack of water and sanitation is the biggest threat to human health during a disaster.

Although the Basic Societal Systems are interdependent, as well as dependant on each other, for the sake of evaluation and analysis, these systems must be considered as separate, but highly interdependent systems. The water system is interdependent with the Public Works and Engineering System that is responsible for the mechanics of developing, constructing,
maintaining, and modifying infrastructure and the processes associated with supplying potable water. Thus, the Water and Sanitation subsystems will be considered separately. Furthermore, the pre-event status of water and sanitation within the five countries differed substantially from each other as did the nature of the precipitating and secondary events.

**Water**

The critical threshold for water is estimated at 2-4 litres/day for adults.¹ The Sphere Project Guidelines note that:

> Water is essential for life, health and human dignity. In extreme situations, there may not be sufficient water available to meet basic needs, and in these cases supplying a survival level of safe drinking water is of critical importance. In most cases, the main health problems are caused by poor hygiene due to insufficient water and by the consumption of contaminated water.

Everyone has the right to water. This right is recognized in international legal instruments and provides for sufficient, safe, acceptable, physically accessible and affordable water for personal and domestic uses. An adequate amount of safe water is necessary to prevent death from dehydration, to reduce the risk of water-related disease and to provide for consumption, cooking, and personal and domestic hygienic requirements.¹

Thus, everyone has the right to a sufficient amount of water that is safe, acceptable, physically available, and affordable. The average water use for drinking, cooking, and personal hygiene in any household is at least 15 litres/person/day.¹ The basic needs for water for an adult human as agreed in the Sphere Project are summarized in Table 12.1. The critical threshold is 2.5 to 3.0 litres of water/day/adult person and varies with the level of activity and climate. Failure to access this amount of potable water ultimately results in death due to dehydration. Thus, the Crude Mortality Rate (CMR) of the affected population increases when the critical supply is not met. Estimates indicate that without access to any water, death will ensue within three to eight days.²,³ Most hold that death from dehydration with absolute water deprivation will begin to occur at about three days, though there are examples of death occurring at eight days. Failure to access adequate water supplies results in an inability to perform the tasks listed in Table 12.1.

As the supplies of water fall, the ability to perform the tasks noted in the table progressively become compromised. Clearly, as the water supplies decline, the tasks listed must be abandoned. The reverse also is true as the supplies of available water increase. It is important to appreciate that during normal times, some societies operate just at or slightly above the critical threshold. As noted, in order to perform the important tasks of life, a minimum of 15 litres/person/day is required.

Progressive dehydration results when the intake of water is less than the loss. Some of the symptoms associated with progressive dehydration are listed in Table 12.2.²,³ Thirst generally is the first symptom; inability to perform routine tasks may occur with only a 2% level of dehydration. At 4% dehydration, emotional instability may occur. Often, this results in abnormal and aggressive behaviour that may result in interpersonal violence, a very undesirable behaviour in a disaster situation. Thus, the rapid provision of potable water to at least critical threshold levels is essential.

The distribution of the available water is an important consideration in meeting supply needs. While some portions of the population may have access and use 15 litres/person/day, others may not even have access to the 2.5 litres/person/day required for survival. The quality of the water also is important. Contaminated water results in a host of water-borne diseases that may result in increased mortality rates. Water also provides a breeding ground for water-borne infectious disease vectors.

Importantly, the amount of water required for the operations of medical facilities and other industries is not included in the critical and...
The impact of the earthquake in Indonesia and the Andaman and Nicobar Islands and of the tsunami in each of the five countries resulted in impaired water availability in the areas impacted. It is important to note that the availability and sources of the water supplies differed in each of the countries.

Pre-Events status of water supplies

Before the earthquake and tsunami struck, the availability of “improved” water varied substantially between the countries. India and the Maldives were facing water crises; neither country had sufficient buffering capacity at the time of the tsunami. The demand for water in India was increasing due to increases in population, industrialization, irrigation for agriculture, and the rapidly expanding urban population; and the quality of the water was decreasing due to poor management of waste water and other wastes. The few sources of fresh water in the Maldives were becoming exhausted and/or contaminated by sea water and wastes. The remaining three countries gradually were improving their respective water supplies and access to them.

The pre-event water situations for each of the five countries are listed in Table 12.3. Each of the countries is subjected to monsoons and wet, rainy seasons, but there are substantial variations as to when these seasons occur even within the countries. At the time that the tsunami struck, only Aceh, Indonesia and northeast Sri Lanka were within their respective wet periods. It also was the wet season for Tamil Nadu, India, since the months of December to March in Tamil Nadu are its monsoon season. For the other affected areas, the wet season had passed.

Each of the countries relied, at least partially, on groundwater as a source for their water. India and Sri Lanka were able to extract water from surface rivers and ponds, and Thailand stored water in manmade ponds and pits that were residuals from abandoned, open-pit mines. Groundwater was accessed by wells. Interestingly, Banda Aceh obtained its groundwater from wells several kilometres inland and piped it into the city where it was distributed by commercial, independent companies (up to 50% of the total supply). Shallow wells that are vulnerable to contamination from waste water and other substances were important sources of water in India and in the Maldives. The wells in India were becoming progressively salinated. The Andaman and Nicobar territorial islands also obtained water from shallow wells. Although rain was abundant during the wet season, it could not be collected as most of the roofs were thatched. However, desalinization of sea water was a major mechanism to provide water for Malé and provided almost all (98%–100%) of the water needs of that main urban area of the Maldives. Some of the water in Malé was obtained from household wells. Two other islands received portions of their water from desalinization installations. Desalination requires fuel, which had to be imported by the Maldives. Although a principal source of water in the islands and atolls of the Maldives came from the harvesting of rainwater with storage in containers and tanks, a substantial portion of the water supply had to be imported. Thus, the costs for acquisition of potable water were quite high.

Given these sources and mechanisms, Aceh province was able to meet the water needs of only 48% of its population, overall, and the Maldives, only 78%. Of its population, India was aiming to reach 85%, but the surface and ground water were becoming exhausted and increasingly contaminated. Sri Lanka provided improved water to 82% (range 74%–97%) of its population. However, while 75% of the urban population in Sri Lanka received piped water, only 14% did so in the rural areas.

The Indian government attempted to augment the water supply in the Nicobar Islands by
installing a desalination plant, but many of the indigenous inhabitants refused to use the desalinated water. Also, the resort areas in the Maldives tended to supplement their respective water supplies by using small desalination plants and importing bottled water. During the dry season, when there was a shortage of water supply in the Maldivian atolls, water was imported by boat from other, better-supplied atolls; coconut water, and/or water obtained by bucket from mosque wells located in the centre of the atolls also supplemented the low water supply.

Given the above situation, each country experienced different levels of vulnerability and ability to buffer (find alternatives) the effects of loss of sources or supplies damaged by the tsunami.

**Damage to the Water Subsystem**

The damage to the water supply infrastructure related to the earthquake and tsunami has been difficult to quantify as it is tightly intertwined with the damage to the sanitation systems. The direct and indirect economic costs of these damages for each of the countries are summarized in Table 12.4. These estimated costs include the direct and indirect costs associated with the relief and recovery efforts in each of the countries; the true economic costs are difficult to estimate. The greatest economic costs were incurred in Sri Lanka and Indonesia. Although the Maldives incurred little costs in loss of resources, the system was poorly developed and was highly dependent on groundwater from lenses, mosques, and from the harvesting of rain water. Replacement of the latter constituted a small relative amount of resources, and thus, the estimated total cost is small relative to the loss of function that resulted from the damage. But, considering the cost burdens to the countries, the greatest economic burden (cost/10 000 population) for water was in the Maldives, where it was twice that for Sri Lanka. And, the burdens in the Maldives and Sri Lanka were several times greater than for the other three countries.

Most of the damage was related to the destruction and/or contamination of the wells and aquifers with salinated water, debris, and bacteria. Additionally, water storage tanks were washed away. In the areas in which rain harvesting was an important source of water, rain harvesting equipment was damaged, destroyed, or swept away. Damage to the wells and distribution equipment was greatest along the shores. In addition, boats and other means of transportation routinely used for transporting water from islands with water to those without were damaged/destroyed. Displaced persons gathered in camps where the supplies of water were severely limited.

Unfortunately, it was not possible to find information on the number of people who died due to dehydration or infections related to the loss of adequate and drinkable supplies of water. Such deaths are part of the damage sustained by the affected societies.

**Changes in Water Subsystem functions**

As usual, the physical damage sustained did not always correlate with subsequent changes in function. Changes in function resulting from the damage relate more to the buffering capacity (ability to find alternatives) provided by the impacted society for the supply of water. All of the areas impacted in each of the countries suffered from some degree of water shortage. It is not known how much the shortages contributed to the overall mortality rate or to the burden on the Medical Care System. Initially, major shortages occurred in each of the IDP camps.

Of all of the countries impacted by the earthquake and tsunami, the population of Thailand suffered the least from the loss of water supplies; the water supply was disrupted for approximately three weeks for some 30 000 persons. In the islands and atolls of the Maldives and in the Andaman and Nicobar Islands, the shortage of water was most acute. Essentially, there was no buffering capacity available in the Maldives where the already scarce water supply was disrupted in at least 70 of its 200 inhabited islands. On 29 December, 31 of the
islands in the Maldives had no safe water sources, and still, on 2 January, 37 islands had little or no potable water, and in at least 20 of the islands, much of the water available was too contaminated for human consumption. In addition, there was a sudden shortage of containers required for the transport of water from other sources to areas in need.

In each of the countries except Thailand, much of the available water was contaminated by saline, wastewater, and open latrines. Again, this was particularly apparent in the camps. Much of the available water was unfit to drink and much of the available supply had to be boiled before it could be consumed. Where water stores had been available, such as vessels containing harvested rainwater and collected water stored in tanks, many of the vessels/tanks either were swept away by the tsunami or were severely damaged. Thus, generally, the damage created acute and often profound shortages of potable water in areas where there were little available backup supplies or alternatives to obtaining water. The shortage of potable water became an immediate, major crisis.

In many places such as in Banda Aceh, untreated water was consumed during the immediate phases. The impact of this acute shortage on the affected population could not be identified either in existing literature, reports, or through interviews. This also holds for the compromise in the functional status of the medical facilities. Water is required for many of the medical functions, and it is not known how much of the buffering capacity of the medical facilities was lost or for how long the needed water supplies were compromised, or what changes in functions resulted from the lack of water.

Monitoring of the availability and quality of the water supplies constituted a major challenge for the Public Health System.

**Relief responses in the Water Subsystem**

As generally has been the case in sudden-onset disasters, immediate responses to the shortages of potable water in each of the countries following the earthquake and tsunami, came from the affected population who sought alternative sources of water. In the Maldives, coconut water was used, or the population migrated to islands where water supplies were available, or water was transported between the islands using small boats. As the tsunami washed over many of the islands and atolls, it contaminated the water sources. Where it washed over the entire island, it also eliminated the mosque wells as a backup (buffer) source for water. The extent to which this occurred was not known as communication was interrupted between the islands. Although similar problems were encountered in some Nicobar Islands, water was transported from wells that were farther inland, and thus, were not affected by the tsunami.

In the mainland countries, when access was not possible, water was imported, usually using tanker trucks from neighbouring areas not directly impacted by the events. In these countries, the inland water sources were not damaged by the tsunami. This was especially the case in Thailand and India. In Thailand, water was transported by tanker truckload, and bottled water was transported by trucks into the areas affected. In areas that were not immediately accessible, supplies of water from outside of those areas directly impacted were delayed for at least 24–48 hours. In some of the Andaman and Nicobar Islands, no assistance with water supply was possible; hence, the supply was delayed for several weeks, as it had to be transported over long distances, and the destruction of harbour facilities also impeded the ability of ships to dock. As noted, in many places such as in Banda Aceh, untreated water was consumed during the immediate phases. The impact of consuming untreated water on the medical care and public health functions is not clear, but no increases in infectious diseases were reported, and there were no apparent increases in the mosquito population.

Relief supplies provided by outside agencies, including national governments, generally began
24-48 hours after the earthquake and tsunami struck. In most of the areas not immediately accessible by ground transport, augmented water supplies were transported by air. These services generally were provided by the government and/or military (often international) helicopters and/or seaplanes. This was the case especially in Aceh province and in devastated areas of Sri Lanka. This dependency on such transportation resources initiated a relatively new strategy for improving the use of military resources for non-conflict-generated needs. In addition, supplies of bottled and packaged water were imported to areas by ships from several countries including Singapore, India, and the United States. Supplies often were donated by humanitarian organizations including United Nations agencies (especially UNICEF, WHO-SEARO, UNDP, and OCHA), and many NGOs such as OXFAM and the IFRC. Responsibility for the coordination of these activities was undertaken by default by UNICEF, with frequent meetings of the stakeholders.

Of substantial importance is the duration that supplemental water had to be supplied from outside sources. In Banda Aceh, water had to be supplied by pipelines from wells situated further inland. It is reported that 50% of the surviving population in Banda Aceh were receiving “adequate” amounts of water within three weeks of the earthquake and tsunami. Supplemental water had to be imported into the affected areas of Thailand for approximately three weeks. Except for the Andaman and Nicobar Islands and other Indian territories, the Indian government reported that adequate water supplies were being provided to the affected areas within 10 days of the event. However, external water had to be supplied to other areas for much longer periods before the supplies could be restored from the local infrastructure; the wells had to be cleaned and disinfected (where possible) or the salination had to be overcome by natural mechanisms. Often, supplies of disinfecting tablets for treatment of contaminated water were provided by external agencies. Load after load of bottled water was donated and distributed to areas of need. In addition, the development of new sources, especially desalinating plants were installed or delivered by a desalinating boat. Canada, the UK, the USA, and other countries contributed to providing supplemental supplies of potable water while concurrent efforts at recovery were being conducted. Such efforts continued for as long as one year. In Indonesia, reports indicate that within the first six months of the events, only 25,000 of the directly affected population were receiving 15 litres/person/day and another 84,000 were receiving 5 litres/person/day. By the end of 2007, water was being trucked into the affected areas by tankers. Relief activities often were continued for extended periods of time—up to three years.

There are two major issues regarding water supplies during disasters: (a) quantity of water and (b) quality of water. A locally available option in the face of no relief arriving for several days was a consideration for use of solar disinfection. During the dry season, solar disinfection can be a promising alternative. However, the use of solar disinfection would not tackle the problem of salinity and chemical contamination. Clearly, some of the options were not practiced. But, the incidence of diarrhoeal disease may have been worse if the population was more sensitive. The protective factor may have been the innate immunity of the population, since before the event, the population must have been exposed to the risk of infection.

Recovery responses in the Water Subsystem

In each of the countries, efforts to restore the water supplies to their pre-event levels, and in some cases, even beyond, were begun simultaneously with the relief responses. Many of the resources were provided by outside agencies. For example, in Indonesia, more than 250 agencies were participating in the water recovery processes (including efforts at restoring sanitation—see below). Depending on the pre-event structure, several methods were implemented to restore the impacted regions with self-sufficiency for their respective supplies of potable water.
In Indonesia, UNICEF took the lead and was assisted by WHO-SEARO, and IFRC. On 06 January, Singapore provided a water purification plant. Wells were cleaned of debris and disinfected, and where this action proved inadequate, new wells were drilled. New bore wells also were drilled in India. Repairs to the damaged water infrastructure were accomplished within three weeks in Thailand. WHO-SEARO helped to repair water treatment plants in Aceh province. Containers for the storage and transport of water were donated for use in Sri Lanka, the Andaman and Nicobar islands, and in the Maldives.

In the Maldives and the Nicobar Islands, efforts also were directed towards the repair and/or replacement of water harvesting equipment and supplies, and in the provision/replacement of storage vessels and tanks that were damaged or swept away by the tsunami.

**Developments in the Water Subsystem**

In an interesting turn, water desalinating plants were established in many of the countries. Such equipment was donated by the international community. In efforts to restore the levels of water to pre-event levels and even beyond, desalination equipment was supplied to Sri Lanka and the Maldives. For example, by the end of 2007, 38 desalination plants had been installed and were operational in the Maldives; these were in addition to smaller units that were operational in the resort islands before the tsunami. The installations supplemented the normal processes used pre-event as sources for water. The process of implementing desalination of sea water often superseded efforts to restore the pre-event sources of water. However, desalination operations require substantial amounts of fuel; approximately one liter of fuel is required to desalinate 100 litres of sea water. For the most part, especially in the Maldives, all fuel had to be imported. This drove the unit cost even higher.

The question remains as to whether the implementation of substantial desalinating operations as part of development of the countries will be sustainable once the pre-event state has been recovered. Unfortunately, many of the installations initially were operated by well-trained expatriates: when they departed the scene, locals, largely inadequately trained for operations and maintenance, were unable to sustain the operations. Replacement parts were difficult to obtain. And, when the wet season arrived, many of the plants were shut down, and could not be started again. Furthermore, such operations often were outside of the cultural norms of the affected society who would not consume the water produced by such machines. Lastly, a relatively simple, new method to decontaminate water was initiated in which plastic water bottles were filled with water and placed on a reflective surface in the sunlight for six hours.

New, improved methods for the collection, decontamination, and distribution of water have been difficult to track. In some places such as Malé and Colombo, the addition of desalination plants represented real development. Little other evidence was uncovered that supports the further development of the water systems in any of the countries.

**Summary**

The tsunami in each of the countries and the earthquake and tsunami in Indonesia and the Andaman and Nicobar Islands profoundly affected the availability of water in the areas directly impacted. It is not clear how such deficits impacted the Public Health and Medical Care Systems. Given the destruction of much of the medical infrastructure in these countries (except for Thailand), shortages of water would also have had a profound impact on the provision of health services. The buffering capacities of the various medical facilities to use alternate sources for their water could not be assessed and only can be assumed. This is of particular importance for the facilities located within the impacted areas.

The overall impact on the affected populations was, by far, most significant in the Maldives and the Andaman and Nicobar Islands and in other difficult-to-reach areas such as Banda Aceh. It is
of importance to factor into the equation that the islands had the most vulnerable water supply in all of the countries involved.

**Sanitation and Hygiene Subsystem**

According to the Sphere Project:

*People affected by disasters are generally much more susceptible to illness and death from disease, which are related to a large extent to inadequate sanitation, inadequate water supplies and poor hygiene. The most significant of these diseases are diarrhoeal diseases and infectious diseases transmitted by the faeco-oral route (see Appendix 4). Other water- and sanitation-related diseases include those carried by vectors associated with solid waste and water.*

Safe disposal of human excreta creates the first barrier to excreta-related disease, helping to reduce transmission through direct and indirect routes. Therefore, Safe excreta disposal is a major priority, and in most disaster situations should be addressed with as much speed and effort as the provision of safe water supply. The provision of appropriate facilities for defecation is one of a number of emergency responses essential for people’s dignity, safety, health and well-being.

If organic solid waste is not disposed of, major risks are incurred of fly and rat breeding (see vector control section) and surface water pollution. Uncollected and accumulating solid waste and the debris left after a disaster or conflict also may create a depressing and ugly environment, discouraging efforts to improve other aspects of environmental health. Solid waste often blocks drainage channels and leads to environmental health problems associated with stagnant and polluted surface water.

Surface water in or near emergency settlements may come from household and water point wastewater, leaking toilets and sewers, rainwater or rising floodwater. The main health risks associated with surface water are contamination of water supplies and the living environment, damage to toilets and dwellings, vector breeding and drowning. Rainwater and rising floodwaters can worsen the drainage situation in a settlement and further increase the risk of contamination. A proper drainage plan, addressing storm water drainage through site planning and wastewater disposal using small-scale, on-site drainage, should be implemented to reduce potential health risks to the population. This section addresses small-scale drainage problems and activities. Large-scale drainage generally is determined by site selection and development.

Sanitation and the practice of hygiene sub-functions are related closely to the Public Health Systems. Public health has the responsibility for monitoring the health aspects of sanitation and hygiene, tracking the possible outbreaks of diseases and identifying their etiology, and developing and promulgating recommendations for the correction of possible problems in the Sanitation and Hygiene Subsystem that are responsible for or potentially are harbingers of diseases yet to become manifest. The Sanitation Subsystem is interdependent with Public Works and Engineering System—that is responsible for the mechanics of developing, constructing, maintaining, and modifying the infrastructure and processes associated with sanitation.

Thus, the Sanitation and Hygiene Subsystem consists of five elements that should be borne in mind while perusing this section: (1) access to toilets; (2) design and use of toilets; (3) vector control; (4) solid waste management; and (5) drainage of wastewater and precipitation. Some of the measures used to gain control of the disease vectors are described in the Chapter 10 on public health.

**Pre-events**

Other than in Thailand and Sri Lanka, in general, Sanitation Subsystems were not highly developed in the areas struck by the tsunami. Pre-events, Sri Lanka boasted of good access to sanitation for 93% of its population, despite the ongoing civil
war raging in the east and north of the country. However, the poorest systems were situated in the areas ravaged by the tsunami. In Sri Lanka, Colombo was the only location that had a wastewater processing system. Latrine coverage in Thailand was assessed at 98.2% of the Thai households, but there was a problem in some areas where the latrines were too close to the water sources. Indonesia had a poor sanitation infrastructure, and for the most part, used open pits or toilets that drained into septic systems that were managed by the government.

**Damage to the Sanitation and Hygiene Subsystem**

Despite the remarkable importance of sanitation and hygiene during disasters, there is little information available about the damage to the Sanitation and Hygiene Subsystem, the changes in function resulting from the damage, and responses to the changes in function. The pumping system was damaged in Colombo and where drainage systems were in place, many of them became clogged with debris. The most severe damage in Sri Lanka occurred in the east. In the impacted areas in India, there was an estimate US$ 0.8 million of damage to the toilets, but none of the sanitation facilities were severely damaged. The majority of toilets in the Maldives were damaged and where available, sewage systems became blocked by debris. Furthermore, in the Maldives, pollutants and wastes were released into the sea. In the impacted areas of Thailand, the groundwater became contaminated with coliforms.

No information specific to the damages to Sanitation and Hygiene Subsystem could be found for Aceh province or the Andaman and Nicobar Islands.

**Changes in the Sanitation and Hygiene Subsystem functions**

Since no information specific to the damages to the sanitation and hygiene subsystems could be found, for the most part, the changes in function that resulted primarily are conjecture. This is especially the case in those areas in which the pre-events status of the sanitation subsystem was poor or not known. However, it is known that open-field defecation became more widespread and that drainage systems that were clogged with debris and pump failures (Colombo) could not handle the wastes. Whereas, the collection of wastes and trash were marginal in most of the areas impacted before the earthquake and tsunami, what remained of the Public Works and Engineering Systems due to loss of personnel and equipment, now became almost totally dysfunctional. Thus, garbage, trash, human wastes, and other materials piled up in the streets of the urban communities, and often, when collections were made, the materials were indiscriminately dumped wherever open space seemed available (see Chapter 15: Public Works and Engineering). Some non-specific problems were encountered in the IDP camps in Aceh and in the camps in Sri Lanka. In some of the camps in Sri Lanka, there was poor access to toilets and inadequate disposal of wastes. All of these issues provided ideal conditions for the development and spread of infectious diseases and presented a huge challenge for public health (see Chapter 4, Public Health).

**Relief responses in the Sanitation and Hygiene Subsystem**

In response to the loss of so many of the basic societal functions, many people fled their communities and were collected in camps where improvised sanitation systems had to be installed. Often, the governments, UN Agencies (UNICEF and WHO-SEARO in particular) and a multitude of NGOs assumed responsibility. Squatting plates and shovels were provided; open-pit latrines were constructed and eventually, the sludge was removed. However, it was reported that maintenance of these facilities was difficult, if not impossible. Remarkably, other than for an occasional outbreak, especially of diarrhoea, no major disease outbreaks or epidemics occurred. The few outbreaks that did occur may have been a function of enhanced surveillance capacities and were nipped in the bud by the application of good public health measures.
Recovery responses and developments in the Sanitation and Hygiene Subsystem

By the time of this writing, no evidence was recovered that cast doubt on the observation that most of the sanitation issues had been resolved. However, it seems that the progress was slow. For example, in Aceh, by the end of 2006, 41% of the population still had no access to proper sanitation. A sludge treatment plant was built and became operational in Aceh at the end of 2005. WHO-SEARO and UNICEF also promoted improved hygiene through the delivery of materials and education on good hygiene practices. No comparative data before and after such efforts could be found.

Summary of responses in the Sanitation and Hygiene Subsystem

In summary, it is quite remarkable that no outbreaks of diseases occurred in any of these countries following the earthquake and tsunami, especially given the poor pre-event sanitation status in some of the countries. It can be assumed that the failure of the sanitation subsystems would have resulted in a greater impact. The principal manifestation of failures of sanitation systems was contamination of the scarce supplies of water, but no increases in water-borne diseases resulted. It is entirely possible that following the earthquake and tsunami, the pre-disaster situation did not change much (except in Thailand where the relief measures may have been more prompt).

Summary

The WATSAN system is heavily dependent and interdependent on Public Health, Transportation and Logistics, and Public Works and Engineering Systems. The provision of potable water presented some major problems especially in the Maldives, the Andaman and Nicobar Islands, and some affected parts in India. Although the provision of adequate supplies of water to a stricken population is crucial and time limited, there are no reports that could be accessed pertaining to deaths from dehydration. This was a remarkable accomplishment considering the severe damage and limitations imposed by the earthquake and tsunami. Among the methods used to provide the stricken population with adequate supplies of water required for survival, was the use of the military to access areas not accessible by ground. This entails a new and important mission for the military. Furthermore, despite the severe lack of sanitation facilities and functions, no major outbreaks of diseases occurred.

Also, despite serious sanitation issues, no epidemics or major outbreaks of faeco-orally transmitted diseases occurred.

References


Table 12.1: Basic human needs for water. The critical threshold for water supply for an adult is estimated to be 2.5–3.0 litres/person/day.

<table>
<thead>
<tr>
<th>Survival needs: water intake (drinking and food)</th>
<th>2.5–3 litres/day</th>
<th>Depends on the climate and individual physiology</th>
</tr>
</thead>
<tbody>
<tr>
<td>Basic hygiene practices</td>
<td>2–6 litres/day</td>
<td>Depends on social and cultural norms</td>
</tr>
<tr>
<td>Basic cooking needs</td>
<td>3–6 litres/day</td>
<td>Depends on food type, social, and cultural norms</td>
</tr>
<tr>
<td>Total basic water needs</td>
<td>7.5–15 litres/day</td>
<td></td>
</tr>
</tbody>
</table>

Table 12.2: Symptoms and signs of progressive dehydration

<table>
<thead>
<tr>
<th>Dehydration</th>
<th>Symptoms and Signs</th>
</tr>
</thead>
<tbody>
<tr>
<td>1%</td>
<td>Thirst</td>
</tr>
<tr>
<td>2%</td>
<td>Anxiety, decreased appetite, decreased capacity to work</td>
</tr>
<tr>
<td>4%</td>
<td>Nausea, dizziness, emotional instability, fatigue</td>
</tr>
<tr>
<td>10%</td>
<td>Loss of ability to regulate body temperature, confusion, cells begin to die, kidney failure, hypovolemia, and shock</td>
</tr>
<tr>
<td>15%</td>
<td>Loss of consciousness (coma)</td>
</tr>
<tr>
<td>20%</td>
<td>Death</td>
</tr>
</tbody>
</table>

Table 12.3: Water availability before the tsunami

<table>
<thead>
<tr>
<th>Indicator</th>
<th>India</th>
<th>Indonesia Aceh province</th>
<th>Maldives</th>
<th>Sri Lanka</th>
<th>Thailand</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rainy season</td>
<td>Jan–Sept (75%)</td>
<td>Dec–Mar</td>
<td>May–Nov</td>
<td>SW: May–Aug</td>
<td>N: May–Nov</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>NE: Nov–Feb</td>
<td>W: Apr–Oct</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>E: Sept–Dec</td>
</tr>
<tr>
<td>Sources</td>
<td>Groundwater</td>
<td>Groundwater</td>
<td>Sea water</td>
<td>Urban: Surface</td>
<td>Groundwater</td>
</tr>
<tr>
<td></td>
<td>surface (rivers)</td>
<td></td>
<td>Rain</td>
<td>Rural: Groundwater</td>
<td>Manmade ponds/</td>
</tr>
<tr>
<td>Access</td>
<td>Shallow wells</td>
<td>Inland wells</td>
<td>Desalination</td>
<td>Urban: Pumped/</td>
<td>Water: Piped</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Independent / commercial</td>
<td>Harvest rain</td>
<td>piped Wells</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>- 77%</td>
<td>Shallow wells</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Mosque wells</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Delivery methods</td>
<td>Pipes/taps</td>
<td>Steel pipelines</td>
<td>Household wells</td>
<td>Urban: piped</td>
<td>Urban: piped</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Household wells</td>
<td>Piped (Malé)</td>
<td>(75%)</td>
<td>(14%)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Rural: piped</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
The numbers provided are for the countries as a whole and may not accurately reflect the situation in the areas struck by the earthquake and tsunami.

<table>
<thead>
<tr>
<th>Indicator</th>
<th>India</th>
<th>Indonesia</th>
<th>Maldives</th>
<th>Sri Lanka</th>
<th>Thailand</th>
</tr>
</thead>
<tbody>
<tr>
<td>Access (% population)</td>
<td>85%+</td>
<td>48%</td>
<td>Malé: 98–100%</td>
<td>82%</td>
<td>Urban: 91–97% treated</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Overall: 78% +</td>
<td>74.1–96.6%</td>
<td>Rural: 98%; untreated</td>
</tr>
<tr>
<td>Distribution</td>
<td>Very uneven—geography and seasons</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Quality</td>
<td>Progressively contaminated</td>
<td>Boil before drinking</td>
<td>Declining</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Contamination from</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 12.4: Damage to Water Subsystem caused by the earthquake and tsunami

<table>
<thead>
<tr>
<th>Indicator</th>
<th>India</th>
<th>Indonesia</th>
<th>Maldives</th>
<th>Sri Lanka</th>
<th>Thailand</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost (million US$)</td>
<td>8.4</td>
<td>28.8</td>
<td>0.6</td>
<td>32.5</td>
<td>0.64</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(estimate includes sanitation)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wells damaged/destroyed</td>
<td>60 000</td>
<td>62 000</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Population (million)</td>
<td>1065</td>
<td>242</td>
<td>0.3</td>
<td>19.3</td>
<td>64.9</td>
</tr>
<tr>
<td>Cost US$/10 000 population</td>
<td>0.00008</td>
<td>0.0012</td>
<td>0.0200</td>
<td>0.0168</td>
<td>0.0001</td>
</tr>
</tbody>
</table>
Part IV

Analysis

Chapter 13

Shelter and Clothing
Shelter and Clothing

Introduction

Although the countries impacted by the earthquake and tsunami are in tropical zones, shelter from the elements is essential for human survival. Monsoons, a principal source of water, bring heavy rains, high winds, and high seas. In Indonesia and the Andaman and Nicobar Islands, the earthquake and tsunami damaged or destroyed much of the human-built structures including housing. However, there were substantial differences in the types of construction and the materials used in the areas directly impacted in the five countries.

Of great importance to the health community was that the damage and destruction to dwellings resulted in huge displacements of the affected population. People migrated from the shores due to the inability to use their dwelling for shelter either because of damage or destruction, or due to fear that further damaging waves would impinge on their places of living. Overall, estimates indicate that some 5 million people fled inland or to other islands. In most circumstances, the numbers reflect only those who registered at camps. It is likely that many of the displaced found shelter in buildings that remained relatively intact (public buildings, religious structures, and industrial buildings), or moved in with families and friends (hosts) whose dwellings were not damaged; others gathered in spontaneously formed or already operational camps (especially in Sri Lanka). Uniformly, in each of the countries, the number of IDPs immediately following the tsunami was astounding, but generally, their numbers and the camps in which many were forced to reside decreased rapidly as some returned to their homes. Others moved into transitional housing provided by the governments, intergovernmental agencies, and nongovernmental organizations, and others made arrangements with families and friends.

In each of the countries, the numbers of IDPs posed a huge burden on the respective governments. IDPs required resources including food, clothing, water, and sanitation, and represented a group vulnerable to the development of diseases including mental health problems. Many had to reside in temporary shelters, such as tents, for extended periods of time. In addition to the burdens on the respective governments, victims who had moved to the dwellings of relatives or friends placed considerable social and economic burdens on the host families.

Shelter has a major impact on the health of any population, regardless of the setting. The losses of shelter were addressed by many external actors and with huge donations, some of which still have not been spent.
Pre-events
Overall, the climate in the areas affected by the earthquake and/or tsunami in these five countries is tropical; ambient temperatures range from 21–34°C (Table 13.1). The widest ranges in average temperatures occur in India and its territorial islands. However, the wet seasons differ substantially between the countries and even within the countries. The precipitating events occurred within the wet and humid months in Aceh province, northeastern Sri Lanka, and Tamil Nadu (India). The monsoons not only bring rain, but also high winds and rough seas. Furthermore, the wetness provides good breeding grounds for mosquitoes, and hence, for infections with malaria and/or dengue. Thus, shelter is required not only against the weather, but also for protection from water-borne and vector-borne diseases.

Substantial differences existed in the construction methods and materials used for housing between the countries and regions impacted, and hence, differences in the respective absorbing capacities for the energy released by the earthquake and/or the tsunami (Table 13.2). The structures with the highest absorbing capacity were in Thailand (reinforced concrete walls). Concrete (cement) also was used in some of the housing structures in India and Sri Lanka. The structures with the least absorbing capacity were those with masonry walls and thatched roofs, and those in which leaves or thatch were used for the walls and/or roofs, such as were used in the impacted areas of India, Aceh province, and Sri Lanka. Many of the houses in the Maldives were constructed of coral and/or limestone, neither of which have sufficient absorbing capacity to withstand the forces that were generated by the tsunami. Some of the houses in Aceh province were built of scraps of metal and other materials that could be gathered, as much of the population was migrant due to the ongoing conflict. This also was true for the northeastern parts of Sri Lanka, where the civil conflict was ongoing at the time of the events of 26 December.

Damage
The number of houses damaged and destroyed in each of the countries is in Table 13.2. All together for the five countries, almost 600 000 houses were damaged or destroyed. Aceh province and the Andaman and Nicobar islands sustained the greatest damage to shelters as a result of the impact of the earthquake and tsunami.

The most comprehensive data available relative to houses destroyed are from Aceh province (Figure 13.1). More than 190 000 houses were damaged in Aceh province (68% of all the damaged housing in Indonesia). In four selected districts within Aceh province, 19% of the damaged houses sustained at least 50% damage and 14% were destroyed. For the most part, these structures were flimsy and directly faced the sea. The burden of destruction in Aceh province, as described by the number of houses damaged/10 000 population (487), also was the highest—more than 40 times that of Indonesia. Sri Lanka lost 145 700 houses to the tsunami. The number of houses destroyed was unevenly distributed between the districts in Aceh province; the greatest number of houses destroyed occurred in Aceh Besar, which also had the highest population. However, the greatest proportion of houses destroyed was in Aceh Jaya, which also had the lowest population of the four districts evaluated. The district that was most widely studied, Banda Aceh, was considered by many to have sustained the greatest damage; however, only 23.3% of its houses were destroyed as a result of the events; however, only 23.3% of its houses were destroyed as a result of the events, although Banda Aceh did not have the highest number of houses destroyed, the number of people whose homes were damaged essentially was at least twice that of the other three districts, and the total number of people with damaged/destroyed homes was at least 25% greater than for any of the other three districts (Table 13.3).

Housing construction was tenuous with poor absorbing capacity for the forces to which they were subjected (Table 13.2). However, it appears that wood frame buildings fared better...
(had a greater absorbing capacity) than did those built with cement and tile. The burden of the houses lost or damaged in Sri Lanka (75.5/10 000 population) was the second highest, but was only one-sixth of that which occurred in Aceh province. Although some 150 000 houses were damaged in the parts of India impacted by the tsunami, the burden on the country was quite low compared with that sustained by other countries. And while the southern and western parts of Thailand were exposed to severe forces, only 6570 houses were damaged (Figure 13.2). Most of the structures in the areas impacted were built with reinforced concrete skeletons. And, although many of the structures, e.g., tourist resorts, were more robust, still some were heavily damaged or destroyed. Damage to the resorts resulted in a large number of injuries and death among expatriate tourists. However, the housing burden in Thailand (0.56 buildings damaged/10 000 population) was the lowest of the five countries.

Some 7200 houses were damaged in the Maldives (Figure 13.3), where construction consisted mostly of coral and limestone (Table 13.2); some were constructed using reinforced concrete. Although the total loss of housing seems small in relation to that of Aceh province and Sri Lanka, the burden of the losses on the country was the greatest of all of the countries studied, and was second only to Aceh province.

The number of medical facilities damaged is outlined in the Medical Care System analysis (Chapter 11). In Aceh province, 114 healthcare centers were damaged/destroyed along with eight hospitals.2 The nature of the construction and the location of these buildings relative to their distance from the shore require further study and review.1

Changes in functions
The damages to homes and places of employment and a fear that more was yet to come, resulted in more than two million people in the five countries moving away from the seashore and their homes (Table 13.4). Those fleeing ended up in undamaged public buildings, such as schools, mosques, temples, government buildings, and the like, or in camps—makeshift or formal. Some of the displaced (numbers not identified or estimated) intruded on the homes of family and friends that were not directly impacted by the forces of the events. All were seeking shelter and assistance. In Aceh province, in the Indian state of Tamil Nadu, and in Sri Lanka, the events struck during the monsoon season. The immediate number of camps reached at least 2200; most were formed within the first 24 hours following the tsunami. This migration produced an immediate logistical, public health, and medical care nightmare for the countries impacted. Camps had to be established and temporary shelters had to be provided within the camps; the displaced could not remain in the public buildings in which they had sought shelter. It remains unknown as to how many people perished during this migration or due to inadequate assistance that was required immediately (within 24 hours). Everything needed to be supplied within the camps: water, food, sanitation, shelter from the elements and the insect vectors, and health care. Surveillance for outbreaks of infectious diseases had to be initiated. The settings were ripe for the development of epidemics. The media grasped this possibility and published the myth that the epidemics could result in more deaths than were caused by the earthquake and tsunami. The ability of the respective countries to manage this unfortunate burden reflects their respective buffering capacities.

The financial costs of the damages to houses and other buildings in the five countries totaled US$ 2140 million; this equates to US$ 1.10/capita. The highest financial burden/capita was suffered by the Maldives (US$ 216/capita). The estimated cost of the damage to housing in Aceh province (US$ 749 million) was two-thirds of the total costs for Indonesia. The burden becomes even more striking when the shelter burdens are calculated for Aceh province, where the damage to buildings represented a burden of US$ 192/capita compared with US$ 23/capita in Sri Lanka.
These burdens attest to the need for outside financial assistance in the Maldives, Sri Lanka, and Indonesia. The financial burdens for India and Thailand were minor compared to those suffered in the other areas impacted; and, they did not request outside assistance.

Estimates of the actual numbers of IDPs (in camps) and the burdens inflicted on their respective affected societies are listed in Table 13.4. An estimated 900,000 persons were displaced in Sri Lanka. Due to the civil unrest, as many as 400,000 may have been in camps before the tsunami struck. This represented 4.7% of its total population. Initially, the IDPs were contained within 750 IDP camps. Given the estimated 146,000 houses that were damaged or destroyed in Sri Lanka, an average of 6.2 persons was displaced from each damaged structure (see Social Systems, Chapter 17). When combined the 36,603 persons killed by the tsunami—an average is 6.4 persons/house. This computes to 466 IDPs/10,000 population.

The exact reasons as to why so many people (in proportion to the population) migrated in Sri Lanka are not clear. It could have been related to the ongoing conflict, especially in the heavily impacted northeast. What is obvious is that this massive migration of almost 5% of the population of Sri Lanka placed an enormous burden to provide essential services on the government of Sri Lanka.

In addition to the 122,736 persons who were killed as a result of the earthquake and tsunami in Banda Aceh, more than 400,000 persons fled from the shore to safe havens in structures still standing or inland. This represented 80% of the total migrants in all of Indonesia. 10% of the total population of Banda Aceh, and an IDP burden of more than 1000 IDPs/10,000 population that assembled in 637 camps (average = 637/camp).

Another major aspect of the exodus of the victims was the experiences suffered by those fleeing. Not only did they witness the massive destruction of their homes and belongings, but also the misery and trauma of death experienced by members of their family, friends, and others. Many barely escaped with their life accompanied by the terror of not knowing where they were going and what would happen to them. These near-death experiences and the fear of the unknown created the burden created by the IDPs also approached 1000/10,000 population. An estimated 12,000 persons migrated from their island of residence to islands that had better resources (Figure 13.4A and 13.4Bb). However, only four IDP camps have been reported in the Maldives. The implications of 7500 persons/camp raises questions as to the accuracy of the reported number of camps.

A similar pattern occurred in the Andaman and Nicobar island territories. These islands received the brunt force of the earthquake as well as intense tsunami waves. Due to the inability to sustain themselves on the island of their residence, many migrated to other islands.

Although India reported the second highest number of IDPs (572,578) distributed throughout 644 camps (average = 890 IDPs/camp), the burden spread over the entire population of India was only 5.9/10,000 population). Nonetheless, this was a huge number of persons to shelter, feed, and provide water and health care, and thus, the logistics of providing for them were similar to those required in Sri Lanka. However, more resources were available from within the Indian states and nearby communities.

Similarly, Thailand estimated that some 50,000 persons were displaced from their homes. Like India, the burden that the IDPs placed on the Thai government was remarkably small compared to the other countries. It is not known where Thailand’s IDPs migrated, though it is reported that many of them wound up in camps where they were sheltered in tents.

Importantly, although nearly 30,000 persons migrated in the Maldives (10% of the population),
psychological reactions that were comprised of a mixture of grief over their losses, horrifying experiences, uncertainty, and depression. In many instances, the victims literally were herded into buildings or camps. The psychosocial impact of all these factors combined to create a huge public health and medical care crisis. This aspect of the events is described in further detail in the Social Systems (Chapter 17). Overall, the provision of essential societal services was disrupted, including for those structures that survived. People had to cope without support services.

Lastly, except for Banda Aceh, it must be highlighted that damages to buildings occurred within a few kilometres (often a few hundred metres) of the shore. In Aceh, the intrusion of the tsunami moved up to 6.4 km inland. Also, it has not been possible to differentiate between the amount of damage in Banda Aceh that can be attributed to the earthquake and not the tsunami.

In summary, loss of shelters contributed to huge displacements of a significant proportion of the populations in each of the countries. The IDPs presented a myriad of problems to the countries, states, and districts and had huge implications for the delivery of medical care and for the protection and surveillance requirements for public health.

Relief responses
The financial burdens placed on the total population due to damage to buildings relates to the amount of resources that had to be directed towards relief and/or recovery. These demands for resources for repair/reconstruction of buildings competed for resources needed for relief and recovery of the other Basic Societal Systems including Medical Care, Public Health, Food and Nutrition, and Water and Sanitation.

Relief responses are those that are required to prevent additional deaths and further pain, suffering, and morbidity. The immediate needs of the affected population and their respective societies were to maintain supplies of water that were above the critical threshold in an effort to preserve life. Shelter was needed from the climate (monsoons), for privacy, and from disease-bearing insects. In addition, all of the services and supplies needed had to be provided in the face of power outages and competition for resources that developed between the Basic Societal Systems.

In each of the countries except Thailand and mainland India, responses to provide relief services were delayed for several days and the affected populations had to do without while focusing their efforts on their survival. Initial relief responses in Thailand and to the affected, mainland states of India were relatively prompt; generally, they began within 24 hours of the event. Assistance from outside the impacted area of Indonesia began slowly at first, and then rapidly increased with the involvement of hundreds of international relief organizations. Similar assistance occurred in the other areas impacted. Notable exceptions to this occurred in the island nation of the Maldives and in the Andaman and Nicobar Islands, where the responses were much slower due to rough seas and logistical barriers. The Maldives also had little reserves on which to fall back (almost no buffering capacity), as it had to import almost everything needed. In the island settlements, many departed their home islands, some seemingly never to return to their point of origin. These migrations have not been included in the accounting of the IDPs, but placed a huge load on the receiving communities.

As part of the initial relief responses, the government, responding nongovernmental organizations (NGOs), and inter-governmental organizations (IGOs) (especially WHO, UNICEF, and UNDP), and often, the military, initially provided emergency shelter with tents, plastic sheeting, and mosquito netting. Several NGOs attempted to improve conditions in existing camps. In Aceh province, three weeks after the earthquake and tsunami, more than 2000 IDPs remained in the schools and interfered with the resumption of classes. These persons had to be removed from these schools and moved into tents in the camps. Unfortunately, many of the
tents provided had no provisions for ventilation and became uninhabitable in the tropical climate. In the Maldives, tents were supplemented by the IFRC with shelters composed of corrugated metal. “Temporary” shelters were distributed to 27 of the 200 inhabitable islands of the Maldives. In Aceh Province, some of the tattered tents were replaced with metal containers. The IFRC contributed 21,000 metal shelters in the Maldives.

As noted above, the loss of shelter was a major contributing factor to the huge migration that followed the events of the day. These IDPs either congregated in camps (often makeshift) or imploded on family and friends that were not in harm’s way. When it became possible and relief teams were able to reach the people in camps, the migrants were provided tent shelters and other amenities afforded to these unplanned camps. In many instances, the individuals in the camps were supplied with whatever drinking water, food, and sanitation could be accumulated and delivered to the camps. Several interesting phenomena are apparent: (1) the number of camps and the number of IDPs living in them declined rapidly; and (2) ongoing efforts were mounted in each of the countries to move persons (families) from these tent cities into temporary or transitional housing while more permanent structures were being built.

As illustrated in Figures 13.7 and 13.8, the departure of migrants from the IDP camps occurred in nearly a linear fashion. In Sri Lanka, the number of IDPs in camps declined on an average of 25,000/day during the first month following the tsunami—from more than 850,000 to 200,000—three-quarters disappeared. Similarly, the number of camps in Sri Lanka declined at an average rate of 13/day. This exodus from the camps occurred before any significant numbers of temporary or transitional housing could be constructed. A similar trend was observed in India, where the number of IDPs declined from the immediate number of 627,000 to 100,000 within the first three weeks of the tsunami (average 25,000/day). It seems that the displaced families wished to return to their pre-event shelters as quickly as possible.

The movement of the IDPs out of the camps within a remarkably short time period indicates that the IDPs found alternative places to shelter. Another aspect of this movement of the IDPs away from the camps is reported from India, where the IDPs often returned to the camps during the days to collect the supplies being provided primarily in the camps, and then returned to their homesteads for the night. This was one mechanism that decreased the burden on the hosts of the IDPs. Thus, it seems that the IDP burden on each of the other Basic Societal Systems declined rapidly in a relatively short time interval following the massive exodus. For many, the association with the camps was to gain access to relief supplies and not use them as dwellings.

Relief supplies were sent primarily to the camps, and little attention was paid to providing resources to the host families. In February, a Swiss NGO began to supplement the resources of host families in Indonesia by providing US$ 40/month to host households at a total cost of US$ 850,000.

Little information was available about the donation of clothing in the relief phase of the responses. Some information points to the dumping of inappropriate clothing that was unsuited for the climate and/or the culture. Some of the traditional clothing was an impediment to swimming. Much was unneeded, and much was inappropriate culturally, including high heeled shoes, evening gowns, soccer shoes, and the like. This material consumed warehouse space and required transport by the recipient countries/states.3

**Recovery responses**

Recovery interventions (responses) were directed toward returning the affected population and society to their pre-event state. In terms of housing, initially, there were concerted efforts in each of the countries to move IDPs from camps as well as those who were living with hosts at
least into temporary housing, and eventually, into permanent structures. This was a main objective of many of the international NGOs who came into the countries to offer assistance. However, in each of the countries, progress was slower than initially expected. Disputes occurred between the government and those for whom new structures were to be built. True ownership of the land often was not clear, and arguments ensued regarding sites for the new housing. Many of the families who lived at the seashore before the tsunami wished to return to or in close proximity to the water, as fishing was a major profession for those living close to the sea. However, the governments in Indonesia, Sri Lanka, and India attempted to keep new structures at a safer distance from the shore, in an effort to limit the damage that would be created by the next tsunami. For the most part, such efforts were to no avail. However, such disagreements slowed the recovery process for housing. In general, little attention was given to the wishes of the beneficiaries and hence, to the local culture.

In each of the countries, efforts for the recovery of shelter occurred in three phases: (1) the provision of emergency shelter, such as tents, that comprised immediate relief; (2) construction and settlement of temporary (transitional) housing; and (3) construction and resettlement of the communities in permanent housing. By the end of February 2005, 397 of the planned 997 (39.8%) transitional housing units in Indonesia were completed, and by the end of 2006 (Figure 13.6), 57 175 permanent housing units were constructed under the auspices of the BRR and several NGOs. There remained a large number of permanent houses that had to be repaired or constructed (Figure 13.6). By the third anniversary of the earthquake and tsunami, 100 000 units had been constructed in Indonesia.

By 1 May 2005, 32 858 transitional housing units had been constructed in Sri Lanka, and donations by 30 donors provided resources sufficient to build 53 000 additional transitional housing units. But, by the end of the first year, only 55 000 such units had been completed in all. At three years, the goal of providing 100 000 new homes still had not been achieved.

In India, after two years following the events, NGOs had completed only 30% of the housing units that were needed. And, in Tamil Nadu, one of the areas hardest hit by the tsunami, only 5000 units had been completed at one year; at two years, 23 000 had been finished; and at three years, nearly 30 000 had been provided. In the Andaman and Nicobar islands, a shortage of building materials and disputes over locations delayed construction. The affected population wanted to return to their pre-event locations to ease their ability to earn a livelihood. In many places, foundations had been placed, but no buildings were constructed.

Similarly, in Maldives, progress in the recovery of housing also was slow (Figure 13.9). Inordinate delays were encountered in importing essential building supplies. At the two-year mark, repairs of only 1103 of the 5347 houses (20.6%) needing repairs had been completed, and 158 of the 1847 (8.6%) houses that were destroyed had been rebuilt. Eventually, the French government provided 500 permanent houses and the IFRC provided 800 houses.

Even Thailand, with the lowest burden of loss of housing units, had a relatively slow recovery of housing. By 18 January, World Vision had constructed 375 temporary shelters and the government and NGOs had initiated reconstruction efforts. The government provided US$16 million for the construction of 3600 permanent housing units, but in June 2005, 7000 IDPs remained in temporary shelters, and at one year after the events, 2900 IDPs were contained in temporary structures. In the other countries, major problems arose regarding the location of new units and the IDPs for whom the structures were being constructed felt that they did not have input into the location or design of the new dwellings.

Continuation of migration did not indicate that the recovery of permanent shelters had been completed, and 158 of the 1847 (8.6%) houses that were destroyed had been rebuilt.
achieved for the IDPs. Although they no longer were contained within camps, they still had lost the homesteads and any belongings that they could not carry with them during their sudden departure. Although they were not counted as being resident in the camps, they still remained displaced and in need of permanent housing. Clearly, some returned to their homes if they were still standing, but others had to be moved into hastily constructed temporary shelters. Those unable to leave the camps were subjected to rapidly deteriorating tents that became tattered and torn, and when possible, had to be replaced. Thus, the IDP burden for housing was much greater than was evident from the numbers of persons remaining in the camps.

It is not clear what the implications of the needs of IDPs no longer in camps had on the Public Health and Medical Care Systems, and if and how they were met. This phenomenon must be studied further and the findings integrated into future planning. As noted above, at the time of this writing, not all of those who survived and fled following the precipitating and secondary events had resettled into permanent housing. And, in most of the countries, it has taken years for society to return to pre-event levels of functioning, and some had not recovered.

In summary, the recovery of permanent housing for those who lost their residence due to the earthquake and tsunami has been a slow process. Initially, efforts were directed at the provision of emergency shelters; then towards building temporary-transitional units, and permanent housing. These latter two phases generally overlapped—and recovery of shelter is not complete.

Development

It is difficult to determine whether things have been “built back better” and whether the absorbing and buffering capacities of the affected societies have been improved. It is clear that some of the “permanent” housing provided was poorly constructed and that some was constructed in areas that were not satisfactory, acceptable, or useful to those in need of permanent shelter. Basically, many victims wished to return to their location before the earthquake and tsunami in order to return to productive lives (regain livelihood). Hopefully, the shelters made available during the recovery processes are better than they were before the events. Attempts by the governments in the Andaman and Nicobar Islands, mainland India, and in Sri Lanka to prohibit rebuilding in areas prone to another tsunami for the most part were not successful.

Summary

The earthquake and tsunami destroyed much of the built environment in the path of the huge forces created and, as a consequence, created many IDPs. The IDPs created multiple issues for many of the Basic Societal Systems that were in place. The migrations related to the destruction of their homes resulted in substantial increased burdens and translocation of resources on the Public Health and Medical Care Societal Systems. Recovery programmes have paved the way for better systems than were present prior to the events.

References


2. WHO-SEARO: Why a Safe Hospitals Initiative in South-East Asia? Available at http://www.searo.who.int/LinkFiles/Hospitals_Safe_from...
Figure 13.1: Number and percentage of houses destroyed by the earthquake and tsunami in four districts of Aceh province, Indonesia.


Figure 13.2: Percentage of houses destroyed in Thailand relative to houses present pre-event. (Map shows southwest shore of Thailand)


Figure 13.3: Number of houses damaged in the Maldives

Figure 13.4: The number of IDPs created by the tsunami in the Maldives: A = stayed on their island of residence; B = migrated to other island


Figure 13.5: Houses damaged in the Maldives

Table 13.1: Climate in the five countries (A+N = Andaman and Nicobar islands; mm = millimetres)

<table>
<thead>
<tr>
<th>Indicator</th>
<th>India</th>
<th>Indonesia</th>
<th>Maldives</th>
<th>Sri Lanka</th>
<th>Thailand</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rainfall/year (mm)</td>
<td>1700</td>
<td>1000–3000</td>
<td>Central: 1 925</td>
<td>North: East = dry zone: 1200–1800</td>
<td>Phuket: 2500</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>South: 2 278</td>
<td>SW = 2540–5080*</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>North: 1 786</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rainy (wet) season</td>
<td>January–September</td>
<td>December–March</td>
<td>May–November</td>
<td>South+West: May–August</td>
<td>North+: May–November</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>North-East:: November–February</td>
<td>West:: April–October</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>East:: September–December</td>
</tr>
<tr>
<td></td>
<td>A+N: 23°–33°C</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hottest months</td>
<td>Jun–Jul</td>
<td></td>
<td></td>
<td></td>
<td>April–May</td>
</tr>
<tr>
<td></td>
<td>A+N: Feb–Apr</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>


Table 13.2: Types of shelter construction prior to the events and damage sustained to housing from the events

<table>
<thead>
<tr>
<th>Indicator</th>
<th>India</th>
<th>Indonesia</th>
<th>Aceh Province</th>
<th>Maldives</th>
<th>Sri Lanka</th>
<th>Thailand</th>
</tr>
</thead>
<tbody>
<tr>
<td>Construction</td>
<td>Walls: plaster/masonry; reinforced concrete</td>
<td>Walls: not brick</td>
<td>Walls: not brick, Roofs: 1/5 of sugar palm or leaves</td>
<td>Coral+ limestone</td>
<td>Walls: cement or brick; Roof: tiles cement, asbestos sheets 1 floor</td>
<td>Un-engineered reinforced concrete</td>
</tr>
<tr>
<td>Houses damaged/destroyed</td>
<td>150 000</td>
<td>278 900*</td>
<td>190 000++</td>
<td>5 347</td>
<td>145 700</td>
<td>3578</td>
</tr>
<tr>
<td>Population affected (millions)</td>
<td>1065</td>
<td>242</td>
<td>3.9</td>
<td>0.3</td>
<td>19.3</td>
<td>64.9</td>
</tr>
<tr>
<td>Number of houses damaged/10 000 population</td>
<td>1.41</td>
<td>11.52</td>
<td>487.18</td>
<td>178.2</td>
<td>75.45</td>
<td>0.56</td>
</tr>
<tr>
<td>Costs (US$ millions)</td>
<td>574.5 *</td>
<td>1100*</td>
<td>749**</td>
<td>64.8</td>
<td>450</td>
<td>9.71</td>
</tr>
<tr>
<td>Cost/capita (US$)</td>
<td>0.54</td>
<td>4.54</td>
<td>192.05</td>
<td>216.00</td>
<td>23.32</td>
<td>0.15</td>
</tr>
</tbody>
</table>

* Phuket: www.phuket-guide.net/phuket_home/index.htm 10 Feb
*www.siterssources.worldbank.org, 10 Feb
**Calculated as 68% of houses damaged/destroyed in Indonesia
### Table 13.3: Damage and destruction to houses by the events in four selected districts in Aceh province of Indonesia. (est=estimated)

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Aceh Barat</th>
<th>Aceh Besar</th>
<th>Aceh Jaya</th>
<th>Banda Aceh</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Population</td>
<td>160 755</td>
<td>306 716</td>
<td>79 218</td>
<td>283 819</td>
<td>836 508</td>
</tr>
<tr>
<td>Number of houses (pre-event)</td>
<td>32 122</td>
<td>61 385</td>
<td>15 874</td>
<td>52 356</td>
<td>161 737</td>
</tr>
<tr>
<td>Houses/10 000 population (pre-event)</td>
<td>1998.1</td>
<td>2001.4</td>
<td>2003.8</td>
<td>1844.6</td>
<td>1933.5</td>
</tr>
<tr>
<td>Average occupants/house (pre-event)</td>
<td>5.0</td>
<td>5.0</td>
<td>5.0</td>
<td>5.4</td>
<td>5.2</td>
</tr>
<tr>
<td>Number of houses destroyed</td>
<td>15 483</td>
<td>16 881</td>
<td>9080</td>
<td>13 199</td>
<td>54 643</td>
</tr>
<tr>
<td>Houses destroyed (%)</td>
<td>48.2</td>
<td>27.5</td>
<td>57.2</td>
<td>23.3</td>
<td>33.8</td>
</tr>
<tr>
<td>Houses destroyed/10 000 population</td>
<td>963.1</td>
<td>550.4</td>
<td>1146.2</td>
<td>485.0</td>
<td>653.2</td>
</tr>
<tr>
<td>Number of people with destroyed homes (est)</td>
<td>77 415</td>
<td>84 405</td>
<td>45 400</td>
<td>71 274</td>
<td>278 494</td>
</tr>
<tr>
<td>Number of people with damaged house**</td>
<td>69 709</td>
<td>56 58</td>
<td>49 718</td>
<td>112 063</td>
<td></td>
</tr>
</tbody>
</table>


### Table 13.4: Internally displaced persons following the earthquake and tsunami (mil=millions; IDP = internally displaced person)

<table>
<thead>
<tr>
<th>Indicator</th>
<th>India</th>
<th>Andaman &amp; Nicobar islands</th>
<th>Indonesia</th>
<th>Aceh province</th>
<th>Maldives</th>
<th>Sri Lanka</th>
<th>Thailand</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number pre-event</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>1 000-38 000*</td>
<td>-</td>
<td>73 000***</td>
<td>-</td>
</tr>
<tr>
<td>Population (mil)</td>
<td>1065</td>
<td>0.356</td>
<td>242</td>
<td>3.9</td>
<td>0.30</td>
<td>1.93</td>
<td>64.865</td>
</tr>
<tr>
<td>Total number displaced</td>
<td>627 119</td>
<td>1346</td>
<td>450 000</td>
<td>400 000</td>
<td>29 577+++</td>
<td>900 000***</td>
<td>50 000^</td>
</tr>
<tr>
<td>% population displaced</td>
<td>0.06</td>
<td>0.30</td>
<td>0.21</td>
<td>10.26</td>
<td>9.86</td>
<td>46.63</td>
<td>0.07</td>
</tr>
<tr>
<td>Number displaced/10 000 population</td>
<td>5.9</td>
<td>37.8</td>
<td>18.7</td>
<td>1025.6</td>
<td>985.9</td>
<td>466.31</td>
<td>7.71</td>
</tr>
<tr>
<td>Number in camps</td>
<td>572 578****</td>
<td>43 332</td>
<td>450 000</td>
<td>-</td>
<td>-</td>
<td>850 000</td>
<td>-</td>
</tr>
<tr>
<td>Number of camps</td>
<td>644****</td>
<td>164</td>
<td>637+++</td>
<td>-</td>
<td>4+++</td>
<td>750</td>
<td>-</td>
</tr>
<tr>
<td>% in camps</td>
<td>91.3</td>
<td>-</td>
<td>50.0</td>
<td>-</td>
<td>-</td>
<td>94.4</td>
<td></td>
</tr>
<tr>
<td>IDPs/houses damaged</td>
<td>4.2</td>
<td>3.0</td>
<td>1.4</td>
<td>5.5</td>
<td>6.2</td>
<td>1.6</td>
<td></td>
</tr>
</tbody>
</table>

* Increase 2 months following the 2003 declaration of martial Law –then to 14 950 pre-event
** Jan 10, 545 492 in camps, 5 Jan 572 578 in 637 camps, 30 Jan 208 498 in 319 camps
*** in conflict areas
**** end of Dec, +3 wks➔ 100 000 in 256 camps; Tamil Nadu: 43 332 in 169 camps
+ + + 12 000 displaced from their islands
+ + + On 26 January, 417 24 IDPs were resident in 66 camps in Indonesia. (http://www.searo.who.imt/EN/section23/Section1108/Section1835/ Section1851/Section1867_8643.htm)
^ www.gwu.edu/~/sigur/pubs/SCAP23-TsunamiFINAL.pdf, 08 Feb
Part IV

Analysis

Chapter 14

Food and Nutrition Systems
Food and Nutrition Systems

Introduction

The nutritional status of a population is one indicator of vulnerability of the population to damage and loss of function created by a disaster-causing event. Nutritional status is a function of the availability of and access to food, including specific types of food, and the culture and religions of the society in which the population resides. Therefore, the pre-event status often determines the ability of humans to survive the stresses created by an event such as occurred following the earthquake and tsunami. The availability of food not only is a function of gathering (including fishing and hunting) from the natural fauna and flora of the area, but of agricultural production, importation, and economic status. The following information summarizes the nutritional state of the societies impacted by the earthquake and/or tsunami of 26 December 2004.

The feeding practices vary between communities, and these variances determine the nutritional profile. Even though food may be available, the feeding practices affect the nutritional status especially of the most vulnerable segments of the population (pregnant women, lactating women, and children under the age of five years, and the elderly).

An acute lack of food rarely presents an emergency, in terms of a critical threshold. Although reports vary, most agree that a healthy individual will survive for up to three months of food deprivation. The threshold also is dependent upon the level of activity of the deprived person and the physical makeup of the individual.\(^1\) However, hunger is uncomfortable and frightening and may provoke competition for food and violence.

Pre-Events

Important indicators of the nutritional status and diet of the five countries are listed in Table 14.1. The basic caloric intake in each in the countries is quite similar (mean = 2567.8 ±204.32 kcal/day) (Table 14.1). The average intake of kcal/day is highest for Indonesia (2902) (but within 1–2 standard deviations of the mean). The average recommended daily intake includes: adult females = 2200 kcal/day; adult males = 2900 kcal/day; and children = 2200–2500 kcal/day.\(^1\) Thus, it seems that overall, the amount ingested is similar in each of the countries, but the quality and content differ in some respects.

The average protein intake in the five countries was 68.8 grams/day with the average amount ingested by the Maldivians is 113.1 grams/day—

more that three standard deviations (sd) greater than the mean—this skews the mean so that all of the remaining four countries are below the average. The Maldivians also have the highest average amount of fat in their diet (65.8 grams/day vs. 54.5 grams/day as the average for the other countries (>2 sd above the average) and the lowest proportion of their diet is obtained from cereals 40% vs. mean of 53 ±4.2% for the five countries. The population in the Maldives ingests the lowest proportion of cereal and Indonesia and India, the highest (>2 sd below average). This reflects the relatively meagre agricultural industry in the Maldives (produces <10% of its food needs), and the fact that vegetables (including rice and flour), for the most part, must be imported. The Maldivian diet consists mostly of fish and some rice. Interference with imports and damage to what the vegetable-producing industry provides could wreak havoc in the Maldives.

Although the average total caloric intake for the countries basically are the same, the nutritional status differs substantially (Table 14.1). Overall, Thailand, by far, had the best overall nutritional status of any of the countries studied with the lowest rates of children who were underweight, stunted, or wasted and had the lowest proportion of low birth weight infants. India and Indonesia are the main outliers for each of these indices except for the proportion of children that are wasted. Sri Lanka ranked second (close to India) in the proportion of newborns with low birth rates.

The impact of pre-event states upon survival from the earthquake and tsunami, only can be surmised. It seems that children that are undernourished (underweight, stunted, or wasted) had less strength to cope with the forces applied by the earthquake and tsunami, such as ability to swim or hang onto stationary objects. This may have contributed to the inordinate number of children killed by the events. It is noted that malnutrition, hypothermia, and hypoglycemia are the prominent factors associated with high mortality in populations affected by disasters.

Furthermore, in general, the nutritional status was poorer in areas in which conflict was present before the events. For example, one-third of the rice production in Sri Lanka was grown in eastern part of the country. Thus, these national indicators may not be an accurate reflection of the status of the populations in the areas impacted by the tsunami. This is substantiated by information obtained of the nutritional status of the areas of India impacted by the tsunami. The status of persons in some of the areas impacted by the tsunami in India were better than were those for the country as a whole. On the other hand, the nutritional status in the eastern districts of Sri Lanka that were ravaged by the tsunami was notably worse than for the rest of the country. The latter at least in part, was related to the ongoing internal conflicts in the regions that not only interfered with food production, but created food insecurity and inability to provide foods by interruption in the distribution systems.

Another indicator of importance relative to the food and nutrition of the affected populations before the events of 26 December 2004, was the proportion of women who were anaemic. There were huge differences in the rates of anaemia between the pregnant women in India and Indonesia compared with those in Sri Lanka, Thailand, and the Maldives.

Lastly, many children in South-East Asia suffer from deficiencies in micronutrients and vitamins, in particular low intake levels of Vitamin A. Vitamin A deficiencies in children are a major preventable cause of blindness, impaired growth, impaired mentation, diarrhoea, increased incidence of respiratory infections, and are associated with premature deaths.

Reviewing the above, it seems clear that not all of the problems with development and anemia were related to lack of adequate intake. What is not known, but is probable, especially for India, is the number of persons with chronic diseases, infestation with parasites, or poor feeding practices. This particularly applies to the status of the children.
Damage
The earthquake caused damage primarily in Indonesia (especially in Aceh province) and in the Andaman and Nicobar Islands. For example, in the Islands, the earthquake caused subduction of up to 4 metres of the land mass. Some of the farmland in Indonesia was permanently submerged—at least 2000 hectares of agricultural land fell into the sea. Furthermore, this loss of elevation and rearrangement of the landscape may have contributed to the effects of the tsunami and facilitated the intrusion of the tsunami onto the land. The salt-laden tsunami brought with it sediment and debris that flooded the countryside sometimes several kilometres from the shore. In the Maldives, it completely washed over some of the islands. It ruined agricultural land through salination. More than 40 000 hectares of farmland were inundated in Indonesia, 23 000 in Sri Lanka, including 28 000 home gardens, 600 hectares of vegetable farms, 317 hectares of fruit trees, and 9000 rice paddies. It destroyed 30% of the limited agricultural land in the Maldives. In addition to destruction of land used for agriculture, standing crops and harvested crops were destroyed and food was contaminated. It ruined hunting and fishing that is of particular importance to the indigenous population of the Nicobar Islands. In addition, the tsunami killed hundreds of thousands of livestock, especially poultry.

The tsunami and/or earthquake rearranged the mangroves, coral reefs, and jetties that were a source of sustenance for several of the countries, especially Indonesia, the Andaman and Nicobar Islands, and the Maldives. Lastly, large portions of the fishing boats in each of the countries were destroyed or damaged. In Indonesia, more than 3200 boats were damaged or destroyed, 24 000 in Sri Lanka, and 140 in the Maldives. Thailand suffered US$ 44 billion in damage to its fishing industry.

Changes in functions
The damages sustained compromised the availability of food and types of foods available to the survivors and in some settings, those far removed from the areas directly impacted. On 5 January, WFP estimated that 700 000 people in Indonesia needed food. No immediate food shortages were reported in Thailand or India as the supplies were supplemented from non-damaged areas.

Destruction or damage to the fishing boats in Indonesia, Sri Lanka, and the Maldives wiped out a major source of nutrition for those affected both directly and indirectly to those who depended upon fish as a major component of their nutrition. For example, the fishing industry in Indonesia yielded 250 000 tons of fish in 2004 and only 130 000 tons in 2005. The loss of livelihood for many increased the problems associated with food insecurity. Lastly, hunger could have related to violence in the quest for food. Remarkably, no records of such violence occurred. This is a tribute to the culture and resilience of those affected.

Relief responses
As noted above, in India and Thailand, immediate relief of any food shortages was supplied quickly. In India, supplies were brought into the affected areas and the IDP camps from the neighbouring districts and states. Supplies generally were gathered from donors. Food initially was supplied primarily by the governments of the areas directly impacted.

However, other countries and territories were not as fortunate. The Maldives and the Andaman and Nicobar Islands presented considerable logistical problems as distribution was difficult—distances were long and transport was difficult. Transfer of supplies from within the Maldives was begun on the day of the tsunami using National Security Forces (military). UNICEF and WFP were able to deliver food to the Maldives within 48 hours of the event—40 tons of high energy biscuits were provided by 6 January—eventually, the amount reached 100 tons. Overall, they provided 2200 tons of rice, vegetable oil, pulses, and sugar to the Maldives. When necessary, these supplies were distributed to IDPs using the military, host families, and to those who had lost their means of earning a livelihood.
In Sri Lanka, by August 2005, 53,000 tons of food was imported and distributed. Relief packages were provided weekly by the Ministry of Health to all IDPs. They contained wheat, sugar, dahl, cooking oil, and a wheat-soy combination. But, some of the supplies received could not be used. For example, expired salmon packages and baby bottles were provided. There was little possibility to sterilize these bottles. UNICEF supplied 6,800 tons of baby food to children less than 5 years of age. In general, the IDP camps received plentiful food supplies in lieu of adequate supplies being produced within the countries. In January, WFP initiated an Emergency School Feeding programme that reached all the inhabited islands of the Maldives; this programme lasted through March. However, the quality was inconsistent and the types boring. The food relief activities were coordinated by WFP.

**Recovery responses**

Recovery of the supplies of food and nutrients was quite slow. In an assessment conducted in the IDP camps in Sri Lanka in mid-January 2005, 71% of the children were judged to still be receiving inadequate nutrition despite efforts to supplement diets and provide adequate nutrition. Anaemia was detected in 50% of the children in Aceh province, but was present in 73% of those aged 6–11 months compared to 35% in those who were 48–59 months of age.

But, progress was achieved. For example, in Indonesia during the period of March through September 2005, the proportion of children aged 6–59 months dropped from 11.0% to 8.8% and the Acute Nutrition Index decreased from 12.0% to 9.6%. In efforts to restore the fishing industry, FAO trained boat makers in new techniques to build replacement boats.

However, in 2005 and 2006, Aceh province produced a rice surplus. The fishing harvest in Sri Lanka increased from the low of 130,000 tons in 2005 to 206,000 tons in 2006 (from 52% to 82% of the harvest of 2004).

**Developments**

As part of the processes used to provide relief and recovery, supplements with vitamin A and micronutrients were provided in each of the countries. As in India, often these nutrients were administered to the children in conjunction with immunization campaigns. Micronutrients were provided in the form of a supplement called Vitalin®. Vitalin contains essential amino acids. One, glutamine, stimulates the pituitary to increase the production and release of growth hormone. It was believed that administration of this product would help to reverse the impaired growth pattern of children in the countries impacted by the tsunami. Supplementation of Vitamin A is associated with a lower incidence of blindness, lower premature death rates, decreased stunting and wasting, and less frequent episodes of respiratory infections and diarrhoea in children with inadequate diets containing sufficient quantities of Vitamin A.

In Indonesia, within six months of the earthquake and tsunami, 82% of the children aged 5 months through 5 years had received Vitamin A supplements. However, distribution was uneven with more going to older children and to those who were residents in IDP camps. In Aceh province and Nias, coverage with Vitamin A supplements varied between 49% and 96%. And the children in the IDP camps were five times more likely to receive Vitalin supplements than were those not in IDP camps. The Canadian Red Cross provided 385,000 doses of Vitamin A to children in Sri Lanka. Good coverage was achieved even in the Andaman and Nicobar islands.

**Summary**

Overall, food supplies were supplemented in time and deaths due to starvation were not reported in any of the countries supplied. No information could be found relative to the development of violence from lack of food or on the impact of the events on breastfeeding.
## Table 13.1: Pre-events indicators of nutritional status (NA = not available; sd = standard deviation)

<table>
<thead>
<tr>
<th>Indicator</th>
<th>India</th>
<th>Indonesia</th>
<th>Maldives</th>
<th>Sri Lanka</th>
<th>Thailand</th>
<th>Mean ± sd</th>
</tr>
</thead>
<tbody>
<tr>
<td>Per capita protein supply in grams per day</td>
<td>57.1</td>
<td>64.2</td>
<td>113.1</td>
<td>54.1</td>
<td>55.3</td>
<td>68.8 ± 11.2</td>
</tr>
<tr>
<td>Per capita fat supply in grams/day</td>
<td>47.9</td>
<td>55.1</td>
<td>65.8</td>
<td>46.3</td>
<td>50.8</td>
<td>54.5 ± 4.17</td>
</tr>
<tr>
<td>Per capita energy supply in kcal/day</td>
<td>2428</td>
<td>2902</td>
<td>2592</td>
<td>2405</td>
<td>2505</td>
<td>2567 ± 204.3</td>
</tr>
<tr>
<td>Calories from cereal (%)</td>
<td>60</td>
<td>64</td>
<td>40</td>
<td>53</td>
<td>49</td>
<td>53.4 ± 4.2</td>
</tr>
<tr>
<td>Children &lt;5 years of age that are stunted (%)</td>
<td>45</td>
<td>42</td>
<td>27</td>
<td>14</td>
<td>16</td>
<td>28.8 ± 6.4</td>
</tr>
<tr>
<td>Children &lt;5 years of age that are underweight (%)</td>
<td>47</td>
<td>27</td>
<td>45</td>
<td>30</td>
<td>11.5</td>
<td>32.1 ± 6.6</td>
</tr>
<tr>
<td>Children &lt;5 years of age that are wasted</td>
<td>16</td>
<td>12</td>
<td>17</td>
<td>15</td>
<td>12</td>
<td>15.7 ± 1.0</td>
</tr>
<tr>
<td>Newborns with low birth weight (%)</td>
<td>26</td>
<td>9</td>
<td>12</td>
<td>22</td>
<td>9</td>
<td>14.9 ± 3.7</td>
</tr>
<tr>
<td>Pregnant women with anaemia (%)</td>
<td>88</td>
<td>64</td>
<td>20</td>
<td>39</td>
<td>12</td>
<td>52.7 ± 14.8</td>
</tr>
</tbody>
</table>

Source: [www.searo.who.int/EN/Section13/Section38_2247.htm](http://www.searo.who.int/EN/Section13/Section38_2247.htm)
Public Works and Engineering Systems

Introduction
The Public Works and Engineering Systems are responsible for the public infrastructure and for preservation of the natural environment. This system must interact closely with all of the other functional systems that are dependent and/or interdependent upon Public Works and Engineering Systems. Thus, for many of the basic societal systems to be able to function, the Public Works and Engineering Systems must remain operational. It is responsible for the roads, bridges, rail beds, harbours, and runways required by the Transportation and Logistics System as well as for the maintenance of the coral reefs and mangroves. From a public health perspective, it is responsible for the quality of the air, the sewage systems, and so on. It also is responsible for the management of all forms of waste, human and otherwise. It is responsible to the Public Health System for the prevention of contamination of the water supplies and food, for control of the breeding grounds for disease vectors, such as animals and insects, and for the collection and safe disposal of medical wastes and hazardous materials. The information that follows describes the huge tasks associated with the removal of the massive amounts of debris, sludge, and other disturbances in the environment and human constructions including roads, airports, bridges, and railroad routes that resulted from the earthquake and/or tsunami that devastated parts of five countries on 26 December 2004.

Pre-Events
Thailand was faced with the generation of 22 million tons of waste materials per year or an average of 0.65 kg/person/day. However, the load was substantially higher in the resort areas lining the Andaman coast that were struck by the tsunami. The waste load in some of these areas reached levels as high as 5 kg/day/person. The accumulated wastes in Thailand were deposited into 335 landfills and 330 open dumps, often without regard for potential contamination resulting from the disposed waste materials. In general, these systems were adequate, and for the most part, the waste materials did not accumulate in the streets or along the highways or beaches.

However, for the most part, this was not the case in any of the four other countries. In each of these countries, the waste collection and disposal systems generally were ineffective and often mismanaged. In each case, their capacity to handle the load of wastes produced was limited. In Aceh province, the capacity was limited, in part, by years of ongoing civil conflict and inadequate funding. Disposal was into open pits with little regard for environmental contamination. The primary landfill for all of Banda Aceh was a 5-hectare open pit located close to the sea, and thus, vulnerable to the earthquake and tsunami.
Similar problems existed in Sri Lanka where the local governments removed an average of 2700 million tons of wastes/day from residences and industry. However, an average of 6000 tons was generated/day. Thus, as in Indonesia, the capacity to manage this amount of waste was exceeded and wastes piled up in the streets. Furthermore, the collected wastes often were disposed on land in the outskirts of the community. The system used for disposal of medical wastes could not be identified.

In the Maldives, similar problems were associated with waste disposal—the wastes generated by the 50 000 households generally were mismanaged. This included the mismanagement of medical wastes and hazardous materials: there was no policy for the management of these materials. Furthermore, only three of the islands had central landfills. Thus, many of the resorts and some of the industries found it necessary to manage their own wastes.

Thus, the Public Works and Engineering Systems in the five countries were NOT equipped to manage the huge surge of debris and sediment that occurred with the earthquake and/or tsunami. In fact, there are few, if any, countries that could manage the surge of debris and sludge on top of its usual burden.

The typography in Indonesia and Thailand was rugged, and most of the population and transportation routes ran along the coasts and were quite vulnerable to the tsunami. Aceh province was served by six major roads extending a total of 1100 km and using 600 bridges. India and Sri Lanka had extensive road networks that were not well organized. Compared to the other countries, Sri Lanka had a very high density of roads that averaged 153 km/km². However, the densities were very unevenly distributed in Sri Lanka with the lowest density of roads in those areas plagued by the ongoing civil conflict.

Most of the transportation facilities in each of the countries were confined mainly to the urban areas—the rural areas were poorly served. Railroad lines generally followed the road system.

Each of the countries was served by airports. Three airports served Aceh province: the smallest on North Sumatra Island, an intermediate serving Banda Aceh, and a major international airport near Medan, which was some 500 km from Banda Aceh. The Banda Aceh airport could handle aircraft such as Boeing 737 and the Medan airport was able to accommodate larger, international aircraft. The Banda Aceh airport generally handled about 1.5 flights/day and the Medan airport, 60–70 flights/day. The international airport in Sri Lanka was in close proximity to the capital city, Colombo. It was capable of handling large international aircraft such as Boeing 747 and had substantial warehouse space. Many international airports are scattered across India. The Malé International Airport handles an average of 30–40 flights per day (12 000–15 000/year) and approximately 1 million passengers/year. Each of the above is capable of handling large international-type of aircraft. There are three additional small airports on the atolls.

Transportation by boat from the mainland to Port Blair on the Andaman Island required five days. In order to reach the Nicobar islands, another two days often were required. Thus, assistance to the islands from the mainland inherently entailed substantial delays from definition of needs to actual arrival of goods and/or services. Access to health care in the islands often required boats. Most of the major cities on the coasts of each of the countries could manage large cargo/passenger ships. The dock and jetties were well constructed and traffic was coordinated.

**Damage**

The Transportation and Logistics System combined with the Public Works and Engineering System suffered the most in terms of financial costs—where costs of the damage are available, between 60% and 70% of the total costs of damage to the infrastructure was incurred by these two societal systems.
An appreciation of the enormity of the tasks generated for the Public Works and Engineering Systems can be derived from the photographs provided in the country chapters in the previous section of this book. Roadways and bridges were the most vulnerable and extensive damage to the roadways was common. In Aceh province, 10% of the roads were damaged or destroyed (29 800 km). Many bridges were destroyed or could not be used due to structural damage. In Tamil Nadu of India, 31% of the roadways were damaged. In Thailand, most major roads sustained little if any damage, but smaller roads built on sand roadbeds were severely damaged. In the Maldives, jetties, sea walls, quays, causeways, breakwaters, and navigation markers and beacons were destroyed. In the Andaman and Nicobar Islands, severe damage occurred to the docks and some were under water due to the subsidence caused by the earthquake.

As indicated in the photographs included in the country section of this publication, the earthquake and tsunami destroyed houses, businesses, and industrial buildings, including resorts that lined the shores of the Andaman Sea, smashed vehicles as well as trains and boats, and stirred up and lifted the wastes in open dump sites. But, the damage was not limited to the built environment, such as homes, industrial plants, and commercial enterprises; the natural environment was damaged as well. In the Andaman and Nicobar Islands, severe damage was inflicted on the mangroves that represented a major resource for the indigenous population. Reports indicate that in some areas, as much as 94% of the mangroves were destroyed. In each of the countries, coral reefs not only were damaged by the earthquake and tsunami, but were damaged further by the debris that was dragged into the sea as the tsunami retreated. Pools of water were left trapped on the landmass and within the debris that could have served as breeding grounds for the mosquito vectors for malaria or dengue. Dump sites were washed into the sea. The sea around the Thai island of Phi Phi was thought to have been contaminated by more that 1000 tons of debris.

Debris covered the landscape of the impacted areas. In Aceh province and the Andaman and Nicobar Islands, it has been impossible to separate the damage created to the infrastructure by the tsunami from that related to the earthquake that preceded it. The amount of debris in Aceh province and Nias were estimated by UNDP to be in the order of 7–10 million cubic metres. Other estimates were 290 000 cubic metres for the Maldives, 76 250 tons remaining on the land in Thailand, and 900 000 tons in Sri Lanka.

Scattered mounds of debris were not the only evidence of the damage wrought. The tsunami left behind huge quantities of sludge and sediment. For example, in some areas along the Indian coast, the height of the sludge was over a metre.

The presence of broken glass and metal with sharp edges presented another hazard that, in turn, resulted in lacerations and puncture wounds. These wounds were heavily contaminated and presented a source for the development of tetanus in those injured and not currently immunized. Hazardous materials, including medical wastes and possibly asbestos also were distributed widely. This material also included some run-off and organic materials from the victim identification processes (DVI).

Lastly, some of the debris contained medical wastes and other hazardous materials that had not been adequately disposed before the tsunami and earthquake or were washed away with the flooding of medical facilities and industrial sites. Furthermore, increased biological wastes created by handling of the dead also contributed to the ripe environment.

Changes in functions
In the cities, debris, garbage, and wastes clogged the streets and limited access to many areas. The enormity of the tasks of collecting and disposing of this stuff was daunting. Importantly, the marginally functional systems that were
present pre-events, sustained loss of personnel, equipment, and supplies. In each of the areas impacted, routine collection of wastes was impossible, and garbage accumulated everywhere creating a monumental public health hazard. This resulted in the loss of substantial income as many tourists cancelled their reservations or left prematurely following the events. However, though the number of tourists being evaluated and treated in the medical facilities decreased, the number of injured and ill increased and further compromised the ability of the medical facilities to provide care. Furthermore, some of the roads to medical facilities were impassable and bridges, where they existed, were damaged and in some instances, destroyed. The blocked roads and collapsed bridges compromised the delivery of medical supplies and equipment required to keep the hospitals and other medical facilities that remained standing, operational. Damage to roads and bridges isolated many of the rural communities that no longer could be reached by surface transport facilities. Inaccessibility of isolated communities occurred in each of the countries, except for Thailand where access roads to the areas impacted remained open, and there was little disruption in services.

None of the airports were damaged to an extent that resulted in their closure for any significant period of time. For example, the Phuket airport was closed for only two hours. The rest remained operational. The operational status of the principal airport in the North Andaman was not identified. The airport serving Banda Aceh sustained only minor damage to the end of one runway and was operational within hours.

Major damage occurred to the docks and jetties in the Andaman and Nicobar Islands and in the Maldives. This resulted in the inability of ships to dock. When they did arrive, the cargo and people had to be shuttled to the land using small boats. The docking facilities in Aceh province were damaged and ships could not dock. Hospital ships had to anchor off-shore, and hence, access by patients had to be accomplished using small boats or helicopters.

Relief responses
The cleanup was the responsibility of the Public Works and Engineering System in each of the areas impacted by the events of 26 December 2004. The Public Works and Engineering Systems in each of the countries was faced with the disposal of huge amounts of wastes on a daily basis. The collection systems that did continue to function, dumped the wastes onto any open spaces—along roads, in fields, and even on beaches as well as in dump sites.

Relief activities consisted primarily of opening roads to transport people, supplies, and equipment. In Thailand, the military brought in heavy equipment to rapidly reopen the damaged roadways. In Indonesia, the government and UNDP attempted to set priorities for the cleanup activities. Initial attempts were directed towards clearing the way to reach public buildings, including medical facilities. In addition, airport buildings had to be repaired to allow storage of the massive amounts of imported relief goods. In the Maldives, Thailand, and India, the government ordered that no additional, unwanted supplies and personnel be allowed inside their respective borders. Clearing the remaining debris was a slow process.

Recovery responses
Recovery to the pre-events status was long and many of the functional systems in the impacted areas remained incomplete. Recovery was not possible until the rubble, debris, and wastes had been removed. In Indonesia, the government hired private contractors to remove and dispose of the debris. Unfortunately, many of these contractors dumped some of the debris onto private land, into paddy fields, ponds, and other inappropriate sites. In Thailand, the government assumed the responsibility for removing the debris and UNDP assumed the responsibility for clearing the reefs of debris that had been sucked into the sea. The Thai government attempted to clear as much of the rubble as possible so that the resort areas, that contributed a major portion to the GDP, could resume activities quickly. In Indonesia, Sri Lanka, and India, the
governments encountered difficulty finding
workers for the cleanup operations. In Tamil
Nadu, the government assigned municipal health
workers to the task of assisting with the cleanup.
In Aceh province and Sri Lanka, residents often
participated in the cleanup activities. However, in
both these countries, residents often attempted
to remove debris by burning it. The smoke
from such fires contained substantial amounts of
hazardous materials that posed another health
threat and resulted in environmental pollution. In
at least one instance in Banda Aceh, the fire used
to clear debris went out of control and further
destroyed many additional buildings. Disposal by
burning also used fuel—a scarce commodity.

Developments
Several interventions have been directed to
decreasing the risks that another catastrophe will
create as much damage and debris. In addition,
education and training was provided to enhance
the management of such events when they
do occur. For example, the Thai government
purchased incinerators for the destruction of
hazardous materials. In the Maldives, education
and training were provided by the Canadian
and Australian Red Cross agencies in efforts to
enhance the management of wastes, including
the safe management of health wastes by
healthcare workers.

Summary
The earthquake and tsunami left a mess in each of
the areas impacted. Cleanup of the mess was the
responsibility of the Public Works and Engineering
System—a monumental task especially since the
function in each of the areas impacted, except
Thailand, was marginal at best before the events
of 26 December. In addition, the fact that in
each of the countries, personnel, equipment,
and supplies were damaged and/or destroyed
relegating the functional status to levels that
were lower than before the events. Destruction
of roadways including bridges hampered the
delivery of essential supplies and materials, and
compromised the ability of patients and staff to
reach the medical facilities. The impact of the
compromised healthcare functions on mortality
and morbidity remains unknown. Thus, there
is a tight interdependence between the Medical
Care and Public Works and Engineering, and the
Transportation and Logistics Systems.

Public works and engineering and the transport
and logistics functional systems sustained the
majority of the damages due to the events.
Importantly, the military had the resources to
buffer the inadequacies of these systems.
Part IV
Analysis

Chapter 16
Energy Supply Systems
Introduction

Electrical power is essential for the practice of modern medicine. The operation of medical equipment, storage of supplies including refrigeration for blood products and medicines, special requirements of the cold chain for the storage of vaccines, the provision of light, and when necessary, control of the internal environment are required to keep medical facilities operational. Energy in the form of fossil fuels, firewood, and electricity is essential for the preparation of food, sterilization, and the provision of heat. Fuel is essential for the transportation of patients, equipment, and supplies to keep medical facilities operational. Interruption in the available supplies of energy compromises these services often during a period of surge in demand as has been associated with most disasters.

Most of the information available on the energy supplies following the earthquake and tsunami, relates to the supplies of electricity. Little has been uncovered relative to disruption in the supplies of fuels following the events of 26 December 2004.

Pre-Events

Electrical power

As noted in Table 16.1, the bulk of electrical power in the five affected countries was obtained from the burning of fossil fuels. The Maldives have no other source for the generation of electricity and depends entirely on importing fuel to operate its generators. This contributes to the high costs associated with the electricity produced. Even though each of the inhabited islands have access to electricity, in many, the quantity available is limited. At least three of the island households only have access to electricity for less than six hours/day. Most of the resorts on the islands generate their own power using diesel fuel.

Of the countries studied, only India generated electricity from nuclear energy, but only to a limited extent—3% of its electricity was generated from nuclear sources. Electricity also is generated from hydro-electric facilities. In the south, some of the electricity is generated from wind energy. Its other sources are nearly the same as for Sri Lanka and Thailand in which about two-thirds of the electricity is produced by burning fossil fuels. The bulk (87%) of electricity produced in Indonesia is obtained by burning fossil fuels. The remaining electrical energy in Indonesia is obtained from hydroelectric generating facilities.

In Aceh province, 90% of the communities are electrified, but only 60% of the households have access to electrical power. The principal power plant is inland in the North Sumatra Island. Still, there are frequent periods during which no electricity is available, especially in the rural areas. Some households and businesses have small, diesel-powered generators.

Energy Supply Systems
Similarly, 40%–80% of communities in Sri Lanka have access to electricity. Electricity is supplied to about 4 million customers. In the areas impacted by the tsunami, an estimated 51%–86% of household lights were powered by electricity, and in 10%–47%, light was provided by burning kerosene. Tamil Nadu had made substantial progress in avoiding the use of petroleum-based products as a source of energy. Remarkably, 53% of its electrical energy was produced from wind generators, 40% from biogases and biofuels, and 4% from solar-powered devices. All villages in Tamil Nadu were electrified. At least 92% of the population on the Andaman and Nicobar Islands received electricity 24/7. Most of the power was provided by diesel generators and some by one hydroelectric plant. The diesel fuel had to be imported.

In each of the countries, the major sources of electricity were located inland and were not vulnerable to the tsunami. The vulnerability of the medical facilities to loss of electricity could not be determined.

**Non-electrical energy**

Little electrical energy was used for purposes other than those noted above, but the information is scarce. The best breakdown of sources of energy used for cooking was obtained for Sri Lanka. In most districts, burning of firewood scavenged from the environment was a principal source of cooking fuel. Except for Colombo and Gampaha, wood was consumed for cooking in more than 85% of the communities. In Colombo, wood was the principal source of cooking fuel, but was used in only 32% of the households and businesses. Kerosene was used in 14.4%. Estimates in Indonesia indicate that in 2004, 75% of the energy used for cooking came from charcoal. In India, the principal fuels for cooking consisted of burning firewood, twigs, dry leaves, crop residue, and even dried cow dung. Similar patterns were identified in the remaining countries. Thailand has been moving from the fuels noted above to the use of propane.

**Damages**

Of major importance in each of the countries and their territories was that the sources for electricity were located far from the shore and thus, from the areas directly impacted by the tsunami. However, since the tsunami washed entirely from one shore to the other in many of the islands of the Maldives, substantial damage was incurred to the electrical infrastructure: damage was sustained by 24 power-generating plants, 104 generators, and 121 km of cables. No damage was sustained by the major power infrastructure in Thailand. Major local damage occurred in Aceh province. However, the main transmission lines were undamaged by either the earthquake or tsunami.

In some instances, especially in the Andaman and Nicobar islands, fuel storage facilities were damaged or swept away, and their contents leaked into the environment. Otherwise, little information was found relative to damages to fuel supplies.

**Changes in functions**

Significant interruptions in the delivery of electrical power occurred in each of the areas impacted. For example, in the Maldives, electrical energy was disrupted on 98 of the 200 inhabitable islands, and 26 of these islands lost all access to electricity. Some 2% of the population in Sri Lanka lost power with losses for 20,000 households in the Galle district and 14,000 in Ampara. In the Andaman and Nicobar island territories, the tsunami waves combined with the earthquake inundated generators, swept away fuel tanks, and toppled distribution poles downing transmission lines; 70% of the electrical power was interrupted. In some of these islands, electrical power was not restored for months following the tsunami. It has not been possible to determine the impact of power outages on the medical facilities in any of the countries.

The events damaged fuel storage tanks. For example, damages to fuel storage facilities in Indonesia resulted in more than 8000 kilolitres of fuel leaking from the tanks into the environment.
Similar disruptions in fuel storage facilities have been reported in each of the countries.

**Relief responses**
The most significant relief actions taken to compensate for the destruction/damage to the power infrastructure came with the donation of generators by WHO, Japan, and IFRC. Of significance, in the Maldives, some of the generators could not be delivered because they were too large and heavy for the watercraft that could approach some of the islands.

**Recovery responses and development**
Members of the Indian navy repaired the generating equipment in the Andaman and Nicobar islands. New generators were used in some instances not only to replace those damaged, but also to improve overall access to electrical power. Similar to the descriptions of the non-sustainability of the desalinating plants used to restore and improve the supplies of potable water, the lack of education and training of locals on how to operate and maintain the new generating equipment impeded the development of sources of electricity.

**Summary**
The energy provided to the countries came from a variety of sources. Most of the sources were located away from the impacted areas. Therefore, the damage primarily affected the transmission grids and lines. The Andaman and Nicobar Islands, depended largely on imported diesel fuel, but for the most part, sufficient supplies were stored on the islands. Much of the fuel sources for non-electrical energy were impacted by the events, and as best can be determined, were restored quickly.

**References**

**Table 16.1: Sources of electrical energy (blank cells = information not found)**

<table>
<thead>
<tr>
<th>Indicator</th>
<th>India</th>
<th>Indonesia</th>
<th>Maldives</th>
<th>Sri Lanka</th>
<th>Thailand</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sources of Electricity (%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fossil</td>
<td>70*</td>
<td>86.9</td>
<td>100.0</td>
<td>66.7</td>
<td>70*</td>
</tr>
<tr>
<td>Hydro-electric</td>
<td>27*</td>
<td>10.5</td>
<td>0</td>
<td>33.3</td>
<td>30*</td>
</tr>
<tr>
<td>Other</td>
<td>2.6</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Wind</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Solar</td>
<td></td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nuclear</td>
<td>3*</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*www.country-data.com/cgi-bin/query/f-13774.html, 17 February 2009*
Introduction

The Social System within a society has a major impact on the manner in which the society faces the possibility and/or the occurrence of a destructive event regardless of the nature of the event. The Social Systems include the culture, tradition, history, religion, and organization of the sociopolitical system within the society. The Social Systems within the five affected countries and their respective capacities to protect them were as similar as they were dissimilar. The mental health subsystem is included in the Social Systems rather than in medical care.

Pre-Events

The social structures of the five countries differed in many ways. The religious affiliations of the populations are listed in Table 17.1. No single religion linked the countries. The closest is Buddhism, which is the principal religion in Thailand and Sri Lanka. The Muslim faith is the major religion in Indonesia (may have been the origin of the Muslim religion for South-East Asia) and almost the only religion in Banda Aceh (98.5%)—the Acehnese were unified culturally, who, along with the residents of the Andaman and Nicobar Islands, bore the brunt of the earthquake and tsunami. Thus, other than the Maldives where the religion was mandated by law, there were substantial differences in the predominant religions. The Indian population is predominantly Hindu, but it is noted that the proportion of the population varies substantially from state-to-state and in the territories. For example, in the state of Tamil Nadu, 88.1% of the population is of the Hindu faith, but the religious affiliations are much more diverse in the state of Kerala in which only 56.2% are Hindu. In addition, 69.2% of the residents of the Andaman and Nicobar Islands are Muslim. All the residents of the Maldives must follow Sunni Islam by law.

In the Andaman and Nicobar Islands, 63% of the population of 42,000 was indigenous to the islands. They were ritualistic and the culture was shaped by the elders. In general, the indigenous population had little contact with the outside world. Little access and influence by outside persons was tolerated and only a few government officials were allowed to have contact with members of the indigenous population.

It is not clear what the effects of the diversity of religions and cultures had on the types of preparedness for the events of 26 December, and these issues merit further study. But, a few of the effects that are of significance can be noted. Moreover, each of the countries had its own official language. Only India had English as one of its two official languages, but also had 15 other languages spoken in some of the different regions. However, few Indians could converse in English, but many understand English. Some
of the areas affected included persons who were Tamil and Malayalam speaking. They might have been able to understand English and some may have been able to speak and write in English. The use of English may have been better in the state of Kerala than in Tamil Nadu. Language difficulties relate to the expectations of many who respond to disasters that the population can understand and speak English.

In most of the countries, there were substantial gender and age issues. More females than males were killed in most of the countries, and more children and elderly than younger adults succumbed to the forces of the earthquake and tsunami. For example, in Sri Lanka and Indonesia, the tsunami struck at the time when women traditionally bathe in the sea. Also, women generally wore clothing that limited their ability to escape, they were not taught to swim, and often they carried a child while attempting to escape. Similarly, laws in Maldives limited women in terms of remaining near their homes and the culture and social norms limited their employment opportunities and their work. Most of the employed women worked in agriculture, including maintaining gardens and caring for the children; those that worked in the fishing industry generally were employed primarily in processing the catch. In Thailand, some women were employed in the tourist industry where they made up about 4% of the workforce, their jobs primarily were limited to cleaning and cooking.

Thailand had another issue in that a major part of the workforce in the resorts that lined the shores of the Andaman Sea was made up of workers from Myanmar. These migrant workers, estimated at 12,000 or more, were not well-accepted by some, and became an object of discrimination. The migrant workers often were not citizens of Thailand, and were reluctant to go to the authorities for fear of being arrested.

The Acehnese population, especially in rural areas, was terrorized by the separatist conflict raging in the countryside. Many became transient, moving from one location to another in an effort to find safety. This transience rendered them more vulnerable to injury, death, and to further displacement following the earthquake and tsunami. Often, they resided in flimsy, temporary homes that fell prey to the events of the day.

**Damage**

The most apparent damage related to the social systems in each of the countries was the sudden disruption of the social fabric created first by the earthquake in some countries and then by the tsunami in each. Many of the 225,000 deaths were almost instantaneous, but some were accompanied by the agonizing loss of and inability to rescue family members and to the terrifying experiences of watching those who drowned or were carried away by the intruding sea. Some had lost more family members than survived.

In each of the countries, the number of children killed was approximately 50% of the total number of dead [not sure holds for Thailand]. Furthermore, in each country the number of females killed exceeded the number of males. The reasons for this disparity relate in part to the relative position of the women in each of the cultures that made them more vulnerable targets, not only in terms of where they were at the time the events occurred, but also the tendency for women to have less strength than men: they were less able to hold on to some structure or their children so they would not be swept away. Fewer women were able to swim and generally were responsible for their children when the tsunami struck. In addition, the traditional clothing worn by many of the females may have impeded their ability to cope with the forces of the tsunami. In the Maldives, if the numbers of children are excluded from the inventories, the numbers of males and females killed were approximately the same.

It is noted that for the most part in the cultures of the affected populations, men mostly were outdoors while women were either indoors or close to their home, and thus, were more vulnerable to the forces exerted by the events. Fishermen who were out at sea hardly noticed
the tsunami. In addition, the elderly, those who were physically handicapped, the chronically ill, and children also were more vulnerable in that they may not have had sufficient strength to survive the forces to which they were exposed. In Indonesia and the Maldives, the mortality rate of persons ≥65 years of age was disproportionately greater than for the rest of the adults. For example, although those persons ≥65 years of age only comprised 3% of the population, 20% of those killed were ≥65 years of age. Thus, as has been shown in many disaster settings, children, the elderly, and women are most vulnerable.

In Indonesia, the physical losses due to damage to the structures and the contents of the mosques were estimated to have cost US$ 51 million.

The emotional trauma was immense. Only within the decade before this tragedy had the emotional aspects of disasters become increasingly appreciated. The emotional trauma related to losses of family members and friends and watching the deaths or disappearance of loved ones, and surviving near-death experiences was overwhelming to many of the survivors. For many, the reactions to these experiences persist and may continue for the rest of their lives. Recall of the events and their losses add further to the emotional trauma. The actual emotional toll remains untold.

Changes in functions
The Social Systems in each of the areas impacted were shredded and tested. The subfunctions that normally cared for the dead were overwhelmed and many collapsed. Often treatment of the dead as outlined by the respective religions and cultures had to be abandoned; this created additional emotional distress. Family members were separated from each other, from their homes, and for many, their means of earning a living disappeared. Bodies were strewn everywhere. Loved ones could not be found. Grief was rampant everywhere and in many instances could not be attached to anyone or anywhere.

At a time when the social systems operating within the community should have provided support, little if any was available. Some felt that the events were punishment for previous immoral behaviours. People experienced grief for their losses and for their survival. The generally meager support systems available pre-event, collapsed. Although many religious buildings survived the onslaught of nature, many of the trappings of the religions were swept away. Religious institutions lost leaders and the trappings within the mosques. Thus, the survivors also lost the emotional support usually available from their respective religions. For many, there were no explanations and they had nowhere to turn for help. Many were displaced from their homes and wound up in camps with poor living conditions and with persons they had not known. There was nowhere to go and no one to turn to for help. The emotional suffering was overwhelming. Hope was all that many had left, but most felt a sense of hopelessness. However, it is noted that the residents in the areas directly impacted had remarkable resilience to the deluge of stresses to which they were exposed—most have resumed their pre-event life as best they can considering their losses.

Relief responses
Immediate responses to the losses were to endlessly search for those who were lost or dead. Some were found—most were not. Gaining closure has been difficult for most, and for many may not have been attained. Inability to identify the dead posed problems that grew worse as time passed. Early on, attempts at identification were visual. But, existing cold storage facilities quickly were overwhelmed, and the corpses began to decompose so that they no longer could be visually identified. The myth that dead bodies could spread disease was widely touted by the media. Furthermore, in many of the countries, religion and culture dictated that the dead must be buried within 24 hours of the time of death. These factors combined to result in the initiation of and continued mass burials of victims who had not been identified. For example, in Aceh province, where the death
toll exceeded 100,000, the burden created by the dead was so huge and the dangers thought to be so great, that thousands of bodies were unceremoniously shoved into mass graves. The numbers reached as high as 15,000/day during the first week of January following the tsunami. New grave sites had to be identified and opened, even while the search for loved ones continued. This process continued despite the issuance of guidelines for the management of the dead provided by WHO. Eventually, at least 42 NGOs were involved with the recovery, burial, and identification of corpses.

In Thailand, the problems associated with management of the dead were viewed differently. First, many of those killed or injured by the tsunami were tourists from other countries. Furthermore, considerable pressure came from the need to re-establish the tourist components of the economy. Recognizing that its capabilities for identifying remains were overwhelmed, the Thai government requested forensic assistance. This request was met by a huge influx of forensic pathologists. Facilities were rapidly constructed. Refrigeration capabilities were supplemented by Normeca AS. It provided cold storage facilities within 16 days of the event. Every modality possible was directed to identification of the corpses (Disaster Victim Identification). Great care was exercised in collecting DNA samples for use in identification; often, simpler and less expensive methods, such as photographs, fingerprints, and dental records were overlooked. Actually, the use of DNA samples was expensive, generally had poor yields, while fingerprint and dental records had high yields especially for expatriates from Europe. Disposal of wastes from the autopsies created an additional problem and collection and disposal processes had to be developed.

Two additional issues arose around the efforts for identification of the victims in Thailand: (1) many of the Thais killed were from the poorer segments of the population and had no dental records and never had been fingerprinted; and (2) many of those killed probably were migrant workers. Families and friends of those killed often were reticent to try to identify their lost family and friends for fear of being arrested by the authorities. However, ultimately, 76% of the corpses in Thailand were successfully identified. But, only 18% of the Thai remains were identified. Lastly, the burden of the dead created in Thailand was by far the smallest for any of the countries studied. Importantly, the processes used for victim identification initiated in Thailand would have proved futile in Aceh province.

A remarkable effort was launched to repatriate injured survivors from Thailand. Countries and regions provided air evacuation to the injured and some uninjured survivors. For example, the Norwegian military provided five flights into Phuket to retrieve the injured residents of the Nordic countries.1 By previous agreements and memoranda of understanding (MOUs), Scandinavian Airlines (SAS) provided the aircraft that were reconfigured by the military to be able to transport the injured back to their country of citizenship.

Many of the survivors (especially women) encountered difficulty obtaining relief funds from their respective governments. Some required proof of death before such assistance would be granted. In many instances, this was not possible.

One other aspect that bears mention relates to the Maldives. Many of the residents and tourists of the inhabited islands had to be evacuated to other islands that had not sustained total damage. Initially, these intruders were welcomed—but, the welcome grew strained when it became clear that many would stay for a long time or even permanently. This created tensions and sometimes conflict.

In each of the countries studied, many of the responders focused on the psychosocial distress of the affected population. Thailand had educated and trained many volunteers at the community level, to assist those affected and to recognize the presence of mental health problems. Generally, this was not the situation in
the other four countries. Undoubtedly, many of the expatriate responders assisted in mitigation of the psychological distress. However, this was not uniformly the case. Many used psychosocial first-aid techniques. Seemingly, some of the interventions provided may have contributed to the psychosocial distress of some of the affected population. For example, it has been reported that psychotropic drugs may have been inappropriately distributed. Unfortunately, at the time of writing, it was not possible to identify the impacts of these interventions.

**Recovery responses**
The processes involved in recovery of the Social Systems of affected populations were intertwined with the relief efforts. The main objective of the relief responses (interventions) was to prevent further deterioration. The recovery responses were aimed to foster a return of the victims to where they were in their lives before 26 December 2004, and if possible, to levels above the pre-event state. Moreover, the recovery processes selected by the countries also were intertwined with development. The countries attempted to revamp their psychosocial structures not only to foster recovery, but to “make it better for the next time” (Clinton).

Inability of the survivors to identify the remains of their loved ones was not as well organized in the other countries as it was in Thailand. For example, in Indonesia, several mass graves were opened and remains exhumed in an effort to identify lost family members and/or to provide proper ceremonies. The actual success of these efforts remains unknown. For many, recovery still is not complete.

Other attempts were made towards recovery by the affected population. For example, in India, the widowers were pressured to re-establish families. They had lost wives and/or other family members. They were left with no one to care for the children while they attempted to regain their livelihood. Hence, they attempted to remarry, often with very young females. Sri Lanka encouraged the families of orphaned children to care for them recognizing that the development of attachments would be facilitated.

Furthermore, some tried to drown their sorrows. Alcohol consumption increased. This became apparent immediately after relief payments were made. It is anticipated that suicide rates also increased, but this has not been possible to document.

The psychosocial support provided by international responders often was transient. Recovery of those incapacitated by their reactions to the stresses to which they were exposed was slow, and many have not “recovered”, and some never will. The best practices for the treatment of those affected remain to be defined.

Much was learned from the DVI experiences in Thailand. However, respective cultures and the ongoing myth complicated the relief and recovery efforts and the ability of the survivors to gain closure.

**Developments**
As noted, in the four countries, recovery was linked tightly with the development of enhanced systems for the provision of psychosocial support. It is of substantial importance that in its own way, each of the countries developed community-based mental health programmes.

The Indonesian Ministry of Health embarked upon developing a mental health system for Aceh province. It tried to nest this programme within the primary care system that was in the process of recovering from the damage. Together with WHO, it endeavoured to educate and train the primary care physicians and nurses/midwives to provide basic mental health services at the community level. In turn, they recruited and trained volunteer, non-health professionals to recognize mental illness, its precursors, and provide basic psychosocial support to those in need (psychosocial first aid or treatment). The resulting programme seemingly was successful and has become a model for the rest of Indonesia.
In Sri Lanka, the government with the help of WHO trained midwives in the provision of psychosocial support at the community level. A national Institute for Mental Health was developed in India. The Institute charged the states with the responsibility for developing community support programmes. Again, WHO played an important role in the training of teachers, social workers, and others at the community level to provide psychosocial services. Furthermore, it linked these psychosocial programmes to the social services rather than associating it with the Medical Care Systems. This action facilitated the breakdown of cultural and religious taboos that existed before the events of 26 December. WHO helped to identify the teachers that could meet these challenges. Interestingly, no attempts were made to train expatriate medical personnel. Similar efforts were initiated in the Maldives where community workers also have been trained to provide psychosocial services. Many of the expatriate medical personnel were not so trained. Currently, psychosocial services are available at the community level in all five of the countries.

**Summary**

Despite the inherent cultural strength of the populations affected by the earthquake and tsunami, the Social Systems in each of the areas directly impacted were devastated by the events of 26 December 2004. The stresses encountered were multifaceted and the support services usually available to those affected were disrupted or destroyed—the grief was extreme. For the first time during a disaster, substantial efforts were directed to prevent/mitigate the psychosocial reactions of those impacted. No specific interventions implemented for treatment of the disorders that resulted or the impact of the treatments provided could be found. Much remains to be learned as to what are the best practices for the psychological distress that results from such events.

**Reference**

Table 17.1: Religious structures used by percentage of population and the primary languages used for communication

<table>
<thead>
<tr>
<th>Indicator</th>
<th>India</th>
<th>Indonesia</th>
<th>Banda Aceh</th>
<th>Maldives</th>
<th>Sri Lanka</th>
<th>Thailand</th>
</tr>
</thead>
<tbody>
<tr>
<td>Religion (%) pop</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Muslim</td>
<td>12.1</td>
<td>81.6</td>
<td>98.5</td>
<td></td>
<td></td>
<td>4.6</td>
</tr>
<tr>
<td>Christian</td>
<td>2.4</td>
<td>13.2</td>
<td>0.7</td>
<td></td>
<td>6.1 (0.2-41.6)</td>
<td>0.8</td>
</tr>
<tr>
<td>Hindu</td>
<td>82.0</td>
<td>1.8</td>
<td>0.1</td>
<td></td>
<td>7.9 (0.3-17.2)</td>
<td></td>
</tr>
<tr>
<td>Buddhist</td>
<td>0.8</td>
<td>0</td>
<td>0.6</td>
<td></td>
<td>76.7 (39-97)</td>
<td>94.2</td>
</tr>
<tr>
<td>Islam</td>
<td></td>
<td></td>
<td></td>
<td>100.0</td>
<td>8.5 (2.5-41.6)</td>
<td></td>
</tr>
<tr>
<td>Jains</td>
<td>0.4</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td>0.4</td>
<td>3.4</td>
<td>0.2</td>
<td></td>
<td>0.8 (0.2-2.0)</td>
<td></td>
</tr>
<tr>
<td>Misc</td>
<td>0.1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Primary Languages</td>
<td>Hindi &amp; English</td>
<td>Bahasa Indonesia</td>
<td>Bahasa Indonesia</td>
<td>Dhivei</td>
<td>Sinhala &amp; Tamil</td>
<td>Thai, some English</td>
</tr>
</tbody>
</table>
Introduction

Several aspects of education are relevant to health: (1) literacy rate; (2) educational levels achieved; and (3) professional schools and education. Literacy is essential for the dissemination of written information and instructions. The educational levels attained relate to the interpretation of communications, understanding, and problem solving. Lastly, the education and training of health professionals bears heavily upon the operation and sustainability of the healthcare system.

Pre-Events

The pre-event educational status of each of the five countries studied is summarized in Table 18.1. The literacy rates were above 90% in all the countries, except India. At the time of the tsunami, only 65% of the Indian population was literate. In the territories of the Andaman and Nicobar Islands, the literacy rate was 81%. Similarly, the average highest level of education was lowest in the same countries plus Indonesia, and was highest in the Maldives and Thailand.

Each of the five countries had schools for the education and training of health professionals. There was one medical school and three schools of midwifery located in Banda Aceh. India has 202 medical schools and 55 colleges of nursing. Sri Lanka had six medical schools, Indonesia had 31, and Thailand 50. The Maldives did not have a medical school, but the University in Malé had programmes to educate and train nurses, pharmacists, laboratory technicians, and other health professionals. This institution has been unable to meet the needs of the country and a large component of the health staff consists of expatriates.

In Aceh province, schools were one of the targets of the insurgency. During the 21 years of insurgency, at least 248 schools were burned. During this period, school destruction disrupted the education of at least 60,000 students.

It has not been possible to gather information on whether education and training in disaster health was part of the curriculum of any of the schools before the events of 26 December, nor was it possible to gather information on the initial and continuing education in disaster health by the medical facilities in any of these countries.

Damages

The Education System was damaged in the areas impacted by the tsunami in each of the countries and by the earthquake in Indonesia and the Andaman and Nicobar Islands. Damage / destruction ranged from total to none. More than 30 schools in the Andaman and Nicobar Islands were flattened by the earthquake.

Not only were physical structures affected in each of the countries, but textbooks, library books,
records, computers, and the like were damaged or destroyed as well. All levels of schools were affected. The medical school in Banda Aceh remained structurally intact, but books, computers, and teaching materials were damaged or destroyed. Students in each of the schools impacted lost books, papers, and other learning materials. Teachers and students were killed or injured.

Changes in functions
Schools in the impacted areas were unable to operate for varied periods. The events struck just as the school year was beginning. Continuation of education became a nightmare, not only because the schools were damaged, but as with the healthcare systems, staff and teachers were missing or dead, injured, displaced, or had to care for their family or search for missing family members and friends. Often alternate sites in which to locate classes from the damaged schools had to be found and equipped. Furthermore, many, many students had become displaced from their homes and from schools, and had taken shelter in IDP camps or in the homes of relatives or friends. Early on, schools had to close due to IDPs using them as shelters. Those schools that could function rapidly became overloaded. For example, classes in the schools in Malé were jammed with students that were displaced from their home islands and arrived to the capital city. This migration resulted in disruption of the whole Education System in the impacted areas. The status of families and their composition interfered with participation in school activities. In many instances, students were compelled to assist their families with gaining a transitional (and sometimes permanent) livelihood.

The collapse of the Education System added further to the social burden. Students did not attend school and increased the burden on the surviving family members or on the host families. In addition, many of the youth were pressed into helping to meet the survival needs of the family and were withheld from attending school. Emotional trauma was superimposed on top of these huge changes.

Recovery responses
In the areas of India impacted by the tsunami, generally classes were begun after a 2–3 week delay. In the Maldives, the start of the school year was delayed for one month—but 60% of the expatriate teachers failed to return to their posts. The reconstruction and repair of the education infrastructure was slow. The government pressed student teachers to lead classes. By the third anniversary of the tsunami, 800 of the damaged or destroyed schools in Indonesia had been repaired or rebuilt. UNICEF played an important role in assisting with the recovery of the educational system. Psychosocial disruption affected attempts to restore the disrupted educational processes.

Developments
No information pertinent to the public health and /or medical care systems was found relative to developments in the Education System.

Summary
In each of the areas impacted, the educational system was interrupted at all levels. Damage from the earthquake (Indonesia and the Andaman and Nicobar Islands), and from the tsunami was extensive not only to the physical structures, but to the teachers and students as well. In addition, school buildings were used as shelters. For the most part, classes were not convened for a month or more. This further impacted the social burdens on the students and the families or host families.
### Table 18.1: Pre-event education status of countries (2003–2004)

<table>
<thead>
<tr>
<th>Indicator</th>
<th>India</th>
<th>A+N islands</th>
<th>Indonesia</th>
<th>Aceh province</th>
<th>Maldives</th>
<th>Sri Lanka</th>
<th>Thailand</th>
</tr>
</thead>
<tbody>
<tr>
<td>Literacy</td>
<td>65</td>
<td>81</td>
<td>90</td>
<td>96</td>
<td>991</td>
<td>92</td>
<td>96</td>
</tr>
<tr>
<td>Average Educational Level (yr)</td>
<td>5.1</td>
<td>5.0</td>
<td>11.53</td>
<td>6.9</td>
<td>6.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Medical schools</td>
<td>202</td>
<td>0</td>
<td>32</td>
<td>1</td>
<td>0</td>
<td>6</td>
<td>50</td>
</tr>
<tr>
<td>Medical schools/10 000 population</td>
<td>0.002</td>
<td>0</td>
<td>0.001</td>
<td>0.003</td>
<td>0</td>
<td>0.003</td>
<td>0.008</td>
</tr>
</tbody>
</table>

Transportation and Logistics Systems

Introduction

The Transport and Logistics Basic Societal System are essentially responsible for moving people and materials between places and for coordinating these movements. The Transportation and Logistics Systems are interdependent with almost all of the other Basic Societal Systems—and, almost all of the Basic Societal Systems are dependent upon some of the services provided by the Transportation and Logistics Systems. Without a well-functioning transport and logistics system, eventually all of the other functions would cease as the resources consumed by the other Basic Societal Systems would become exhausted due to inability to resupply. For the most part, it plays a key role in the interactions between the other Basic Societal Systems. For example, a Transportation and Logistics System is interdependent with the Public Works and Engineering System as it is not possible to transport goods and persons without the infrastructure required. The Transportation and Logistics Systems moves the materials required by Public Works and Engineering and for the provision of medical care. For the present study, the prehospital emergency medical services (EMS) system is included within the Medical Care System. However, it is recognized that it not only provides prehospital medical care, but also moves patients between locations. Prehospital EMS could also be included as an element of the Public Health Systems.

The logistics component of the transportation and logistics system is responsible for establishing priorities for the use of the available resources by the system. The logistics component becomes essential when the available resources are constrained or when the methods available cannot meet the defined needs for the transport. For example, when would rotary-wing aircraft be required to meet the needs of the afflicted population due to inability to meet the needs using land mechanisms?

Pre-Events

Transportation on land requires a functional road system. As noted in the preceding chapter, generally, these systems varied substantially between the countries. The Transportation and Logistics Systems requires the use of vehicles and the personnel to staff them. The vehicles generally are dependent upon the use of fuel (Energy Supply System) to propel them. It also depends on intact Public Works and Engineering System of roads, bridges, rail lines, harbours, jetties, and airports. Most of the transportation facilities in each of the areas affected by the earthquake and tsunami were confined mainly to the urban areas—the rural areas were poorly served.

As noted in Chapter 15, each of the countries was served by airports: each with at least one airport that could handle international flights carrying relief/recovery supplies. Substantial
hangar space was available at the major airports that could be used as warehouses for imported equipment and supplies. Each of the countries also had docks and jetties that could handle large craft carrying people, equipment, and supplies. These facilities were vulnerable to both the earthquake and the tsunami.

Transportation by boat from the mainland to Port Blair on the Andaman Island required an average of five days. In order to reach the Nicobar Islands, another two days often were required. Access to health care in the islands often required boats. None of the countries had a comprehensive prehospital emergency medical services system. Ambulances were used primarily for inter-facility transport and not for emergency responses.

The military in each of the countries had abundant transportation resources, but disaster response was not part of the military’s mission prior to the events of 26 December.

Damage
Major damage was inflicted on the Transportation and Logistics Systems operational in the areas impacted directly by the events of 26 December. The Transportation and Logistics System combined with the Public Works and Engineering Systems suffered the most in terms of financial costs—where costs of the damage are available, between 60% and 70% of the total costs of damage to the infrastructure was incurred by these two societal systems. These estimates include the damage and destruction to roads, rail lines, airports, and harbours and jetties that are the responsibility of the Public Works and Engineering System and to vehicles and staff of the Transportation and Logistics System. Transportation vehicles were picked up and carried inland, including trains and heavy barges. As noted in Chapter 15, roadways and bridges were the most vulnerable and extensive damage to the roadways was common. Many areas were rendered inaccessible by road. Most of the vehicles destroyed were privately owned. Many bridges were wiped out or damaged to the extent that they could not be crossed. In Thailand, most major roads sustained little if any damage, but smaller roads that were built on sand beds were severely damaged. In the Maldives, jetties, sea walls, quays, causeways, breakwaters, markers, and beacons were destroyed. In the Andaman and Nicobar islands, severe damage occurred to the docks and some were inundated due to the subsidence caused by the earthquake.

Changes in functions
Loss of transport capabilities made access to the medical care facilities difficult. As pointed out, many injured/ill persons were conveyed to medical facilities using taxis or private vehicles, or whatever means that could be commandeered. Furthermore, it was difficult to transport urgently needed supplies, equipment, and staff to the facilities. Thus, staffing levels were lower than during normal times and essential supplies were rapidly depleted. Together, the ability to deliver the medical care required to meet even the day-to-day needs was compromised in all the areas impacted by the tsunami.

Damage to roads and bridges isolated many of the rural communities that could not be reached by surface transport facilities. Inaccessibility of isolated communities occurred in each of the countries, except for Thailand. In Thailand, access roads to the areas impacted remained open, or were reopened using the military, and there was little disruption in services. However, the sudden and huge generation in the numbers of injured temporarily overwhelmed the transport capabilities in each of the five countries. Further complicating the problems was the increase in demand for transportation services by the victims and their families. Functions were compromised further by shortages of fuel with destruction of supplies often without the ability to rapidly replenish them. Even further embarrassment was created by damage to the hospitals that made them unable to absorb the surge, but that bypassing a hospital required transport to a facility that even was further from the location at which the injured person was discovered.
Major damage occurred to the docks and jetties in the Andaman and Nicobar Islands and in the Maldives. This resulted in the inability for ships to dock. When they arrived, the cargo and people had to be shuttled to and from the land using small boats.

**Relief responses**

Initial responses to the chaos that occurred generally came from the military of the respective countries. However, in Indonesia, for example, military support also came from the international community. Even India sent military to support the troops in Indonesia. For the most part, this military support was under the control of the military commanders of the recipient country (see Chapter 22: Coordination and Control). In Thailand, the military and other governmental agencies quickly removed debris from the roads, thus restoring land access to the impacted area.

The immediate relief responses were followed by a flood of international, humanitarian assistance, generally transported to the countries using aircraft. For example, the number of flights arriving at and departing from the Medan International Airport increased from 60–70/day pre-events to some 500/day; and for the airport serving Banda Aceh, the number of flights increased from 15 flights/day to 50–60 flights/day. But, in many instances in each of the countries, the material and personnel arriving could not be transported from the airports to where they were needed due to unavailability of land transport capabilities. Early on, a few of the responding organizations brought land transport equipment with them. Consequently, relief supplies piled up at the airports and overflowed and overwhelmed the capacities to warehouse the supplies and equipment. Creating an inventory and distribution of the supplies and people presented a problem in each of the countries, and eventually, special control mechanisms had to be implemented, usually with the assistance of UN agencies (see Chapter 22: Coordination and Control). In the Maldives, the SUMA inventory and control system was implemented apparently with substantial success.

In the Indonesia, Maldives, and Sri Lanka, UN agencies, several INGOs and the ICRC played important roles in coordinating or attempting to control the logistical nightmare associated with the huge influx of people and materials.

Much of what remained of the transport capabilities often was consumed by incoming relief teams. This created conflict in several of the countries, as many of the responding relief agencies that arrived were not self-sustaining, including their ability to reach the areas for which they supposedly were responding.

Within the first few days, inaccessibility of isolated communities occurred in each of the countries, except in Thailand. When possible, many of the isolated communities were served by military aircraft, especially helicopters. In many instances, helicopters carrying relief supplies, including water, were unable to land because of crowds gathering in possible landing sites. Eventually, the military had to secure landing sites.

Initially, there was little coordination for the use of the available transport resources. Priorities were not assigned and the logistics for uses of available transport resources were haphazard (see Coordination and Control). Eventually, responding relief agencies began to import transportation capabilities so that the relief operations no longer were dependent upon the limited capacities of the host countries. In addition, agencies such as the British Air Force, WHO, WFP, UNICEF, OXFAM, UNFPA, ICRC, and the Saudi military supplemented the transport systems though the provision of vehicles.

The island nations and territories suffered greatly from the loss of transportation capabilities. Ships were unable to reach the Andaman and Nicobar Islands quickly, and when they did arrive, they could not dock. Materials and personnel had to be ferried back and forth by small boats. In the Maldives, not only were the harbours and jetties destroyed, but it became necessary to evacuate persons from their islands of residence to other islands. Hospital ships responding to Aceh
province also could not dock, and patients had to be ferried to and from them.

None of the responses of the Basic Societal Systems could be effective without the availability of transport capabilities and capacity. For example, the huge injury and disease burdens suffered by each of the countries were complicated by inability of staff to reach the respective medical facilities and to obtain the supplies needed to meet the surge.

**Recovery responses**

In each of the countries, the recovery process began while the relief efforts were ongoing. But, generally, the recovery processes were slow and highly dependent upon the progress achieved by the Public Works and Engineering Systems. In Sri Lanka, rail traffic was restored between Colombo and Matura by mid-January. Thailand’s transportation and logistics system was restored within days. In other countries, some of the transport capacities still have not returned to their pre-event levels. Docks and jetties were repaired. The time frames for recovery have not been clearly defined.

**Developments**

Numerous activities have been directed to enhancing the transport capacities of the affected countries. For example, WHO donated two ambulance boats to serve the atolls in the Maldives. In each of the countries, resources have been invested in the development of EMS systems. The shortcomings of the transport systems revealed following the tsunami have been addressed by reorganization of disaster management and preparedness in each of the countries. Transportation and Logistics and Public Works and Engineering suffered the greatest economic losses.

**Summary**

Impairment of the Transport and Logistics Systems hampered almost all of the other societal functions. This was reflected in the functional status of the affected society. All-in-all, the Transportation and Logistics Systems became the major bottleneck in the relief processes. Where resources were available and access was possible, distribution generally was smooth. It seems clear that selection and setting priorities for use of limited transport capacity is an essential element of any disaster relief response. It remains unknown how many potentially preventable deaths occurred due to breaks in the transport system.

The functions of the Transportation and Logistics Systems were profoundly impacted by the damages to the Public Works and Engineering Systems. Together, the loss of functions of the Transportation and Logistics System had profound effects on the ability of victims and staff to reach medical care facilities and thus, contributed to the inability of the medical facilities to maintain even routine functions. Many of the arriving NGOs were dependent on local transportation capacities and capabilities and the inability of the Transportation and Logistics Systems contributed to backlogs at the receiving facilities, especially at the airports. Arriving agencies must be equipped to provide for their own transportation. The logistics for the use of available transportation equipment and personnel should be a responsibility of Coordination and Control.
Introduction

The Economy Basic Societal System functional (BSF) system is the financial engine of a country. The financial capacity is a major factor in the ability of a country to develop disaster preparedness in terms of augmentation and sustainability of the absorbing, buffering, and response capacities (part of development) and ability to respond to losses in function, including relief, recovery, and development. Sudden-onset events that turn into a disaster require the immediate availability of relatively large amounts of cash. Is the country able to financially cope with the disaster without outside assistance? Both Thailand and India made it clear that they had sufficient resources to cope with the damages that resulted from the earthquake and tsunami of 26 December 2004. The economies of the other three countries required huge sums in donated resources to be able to cope with the damages.

Major economic indicators for each of the countries are listed in Table 20.1. The income categories are “low” or “low-middle”. Although the Maldives ranks 187th in the world, it had the second highest GDP/capita of the five countries. Only Thailand had a higher GDP/capita. Although India has the highest GDP of the five countries, due its huge population, India has the lowest GDP/capita. It also has the highest proportion of its population below the poverty line and an extraordinary proportion of the poor in the world.

Each of the countries studied had tourism as a major industry. Thailand attracts the most tourists. The Maldives and Sri Lanka attract about the same number of tourists, but given its relatively small population of only 300,000, when viewed as the number of tourists/10,000 population, the tourist industry in the Maldives takes on special importance. However, it is stressed that these national figures may not accurately reflect the economic situation in the areas directly impacted by the earthquake and tsunami. The discussion of the economies of the five countries that follows relates to the impact of the events of 26 December and speculates on the effects of the changes in the economy had on health.

Pre-Events

When the tsunami struck, India’s economy was one of the 10 most rapidly growing and was the 10th largest in the world. By far, it had the largest GNP of any of the countries. Nevertheless, it was ranked as a “low-income” country. Although, overall, it had the highest percentage of its population living below the poverty line, conditions were somewhat better in the areas struck by the tsunami than in most other parts of the country. Compared to the 27.5% overall population of India, the states of Tamil Nadu, Andhra Pradesh, and Kerala were well below the national average (22.5%, 15.8%, and 15.0% respectively) and the Andaman and Nicobar Islands (22.6%).
Agriculture provided the greatest percentage of employable population in Indonesia (47.6%) and in the state of Tamil Nadu (85%) of India. In Sri Lanka, the services industry employed 56% of the working population while agriculture employed 18%. The services industry and industrial manufacturing were enjoying a growth spurt in the years preceding the tsunami.

Tourism was the backbone of the economies in the impacted areas of the Maldives and Thailand. In the Maldives, tourism generated one-third to one-half of the GDP and 42% of the GDP in Phuket. The rates of unemployment were creeping downward in Indonesia, Sri Lanka, and Thailand prior to the earthquake and tsunami.

All the areas impacted had persons and settlements on the shores that were involved with the fishing profession or the tourism industry. Even though the fishing industry made up a relatively small portion of the GNP, its location made it very vulnerable to damage from the tsunami. In Aceh province, fisheries produced 183,183 tons of fish/year and contributed 6.5% of its GNP. In the Maldives, the fishing industry contributed 6.4% of its GNP and made up 60% of its exports.

The Maldives spent the most/capita for the provision of health care (US$ 265/capita in 2004). Sri Lanka ranked second with US$ 101/capita. The remaining countries spent US$ 27–US$ 37/capita! When viewed as the amount of the GNP invested in health care, the Maldives used almost 9% of its GNP and Sri Lanka spent 6.5% of its GNP on health care. This was 2–3 times greater than the other three countries. The costs of health care in the Maldives like everything else is extraordinary primarily due to the logistics and the use of expatriate physicians; and since all of the medical equipment and supplies must be imported, there is an associated high cost of transport and inability to gain economies of scale. But, there is a disparity between the estimates of SEARO and the Ministry of Health as to where the healthcare funds are spent. Sri Lanka has a federal healthcare system with all costs paid by the government. Thailand underwent a major reform in 2001 when more than 30 million additional persons were added to government-paid health insurance. India’s health insurance scheme was fragmented. It provided accessible insurance and medical care in the public hospitals and clinics for families/persons below the poverty line. In the Maldives, the expenditure on social security was 23% of the general government expenditure on health, more than one-third was spent on prevention, and 20% was spent on medical care (curative).

In 2004, the Indonesian government committed to provide its entire population with health insurance coverage through a mandatory public health insurance scheme. By the end of 2004, it provided coverage to an estimated 76.4 million poor and near poor, funded through the public budget. But, more than half of the population lacked health insurance coverage, and the full fiscal impacts of the government’s programme for the poor had not been fully assessed or felt. The Thai healthcare system suffered relatively minimal damage—estimated at US$ 3.8 million.

Damage to the economic systems

Damage to the economy in each of the countries was huge. The damage from the earthquake and tsunami not only should include direct costs in the losses to infrastructure and equipment, but must include the loss of livelihood and personnel. The total economic loss to the infrastructure in the Maldives was equivalent to 62% of its GNP. It cost US$ 12.2 million to restore its healthcare system and a total of US$ 2.2 billion to recover. It cost Indonesia US$ 91.9 million. To restore health services (81% to repair medical facilities). The estimated costs in India of the damage due to the tsunami totaled US$ 15.71 million. The majority of the damage to the healthcare system (US$ 15.3 million) was suffered in Tamil Nadu. Estimates to restore the healthcare system in Sri Lanka were at least US$ 60 million. The estimated costs of the damage to the healthcare system in Thailand was US$ 3.8 million. Given the limitations in the information available, it has not been possible to estimate the economic costs associated with the loss of life and the loss of livelihood due to physical and emotional injuries.
Changes in functions

In Aceh province alone, 600,000 jobs were lost including 300,000 fishing jobs; in Sri Lanka, 275,000 jobs were lost directly due to the damage and another 125,000 were lost due to the collapse of other entities such as businesses that could not survive. The fishing industry in the Maldives was not heavily damaged. Recall that the nature of the tsunami as it struck the shores of the Maldives was very different from the forces associated with the tsunami in the other countries. Conceptually, this must be balanced by the loss of personnel for these jobs.

In the areas of Thailand impacted by the tsunami, the beaches were soiled and tourists stayed away for more than one year. Phuket lost 28% of its room capacity through damages to 328 resorts/hotels, restaurants, and shops. Occupancy dropped from the 57%–70% range to 30% in 2006. This represented a drop of more than 25% in Phuket and 61% in the Phang Nga province. The direct costs were US$ 374 million. But, these costs do not include the potential revenue lost related to the tsunami’s arrival during the peak tourist season. In the Maldives, 21 of the 87 resorts had to close due to damage and one-third of the hotels, safaris, and guesthouses had to close. The number of tourist arrivals by air decreased by 79% in 2005. In addition, workers at the resorts lost 50% of their usual income that came from gratuities. An estimated 35,000 households in Thailand lost their livelihood.

The decline in purchasing power was another limitation. The impact of this factor on the Public Health and Medical Care Systems could not be estimated.

Relief responses

The two countries with the large economies, India and Thailand, did not request financial assistance from the international community to fund relief activities. Indonesia, Sri Lanka, and the Maldives accepted assistance with the relief processes. In terms of total resources potentially available, India ranked the highest. As noted, the Maldives was faced with a very limited economy and small intrusions on the economy could have resulted in collapse. Its total losses were 62% of its GNP!

The total amount of financial resources raised for providing assistance was the largest ever pledged—a total of US$ 13.690 billion in cash donations was pledged. The donation process may have been fueled, in part, by pleas for assistance from former US Presidents Bush and Clinton. WHO initiated a flash appeal for resources to fund health relief and recovery. The Thai government allocated US$ 1.7 billion (1.4%) of its total budget towards relief and recovery costs. This figure does not include the huge amounts provided in-kind by the humanitarian community, especially through the UN agencies and NGOs. These figures include financial resources for both relief and recovery. The true total contributions in terms of financial value may never be known. In reality, the resources donated were so generous, some still exist as residual. The effects of these donations or the portions directed to the Public Health and Medical Care Systems could not be calculated.

Recovery Responses

In efforts to restore the economy and livelihoods, several governments offered compensation packages. For example, India provided compensation funds to survivors who had lost a relative, to those who were injured as a direct result of the tsunami, and to those who lost their livelihood. More than US$ 100 million was provided to fisherman to compensate for lost boats and equipment. The funds were to be used for rebuilding their livelihoods, and hence, the economy. The benefits from the provision of such funds seem obvious. However, difficulties were encountered by some who deserved compensation, but were unable to produce a death certificate or a body. Furthermore, it was difficult to prove that injuries were due to the tsunami and its effects. It did open opportunities for fraud and this encumbered the process. In the Andaman and Nicobar Islands, attempts were made to ease the process for obtaining
compensation. Unfortunately, this too had a downside in that it tended to change the life patterns of the indigenous population who suddenly found they had the ability to purchase things—things such as television sets, mobile telephones, and other trappings of development. This may have fueled the loss of elder direction/supervision/decision-making for some of these indigenous communities. In the island territories, at least one study documented that in an effort to promote recovery, more than half of the saplings provided to restore the production of coconuts and cashews remained unplanted. In addition, in those areas devastated by the tsunami, relief-recovery funds sometimes were used for the purchase of alcohol and other mind-altering substances that may have been used as ways to deal with the emotional issues that resulted. Thailand also provided compensation to fisherman who had lost their livelihood due to destruction of their boats. UNDP assisted many of the countries with developing and implementing strategies to restore their respective economies. Following initiation of the relief efforts, India agreed to accept financial resources to assist with funding recovery. By the end of 2006, most of the tourist trade had returned to pre-event levels. In general, this component of the economies of Thailand and the Maldives was an essential element in recovery.

Lastly, not everything had a down side. Many of the NGOs employed resident workers in the recovery processes. For example, NGOs in Aceh province employed at least 30,000 workers. Undoubtedly, this was the case in the other countries, but it was not possible to substantiate these efforts.

**Developments**

The Maldives also opened 35 additional islands for further development of its economy. A major contribution to the economic development in the health systems was implemented by WHO-SEARO. In a series of meeting when relief and recovery efforts were well underway, SEARO facilitated the development of a series of standards and benchmarks to assist the countries to be better prepared for the next disaster. Included in these standards was the establishment of available (cached) resources for disaster preparedness of the public health and medical care systems to meet the next challenges, including development of means for capacity building and for rendering health facilities safe.

WHO-SEARO also convinced the countries to develop a regional emergency relief fund that immediately would be available to countries in times of disaster. Contributions were made on the basis of the sizes of the populations-at-risk. These funds subsequently were used in support of the relief efforts during and following the floods in Bangladesh and the cyclone and floods in Myanmar in 2008.

**Summary**

The Economy Systems of India and Thailand were such that they did not require financial assistance for relief activities following the earthquake and tsunami. However, despite its rapidly growing economy, India did request assistance for meeting the economic costs of recovery. The other three countries in this study received the bulk of the greatest sums of money ever donated for assistance with meeting the costs relief and recovery during a disaster. Parts of the funds received still had not been used at the time of this writing.

In general, the financial engines of the five countries recovered relatively quickly, especially as fueled by donated resources.
References


**Table 20.1: Major economic indicators**

<table>
<thead>
<tr>
<th>Indicator</th>
<th>India</th>
<th>Indonesia</th>
<th>Maldives</th>
<th>Sri Lanka</th>
<th>Thailand</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rank by GDP</td>
<td>13</td>
<td>23</td>
<td>187</td>
<td>82</td>
<td>35</td>
</tr>
<tr>
<td>GDP (millions)</td>
<td>906 268</td>
<td>364 458</td>
<td>206</td>
<td>29 996</td>
<td>206 247</td>
</tr>
<tr>
<td>Income category</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
<td>Lower-middle</td>
<td>Lower-middle</td>
</tr>
<tr>
<td>Pop &lt; poverty line (%)</td>
<td>25</td>
<td>17.8</td>
<td>21</td>
<td>22</td>
<td>10</td>
</tr>
<tr>
<td>% world’s poor</td>
<td>41.01</td>
<td>1.49</td>
<td>0.12</td>
<td>0.11</td>
<td></td>
</tr>
<tr>
<td>Human Development Index</td>
<td>0.602</td>
<td>0.697</td>
<td>0.745</td>
<td>0.751</td>
<td>0.778</td>
</tr>
<tr>
<td>Healthcare costs/GDP (%)</td>
<td>3.1</td>
<td>2.2</td>
<td>8.7</td>
<td>6.5</td>
<td>1.2</td>
</tr>
<tr>
<td>Major products</td>
<td>Rice, wheat, oilseed, cotton, jute, tea, sugarcane, potatoes, cattle, water buffalo, sheep, goats, poultry</td>
<td>Rice, cassava, peanuts, rubber, cocoa, coffee, palm oil, copra, poultry, beef, pork, eggs</td>
<td>Coconuts, Corn, Sweet potatoes, fish</td>
<td>Rice, sugarcane, grains, pulses, oilseed, spices, tea, rubber, coconuts, milk, eggs, hides, beef</td>
<td>Rice, cassava, rubber, corn, sugarcane, coconuts, soybeans</td>
</tr>
<tr>
<td>Tourist arrivals</td>
<td>2 374 000</td>
<td>5 185 000</td>
<td>366 000</td>
<td>366 000</td>
<td>7 294 000</td>
</tr>
<tr>
<td>Tourists/10 000 pop</td>
<td>22</td>
<td>214</td>
<td>12 200</td>
<td>190</td>
<td>1125</td>
</tr>
<tr>
<td>Estimate of costs of damage to healthcare system US$ million</td>
<td>15.7</td>
<td>91.9</td>
<td>14.4</td>
<td>60.0</td>
<td>3.8</td>
</tr>
</tbody>
</table>

Part IV
Analysis
Chapter 21
Communications Systems
Communications Systems

Introduction

The Communications Basic Societal System is responsible for communications between all other Basic Societal Systems including the coordination and control function. Thus, the communications system influences the preparedness and relief and recovery operations during emergencies and disasters. It is responsible for the personnel, hardware, and software that are essential for electronic communications as well as for all other means of communications used in the respective countries including the use of couriers, interpreters, and the media. It is essential for the movement of data and information between the Basic Societal Systems and management and workers, and management and the public. It also incorporates warning systems when such exist.

Any breakdown in the essential communications links within and between countries during disasters compounds the problems associated with the functional losses resulting from the damage caused by the event(s). Communications System in each of the countries discussed in this analysis were disrupted to a variable degree immediately following the events of 26 December. This Chapter examines the impacts of the events of the day on the Communications System as they may apply to the Medical Care and Public Health Systems.

Pre-Events

Each of the countries had an operational telephone system or systems in the areas impacted by the tsunami and earthquake. In some, the mobile (cell) phone system also was robust. In addition, the distribution of radio and television stations and newspapers was similar. As apparent from review of the media available in Aceh province (population of approximately 4 million), most of the information obtained by the population (74%) was acquired from television. Similar access was present in the islands and, by some reports, in parts of the Andaman and Nicobar Islands impacted by the earthquake and tsunami. However, this did not include the indigenous population in the Andaman and Nicobar Islands where contact with the outside world often was limited.

In general, the major telephone facilities/networks hubs were further inland than those areas impacted by the tsunami, and telephone lines into the areas impacted were strung on poles along with power lines, and therefore, were vulnerable to the impact of the earthquake and tsunami. In Aceh province and in the Maldives, the radio and television systems were owned entirely or in part, by the government. In particular, due to the ongoing conflict in Aceh, the range of activities of the Communications System was limited.

Other than for television and radio, no specific emergency information systems existed prior to the events of 26 December. Backup systems...
were not designated or operational. But, many of the fishing and commercial boats had the availability of citizens band and/or very high frequency radios. There were no early warning devices for a tsunami in operation in the region.

Generally, there were no commonly accepted report forms, including within the countries, ministries of health locally, nationally, or within SEAR.

Lastly, as indicated in Table 21.1, the languages used in each of the countries differed as did their cultures. Undoubtedly, there were many additional languages in use, and the table indicates that major differences existed. These differences impacted the visitors or responders who did not know the primary languages spoken. Often interpreters were not readily available. It was not possible to ascertain the communications in and between medical facilities.

**Changes in functions**

An important problem with communications was the apparent failure of the countries in the regions that were impacted to warn the other countries in the region of the impending event. This could have been done for those countries far away from the epicentre of the earthquake that spawned the tsunami. The arrival of the first waves of the tsunami came ashore at least one hour after the earthquake for all countries except Indonesia and the Indian territories of the Andaman and Nicobar Islands. There was little time to warn the northern Indonesian Provinces, especially Aceh, or the Andaman and Nicobar Islands as the tsunami followed the earthquake in very short order. Further, both of these locations were affected by the most severe earthquake in decades.

Wherever mobile phone capabilities were available, the circuits rapidly became profoundly overloaded, and hence, non-functional. In Aceh, all civilian forms of communications became inoperative and the areas impacted on the mainland of India were unable to call for assistance or make known the extent of damage and dysfunction that had occurred. The Maldives lost all direct contact with the islands that were most impacted. Similar disruptions were the rule in the Andaman and Nicobar Islands. Satellite phones, where available, remained operational.

Thus, other than the use, but limited availability of satellite communications, there was little buffering capacity built into the communications systems of these countries. Lack of communication capabilities severely compromised coordination of activities. Overall, the lack of communication capabilities further isolated the communities inside the affected areas as well as with outside organizations and agencies. The probable impact on the ability of the Medical Care and Public Health Systems seems obvious, but no direct reports were found, including in the information obtained through interviews.

Damage

As noted above, each of the areas impacted had at least transient interruption of communications. The most severe problems occurred in Aceh province where not only was hardware damaged or destroyed, but staff members responsible for communications were injured, many of whom did not survive. The telecommunications system in Aceh province, lost 18 of its staff and the damages to its hardware were estimated at US$ 5.9 million; the privately owned television station lost 12 of its staff and its studio facilities, and the newspaper—54 of its staff of 200 plus its offices and printing and other equipment. In addition, the majority of its radio stations were rendered inoperable. On the other hand, the areas in Thailand that were impacted lost landlines, but there was no serious damage to its hardware. Damages to the Communications System in the Maldives were estimated at US$ 18.5 million. Sri Lanka lost 6.5% of its total landlines.

The telecommunications system in Aceh province, lost 18 of its staff and the damages to its hardware were estimated at US$ 5.9 million; the privately owned television station lost 12 of its staff and its studio facilities, and the newspaper—54 of its staff of 200 plus its offices and printing and other equipment.
Relief responses
The immediate responses to the lack of communication capabilities were to utilize what little buffering capacities available. Generally, the buffering was provided through the use of satellite phones and radios. The responding military in Indonesia had access to satellite communications. Communications across the Maldives were achieved using citizen band and/or very high frequency (VHF) radios aboard fishing and/or commercial boats, and also were provided by the Maldivian Coast Guard. In Indonesia, other than the use of satellite phones by the military and the insurgents, communications was relegated to runners and couriers on motorcycles.

Attempts were made by UN agencies to enhance the communication capabilities. For example, UN/OCHA convened meetings initially using face-to-face discussions between responding agencies. By mid-January in Indonesia, OCHA had initiated a website called the Humanitarian Information Centre (HIC) for reporting progress and the results of health surveillance activities. Of importance, the HIC included a standardized reporting form. Initially, participation of the more than 200 responding agencies was sparse, and many of those that did use the HIC did not use the standardized form for reporting. In August, 170 of the participating organizations were using the HIC for reporting process. The ICRC initiated efforts to help victims find relatives and friends and posted listings in local newspapers and in public places.

Health services utilized the HIC for the transfer and accumulation of information from surveillance activities. No available standardized form for reporting surveillance or medical activities could be retrieved.

The communications within and between health facilities and field workers were bolstered by the provision by WHO of computer communications capabilities at the medical facilities including hospitals and community health offices. Furthermore, lack of communications hindered communication between responding agencies, and as a result, contributed to duplication of efforts as well as the provision of goods and services that were not needed by the affected populations.

The national and international media flooded the areas impacted. Media began to arrive in Thailand within 12 hours, but it was at least two days following the tsunami that the first images became available to the world community. The media concentrated on sensationalism associated with images of total destruction and interviews with persons affected. This was the case particularly in Thailand. The media was instrumental in producing reports to donors, and hence, to the outpouring of economic support and donations for the relief efforts. On the other hand, media reports also created unreasonable expectations as well as promoting a sense of doom. A good example was the interpretation that the dead were being buried in mass graves because they posed a threat for the spread of disease. Statements were generated that provided the perception that the diseases originating from the dead would result in a disaster and loss of life that would be greater than the numbers who had succumbed to the earthquake and tsunami. In addition, the media tended to focus on the care provided or not provided to the injured and raised the perceived need that additional medical assistance was needed, when in fact, such assistance was not needed. Thus, the media provided the world with profound images of the catastrophe and helped to raise unprecedented sums of cash and other donations. Hence, the media not only promulgated truths, but untruths and fanned the many myths that continue to surround reporting of such events by the media.

Given all these relief activities, the relief organizations had difficulty communicating, and hence, coordinating with each other. But, of note, many of the responding agencies failed to communicate effectively with the beneficiaries of the aid being provided. Hence, in many places, this created a gap and feelings of distrust between the providers and the recipients. Recipients felt...
they had no input to what was being or not being provided by some of the relief agencies.

It became evident that coordination and control is not possible without an operational communications system and information management that is part of such systems.

**Recovery responses**

Initial efforts to promote recovery of the communication system in each of the countries were directed at restoring mobile phone services. Secondarily, attention was directed towards repairing damaged lines and network systems. This process only required a few days, and hence, for the most part, telephone services were restored to the affected areas relatively quickly. There were some exceptions, most notably delays in reaching some of the islands in the Maldives and in the Andaman and Nicobar Islands.

The lone newspaper in Banda Aceh began to print again within five days, and, in fact, at one year following the events, its subscription services had increased by 25%. Simultaneously, UNESCO issued a flash appeal for US$ 600 000 for restoration of the radio networks in Aceh province.

**Developments**

Much has been done to enhance the available communication systems in each of the countries. For example, the Maldives, with the assistance of the Asia Disaster Preparedness Centre, has developed an emergency radio system and has trained persons on how and when to use the equipment. Similarly, Thailand has implemented a Radio Resource Centre to provide emergency communications.

**Summary**

It is clear that communications are an essential component of emergency responses. Early warning systems for a tsunami were not functional in the region and alerts were not passed from country to country within SEAR. The availability and use of such inter-country alerts potentially could have had a profound impact on the numbers of injured and killed in the affected areas most distant from the epicenter.

Further, it is clear that mobile telephone systems cannot handle emergency traffic and landlines cannot be counted upon. Therefore, radio/satellite communications systems must have high priority in preparedness efforts.

The lack of robust communications capabilities and information management systems profoundly impacted the abilities to buffer the impact of the tsunami. Loss of communications isolated many of the populations impacted, and thus, impaired the identification and transmission of needs.

---

**Table 21.1: Principal languages spoken in the five affected countries.**

<table>
<thead>
<tr>
<th>Primary languages</th>
<th>India</th>
<th>Banda Aceh</th>
<th>Indonesia</th>
<th>Maldives</th>
<th>Sri Lanka</th>
<th>Thailand</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hindi &amp; English</td>
<td>Bahasa Indonesian</td>
<td>Indonesian</td>
<td>Dhivel</td>
<td>Sinhala &amp; Tamil</td>
<td>Thai</td>
<td></td>
</tr>
</tbody>
</table>
Part IV
Analysis
Chapter 22
Security Systems
The need for Security Basic Societal System is obvious. There are many examples of relief workers leaving the sites of disasters when they felt insecure and fearing that their lives were in danger. Governments at all levels are responsible for providing for the safety of its citizens and visitors. However, at the time of the earthquake and tsunami, at least two of the areas directly impacted by the events were in the midst of long-standing civil strife that augmented the relative vulnerabilities of the populations directly impacted by the events. Not surprisingly, the populations in the areas in which safety was not secured suffered the most from the earthquake and tsunami. Each of the countries studied had a full-time military, but providing assistance during a disaster was not part of their mission.

Pre-events

Insecurity reigned in Aceh province and in the north-eastern areas of Sri Lanka. Prior to the events of 26 December, each had been subjected to decades of violence and conflicts between insurgents and the governments. In Sri Lanka, the fighting was related to attempts to achieve an independent state in the northeast. In Aceh province, the insurgency was related to control of the abundant oil and natural gas reserves. Little of the economic gains from the harvesting of oil and natural gas remained within Aceh province, but instead, were controlled by the federal government.

These conflicts were responsible for thousands of deaths in each of the two countries in the decades leading up to the earthquake and tsunami. In both Sri Lanka and Aceh province, the insurgencies were well-organized. The pre-event periods were marked by waxing and waning of the conflicts as numerous cease-fire agreements were achieved only to later be torn-up with the resumption of hostilities.

The impact of these conflicts was substantial in both countries. In Sri Lanka, the social development of the areas was impeded and the area lagged behind in the development of social structures including access to health care and education. Importantly, thousands of landmines were placed in northeastern Sri Lanka. In Aceh province, governmental structures collapsed, and in May 2003, the Indonesian government declared Martial Law for the province. As part of this process, the military limited access to Aceh province by outside observers. This resulted in the disappearance of many of the local NGOs. At the time of the event(s), only four NGOs were present in the area, and their ability to operate was severely constrained. This rendered the population less resilient at the time of the events. In addition, the judicial system had collapsed before the earthquake and tsunami. The military had forced many of the GAM personnel into the mountains, thus rendering them less vulnerable to the events of 26 December.
Although relatively safe, there still was unrest in the Maldives with some protesting against the government. In August 2004, demonstrations had to be broken-up by the National Security Service (military). But, this movement apparently did not impact the vulnerability of the population.

Some unrest was present in southern Thailand at the time of the events. But, these activities had little impact in the areas affected. For the most part, India seemed relatively secure and conflict did not play a significant role in the effects of the tsunami. The territories of the Andaman and Nicobar islands are strategically located for the protection of the mainland and were the home of the Joint Military Command for India. Thus, the islands were the site of substantial Indian military presence. In addition, there was also a sizeable police presence in the islands.

**Damage**

Overall, security forces and infrastructure were not damaged significantly in any of the countries impacted. Some exceptions included the death of some 2,000 military personnel and dependents in Aceh province and substantial damage and loss of military personnel in the Andaman and Nicobar islands (116 service personnel were killed in the damage to the Indian airbase on Car Nicobar island). In addition, the police infrastructure sustained damage including its inter-island communication system. The number of GAM personnel killed in Aceh could not be identified.

**Changes**

The events of 26 December were a challenge for the security of the affected populations in each of the countries directly impacted. The principal problems in Thailand arose from the augmented tensions between the Thais and expatriate workers from Myanmar. The damage to the police infrastructure in the Andaman and Nicobar islands resulted in loss of communications between the police on the various islands.

Tensions were created in the Maldives between some of the permanent residents in the communities that hosted the internally displaced persons (IDPs) from the more severely damaged islands. While initially the displaced were welcomed, tensions arose when their stay became progressively extended. In some instances, this resulted in violence, especially involving women and children.

In Sri Lanka, the number of IDPs was immense. This resulted in many IDPs wandering into areas containing landmines. The numbers of casualties created by landmines could not be determined.

The greatest changes in the security system occurred in Aceh province. Where the military had become adversarial pre-event, its role suddenly changed to the provision of relief. Moreover, the military, which had limited access by external organizations prior to the earthquake and tsunami, suddenly was confronted with the massive influx of personnel associated with aid organizations, and potentially even more threatening, the arrival of military personnel and equipment from other countries including the United States, Australia, India, the UK, Singapore, Japan, Germany, and others. These foreign military forces were ordered to leave Aceh province before the end of March 2005.

Initially, relief organizations that appeared in Aceh had little appreciation of the ongoing conflicts. With the passage of time, this emerged as increasing fears of danger. However, these fears were not realized. It has been noted that looting occurred in some quarters. For example, mattresses were stolen from a hospital in Muebolah.

Lastly, the creation of so many IDPs and their living in crowded camps created a substantial burden on the security forces in each of the countries. Maintaining security in these settings was difficult. Little information is available on how safety was preserved within the camps. It was not possible to find information relative to the management of this additional burden.

**Relief responses**

Importantly, in Sri Lanka, the LTTE and the government initially agreed to cooperate in relief
and recovery efforts. However, fighting re-emerged over the distribution of relief supplies. Some felt the distribution was being selectively withheld from areas dominated by the LTTE. In May, 2005, the LTTE and the government agreed to cooperate in relief efforts. Eventually, a Post-Tsunami Management Structure was approved by both sides. However, this structure was declared unconstitutional by the Sri Lanka Supreme Court.

The Indian government mounted Operation Sea Wave in which abundant military resources were invested in relief operations in India, Aceh province, Sri Lanka, and the Maldives. Cargo aircraft airlifted casualties to higher level medical facilities and air-dropped essential supplies into areas that were inaccessible by land. Naval ships brought water, food, and other essentials. In the Andaman and Nicobar islands, initial responses were provided by local fire and police personnel. Their responses were more rapid than could be achieved by the military, despite their substantial presence in the islands.

The military also was quite prompt in responding in the other countries. The National Security Service provided resources needed initially to the isolated islands of the Maldives. The military relented in its tight control of access in Aceh province and had to accept foreign military assistance. Some disputes arose during this period as to who actually was in charge. The military was forced to interact with foreign military and with some of the NGOs that the military believed might be involved with the insurgents. The threat perceived by the Indonesian military by the presence of foreign military units resulted in all such units being ordered to leave Indonesia by the end of March 2005.

Overall, aid was perceived as being relatively slow in Indonesia. Some considered that these delays were due to retribution by the military for the insurgency—actually the delays were incurred because of the damage and dysfunctions suffered by the Transportation and Logistics and Public Works and Engineering Systems.

Information could not be retrieved relative to how the security of the medical facilities and the medical and public health personnel was supported.

**Recovery responses**

Other than in Thailand and parts of India, the recovery was much slower than expected. Except for Sri Lanka, this seems to have been unrelated to security issues. In Sri Lanka, disputes erupted and accusations of human rights violations were directed at both the government and the LTTE. This became even more pronounced in 2008 and early 2009. Other than for Sri Lanka, the security system has recovered in the areas impacted by the earthquake and tsunami.

**Developments in the security systems**

Two important advancements have occurred since the tsunami. The first is the formation and implementation of a Family Protection Unit in Malé. Its mission is to lessen the threats to women and children in the Maldives. In addition, volunteers were trained to recognize mental illness at the community level and to get such persons into a therapeutic environment.

The second was the achievement in August 2005 of an amnesty agreement between the GAM and the Indonesian government. This has resulted in relative peace in Aceh province.

**Summary**

Overall, it seems that security following the events of 26 December 2004 was not a major problem. There are some reports of human rights violations in the IDP camps, but these could not be substantiated. The military in each of the countries was engaged in protection of the affected populations.
Part IV
Analysis

Chapter 23
Coordination and Control Systems
Coordination and Control Systems

Introduction

Any operation that is complex and extensive requires a system for management and programme development. For purposes of the management of a disaster, this function is referred to as coordination and control. Coordination is defined as harmonious action,¹ and control as the power to direct or regulate.² In most publications to date, this function has been called Command and Control. However, given that a major problem in disaster management has been a lack of coordination, the term Coordination and Control has been substituted for command and control—“control” is taken to include command.

Coordination and Control is defined as the process that directs and coordinates all activities in the responses to a disaster and in the development and implementation of preparedness measures.³ Coordination and control provides the structure for all of the disaster management functions. Following an event, its main role is to ensure that the responses meet the identified needs of the affected society. Pre-event, its main function is to optimize the absorbing, buffering, and response capacities of the community-at-risk for an event. In most societies, the government performs this function.

The integration of all of the Basic Societal Systems, definition of their goals and objectives, and their financing during times of disaster and for preparedness to manage them is provided (dictated) by the Coordination and Control Systems. During a crisis, the coordination and Control Systems are responsible for coordinating the activities related to all of the BSF systems. Failure to provide adequate coordination and control results in confusion, unnecessary duplication, inefficiencies, unnecessary costs, and activities that may be counterproductive with negative consequences to the society for which it is responsible. Numerous examples of the lack of coordination of the relief and recovery responses were a common theme in the report by HH Prince Sadruddin Aga Khan on “UN Capabilities on Disaster Management” (1987), as well as in reports of activities following Hurricane Katrina in the United States.⁴

“In-country, health sector management capacities were overwhelmed by the scope and the suddenness of the tsunami. The subsequent, global response resulted in confusion, congestion, and competition for scarce logistical and transport resources. Within the health sector, some of these operational difficulties could have been prevented. During the Tsunami responses, effective supply systems and logistics often were the key to efficient actions….”⁵

Generally, the government of a country is responsible for the provision of coordination and control for managing emergencies and disasters. It is responsible for the activities of each of the
Basic Societal Systems and for the interactions between them. It charges each of the 13 Basic Societal Systems with its goals and the objectives for each of the interventions and helps to obtain the resources to accomplish them. At times, it must temper these charges by limitations of the resources it can make available. Coordination and Control must be provided by the government prior to the occurrence of an event. Coordination and control operates at the scene of the event(s) and at the local, district, and national levels. It must guide the assessments, planning, and preparedness activities. Coordination and Control Systems are heavily dependent upon data and information, and hence, they are dependent on the functionality and effectiveness of the Communications Systems.

Roles and responsibilities of coordination and control centres
In times of crisis, the functions of coordination and control systems should be vested into one or more Coordination and Control Centres (CCCs). Coordination and control centres are entities that not only are charged with the responsibility for providing coordination and control of a specific level of response to a crisis, but also must be vested with the authority and the resources that enable it to perform its functions. This also applies to the development, implementation, and testing of national and sub-national contingency planning (disaster response plans). Some of the activities and responsibilities of coordination and control centres are listed in Table 23.1. The responsibilities are not ranked by priority, importance, or order of implementation. Each is ongoing and concurrent before, during, and after a disaster. In order to fulfill its commitment and duties with regard to the planning, testing, and exercising of these plans, Coordination and control Systems be permanently appointed bodies that are active between events and incidents.

Coordination and Control entities should be able to operate at all levels of society, including the scene, community, district, state, province, and country. It is recognized that for some societies, the country Coordination and Control Centre (emergency operations centre) may be responsible for activities at all of the aforementioned levels. Coordination and Control entities should be mandated by legislation.

Pre-events
The overall status for the provision of Coordination and Control at the country level before the earthquake and tsunami is indicated in Table 23.2.6 Each of the countries had a designated agency or agencies responsible (at least had a mandate) for the provision of coordination and control during disasters. However, whether they had the authority to control and were able to access necessary resources was not clear. For example, in Indonesia, the Disaster Management Board (BAKORNAS) clearly had the mandate, but another agency controlled the resources. In Sri Lanka, multiple agencies were charged with developing and maintaining the capacities, but none of the designated agencies had either the authority or the resources to implement the mandate. This resulted in dilution of the authority and capacity to respond. Sri Lanka had a National Disaster Management Centre, but it was not supported with enabling legislation or legal policies. In 2004, an attempt to strengthen the structure was rejected, but a task force was charged with further examination of the issues.

India had designated the Minister of Home Affairs as being responsible for disaster management. Also, the Indian military had a strong presence in the Andaman and Nicobar Islands.

In the entire Region, the level of preparedness to manage a disaster such as the one that was to come was poor, at best. Aceh province was probably the least well-prepared of any of the Indonesian provinces to deal with the impending catastrophe. This was due mainly to the more than 30 years of civil unrest in the area. Dealing with this ever-present conflict was about all that Aceh province could cope with—and barely so. Similarly, the northeastern areas of Sri Lanka suffered from the same problem, and it lagged behind the rest of Sri Lanka in development.
No information was available that described the Coordination and Control functions provided by or for the Medical Care and Public Health Systems in the countries studied. It is not clear whether this system had representation in any of the responsible agencies or whether its components participated in any of the planning that preceded the events. There was no evidence of disaster response plans for each of the medical facilities or whether these institutions were prepared for a disaster-producing event. However, countries had their national and sub-national plans for managing disaster in the health sector. For the organization, coordination and control of the public health responses in the Region was provided by WHO-SEARO.

**Damage**

Since coordination and control was poorly developed in the areas impacted by the events of 26 December, it is difficult to define any damage to the Coordination and Control Systems that resulted from the events. Furthermore, other than for Banda Aceh, the seats of the governments were not directly damaged by the events. Most of the governmental infrastructure remained undamaged and the governments remained functional. However, in Banda Aceh, the capital of Aceh province, 90% of the government district was destroyed and 40% of the staff of the provincial government was killed. Thus, the social/governmental structures in Banda Aceh were devastated.

**Changes in functions**

The national and local governments in each of the countries continued to function. Provincial governmental functions were non-existent in Aceh province following the earthquake and tsunami. Following recognition of the events and damages, WHO-SEARO activated an Operations Room for the coordination and control of the public health responses within SEAR.

**Relief responses**

No information was available regarding the immediate coordination of the relief activities of the health systems for any of the countries. Substantial information was acquired relative to coordination and control provided for the Region by WHO SEARO (see Chapter 24). The information compiled here relates to the overall Coordination and Control provided in each of the countries, and it is assumed that the relief responses of the health systems were part of the overall relief activities and met with some successes and failures as occurred in other Basic Societal Systems. Moreover, the information that follows must be tempered further by the realization that most of the deaths related to the earthquake and tsunami were immediate and that very few of the deaths could have been prevented by a more organized, immediate medical response. Some of the patterns of injuries and diseases associated with previous disasters were replicated following the earthquake and tsunami. Those who immediately succumbed to the event due to life-terminating injuries comprised the first phase. Even if the prehospital EMS systems had been well-organized, they would not have been able to significantly impact the deaths that occurred due to life-terminating injuries.

Clearly, a typical trimodal distribution of deaths as occurred in all major trauma events occurred during and following the tsunami and earthquake. The second phase consisted of those injured who survived to reach a medical facility, and the third phase consisted of the complications that were related to the injuries sustained as well as those new injuries related to cleanup efforts. What remains unknown is the number of potentially preventable deaths that occurred during and immediately following the tsunami that were due to lack of the ability to provide adequate medical care to persons that reached functioning medical facilities yet died during this second phase. It is during this second phase that some may have succumbed due to lack of functional medical facilities that could have been able to meet the surge.

The absence of adequate Coordination and Control of the flow of these patients may have contributed to some potentially preventable
deaths. The third phase of complications and the ongoing requirements to diagnose and treat the medical complications potentially could have been impacted by the coordination of outside assistance in meeting some of these challenges, along with assisting in the provision of routine medical care.

Furthermore, one of the responsibilities of Coordination and Control is the conduct and interpretation of assessments that help to determine the medical needs of the impacted population. Without adequate Coordination and Control, such assessments may not result in coordination or even realistic planning.

Other than in India and Thailand, during the first days, weeks, and months, there was a relentless intrusion of humanitarian medical relief teams that may have contributed to saving a few lives, but may also have contributed to the unnecessary duplication of services and the provision of goods that were not needed. Generally, when there is no responsible coordination of activities, these agencies conduct their own assessments and provide responses in accordance with their own assessments. When the results of such assessments were not shared with other agencies, there was unnecessary duplication of services. But, it is important to understand that these mostly well-meaning efforts led to stress on the Coordination and Control mechanisms and posed additional challenges in the management of the relief efforts.

The Indian and Thai authorities (Coordination and Control) insisted that they did not need external support. This must be viewed with the knowledge that their respective injury and public health burdens were the lowest of the five countries. But, by blocking interventions by humanitarian organizations, they were able to avoid much of the chaos that was apparent in the other three countries—but these three countries also experienced huge injury burdens and public health threats compared to India and Thailand.

The initial relief responses in each of the countries, as expected from responses to the losses of function during or following previous events, were from local persons. These responses were followed generally by the infusion into the affected areas of the military of the respective countries. Generally, the military with its established command and control discipline, arrived within the first 24 hours following the tsunami. The military already had a strong presence in the Andaman and Nicobar islands and Aceh province. But, there were positive and negative aspects of mobilizing the military in providing relief. On the positive side, the speed with which relief efforts can be mobilized, past experience in working in resource-poor settings, and the built-in discipline made it ideal to provide early organized responses. On the other hand, military presence may not be readily accepted by the affected community, and its partisan role in conflict-affected areas, human rights, and discrimination.

More importantly, by taking actions to limit the influx of unneeded humanitarian organizations, the governments of India and Thailand limited the amount of chaos that occurred. These countries were able to meet the medical needs in the areas impacted by moving some of their available resources from non-impacted areas into the areas where assistance was needed. And these responses were relatively rapid and well-controlled. In addition, the medical facilities in the areas impacted in these two countries were not severely damaged and continued to function. In India and Thailand, teams were also sent into the field to provide medical care—this, in turn, limited the magnitude of the surge of victims into the hospitals. In both these countries, Coordination and Control came from higher levels of government and the governments of the surrounding, non-directly impacted areas.

The government of the Maldives quickly learned to limit unneeded relief activities. It was assisted in this process by multiple UN agencies and eventually, with their help, was able to provide the necessary coordination and control of relief activities. The difficult logistics contributed to the
government of the Maldives being able to control the receipt and discontinuation of aid.

Quite the opposite transpired in Indonesia, especially in Aceh province and in Sri Lanka. The initial responses by what remained of the local response capacity occurred as well in these two countries. But, these initial responses were unstructured and spontaneous. In Indonesia, this was followed within 24 hours of the events by the arrival of the Indonesian military, which was supplemented in short order by military units from India, Singapore, and Australia. In addition, the aircraft carrier, USS Abraham Lincoln, arrived to provide additional helicopter support to inaccessible areas. However, the use of the military was not a smooth process as there were some conflicts between what remained of the civil society, including the few resident NGOs and the leaders (command and control) of the military as to who really was in charge. Was it the remnants of local government, BOKORNAS or its provincial components, the Defense Ministry, the NGOs, or the military command? Furthermore, there was distrust by the military of the resident NGOs whom the military perceived as assisting the GAM in the ongoing conflict over ownership of the abundant natural resources in Aceh province.

The situation was further complicated by the progressive influx of humanitarian organizations many of whom were not invited by the Indonesian authorities. They just arrived. Many had no knowledge of the language or culture and many also were dependent upon local resources for transportation of their goods and personnel to those areas in which they believed they could contribute. Many conducted their own assessments and determined the needs based on these assessments. Often, the information obtained from the assessments was not shared with other organizations or the government. Many were not self-sustaining and placed an even heavier load on the already over-burdened local and national governments. By early March, there were more than 250 International NGOs (INGOs) operating within Aceh province. The airports were clogged with supplies, some essential and others not needed. There existed poor communication between the NGOs, and there is abundant evidence of competition between the INGOs and also between the national, resident NGOs, and the international contingent. As noted earlier, there was also some poor communication between the INGOs, IGOs, and the affected population.

This discussion is not meant to infer that the assistance provided was not beneficial or well-meaning to the affected population—in fact, much of the relief (humanitarian goods and services) was essential for the survival of many of those affected. Much of the humanitarian efforts were directed to supporting the IDPs, especially those remaining in the camps.

Early in January, there were some attempts to create a coordination process. A summit convened in early January was attended by NGOs from at least 23 countries who were involved in the relief efforts. The local government in Meulaboh (not damaged to the degree manifest in Banda Aceh) began to require that all incoming NGOs had to register with the government before entering the area. By June, UN agencies (OCHA, UNDP) and some humanitarian organizations initiated a new coordinating mechanism, the Humanitarian Information Forum, in an effort to gain some control over what was happening. The Forum attempted to help fill the gaps in which essential needs of the affected population were not being met. Of importance to this effort is that neither OCHA nor UNDP had a medical component.

In summary, the relief efforts in Aceh province had spiralled out of control, and there was great difficulty to bring some coordination into the morass of organizations attempting to do what they perceived was right. This all must be placed in the context that the burdens encountered in Aceh province were the greatest anywhere in the areas impacted by the earthquake and tsunami.

A very similar scenario took place in Sri Lanka. Despite the ongoing civil conflict prior to the
tsunami, Sri Lanka had no designated agency responsible for disaster response that had the mandate, resources, and authority to coordinate and control the responses, and consequently, had no overall disaster response plan. It had no experience with similar events and was consumed in attempts to suppress the insurgency underway in the northeast. It promptly established a National Disaster Management Centre that was charged with planning, especially in relation to restoring the lost infrastructure, coordinating the access and immigration policies for the safe storage of donated goods, and for the recovery of damaged natural resources. In addition, it formed a task force to develop coordination and control of the relief responses. However, it was not vested with the authority to implement such measures.

Much was left to the responding UN agencies. UNDAC assumed the responsibility for the coordination of assessments and sector control. The UN agencies established coordination meetings between the responders and attempted to assign and distribute resources in accordance with needs. The UN-WFP attempted to control the arrival and storage of relief supplies at the Colombo airport and the distribution of goods and services to recipients in accordance with perceived needs.

All in all, both of these countries were besieged by well-doers, and are good examples of what can happen without a well-developed disaster response plan and a Coordination and Control mechanism that has the mandate, resources, and authority to regulate the responses. However, it is clear that although much went well, some things could have been done better—too little, too late.

The role of WHO-SEARO in providing the public health relief and recovery responses is provided in Chapter 24.

Recovery responses in the coordination and control systems
Recovery efforts have been difficult to separate from the responses directed to relief (preventing further deaths and morbidity). It is believed that some of the responses directed toward recovery began early in the responses in each of the countries. Basically, recovery to the pre-event status in each of the basic societal systems has been slow. The role of coordination and control systems in recovery requires further study.

Developments in coordination and control systems
Since the earthquake and tsunami and the responses that followed, several efforts have been made to enhance disaster preparedness. For the most part, each of the countries took advantage of the window of opportunity that opened following the events of 26 December. For example, Sri Lanka formed a Disaster Management Centre in June 2005. The Centre has been engaged in comprehensive planning activities. UNDP has advised the Maldives in disaster risk management. This included sending senior health workers to Singapore for education and training in disaster management including the principles of humanitarian emergencies. Most notably were the results from post-disaster meetings/conferences that included a WHO sponsored meeting in Phuket in May 2005, meetings convened by SEARO in May 2005, June 2006, and June 2008. The results of the meeting convened in Phuket have been published in *Prehospital and Disaster Medicine* 2005 Volume 20, Number 6 and are accessible at http://pdm.medicine.wisc.edu. The outputs from these meetings are included in Chapter 24.

Summary
A Coordination and Control system is an essential part of disaster management (including preparedness). Although each of the countries studied had some agencies charged with the responsibility, other than for Thailand and perhaps India, there were no such structures that had the mandate, resources, and authority to provide the essential coordination and control of the responses at the time of the earthquake and tsunami. This resulted in unnecessary duplication, competition, and in some cases failure to get the needed
resources to where they were needed most. Furthermore, bottlenecks occurred in the distribution of essential supplies, equipment and services that prevented them from reaching where they were really needed. Each of the countries learned from this experience and have taken essential steps to be better prepared the next time.

Additional References


2. Ibid. p 322.


Table 23.1: Some of the responsibilities for coordination and control. (They are not rank ordered.)

<table>
<thead>
<tr>
<th>Responsibility</th>
</tr>
</thead>
<tbody>
<tr>
<td>Planning</td>
</tr>
<tr>
<td>Maintain inventory of available resources (goods and services)</td>
</tr>
<tr>
<td>Activation of contingency plans</td>
</tr>
<tr>
<td>Identify most appropriate indicators of function</td>
</tr>
<tr>
<td>Identify appropriate indicators of effectiveness</td>
</tr>
<tr>
<td>Identify appropriate indicators of benefit/impact on the affected society</td>
</tr>
<tr>
<td>Surveillance and monitoring</td>
</tr>
<tr>
<td>Information management</td>
</tr>
<tr>
<td>Monitor status of each of the basic societal functional systems</td>
</tr>
<tr>
<td>Coordinate the overall activities of each of the basic societal functions</td>
</tr>
<tr>
<td>Decision-making</td>
</tr>
<tr>
<td>Set priorities</td>
</tr>
<tr>
<td>Define goals and objectives of responses and interventions</td>
</tr>
<tr>
<td>Select and assign appropriate interventions</td>
</tr>
<tr>
<td>Exercise authority</td>
</tr>
<tr>
<td>Resource management</td>
</tr>
<tr>
<td>Initiate action as needed</td>
</tr>
<tr>
<td>Exclude resources not needed</td>
</tr>
<tr>
<td>Define progress</td>
</tr>
<tr>
<td>Provide information to all parties</td>
</tr>
<tr>
<td>Interact with the media assuring accuracy of reports</td>
</tr>
<tr>
<td>Liaison with external governments, nongovernmental and inter-governmental agencies, and the private sector</td>
</tr>
<tr>
<td>Provide quality assurance and control</td>
</tr>
</tbody>
</table>
Table 23.2: Status of Coordination and Control mechanisms prior to tsunami. (*not clear because of ongoing conflict, + present, —not present; ?? unknown)

<table>
<thead>
<tr>
<th>Indicator</th>
<th>India</th>
<th>Indonesia</th>
<th>Aceh Province</th>
<th>Maldives</th>
<th>Sri Lanka</th>
<th>Thailand</th>
</tr>
</thead>
<tbody>
<tr>
<td>Designated agency</td>
<td>++</td>
<td>++</td>
<td>++</td>
<td>++</td>
<td>++</td>
<td>++</td>
</tr>
<tr>
<td>Mandate</td>
<td>++</td>
<td>++</td>
<td>++</td>
<td>++</td>
<td>++</td>
<td>++</td>
</tr>
<tr>
<td>Dedicated resources</td>
<td>??</td>
<td>??</td>
<td>—</td>
<td>—</td>
<td>??</td>
<td>++</td>
</tr>
<tr>
<td>Power/authority</td>
<td>??</td>
<td>—</td>
<td>??</td>
<td>—</td>
<td>—</td>
<td>++</td>
</tr>
<tr>
<td>Health represented</td>
<td>+</td>
<td>—</td>
<td>—</td>
<td>?</td>
<td>?</td>
<td>—</td>
</tr>
<tr>
<td>Enabling legislation</td>
<td>++</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>+</td>
</tr>
<tr>
<td>Response plan</td>
<td>++</td>
<td>—</td>
<td>—</td>
<td>++</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Education/ training</td>
<td>+</td>
<td>+</td>
<td>?</td>
<td>+</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Experience</td>
<td>++</td>
<td>++</td>
<td>++</td>
<td>—</td>
<td>**</td>
<td>??</td>
</tr>
<tr>
<td>Ongoing conflict</td>
<td>—</td>
<td>++</td>
<td>+++</td>
<td>—</td>
<td>++</td>
<td>—</td>
</tr>
</tbody>
</table>

Source: Regional Office for South-East Asia, World Health Organization: Regional Meeting on Health Aspects of Disaster Preparedness and Response. Prehosp Disaster Med 2006;21(5):s62–s78.)
Part IV
Analysis

Chapter 24
Role of the WHO/SEARO
Introduction

The WHO Regional Office for South-East Asia provided support to the Public Health Systems of each of the five countries discussed in this book (India, Indonesia, the Maldives, Sri Lanka, and Thailand). It served as the hub for all of the WHO activities following the earthquake and tsunami of 26 December 2004. WHO-SEARO activities included the provision of assistance for the ministries of health for countries of the South-East Asia Region (SEAR) as a whole and for specific areas of need in the respective countries.

Pre-events

WHO-SEARO had in place an Emergency Response Plan (ERP) that outlined the responsibilities of each level of the Organization in case of an event. These responsibilities included:

- Implementation of SEARO-related activities in the affected areas at the initiative of the WHO Country Offices (WCO);

- Provision of primary technical back-up support and harmonization of activities between the affected countries in the South-East Asia Region (e.g., technical, financial, logistics) under the overall guidance of WHO Headquarters (WHO-HQ); and

- Provision of secondary back-up support in SEAR, and global coordination, harmonization, and direction by WHO-HQ, including establishing policies and guidelines, resource mobilization, and linkages with other organizations.

WHO-SEARO had been working with its Member-States for several decades—thus, the pre-event public health situation in each country was well-known.

Events

Information about the earthquake and tsunami on 26 December 2004 that impacted the five countries (that are the subject of this book) reached WHO-SEARO three hours and 15 minutes after the earthquake. The first sign that something was amiss was a telephone call from the Maldives: “We’re being flooded! Malé is being flooded!” the voice shouted through the crackling telephone line. Gradually, news of the scope of the damage arrived from the other countries: India, Indonesia, Sri Lanka, and Thailand. Besides the countries in SEAR, one country (Somalia) the African Region of WHO (WHO-AFRO) and few island countries in the Western Pacific Region (WHO-WPRO) were also affected. Once tsunami-related information began to trickle down in SEARO, WHO functioned as a unit based on the responsibilities at each level of the Organizational structure.
Regional public health responses of WHO-SEARO

The WHO-SEARO relief responses were extensive in the Public Health Basic Societal Systems and can be categorized into the following actions: (1) Planning; (2) Rapid health assessments; (3) Tsunami Technical Group (TTG); (4) Technical Working Groups; (5) Technical support; (6) Global Outbreak and Alert Response Network; (7) Utilization of technology; (8) Feedback-based responses; (9) Human resources; (10) Relief supplies; (11) Assessments, coordination, and communications; (12) Risk communications and management of the media; and (13) Financial assistance. Each of these areas is discussed below.

Planning

Based on the information received at WHO-SEARO relative to the scope and nature of the devastation created by the earthquake and/or tsunami, the Emergency Response Plan for each of the respective WHO country offices of the affected countries was implemented by WHO-SEARO. Since five SEAR countries were affected, as part of its regional responsibility, beginning on 27 December 2004, WHO-SEARO assumed a leading role to assist with setting the directions for responses. With support from WHO headquarters in Geneva (WHO-HQ), SEARO became the nodal point for coordinating WHO’s post-tsunami relief responses in each of the five countries being discussed.

Relief responses of WHO-SEARO

In order to meet the public health needs of the affected communities located in the far-flung and remote areas, WHO-SEARO directed its country offices to establish a number of field offices to provide immediate and timely assistance. Responsibilities that were shared between the different WHO Country Offices included:

- Establishing a WHO field office in each of the respective countries that could coordinate the respective Public Health Systems at the community level, and could implement WHO community-related activities;

- Empowering the WHO country offices to coordinate with other UN agencies, donor partners, and the respective ministries of health for the procurement and dispatch of needed supplies to the respective field offices, and to mobilize technical manpower and other technical support based on needs; and

- Enabling WHO-SEARO to provide regional-level coordination with the five tsunami-affected countries, mobilize technical manpower from the Region and globally, to provide technical support, to monitor the post-tsunami regional public health situation, and to mobilize financial support.

With this organizational structure in place, it was possible for WHO to meet the post-tsunami public health needs with appropriate technical support in a very short time-frame. In SEARO, a 24-hour-7 day/week operations room (Ops Room) was set up in the WHO Regional Office in Delhi and in the country offices of those countries affected by the earthquake/tsunami. This network became the hub of WHO’s public health responses (a regional Coordination and Control Centre).

The regional responses (WHO-SEARO) were guided by: (1) a Task Force Policy Group; and (2) a Task Force Working Group. The Task Force Policy Group was comprised of senior management personnel and was responsible for policy decisions, guided the Task Force Working Group, and made decisions on major or sensitive issues that arose as the operations evolved. The Task Force Working Group was responsible for the day-to-day operations. The team was composed of an Ops-Room Coordinator, an information manager, staff dedicated to resource mobilization, a public health expert, a logistics and supplies expert, personnel required for coordinating recruitment and travel; and a communications person to deal with the media and other communications needs.
The Task Force Policy Group focused on coordinating the operations and providing technical support to the governments of the affected countries. Based on country feedback, the Policy Group determined public health priorities and decided on how best to address the needs defined in the list of priorities. This included developing proposals for immediate and medium-term restoration of public health services, as well as procuring supplies required. The Policy Group also managed the dissemination of information.

Since SEARO had been working with its Member States for several decades, the pre-event public health situation in each country was readily available. Taking advantage of pre-event public health information in the affected countries, by the end of December 2004, the Regional Technical Team at SEARO, in close consultation with the WHO country offices, had developed a 100-day Strategic Plan. This plan became the basis for supporting the national authorities together with the local health system partners to protect the health of survivors and other vulnerable people involved in the disaster.

This Strategic Plan focused on monitoring the public health situation in the tsunami-affected countries with the goals of preventing or containing outbreaks, replacing lost health assets and supplies, and providing technical expertise to fill identified key gaps. The target population for supplementing the health coverage was four million people in the affected countries of the Region, including two million internally displaced persons (IDPs), and at least 100 000 injured survivors. The initial emerging responses encompassed technical assistance for the provision of safe drinking water, setting up or reactivation of communicable disease surveillance and response systems, and actions for re-establishing the basic healthcare system, including hospital care. Thus, the objectives of the public health relief strategy interventions were to:

- Monitor the status of public health in order to provide an early warning of emerging public health threats, and to assist in enabling the timely organization of necessary responses;
- Provide technical expertise to health authorities in order to assist with filling gaps;
- Establish and sustain effective regional, national, and local health coordination to ensure efficient deployment of assistance; and
- Ensure the provision of up-to-date information on the health situation to local, national, and international partners.

**Rapid health assessments**

Within one week of the earthquake and tsunami, technical teams were sent to each of the affected WHO Country Offices to rapidly assess the extent of the impact of the earthquake and tsunami on the health infrastructure, the number of people displaced, living conditions, and access to safe drinking water, sanitation, and food. For example, in Sri Lanka, rapid assessment teams were dispatched to each of the affected areas in the south, east, and north of the country. Each team consisted of an official of the Ministry of Health, a national professional working in the WHO Sri Lanka Country Office, and a locally available WHO staff from either WHO-HQ or SEARO. Several WHO staff who had been on holiday in Sri Lanka when the tsunami occurred, immediately offered their services—thus conserving valuable time that would have been lost in travel.

While these assessments were being conducted, the acquired information was collated. The Core Tsunami Team in the WHO-SEARO Country Offices participated in daily coordination meetings convened by the UN Country Team. Besides the UN meetings, the WHO facilitated public health system coordination meetings convened at the respective Ministry of Health; each was chaired by the Minister of Health. These regular meetings included health partners from national and international agencies, and facilitated the formulation of joint health plans at various stages following the tsunami, including coordination of emergency relief and recovery responses.
**Tsunami technical group**

A Tsunami Technical Group (TTG) headed by the Director for Communicable Diseases and Surveillance was established at WHO-SEARO. The SEARO-TTG coordinated the mobilization of expertise, and developed guidelines/operational tools and other resources. The TTG was charged with anticipating the public health needs based on surveillance information for communicable diseases, and for the needs of the health systems of each of the affected countries. In addition, daily meetings were convened by the TTG and a representative from the Operations Room—these discussions facilitated close monitoring of the public health situation, and thus, contributed to the effectiveness and efficiency of the interventions implemented by the TTG.

**Technical working groups**

In addition to the TTG, four technical working groups were established to help to: (1) Develop and adapt guidelines and tools; (2) Mobilize technical experts; (3) Manage data; and (4) Provide communications and updates. More than 80 guidelines that outlined best practices were developed, transmitted to the field, and posted on the Internet. In order to make it easier for those in the field who were pressed for time, these guidelines also were summarized into short ‘ready-reckoners’ to make them user-friendly at the field level (see Appendix).

**Technical support**

Senior WHO staff from within and outside the Region (with assistance from WHO-HQ) were mobilized to support the emergency response initiatives implemented by SEARO. The post-tsunami response initiatives of WHO were broadly grouped under four strategic relief functions and one recovery function:

a. Measuring ill health and promptly conducting assessments to be used for the identification of health needs;

b. Identifying priority causes of ill health and death;

c. Supporting the Member States in the coordination of health interventions;

d. Identifying and filling critical gaps in the health responses; and

e. Revitalizing and building the capacities of local and national health systems (recovery interventions).

Given these strategies, WHO’s primary functions during the first days following the tsunami included:

- **Surveillance and response**—tracking patterns of life-threatening diseases among those at risk through the prompt establishment of a surveillance and early warning system that provided daily epidemiological reports;

- **Access to essential health care**—working with each of the partners to ensure equitable access to adequate quality of essential health care through the use of functioning key hospitals and health centres;

- **Public health**—providing technical guidance on critical public health issues (responses to disease outbreaks, water quality, excreta management, chemical threats, chronic disease management, and mental health). WHO-SEARO attempted to fill critical gaps until others were able to take on the tasks;

- **Medical supplies**—helping to ensure that medical supply chains functioned as efficiently as possible, and were responding to the needs of those affected; and

- **Joint action**—coordinating health actions at the local, national, and international levels in accordance with agreed strategies and by joint actions with partners.

In order to carryout these technical functions, operational teams were formed at the WHO Country Offices and the Regional Office by scaling-up available human and other resources.
Global Outbreak and Alert Response Network

By 3 January, WHO-SEARO had established a Global Outbreak and Alert Response Network (GOARN)-Operational Support Team in New Delhi. GOARN provided a mechanism for technical collaboration between existing institutions and networks in order to pool human and technical resources required for the rapid identification, confirmation, and response to disease outbreaks that have epidemic potential—e.g., malaria, acute watery diarrhoea. GOARN provided an operational framework that linked this expertise and the skills used to alert the international community of a threat of outbreaks as well as of the readiness to respond to such an outbreak. One of the regional tasks at SEARO was to coordinate the support provided by GOARN partners. Key people were needed for outbreak responses, including epidemiologists, laboratory experts and technicians, logisticians, data managers, and risk communication experts. GOARN was activated by 8 January and had 120 epidemiologists on standby. Twelve epidemiologists from GOARN and 10 from the different WHO offices were dispatched into the affected areas.

Utilization of technology

The human efforts were complemented by the use of technology. While Sri Lanka had a good network of roads before the tsunami (1.53 km of roads/km²), most of the roads in the directly impacted areas were severely damaged. Satellite imaging technology using Sri Lanka’s well-established Global Information System (GIS) mapping framework, proved useful in assessing damage to the health infrastructure.

By the second week of February, WHO’s Epidemic Alert and Response Team in Banda Aceh consisting of six GOARN epidemiologists, in collaboration with the provincial Ministry of Health, had developed a weekly surveillance system that included NGOs, hospitals, and laboratories in Banda Aceh, Meulaboh, and other towns. The system was targeted to identify diseases with epidemic potential based on syndromic surveillance and reporting.

Feedback-based responses

Based on the information received from the Country Offices, it was clear public health needs differed depending on the geography and field situations of the affected areas. The only thing in common was that all the needs were “urgent”. In light of this urgency, pressure was placed on the Regional Country Teams at SEARO to provide the required information in a timely manner. For example, in Aceh province, the Public Health System was disrupted with 693 health facilities incapacitated (66% destroyed and 6.2% with major damage). There was severe damage to the provincial general hospital, the provincial health office, the provincial public health laboratory, district hospitals, district health offices, health centres, and health posts. The Public Health System needed support to provide immediate services to the affected people, including rebuilding/repairing the damaged facilities (recovery). In contrast, in the Maldives, the main challenge was to transport the required supplies to the affected islands, and as the wells and other main sources of water had been polluted by the tsunami, to provide supplies of clean water.

Human resources

Transporting the “right” people with the “right” experience to the “right” place was critical, and SEARO, with assistance from WHO-HQ, helped to mobilize resources from all over the world. The organizational challenge was to recruit and deploy the best experts quickly in accordance with the expressed or anticipated needs of the countries: these personnel included epidemiologists, water and sanitation experts, communicable disease experts, logisticians, and information technology and media/communications experts. More than 250 WHO staff and consultants were mobilized for the relief activities in the three most-affected countries, Indonesia, Sri Lanka, and the Maldives.

Relief supplies

Supply logistics presented a great challenge particularly in the early days following the earthquake and tsunami. For the most part, based on previous experiences, the needs of
Emergency health kits (EHK) were dispatched to the affected countries in need from various places and warehouses. Each individual kit is designed to support 10,000 people for three months. Nine emergency health kits were distributed immediately to the affected countries. During Day 1 following the tsunami, WHO had mobilized 190 EHK, to cover the needs of approximately 2 million people for three months. For example, in the Maldives, WHO procured an EHK by 2200 hours on 30 December. Also distributed were anti-malaria drugs, vaccines, and medicines to treat diarrhoea or for use for surgery.

Medical supplies donated by agencies, donors, national private companies, and other sources, poured into SEARO and the WHO country offices of the affected countries. For example, at the height of the relief operations, an average of 20 metric tons of medical supplies was arriving in Indonesia every day.

The rapid arrival and large volumes of supplies also generated problems. The drugs often were labeled in different languages, were of different doses, and not always relevant to the needs of the earthquake-tsunami-affected populations. These drugs had to be sorted and transported. In areas that were devastated and inaccessible, this was not an easy task and required the input of qualified technical personnel.

Assessments, coordination, and communications
Regular communication through regular video-conferencing between each of the tsunami-affected countries and WHO-HQ was maintained by SEARO. Every morning, the staff of the Ops Room at WHO-SEARO convened a teleconference between the WHO headquarters in Geneva and the WHO Country Offices in Banda Aceh, Colombo, Malé, Bangkok, and Yangon. This information formed the basis for situation reports that were compiled and distributed (through a mailing/e-newsletter list) as well as uploaded onto the Internet.

Risk communications and management of the media
Senior management at WHO-SEARO also responded to media queries about health concerns, latest information, and outbreak precautions. Technical/expert comments were distributed using the Internet, television, and the print media.

Financial assistance
The UN mechanism for fund raising during emergencies called Flash Appeal, was used as a mechanism to generate required funds.

Background—the process used by the UN mechanism for a Flash Appeal always starts at the level of emergency-affected countries. Identification of a community’s needs based on the rapid assessments are conceptualized and formulated by the country-based UN agencies chaired by the UN Resident Coordinator. The appeal is drafted by the experts from the country-based UN agencies in close consultation with the government of the affected country and other international partners, such as the World Bank, International Monetary Fund, other development banks and partners, i.e., the US Agency for International Development (USAID), the UK Department for International Development (DFID), and the Swedish International Development Cooperation Agency (SIDA). Compilation of the flash appeal documents comprised of combined humanitarian assistance needs and required resources initially is completed by the country staff of the Office for the Coordination of Humanitarian Affairs (OCHA), and finally by the OCHA office at the UN Headquarters in New York. Then, a formal Flash Appeal is launched at the UN Headquarters that invites donor assistance.

Post-tsunami flash appeal—the post-tsunami flash appeal was used to fund the purchase, rental, or borrowed resources (goods and services) required to meet the essential needs
of approximately five million survivors. Requests included consideration of the likely magnitude of the public health needs for well beyond the immediate relief phase, including the resources that will be required for recovery. Mobilization of the post-tsunami financial resources reflected the efforts of 40 UN agencies and NGOs to assist with implementation of the strategic plan of the respective national governments.

Results of the flash appeal—Great generosity was demonstrated for helping the tsunami-affected communities meet the costs of relief and recovery. The total flash appeal target was US$ 977 million to fund the critical needs of the affected population from January–June 2005. WHO received a total of US$ 60.3 million for the implementation of tsunami-related programmes. Of this total, SEARO funding assistance amounted to US$ 352,908,700. Appropriate and effective management of the funding at the regional level by WHO-SEARO was essential. Part of the Emergency Response Fund provided to SEAR was utilized for facilitating coordination of health actions including monitoring and containment of disease and disease outbreaks, provision of logistical support, and procurement of required equipment and supplies. Additionally, the fund also supported activities relating to emergency preparedness, contingency planning to meet future emergencies, and strengthening early warning mechanisms. For example, the total funding received by Indonesia was US$ 371 million, of which the health systems required US$ 69 million (18.6% of the total available funds). The Maldives requested US$ 66 million (US$ 10 million for health (15.2% of the total available funds) ), and Sri Lanka requested US$ 166.9 million for six months out of which the allocation for health was US$ 28.6 million (17.1%)

Unfortunately, the funding was not immediately available and the delays caused their use to be less than optimal. The delays indicated a need for an emergency fund that could be mobilized immediately during crisis.

Recovery responses of WHO-SEARO

Using the 100-day Strategic Plan as the basis for promoting recovery, WHO-SEARO implemented the following actions:

- Refine the health needs assessments and facilitate early recovery (rehabilitation, reconstruction); and
- Replace lost assets, infrastructure, and supplies that were crucial for meeting the additional health threats consequent to the disaster, as well as the reactivation of previously available health services recovery.
**Assistance to specific countries**

The WHO-SEARO provided assistance to the Public Health Systems of each of the five countries to help them meet their specific needs. The actions by SEARO related to the individual countries are outlined below.

**India**

More than 2000 km of the eastern Indian coastline, as well as the Andaman and Nicobar islands experienced destruction on an unprecedented scale. It affected >3.6 million people. The damages to the health infrastructure included 80 sub-centres, 13 primary health centres, and seven partially damaged, district hospitals. India did not request or require external assistance either financially or for the provision of relief activities. The UN system, including WHO, worked with the central and state governments to provide support as needed. WHO-SEARO provided technical support through its collaborating centres and by sharing guidelines. To cover some of the immediate needs after the tsunami, the WHO India country office provided: (1) 10 surgical and 24 emergency health kits; (2) 20 000 insecticide-treated bed nets to help prevent the occurrence of mosquito-borne diseases; (3) 1000 chloroscopes that were used to monitor water quality; (4) 30 tons of bleaching powder to use for treating water; (5) oral rehydration salts for treating diarrhoea; and (6) computers for tracking data/information for disease surveillance.

The most significant role of WHO-SEARO in India was in the provision of education and training required to build the public health capacities in the affected districts. A WHO-SEARO Task Force at the National Institute of Communicable Diseases (NICD) trained 50 medical officers and 50 paramedical workers and trainers in each of the 12 districts affected. These trained personnel, in turn, trained others: more than 961 medical workers and 4179 health workers eventually received training.

WHO-India also assisted in strengthening the public health systems by conducting GIS mapping and developing a database of health and educational facilities in 373 villages in the states of Andhra Pradesh and Tamil Nadu. WHO and other UN agencies, along with the Government of Tamil Nadu, developed an accreditation system for district hospitals across 10 districts in the states. The Government of Tamil Nadu, WHO-India, and other UN organizations formed a partnership to develop an insurance scheme to provide protection to the poorest sections of society.

A major gap identified following the tsunami was the absence of a repository of information on how to deal with various aspects of disaster management, including availability of guidelines, standard operating procedures (SOPs), etc. WHO-India assisted in setting up the Data Resource Centre at the Directorate of Public Health (Chennai).

**Indonesia**

**Pre-event**

In the provinces of Aceh and North Sumatra, the existing pre-event functional administrative systems, including the Public Health System, were on the brink of collapse. The immunization status of the population was poor prior to the events of 26 December. Pre-event, there were no clear, enforceable policies or budget for environmental health issues in Aceh province.

**Damage and changes in functions**

Indonesia was the country closest to the epicentre of the earthquake that caused the tsunami. It was the most heavily damaged country with >166 000 people killed directly from the impact of the earthquake and tsunami. Many health personnel were injured and/or killed, and 50% of the hospitals and health centres were damaged or rendered non-functional.

**Relief responses by SEARO**

In order to provide assistance to the health systems, WHO established field offices in Aceh province that were used exclusively for supporting community-level public health
activities. Responsibilities shared among the WHO Offices included: (1) The WHO Field Office in Aceh provided coordination of the public health interventions at the community level and implemented community-related activities; and (2) The WHO Country Office in Jakarta (WHO-Indonesia) provided coordination of health activities with other UN agencies, donor partners, and the Ministry of Health, procured supplies and dispatched them to the Field Office, and mobilized technical personnel and other technical support services based on defined needs.

Disease prevention—Disease prevention was a top priority. Epidemiologists from WHO-GOARN provided assistance for the identification and implementation of the technical, structural, and operational needs for establishing an early warning system for potential outbreaks of disease. By mid-February, the WHO-SEARO Office in Banda Aceh had developed a weekly surveillance system that included hospitals and laboratories. Its goal was to identify the occurrence of diseases with outbreak potential. This syndromic surveillance system was used for the detection and reporting of cases of cholera, acute respiratory diseases, measles, and injury-related tetanus. The system was designed so that suspected cases could be reported through the use of Short Message Services (SMS), telephone, and email. WHO-SEARO jointly with Indonesian Ministry of Health staff, carried out field investigations of potential disease outbreaks or a rumour of an outbreak, and also collected appropriate specimens.

The water and sanitation infrastructure, including treatment plants and their distribution networks in Aceh province sustained extensive damage. Available ground water was contaminated by seawater. As a result, the provision of clean water and sanitation became an important issue for WHO-SEARO. In addition, some of the water being transported by tankers was found to be inadequately chlorinated and sometimes contaminated. Thus, the WHO Field Office with technical support from WHO-SEARO outlined a plan of action that included a manual translated into Bahasa (Indonesian language) on a minimum dose of chlorine and the operation of an improved water monitoring system. The WHO Country and Field Offices also procured and distributed hundreds of water testing kits for water quality monitoring and surveillance.

An electronic system for data entry and processing was implemented, and, after mid-January, a routine and ad-hoc reporting system on the key health conditions that existed in the field was developed and implemented—information that summarized the disease situation was accessible in real-time. The WHO-SEARO epidemiology team developed a computer application that was based on EPI-DATA/EPI-INFO and HealthMapper,* tailored for use during the emergency. The system was used weekly by more than 122 sites (from every sub-district) to report data for nine epidemic-prone clinical diseases (cholera, dysentery, typhoid, hepatitis, measles, malaria, dengue, meningitis, and tetanus). These reports provided information on disease trends. More than 100 alerts involving 465 disease events were received. Each reported sporadic outbreak was investigated promptly by the Outbreak Alert and Response Teams established with the assistance of SEARO.

The use of this system has lasted well beyond the relief phase, and established the foundation for a future, modern, effective disease surveillance system.

*The HealthMapper is a surveillance and mapping application, developed by WHO, that aims to address critical surveillance information needs across infectious disease programmes at national and global levels. The HealthMapper is a user-friendly data management and mapping system customized specifically for public health users. The system facilitates data standardization, collection, and updating of data on epidemiology and on interventions and provides immediate visualization of data in the form of maps, tables and charts. The HealthMapper also packages a database of core baseline geographic, demographic and health information, including the location of communities, health care and education facilities, accessibility by road, access to safe water and demography. The system is in operation to cover a range of infectious diseases in over 60 countries in all Regions of the WHO. Source: http://gis.emro.who.int/PublicHealthMappingGIS/HealthMapper.aspx. Accessed 27 March 2011.
system in Aceh province (development). Once Aceh province had entered the recovery phase, the post-tsunami surveillance system became the Integrated Disease Surveillance System.

**Health coordination and planning**—More than 250 NGOs established their presence in Aceh province by setting-up field offices; each had its own organizational mandate and agendas that were specific and frequently overlapping. Many international organizations were working in the Medical Care and Public Health Societal Systems. Coordinating their activities was essential in order to make the most efficient use of the resources available and provide effective assistance to the affected people. While recognizing the daunting task of coordination of such a large number of agencies at the field level, the WHO Country and Field Offices assumed a facilitating role of coordination of the health responses (interventions), thus coordination effort was led by staff from the Ministry of Health and the provincial health offices. Initially, health coordination meetings were convened daily (and subsequently weekly) to which all of the agencies working in the area of health were invited. Access to information on the activities of each of the agencies involved in providing health interventions was necessary to streamline the work in the field, and using WHO support, the inventory was posted on a website (acehhealthinfo.com) as well as distributed using a local mailing list.

Tons of donated medicines that were not considered appropriate for use (e.g., expiration date had passed) required disposal. Inappropriate dumping of healthcare wastes from hospitals could have led to another health and environmental crisis in an already difficult situation. With funds from the European Community Humanitarian Offices (ECHO), the WHO Field Office began a Healthcare Waste Management (HCWM) project, which was among the largest known HCWM initiatives in resource-poor countries. The challenge was procuring supplies and equipment, such as colour-coded, foot-operated bins, plastic bags, trolleys, and incinerators. These were made to order according to technical specifications, taking into consideration their cost-effectiveness and acceptability by the healthcare system. These initiatives most probably contributed to limiting outbreaks and containment of infections related to wastes from health facilities.

**Recovery responses by SEARO**
The WHO Country and Field Offices duly supported by WHO-SEARO were active in rebuilding the health system in Aceh province, both in terms of infrastructure and human resources. WHO-SEARO provided the funding necessary to recruit temporary personnel, re-establishing midwifery and maternal health services, creating satellite health posts with a doctor, midwife, and two nurses in each resettlement point in Aceh province in order to provide basic health care 24 hours/day. WHO also provided US$ 762 000 to re-establish a functional provincial and district health office for reproductive health services. The re-establishment of a midwifery clinic in Aceh province was also supported by WHO.

**Development efforts by SEARO**
WHO helped to establish referral laboratories. The WHO Country and Field Offices also supported education and training for disease surveillance and control for 273 public health workers, and in the integrated management of childhood illnesses for 220 healthcare providers. These workshops also provided the WHO Country and Field Offices with an opportunity to identify gaps and needs that could be addressed by the participating agencies/organizations together with WHO. The WHO Country and Field Offices with technical assistance provided by WHO-SEARO, supported education and training for counselors in nutrition stationed in the health centres, severe malnutrition management for hospital staff in seven hospitals in Nanggroe Aceh Darussalam Province, and for counselors for breastfeeding. In addition, the WHO country and field offices with technical assistance by SEARO, provided education and training for district health office staff and the staff of 42
Health Centres from 11 of the affected districts in capacity building and logistical support for the clinic-based management of severe malnutrition. In order to help to supplement nursing services, The WHO Field Office, in partnership with the Indonesian National Nurses Association, worked on a project to improve services offered by the Community Health Nursing Programme through training nurses and health workers.

**Psychosocial and mental health support**
To a population that long had been traumatized by internal conflict, the further losses from the earthquake and tsunami were particularly devastating. To address this problem, the WHO Field Office together with other participating agencies constituted a Psychosocial Coordination Group, which was a subgroup of the Health Coordination Group. This group facilitated a structure through which 130 international and national NGOs involved in the provision of mental health services could work together. A draft plan was drawn up, and after discussion with the Directorate of Community Mental Health of the Ministry of Health (MoH), WHO put forward recommendations on mental health in Aceh—these recommendations subsequently were adopted into the MoH Strategic Plan for Mental Health; they included emergency strategies as well as recovery (rehabilitation) strategies in five components: (1) assessment and monitoring; (2) coordination; (3) evidence-based interventions; (4) strengthening the capacities of the communities and the health system; and (5) Building a comprehensive mental health system. The WHO Country and Field Offices with regional technical assistance from WHO-SEARO, facilitated support for the education and training of 600 community leaders, teachers, religious leaders, and women leaders in mental health.

**The Maldives**
Due to its unique geography, the tsunami posed unique problems for the Maldives. In a chain of islands that were at the most 1.5 metres above sea level, the 4 metre tsunami completely washed over many of the islands.

**Relief**
Many islands were not easily accessible, so reaching the people in the islands was difficult. Yet, reaching them was crucial—for example, at least 1800 pregnant women were scattered across 200 islands, and 500 pregnant women did not have access to delivery facilities. Fresh water supply, already scarce pre-tsunami, became more scarce as the tsunami damaged or contaminated available water resources. WHO-Maldives assisted the government in addressing the public health issues.

Information technology played a key part in the initial assessments. Health mapping (GIS) support in the Maldives was crucial for conducting assessments of temporary camps, displaced persons, injuries, deaths, and affected health centres and hospitals. The Information and Communication Technology (ICT) Team at WHO-SEARO was strengthened with additional staff—officers were placed both in the Maldives and the Regional Office for the long term. Logisticians were deployed from SEARO. They set up a drug supply chain for donated drugs, and ensured that the drugs obtained from WHO were procured from pre-qualified (technically approved) suppliers, were labeled appropriately, and were not past their expiration date. The SEARO Integrated Data Analysis System (SIDAS) was adapted to Maldivian needs and implemented by August 2005. As part of the Tsunami Strategy Recovery Plan, WHO-SEARO assisted the Ministry of Health in introducing a proven supply and management system (SUMA) in the Maldives Public Health System. In addition, WHO-Maldives provided two speedboats to the Ministry of Health on 14 September 2005. They were used to transport patients, supplies, and equipment to and from remote islands.

**Water and sanitation:** following the tsunami, wells and groundwater were contaminated, and, in many places, the rainwater storage systems were damaged. For several weeks, bottled water and desalination using reverse osmosis were the only recourse for obtaining potable water. Among the first tasks for WHO-SEARO was to dispatch...
a team of water and sanitation specialists to the affected islands. After a rapid assessment, WHO-SEARO sent two sanitary engineers/hydrologists to the Maldives. To address long-term sustainability of potable water supplies, a WHO-funded hydrologist conducted detailed assessments of groundwater resources and the existing supply of potable water. Based on these assessments, a water safety plan was drafted. Simultaneously, community health workers, as well as staff from hospitals and health posts were oriented in the water safety plan and to a water quality surveillance system. It facilitated preventing outbreaks of waterborne diseases. This programme is ongoing.

**Environmental health and healthcare waste management**—the management of wastes was a serious issue in the Maldives. The tsunami created approximately 290,000 m³ of debris and waste, much of which had accumulated on the beaches. This material posed a threat to public health, the groundwater, the soil, and the coral reefs. Cooperating with other UN agencies, WHO-SEARO procured waste bins costing US$100,000 for the collection of ‘toxic’ wastes. Also, it provided technical guidance and was involved in supporting a 10-day training course in Bangalore, India for health workers from the regional and atoll hospitals.

**Sri Lanka**

**Pre-event**

Like Indonesia, the tsunami augmented the human suffering in Sri Lanka that was due to a long-running internal conflict.

**Damages addressed**

Fourteen of the 28 districts in the country were affected. Of these, eight were in the conflict areas in the Northeastern part of the country. The tsunami displaced >500,000 people and the 59,662 people injured, 36,603 (61.4%) died. This equates to a burden of 18 deaths/10,000 population—almost three times that of Indonesia and several orders of magnitude greater than for the other three countries (see Chapter 10). This ranked third to the 314.7 deaths/10,000 population in Aceh province and the 98.7 deaths/10,000 population in the Andaman and Nicobar islands. The reasons for this disparity are not clear, and require further investigation. Several health facilities, including 35 hospitals, were destroyed.

**Relief responses by SEARO**

WHO-SEARO assisted in the relief/recovery of the Medical Care and Public Health Societal systems. In order to provide assistance to the public health system, WHO established field offices in Jaffna, Ampara, and Galle exclusively for supporting community-level activities. Responsibilities shared between the different WHO offices included: (1) WHO Field Office provided coordination of public health activities at the community level and implemented community-related activities: and (2) WHO Country Office in Colombo (WHO-Sri Lanka) provided coordination with other UN agencies, donor partners, and the MoH, for the procurement of supplies and their dispatch to the field offices. In addition, it mobilized technical personnel and other technical support based on needs.

Assessments, surveillance, and disease prevention—WHO staff from Sri Lanka, SEARO, and/or Geneva were included in teams of experts that conducted the initial situation analysis and assessments to determine the health needs in the affected districts. As hundreds of thousands of people crowded into approximately 700 IDP camps, the threat of the rapid spread and/or epidemics of communicable diseases loomed large. Pre-event, Sri Lanka had in place an effective epidemiological monitoring and reporting system. Staff from SEARO and GOARN were deployed to help the Ministry of Health establish supplemental surveillance and early warning alert and response systems (EWARN). This was supported further by improvements in the GIS for health mapping and health-related databases.

**Health coordination and planning**—coordination between the Sri Lankan government, other UN agencies, bilateral donors, and international
NGOs was an important part of the WHO Country Office role. Staff from the WHO Country Office helped the Ministry of Health in setting up a 24-hour Tsunami Operations Cell in each district. The WHO-Sri Lanka Office also established three operational units at Galle, Ampara, and Jaffna to improve coordination with the district health staff. It supported the Ministry of Health in providing technical material and support, and in facilitating the deployment of the 300 foreign medical doctors to the affected areas. The WHO-Sri Lanka office assumed the lead in the coordination of health-related work by UN agencies and international NGOs.

Mental health and psychosocial support—the President of Sri Lanka identified the need for psychosocial support within the community as a top priority. She established a National Psychosocial and Mental Health Committee to oversee a psychosocial support programme aimed at reaching and providing appropriate services to every tsunami survivor. The WHO, including experts from SEARO, supported this programme and provided advice that eventually led to the revision of a 100-year law, and then, drafted a new Mental Health Policy (2005). As a result, Sri Lanka’s Mental Health Policy has undergone a fundamental change from a medicine-based to a community-based approach to the provision of services.

Transportation and Logistics—WHO-SEARO helped to procure vaccines and lifesaving drugs needed by the affected population of Sri Lanka, along with 65 Emergency Health Kits, 40 diarrhoea kits, and 10 surgical kits, which would serve >65,000 people for three months. Two million chlorine tablets were supplied for purifying water. By 8 January 2005, three logisticians had been deployed to set up a mechanism from which public health officials could work. Drug supply chains were established. Transportation of the supplies and personnel was difficult, since many roads had been washed away. The WHO-SEARO facilitated procurement of 81 vehicles for use by the MoH in the affected areas. Health volunteers were provided with 66 bicycles for regular field visits as part of intensified disease surveillance. Midwives and public health inspectors also were provided with >200 mopeds/motorcycles to assist expansion of reproductive, maternal and child health, and regular monitoring of services. Generators procured using funds from WHO-SEARO provided electricity in hospitals, and 20 sets of telecommunications equipment helped to keep health officials in touch with WHO-Sri Lanka even in the more remote areas of Sri Lanka.

Water and sanitation—WHO water and sanitation specialist worked with the government and other agencies to chart priorities for the provision of potable water and sanitation, and to help to ensure that these priorities were met to: (1) provide clean water to relief camps and health facilities; (2) ensure that water quality was systematically tested; and (3) provide sanitation facilities in all areas including the disposal of garbage in areas in which people were returning to their homes. In order to ensure that adequate residual chlorine remained in the water at the delivery point, at the request of the National Water Supply and Drainage Board, WHO-Sri Lanka developed a one-page, good-practices sheet for use by those agencies that transported the water to the IDP camps. WHO-Sri Lanka also provided chloroscopes, dewatering pumps, chlorine tablets, and water storage tanks to local health departments. Local water authorities confirmed that the water testing kits provided by WHO-Sri Lanka were used for spot-testing water quality.

Recovery responses by SEARO
WHO-Sri Lanka supported the education and training of 831 people, including public health employees, engineers, supervisors, and other water and sanitation specialists. WHO-Sri Lanka promoted the use of solar disinfection of water (SODIS) in its training courses. However, many of the initial actions were geared towards providing immediate solutions to a pressing situation, and did not always consider their long-
term sustainability. For example, desalination plants were provided even though in the long term such equipment could not be maintained by the community without external help. Efforts also were directed to restoration or construction of institutional water supply and sanitation systems in health facilities and schools.

**Thailand**

Thailand was the first country to draw international attention to the devastation caused by the tsunami as the six provinces affected were popular tourist destinations that were packed with expatriates during the peak season. More than 16,784 persons were injured of which 8,327 (49.6%) died. Some of the reasons for not requesting external assistance indicated a strong, and pre-existing health system, dedicated resources, a disaster management structure with prior experiences with the Severe Acute Respiratory Syndrome (SARS) and avian influenza epidemics, However, WHO-Thailand worked with the Ministry of Public Health to provide technical support. Relief responses by SEARO

Immediately after the tsunami struck, WHO-Thailand contacted the Ministry of Public Health inquiring if any assistance was needed. SEARO established a coordination centre called the WHO Inter-Country Crisis Support Unit (ICSU) for Tsunami Response in the UN Building in Bangkok. The WHO-Thailand Technical Team also formed part of the UN Disaster and Assessment Coordination (UNDAC) mission from the UN Office for the Coordination of Humanitarian Affairs (UN-OCHA) that arrived in the aftermath of the tsunami and assisted local authorities in coordinating international support.

WHO-Thailand shared technical guidelines on the appropriate management of dead bodies. The Thai government requested the assistance of WHO-Thailand in conducting rapid health assessments, monitoring, and reporting of communicable disease outbreaks. WHO-SEARO provided technical information and guidelines on forensic operations, psychological and mental health, water and sanitation safety, and health promotion.

The most significant contributions of WHO-SEARO and WHO-Thailand was initiating orientation and an educational and training programme for epidemiologists using the WHO Field Epidemiology Training Programme (FETP) so as to strengthen the public health infrastructure. It provided education and training of field personnel and in disaster preparedness. Infrastructure, staffing, and funding support were provided by WHO-SEARO for forensic operations and services to deal with psychological trauma. In all, WHO funded >30 projects, including: (1) strengthening expertise in disaster preparedness, including engineering aspects for building hospitals and health centres; (2) strengthening disease surveillance and response capacities; (3) providing psychological care and mental health support; (4) developing environmental health, health promotion and care and treatment services; and (5) documenting and sharing of experiences. WHO-SEARO also deployed a team of mental health experts to analyze the mental health responses in the country: the assessment indicated that the work done by Thailand’s village health volunteers was “outstanding”.

As in other countries, WHO-SEARO besides WHO-Thailand also played an important role in Thailand in attempting to coordinate the work of hundreds of health agencies and NGOs involved in tsunami relief activities.

**Evaluation of the WHO-SEARO responses**

The earthquake and tsunami created one of the worst disasters in recent human history and the most massive that WHO-SEARO ever had faced. Considering the enormity of the damage and dysfunction, WHO-SEARO promptly responded to provide assistance to meet the public health needs of the affected countries. A comprehensive evaluation of the post-tsunami initiatives was conducted in order to identify some of the gaps that urgently had to be eliminated. The
recommendations from the evaluation included that WHO-SEARO should:

1. Improve its structures and functions so that greater priority is given by the Regional Office to disaster preparedness and response;

2. Improve inter-departmental and intra-organizational workflow with a five-year plan on how all technical and administrative units will work with the Emergency and Humanitarian Action (EHA) Unit at WHO-SEARO and Health Action in Crises (HAC) at WHO-HQ;

3. Improve procedures for procurement, warehousing, and deployment of supplies to meet anticipated needs during future disasters/emergencies by partnering with other regional organizations;

4. Develop Standard Operating Procedures for emergencies;

5. Augment the resource mobilization capacity for disasters at both the Country and Regional Office levels;

6. Begin a major education, training, and simulation programme with SEAR Member States and others in the area for disaster health preparedness and response that emphasized the links between disaster preparedness, response, and overall development of the country;

7. Record and integrate the good practices that emerged from the earthquake and tsunami into future emergency response guidelines and promote research in this area;

8. Strengthen the use of information technology in the area of disaster preparedness, relief and recovery responses, and education and training;

9. Develop plans and training with other sectors, such as the military and religious sectors, in order to improve local response capacities; and

10. Coordinate with other WHO Regional Offices to learn from their experiences in preparing for and providing relief and recovery responses to disasters and for development.

Contributions of SEARO to development

Following the earthquake and tsunami, WHO-SEARO convened four meetings in which the emergency focal points from the governments of the Member States together with the WHO-Country focal points for emergencies participated.

Phuket conference

The first of the conferences regarding the Health Aspects of the Tsunami Disaster in Asia was convened by WHO in Phuket, Thailand from 4–6 May 2005. What follows has been abstracted directly from the Phuket Papers. The conference was attended by some 400 senior policy advisers and expert practitioners from national governments, UN agencies, NGOs, civil society groups, academic institutions, and countries that had provided assistance to the affected populations. The experiences of the Public Health and Medical Care Systems following the earthquake and tsunami were shared with emphasis on what was done well and what could have been done better with the goal of incorporating the lessons learned into actions that should mitigate the damage and losses of societal functions created by future events. The national and international relief and recovery efforts were discussed and some of the actions taken and not taken by the international community in support of the countries affected were outlined. Specific issues addressed included: (1) needs assessments; (2) coordination; (3) filling gaps in essential services, and (4) capacity building at the country level. Each of these aspects was analyzed as to: (1) appropriateness; (2) adequacy; (3) effectiveness; (4) efficiency; and (5) connectedness.
The proceedings of the conference were synthesized into 12 inter-related areas: (A) developing national capacities; (B) information for needs assessment and needs-based actions; (C) neglected public health issues; (D) gender dimensions; (E) benchmarks, standards, and codes of ethical practice; (F) management and coordination of responses; (G) role of volunteer bodies; (H) private sector partnerships; (I) government donor funding policies and practices; (J) civil-military cooperation; (K) working with the media; and (L) commitment to act. Some of the significant findings from the Phuket Conference include:

**National capacities**

1. Communities that had experienced disasters and developed mechanisms to cope with such events were more resilient and responded better to the earthquake and tsunami than those that had not;

2. Community bodies and national agencies that had established emergency and disaster response plans and had undergone regular practice drills reacted to the earthquake and tsunami with greater promptness and worked in a more coordinated manner;

3. National and international health agencies with previous experience in crises had pre-defined procedures and systems, and were better prepared to respond to the disaster than were those without previous experience;

4. Pre-existing governmental capacities were important in determining the intensity with which the health systems could respond, and in facilitating the rapid restoration of the provision of essential goods and services;

5. The profound emphasis on coordinated public health responses with effective early warning of potential disease outbreaks had a crucial impact on limiting disease outbreaks and preventing epidemics—despite significant displacements of populations;

6. The prompt deployment of military logistical capabilities advanced and facilitated the delivery of assistance, especially in hard-to-reach areas, thereby enhancing chances for survival of the injured;

7. Millions of people in South Asia still live in hazard-prone areas without adequate infrastructures that could reduce their vulnerability to events caused by such hazards;

8. There were no pre-existing systems for early warning, alert, response, and evacuation in the health system (though disease surveillance, early warning alert, and responses were implemented after the earthquake and tsunami impacted the affected areas);

9. Mechanisms for managing the logistical aspect of the responses, including customs, warehousing, and contingency plans for distributing supplies and drugs were largely absent, obsolete, and/or under-resourced;

10. Key health facilities were destroyed—though damage was inevitable (given the overwhelming force of the earthquake and tsunami), some buildings could have withstood major damage if constructed to more robust standards based on local hazard analyses;

11. The speed of the health responses was uneven and existing health services were overburdened by a sudden influx of injured victims;

12. Because of unnecessary anxiety about the possibility of disease spreading from dead bodies, many were buried quickly in mass graves with no opportunity for visual identification, photography, or tagging; and

13. Although there were community networks for response or public health interventions, it seems that community awareness of the
hazard was lacking. Not many of the coastal communities of the tsunami-affected areas knew what to do when the water receded from the shores.

**Assessments and needs-based actions**

Uncoordinated, incomplete, inaccurate, competing, and overlapping assessments were undertaken by different agencies and organizations. These assessments not only wasted time and resources, but also raised ethical concerns in relation to traumatized populations being subjected to repeated questioning by representatives of different entities.

Many assessments had been undertaken, yet assessors were not able to access all of the baseline data that they needed in the aftermath of the events. Good data were available from some communities in which public health surveillance systems had been well-developed before the event. Information derived from these data enabled more rapid and effective relief responses and shortened the respective relief phase.

**Neglected public health issues**

The initial health responses to the earthquake and tsunami focused on the rescue of the living, treatment of casualties, and recovery of essential services. These critical tasks were undertaken by many partners with varying degrees of success that depended on the extent of the devastation to which they were exposed and the practical difficulties of access and assistance delivery, availability of resources, competence of service providers, and cooperation between them and local and national counterparts.

The uneven availability and distribution of food was exacerbated by the wide dispersion of displaced people, often in remote locations. Some of the more important public health issues that did not receive adequate attention include: (1) efforts directed toward the preservation of the mental health of the affected population; (2) the management of massive numbers of casualties; and (3) the management of the forensic aspects of the fatalities.

1. **Mental health**—assistance efforts should be sensitive to the psychological trauma of the survivors, many of whom also were troubled by the uncertainty of not knowing the fate of their loved ones. The tsunami experience suggests that unregulated counselling and other psychosocial interventions were problematic in several locations.

2. **Management of mass casualties**—Most of the countries affected were ill prepared to handle large numbers of casualties. They lacked standardized triage systems and pre-established networks of hospitals for referrals and burden-sharing. Most of the immediate assistance given to the injured was provided by less-injured or uninjured survivors. This suggests that training of the public in first-aid techniques might have had large-scale, life-preserving, and morbidity-mitigating benefits. The special role of the national Red Cross and Red Crescent Societies, supported by the International Red Cross and Red Crescent movement, was commended during the Conference. Reference was made to cooperative arrangements between the societies, national and local health authorities, and the WHO.

3. **Forensic aspects of management of fatalities**—Participants questioned whether excessive human resources were devoted toward managing the dead while the survival and welfare needs of the living were not being met. They recognized that political and cultural factors often were key determinants of practices used to dispose of human remains, as well as the myth that dead bodies generate disease, often influenced decision-makers. There were other reasons for not rushing to cremate or bury victims. The lack of identified bodies impeded attempts by survivors to establish their rights over assets and property, to grieve over the loss of a loved one(s), and to perform death rituals. Many gaps in systems for managing mass fatalities in the tsunami-affected countries were discussed.
Gender dimensions
There was a significant impact of gender on the survival and welfare of populations affected by the earthquake and tsunami. In most locations, more women than men died. This was due to multiple factors, including biological, physical, social, and cultural differences. It also was reported that subsequent service delivery sensitivity was insufficient to the needs of women.

Benchmarks, standards, and codes of ethical practice
Different organizations used different measurements, methodologies, and interpretations in their own assessments, making it difficult to compare results, identify the populations with the greatest needs, and/or achieve consensus on priorities. This lack of coordination between different organizations resulted in wasted resources, and was partly explained by inconsistencies in leadership, undue pressure to generate information rapidly, and a lack of expertise in the application of available standards.

Management and coordination of responses
In-country, health-system management capacities were overwhelmed by the scope and suddenness of the earthquake and tsunami. The subsequent global response resulted in confusion, congestion, and competition for scarce logistical and transport resources. Within the health sector, some of these operational difficulties could have been prevented. During the responses, effective supply systems and logistics often were the key to efficient actions.

Role of volunteer bodies
The interface between the voluntary and government sectors sometimes was tense. There was a lack of clarity on mutual roles, obligations, and accountabilities.

Private sector partnerships
There was an unusually high level of both national and international private sector involvement in the responses to the earthquake and tsunami, with contributions of professional skills, in-kind relief supplies, and funding. This participation included private companies in the Region as well as global corporations.

Reviews indicated that successful partnerships between the private and public sectors reflected the preparations made by the partners before personnel or materials were deployed. In the responses, private sector experts were successfully deployed to work with international agencies. Their roles were defined carefully, enabling skilled personnel to be identified and deployed rapidly. The deployments were facilitated through support provided by key UN and government officials (including briefing and debriefing arrangements). Private entities were able to work with the government and other stakeholders to map and estimate generic needs during the crisis.

Government donor funding policies and practices
The generous response of donor governments from around the world was characteristic of the earthquake and tsunami experience. However, participants debated the extent to which the agreed principles of “good humanitarian donorship” were put into practice. The earmarking attached to individual donor contributions did not always reflect community-level needs. Some of the frustrations expressed by donors focused on information provided by agencies and their accountability for utilized resources. Donors reported receiving inconsistent messages from agency field offices and from their headquarters, particularly with respect to what was needed most urgently. They called for more consistency and predictability at different levels within individual agencies, better tracking of project implementation, and more rigorous reporting systems that indicate how funds are used. Within the tsunami responses, some donor agencies felt that there was an excessive focus on curative health care, and not enough on the delivery of public health interventions especially in peripheral areas.

Civil-military cooperation
The relief responses to the damage and
disturbances in societal functions, in particular, the Public Health and Medical Care Systems, to the earthquake and tsunami-caused disaster in Asia were characterized by extraordinary cooperation between civilian and military relief efforts. This interaction was facilitated by the establishment of the Combined Support Force 536 at the Royal Thai Air Base in Utapao, Thailand, and the staffing of the UN cell with a Civil-military Liaison Officer from WHO. Soon after the tsunami, the military responses were coordinated by the Combined Support Force. It brought together the military capabilities of 30 nations alongside a UN civil-military liaison cell. The arrangement enabled the early dispatch of several assessment and response missions. These efforts culminated in the Health Assessment Missions in which military, sea-based assets flew WHO-led, multi-agency teams to 24 internally displaced person (IDP) camps in Aceh province, where an estimated 500,000 people were at risk for communicable diseases. The Multi-agency Health Assessment Mission in early January systematically conducted assessments in several hard-to-reach locations in Aceh province—the first comprehensive assessments that involved 500,000 vulnerable people. No widespread outbreaks occurred, and the continuous flow of information gathered during the missions helped to address the immediate health concerns, such as directing limited supplies of measles vaccines to where they were needed most. The civil-military interface worked best when civilian authorities assumed the responsibility for specifying what was required from the military in the way of logistical, transportation, and other practical measures for the provision of assistance.

Working with the media
Immediately after the tsunami, many journalists observed that population-based information about health risks was in short supply. As a result, critical issues, such as psychosocial trauma, mental illness, risks for diarrhoea and malaria, and women’s health received media coverage that was out of proportion to their public health importance. Decision-makers, who tend to rely on the international media for up-to-date information, were uninformed regarding some of these issues.

It was agreed that much of what occurred provided benefits to the stricken population, but substantial room for improvement through implementation of the lessons learned was defined. It was stressed that these lessons must be converted into actions in order to mitigate the damage sustained and to enhance responses to the damage from future events.  

SEARO Bangkok meeting: health aspects of disaster preparedness and response
Of the four meetings, the second meeting was convened in Bangkok, Thailand on 21–23 December 2005. This meeting was a follow-up to the WHO Conference of May 2005 in Phuket, Thailand. The meeting brought together representatives of 11 countries impacted by the events. The goal of the meeting was to produce a plan for action that could meet the specific health needs of each of the countries and ensure that the countries of the Region will be better equipped to cope with any future event.

The objectives of the Conference were to: (1) identify gaps in the health needs of the affected and vulnerable populations for preparedness, relief responses, and recovery; (2) determine the next steps for addressing these gaps; and (3) develop benchmarks and a corresponding framework for action that must be achieved to solidify the capacities and capabilities of the Public Health and Medical Care Systems to meet emergencies.

Presentations of background papers, panel discussions, and working groups were used to accomplish these goals. Based, in part, on the materials presented, the working groups drafted benchmarks that could mark the progress in achieving the overall goals and proposed strategies that could be used to reach the benchmarks. Representatives of the participating countries summarized the current status of their respective countries relative to each of the defined benchmarks.
The 12 benchmarks identified through group processes related to: (1) legal framework for preparedness and response; (2) national disaster plan for preparedness and responses; (3) budgets; (4) rules of engagement for external actors; (5) community plan based on risk identification and vulnerability assessments; (6) community-based health capacities; (7) local capacity for provision of essential services and supplies; (8) awareness and advocacy programmes; (9) identification of hazards, risks, and vulnerabilities; (10) education and training; (11) “safe” health facilities; and (12) surveillance and early warning systems (Appendix 24.A).

It was evident that most of the Member States already had initiated activities relating to better emergency preparedness and a few countries were keen to develop their National Emergency Preparedness Programme immediately. In view of the variable and wide range in the levels of preparedness in Member States particularly at the community level, the country representatives agreed that community-level preparedness, legal frameworks, local and national disaster plans, surveillance and early warning systems, and advocacy and awareness programmes demanded more attention.

The strategies and mechanisms that should facilitate achievement of the benchmarks were grouped into seven categories: (1) monitoring, evaluation, surveillance, and assessments; (2) education and training (human resource development); (3) information and communications; (4) legislation, policies, and authority; (5) funding; (6) planning and preparedness; and (7) coordination and control. Any or all of the strategies suggested could be implemented by the countries in the Region.

The conference delivered an important set of standards (benchmarks) and strategies that, when implemented, should facilitate the countries and the communities within them reaching better levels of preparedness.

Attaining the benchmarks should result in decreased numbers of lives lost and should minimize the pain and suffering associated with such events.

**From lessons to actions: Bali, Indonesia**

“While much of the information for improving responses in crisis situations is known, the same mistakes often are repeated. ‘Lessons learned’ may be more accurately titled ‘lessons identified’. They not always are learned. In order to benefit from lessons learned from past experiences, there must be movement from just talk and apparent commitment to action. Knowing is not enough; we must apply. Willing is not enough; we must do.”

The third meeting From Lessons to Action, was convened by SEARO on 27–29 June, 2006 in Bali, Indonesia. In the interim since the Bangkok meeting, following presentation of the material from the Bangkok meeting, a political commitment to disaster management has been seen in the World Health Assembly 2005 Resolution WHA 58.1, and the World Health Assembly 2006, Resolution WHA 59.22.

The meeting focused on how to act on and incorporate the lessons learned from the earthquake and tsunami into disaster management policies and plans of every nation, so that they could be implemented to strengthen emergency preparedness and responses at every level in every country in the Region. The emphasis was on action.

The health responses to the damage and losses in the abilities of the Basic Societal Systems to provide needed goods and services following the earthquake and tsunami were reviewed. Among the key lessons observed was the need for: (1) community empowerment to deal with disasters; (2) multisectoral and inter-system coordination; and (3) national capacity building. The experience of the Thai Red Cross in working with the tsunami-affected communities emphasized the need for the community to be educated and trained to recognize and
respond appropriately and immediately when a potentially destructive event is about to occur, is occurring, and/or has occurred without relying on external assistance—the arrival (influx) of external assistance always requires time, and delays cost potentially preventable deaths and additional morbidity. To achieve this, the people must: (1) be aware of the risks of hazards in their geographical area, and potential events related to these hazards; (2) organize and implement warning systems; (3) have a community-based leader and trained volunteers; and (4) know in advance of any event, the appropriate evacuation points and the closest hospital/health centre/place of assistance. In addition, the communities-at-risk must conduct exercises and drills for emergencies in real-time based on likely scenarios—the conduct of these exercises is crucial for effective community preparedness.

During the Bali meeting, participants analyzed the progress towards the benchmarks in their respective countries, especially in relation to community empowerment, multisectoral coordination, capacity building, and standards and guidelines. They reported specific achievements, as well as barriers to achieving the benchmarks. Some of the benchmarks were modified, e.g., the benchmark on advocacy and awareness was changed to include media relations:

‘Advocacy and awareness developed through education, information management and communication, including effective media relations (pre-, during, and post-event)’

For all activities, financial resources are needed. The development of a Regional Emergency Fund was suggested, and more flexibility in funding mechanisms was emphasized.

The Bali Declaration (Appendix 24.B) urged Member States to improve multi-hazard disaster preparedness, and convert the Bangkok meeting benchmarks into a strategic action framework by developing measurable indicators with timelines. The importance of multisectoral and multi-system coordination during disasters has emerged as a fundamental issue following the tsunami. It was recognized that no single agency or sector can respond effectively to the losses of functions due to damage from an event, and that competition among agencies is detrimental to the agencies and, more importantly, to the affected people.

While in many countries such as India, the vertical chain of command during emergencies has been established, coordination within the government, at the central, state, district, and local levels has been put in place, but ways to consolidate ‘horizontal coordination’ among partners seemed less clear. Implementation of the health cluster approach in which all health-related agencies work together was successfully implemented in Indonesia following the Yogyakarta earthquake of May 2006. The role of nongovernmental agencies was also discussed. While NGOs that possess the required skills and logistical capabilities can play a very important role in a disaster-affected community, actions taken by NGOs that do not possess the required skills often cause difficulties.

Also, the issues associated with “accountability” were discussed. The general consensus was that the role of NGOs should be coordinated by the government at the local level. Political commitment was seen as crucial for effective multisectoral, multi-system coordination—where implemented, this has led to the development and implementation of disaster management agencies headed by the Prime Minister or President (India and Sri Lanka).

Even with the highest level of political commitment, no country can be prepared for an event without the capacities to cope with damage and losses of function that result. Therefore, capacity building through the provision of appropriate education and training of human resources is integral to disaster management. Experiences from recent disasters indicate that while technical knowledge is necessary, successful management of disasters requires efficient and capable managers and responders. Accordingly, the Asian Disaster Preparedness Centre (ADPC) has adapted its training courses to emphasize
wider skills to build more effective ‘managers’ rather than building technical skills. The first step in capacity building is capacity assessment, and benchmarks are needed to assess what one needs to achieve and how far one has to go in each country.

**Development and implementation of an emergency relief fund**

One key lesson recognized during the preceding three meetings was the need to provide funds immediately after the onset of an event, when help is most urgently needed. Yet, although pledges of donations frequently are prompt, the actual acquisition of most funds takes weeks. Therefore, during the 24th Health Ministers Meeting in Dhaka on 20–21 August 2006, Member States recommended the creation of an emergency fund. Subsequently, an in-house working group was constituted to formulate the details of the proposal for establishing a regional emergency fund, with the Emergency and Humanitarian Action Unit (EHA) of SEARO functioning as its secretariat. Draft proposals on the South-East Asia Regional Health Emergency Fund (SEARHEF) were then submitted to the following meetings for consultation: (1) 58th Meeting of the Regional Director with WHO Representatives convened from 13 to 21 November 2006; and (2) Regional Consultation for the South-East Asia Regional Health Emergency Fund convened on 12-13 April 2007. The Regional Consultation recommended that “a working group be formed” that would meet in Bangkok in June 2007 to discuss and finalize the business rules, including those related to monitoring and reporting. The objectives of the Bangkok meeting were: (1) to discuss and finalize the guidelines for managing the South-East Asia Regional Health Emergency Fund (SEARHEF); and, (2) to discuss and finalize proposed draft resolution/documents to be submitted for consideration by: (a) a Joint Meeting of Health Secretaries and Consultative Committee on Programme Development and Management; and (b) the Regional Committee.

Average projected immediate needs for funding were provided that recognized that the main expenditures for medium-sized emergencies include items and services such as procurement of essential medicines, supplies, logistical support (e.g., transport, communication), public health interventions, operational field presence, and staff and technical support to national and sub-national health authorities. Leeway was to be provided for: (1) more emergencies in the year than expected; (2) more underfunded emergencies; and (3) eventually, the fund also should have more of a Voluntary Contributions (VC) component, so the targets should be set with that in view.

The topics discussed included: (1) general issues; (2) governance and roles of Member States; (3) principles; (4) criteria for allocation of funds for emergencies; (5) funding needs and estimates; (6) building the corpus of the fund; (7) management and processes; (8) processing requests and reporting; (9) ceilings on releases; and (10) limits and WHO financial rules. It was determined that 1% of the regular budget (source may be multi-country activity) will form the initial corpus of the fund and these funds will be pooled. The funds also have an extra-budgetary component. The pooled funds are located in the Regional Office and WHO financial rules apply.

For the corpus of the fund, the following points were agreed that the SEARHEF will be composed of two distinct portions: (1) AC from biennial allocation, and; (2) VC from donors, countries and other agencies; Member States AC portion: up to an amount of US$ 1 million per biennium. The VC will be mobilized to: (1) raise ceilings for allocations; and (2) relieve countries from their part of AC. The target for the VC portion was initially set at US$ 1.5 to US$ 2 million.

The funds can be provided from SEARO within 24 hours of a request from a country impacted by an event. The fund has been established and has been used following Cyclone Nargis in Myanmar.
Another significant improvement occurred for the coordination of health activities during an emergency—all agencies in the Public Health and Medical Care Systems now should respond to an emergency by coordinating their work through the global and country health clusters.

**Summary**
The Regional Office for WHO South-East Asia and through it, the WHO-HQ played a significant role in the public health responses to the damages and losses of function that occurred following the earthquake and tsunami and to the recovery which at the time of this writing is still ongoing. In addition, with their assistance, there occurred significant developments which should manifest by decreased mortality and morbidity from the next potentially disaster-causing event. This application of lessons learned has been responsible for attenuating the losses of life and morbidity from events that have occurred in SEAR since the earthquake and tsunami of December 2004.

**References**
## Appendix 24.A: Matrix of status of the five countries vis-à-vis the 12 benchmarks (EPR=emergency preparedness and response; NA=not available; SOP=standard operating procedure)

<table>
<thead>
<tr>
<th>Benchmark</th>
<th>India</th>
<th>Indonesia</th>
<th>Maldives</th>
<th>Sri Lanka</th>
<th>Thailand</th>
</tr>
</thead>
<tbody>
<tr>
<td>Local capacity for emergency provision of essential services and supplies (shelters, safe drinking water, food, communications)</td>
<td>Present</td>
<td>Present for medical supplies, water, &amp; sanitation</td>
<td>Capacity in place</td>
<td>Currently ad hoc; must be systematic</td>
<td>Sometimes inappropriate supplies are available</td>
</tr>
<tr>
<td>Advocacy and awareness development through education, information, management, and communications (pre-, during, and post-event)</td>
<td>SOPs needed</td>
<td>Education on NPR piloted in province</td>
<td>None</td>
<td>Needs strengthening at state/division/town levels in more disaster-prone levels</td>
<td>NA</td>
</tr>
<tr>
<td>Capacity to identify risks and assess vulnerability at all times</td>
<td>Present</td>
<td>Needs assistance</td>
<td>Needed</td>
<td>Done through universities</td>
<td>Need to update existing hazard and risk maps</td>
</tr>
<tr>
<td>Human resources capabilities continuously refreshed and maintained</td>
<td>Must incorporate regular refresher courses</td>
<td>Inclusion of curricula in university courses</td>
<td>Limited; need for systematic training</td>
<td>Formal courses have begun</td>
<td>Training in specific skills needed, especially for local authorities in planning for EPR</td>
</tr>
<tr>
<td>Health facilities built/modified to withstand expected risks</td>
<td>New initiative has begun recently</td>
<td>Has been started only in Aceh, but training also has begun</td>
<td>No initiative as yet</td>
<td>Must incorporate into plans</td>
<td>NA</td>
</tr>
<tr>
<td>Early warning and surveillance systems for identifying health concerns</td>
<td>Needs strengthening</td>
<td>Needs improvement</td>
<td>Functioning reporting systems</td>
<td>Existing for health sector</td>
<td>Present</td>
</tr>
<tr>
<td>Legal framework and a functioning mechanism and organizational structure in place for health, EPR (emergency preparedness and response) at all levels involving all stakeholders</td>
<td>Present</td>
<td>National disaster law still to be endorsed</td>
<td>Initial steps have been taken drafting law</td>
<td>Disaster Management Act No. 13 approved May 2005</td>
<td>Needs strengthening for pre-disaster phase</td>
</tr>
<tr>
<td>Benchmark</td>
<td>India</td>
<td>Indonesia</td>
<td>Maldives</td>
<td>Sri Lanka</td>
<td>Thailand</td>
</tr>
<tr>
<td>--------------------------------------------------------------------------</td>
<td>-----------------------</td>
<td>----------------------</td>
<td>-----------------------</td>
<td>------------------------</td>
<td>---------------------------------------</td>
</tr>
<tr>
<td>Have and regularly update disaster preparedness and emergency management</td>
<td>Present</td>
<td>SOPs needed at</td>
<td>Draft plan ready</td>
<td>To be initiated</td>
<td>No clear focal point in health sector</td>
</tr>
<tr>
<td>plan for health sector and SOPs (emergency directory, national coordination</td>
<td></td>
<td>national level</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>focal point)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Emergency financial (including national budget), physical and regular</td>
<td>Present</td>
<td>Amounts should be</td>
<td>Open emergency fund</td>
<td>Available in patchy</td>
<td>None</td>
</tr>
<tr>
<td>human resources allocation and accountability procedures</td>
<td></td>
<td>increased</td>
<td></td>
<td>manner</td>
<td></td>
</tr>
<tr>
<td>Rules of engagement (including conduct) for external humanitarian actors</td>
<td>System is present</td>
<td>Ministerial decree</td>
<td>Present only for UN/Red Cross</td>
<td>Must develop and address ethical issues</td>
<td>None</td>
</tr>
<tr>
<td>based on needs</td>
<td></td>
<td>present, but must</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Community plan for mitigation, preparedness, and response based on risk</td>
<td>SOPs needed at this</td>
<td>Safe communities</td>
<td>None</td>
<td>Comprehensive plan must be specified</td>
<td>None</td>
</tr>
<tr>
<td>identification and participatory vulnerability assessment and backed by</td>
<td>level and tapping of</td>
<td>programming in 7 of</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>higher level of nearby capacity</td>
<td>ASHA</td>
<td>33 provinces</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Community-based response and preparedness and capacity supported with</td>
<td>SOPs needed at this</td>
<td>Quick responses</td>
<td>None</td>
<td>Comprehensive plan must be developed</td>
<td>Not complete</td>
</tr>
<tr>
<td>training and regular simulations/mock drills</td>
<td>level and ASHA</td>
<td>present in 21 of 33 provinces</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The participants at the Regional Meeting on Emergency Preparedness and Response: From Lessons to Action, held in Bali, Indonesia from 27-29 June 2006,

Recognizing That

- The devastating Tsunami of 26 December 2004 yielded profound lessons and, as we move forward, it has opened windows of opportunity to improve the health management of and response to future disasters;

- Despite efforts to improve disaster preparedness and reduce the impact of disasters on the health and well-being of their populations, the frequency and magnitude of impact of natural disasters continue to grow and will have a negative impact on health, health infrastructure, and social and economic development;

- Affected communities themselves are the first to respond to disasters and that the effectiveness of their response is directly linked to community solidarity and a commitment to invest in emergency preparedness;

- An effective health response to emergency situations demands continuous coordination with multiple actors across sectors before, during and after disasters; and

- The benchmarks established at the November 2005 Meeting on the Health Aspects of Emergency Preparedness and Response (Bangkok, Thailand) provides a guide for sustained Regional and national action.

Resolve To

- Urge Member States in the Region to improve multi-hazard disaster preparedness, with particular emphasis on creating an appropriate disaster management structure in governments, with adequate human and financial resources and access to decision-making levels;

- Reinforce efforts to empower communities to take a pivotal role in the multi-sectoral response to disasters by identifying and fulfilling resource gaps including training and building on already existing capacities;

- Develop new and/or improve existing coordination mechanisms among sectors, governments, NGOs and other agencies within and across countries to improve the flow of information in all directions and facilitate the optimal use of resources;

- Advocate and plan for responses that ensure that recovery, reconstruction and rehabilitation contribute to long term functioning of health systems;

- Convert the Bangkok Meeting Benchmarks into a strategic action framework by developing measurable indicators with timelines;

- Promote the creation of a Regional Solidarity Fund for Emergency Response, a regional team approach and other mechanisms;

- Capitalize on the lessons learned from recent emergencies by systematically capturing, documenting and exchanging examples of progress achieved and translating these into best practices for reducing disaster vulnerability in Member States of WHO’s South-East Asia Region in a sustainable and cost-effective manner.
Part IV
Analysis

Chapter 25
Data Collection, Barriers, and Indicators
Data Collection, Barriers, and Indicators

Introduction

The preparation of a detailed, retrospective analysis of the health aspects of the earthquake and tsunami that impacted India, Indonesia, the Maldives, Sri Lanka, and Thailand in December 2004 was undertaken by the WHO Regional Office for South-East Asia and the World Association for Disaster and Emergency Medicine (WADEM) in February 2006. Several barriers were encountered in the collection of information essential for this project which resulted in inordinate delays in its completion.

The format used in presenting the country reports and in the analyses that followed is based on the Conceptual Framework provided in Health Disaster Management: Guidelines for Evaluation and Research in the Utstein Style, and other frameworks as promulgated by WADEM. The advantages in using this structure relate to its ability to aid in the synthesis of what actually occurred and in identifying the differences in preparedness, events, damage, and responses to the changes in functions created by the events, and identifying gaps that occurred in the countries studied. This is the first time the guidelines have been applied to a major study.

In some instances, forcing the data/information that could be accessed into the longitudinal and transectional frameworks as outlined in Chapter 2 was arduous, and some of the disaster phases into which information was assigned may be controversial. However, the processes used helped to organize the material that was identified, and hence, to gain better understanding of what transpired.

Extensive efforts were invested in obtaining essential information. Several sources were used, including: (1) peer-reviewed, published literature; (2) non-peer-reviewed publications; (3) reports of governmental, inter-governmental, and non-governmental agencies; (4) the lay media; and (5) the Internet. Barriers encountered in accessing and integrating the information were accounted during the process.

Some of the barriers confronted include: (1) difficulty accessing the relevant data and information; (2) identifying candidates to be interviewed to help to fill the gaps in the material collected; (3) differing descriptions of the events for each of the countries; (4) indicators for defining the baseline health structures and pre-event status differed and often the information needed was not available; and (5) placement of some of the information acquired into the frameworks of the guidelines was arbitrary.

However, this application of these frameworks helped to identify major gaps in the data that were available at the time of initiation of this project. As noted in the preceding chapters, difficulty was encountered in retrieving and matching the data/information that had survived
to the time of inquiry. This was due, in part, to the fact that so much of the data that had been collected initially had perished or was not accessible. In addition, the data/information had no consistent structure. It was erroneously assumed that data would be preserved indefinitely, but this was not the case—much had been withdrawn from access including that which had been posted on the Internet. Further, some of the information collected by the governmental, inter-governmental, and non-governmental agencies was not accessible. This was true not only retrospectively as required for this study, but also concurrently with the disaster, making coordination and control difficult, at best. Therefore, much of the information used in this study had to be collected by interviewing some of the individuals involved. Forty-three interviews were conducted and synthesized into the information provided in the country chapters of this book (Chapters 4–8).

It should be noted that very little information could be retrieved regarding the effects, outcomes, efficacy, efficiency, and impacts of specific interventions/projects. Even specific project after-action reports could not be accessed—in fact, identification of specific interventions, generally, was not possible.

Access to data and information

The sources for the information used in this project were widely scattered. Multiple databases were searched including MEDLINE, PUBMED, CINHALS, and CRED for peer-reviewed papers and reports; non-peer-reviewed publications including the media and the Internet; published reports of evaluations including the report of the Tsunami Evaluation Coalition (TEC), and the Tsunami Recovery Impact Assessment and Monitoring System (TRIAMS) reports, and other pertinent UN and WHO publications; records/reports of inter-governmental, governmental, and non-governmental agencies; and one-on-one interviews with knowledgeable persons or persons who had been directly involved in the disaster. Some of the information was obtained from the “gray” literature.

An example of the diffuseness of the sources is illustrated in Figure 24.1. As of 16 February 2007, of the first 167 journal articles accessed, two-thirds (110) were published in journals that had published only one article relative to the earthquake and tsunami. Another 13% (22) were published in sources that had published only two articles relative to the events of 26 December 2004. Only 8% (13) of the total sources contained >5 articles relative to the events. In a comprehensive review of peer-reviewed, published articles from 1977 to 2009, Smith et al identified a total of 155 papers pertaining to disasters caused by natural hazards. The distribution of these articles essentially was identical to that noted above.

There were only a few comprehensive evaluations that included the health aspects of the disaster that had been completed prior to the initiation of this project. These included the TEC and TRIAMS reports. Much of the information in these reports was obtained by interviews. There were no comprehensive bibliographies available.

Of crucial importance, no evaluations of the effectiveness, efficacy, efficiency, benefits, and/or costs of specific interventions were identified. The paucity of such studies lends further credence to the observation that few evaluations of interventions/responses have been published. Those that have been published have been in the form of after-action reports as well as a few case studies. Most of the after-action reports have been retained by the organizations that have conducted them, and have been used to demonstrate to donors that their resources have had some results. For the most part, the outcomes have been limited to achievement indicators and have not addressed the impacts of the interventions provided. Other effects of the interventions provided generally were not accessible. A general perception exists that negative evaluations could have the potential
to discourage donors from support of further projects.

In addition, much of the data/information accessed was published in the gray literature that had not been peer-reviewed. This includes newspapers, television and radio reports, and non-indexed, scientific magazine articles. The gray literature is difficult to find as there is no common indexing system available. Many such reports were identified through the use of the search engines available for the Internet. Such efforts required substantial sifting and winnowing through the plethora of gray information provided by these search engines. Generally, the information obtained from these sources was triangulated before it was synthesized into the information used for this project.

There were several additional barriers encountered in accessing the data/information. These included, but were not limited to: (a) data/information had perished; (b) data were withheld; (c) country-level pre-event data were lacking; (d) all damages were ascribed to the tsunami; (e) no standard (common) framework/structure was used; (f) no common terminology was used; and (g) no standardized set of indicators was used.

Data/information had perished
Planning for this project began in 2006, less than two years following the earthquake and tsunami. By this time, a substantial amount of information that had been posted on the Internet had been removed and could not be accessed. This was true especially for reports by the countries being studied. Similarly, several of the reports listed, including information from SEARO, no longer could be accessed. In particular, there was no central or common repository for information pertaining to the health aspects of the earthquake and tsunami.

Data withheld
Information, including some collected by NGOs, was not available. The reasons for this are not clear. It certainly is possible that some withheld information because they perceived that its release possibly could have had a negative impact on their ability to obtain resources from their donors. Some of the NGOs performed assessments, but did not share the results of the assessments with other organizations.

No standard (common) framework/structure
The reports accessed lacked a common or even similar structure. In many instances, the format used seemed random or parochial. Often, this made the synthesis of the information difficult. There were no standardized report forms, health assessment tools, or progress reports as to the health aspects of the disasters. Therefore, often it was difficult to assign information into the proper longitudinal phase for which it was applied. Furthermore, record-keeping was inconsistent—some records were complete, some incomplete, and some happenings were never recorded, or information about them was not available.

Country-level pre-event data
In general, data describing the pre-event health status were available only at the country level. Little pre-event data could be found for those areas directly impacted by the earthquake and/or the tsunami. Thus, for the most part, the national pre-event information was used and these data had to be presumed to be characteristic for the areas directly impacted by the events. Generally, it was difficult to obtain information either on the populations that were at risk or the populations directly impacted. Therefore, it was not possible to analyze clusters within the areas impacted or compare data with those of the areas not impacted.

Damages related to the tsunami
Even for Aceh province, it was not possible to analyze the impact of the earthquake in areas adjacent to those directly impacted by the tsunami, i.e., to factor out the damages from the earthquake alone. This made comparisons of the longest, most intense, and highest magnitude earthquake of the last 40 years, with other earthquakes during the same period, impossible. The damages related to both events were
considered by most to have been related solely to the tsunami!

**No common terminology**
Use of a standardized terminology is essential for understanding information. However, currently, there is no standardized terminology for communications relative to the health aspects of disasters; and this contributes to misunderstanding and misinterpretation. There was no agreement in the meaning of terms in the information abstracted. For example, there was no agreement as to the use of the commonly used terms of “relief”, “recovery”, or “development”. “Response” seemed to incorporate all of the interventions regardless of when and how the interventions were applied or evaluated. The widest gaps in the use of terminology occurred between the various operational Basic Societal Systems. The same terms were used in different ways by the Basic Societal Systems of the stricken society and by those who provided assistance. The use of different meanings for the same terms made it difficult to apply the findings across disciplines.

**Standardized indicators**
Where data were and/or information was available, most often no standardized indicators were used. Similar findings were expressed using different indicators; these disparities led to confusion and may have resulted in some misinterpretations. Thus, some of the important, relevant information could not be identified in some reports. There did not exist any standardized minimum set of indicators that all reports dealing with a specific aspect of the events, damage, changes in functions (disturbances related to damages), the relief response phase, the recovery response phase, and/or development. Therefore, some of the reports that were available often contributed to confusion and rendered some comparisons impossible.

For example, there were few consistent descriptions of the pre-event healthcare systems or their relative effectiveness in meeting the healthcare needs of the communities impacted, or even of those not directly affected. There were no standardized indicators that could be used to judge the severity of the damages or losses of functions—especially as they related directly to the areas directly impacted. This impaired the reproducibility and reliability of some of the data/information collected, and hence, the validity of some of the conclusions drawn from the data/information was difficult to establish.

**Interviews required**
Due to the inability to access sufficient data/information, it was necessary to obtain information from interviews. Structured and semi-structured interviews were conducted by one of the researchers for this project. Interviews were conducted with specific persons at SEARO and with persons (including focal points) identified as knowledgeable or having been involved in the health aspects associated with the earthquake/tsunami. The interviews with SEARO staff were conducted in person at the Regional Office. The remainder of the interviews was conducted via telephone or Skype. Interviewees were selected based on recommendations of other persons involved, or by the material they had authored on the disasters. Every effort was made to verify the information obtained by using the structure and through triangulation with multiple interviewees. Most of these reports obtained from the interviews were observational and contained some opinions of the person being interviewed. Reproducibility and reliability of the information were verified by the structure used for the interviews and triangulation. A total of 43 interviews were conducted; the results were synthesized with the data and information obtained from other sources.

**Descriptors of events differed**
Since the characteristics of the earthquake and tsunami that impacted each of the countries studied differed substantially, the project was designed to examine the impact of these differences. However, the descriptors used for the characteristics of the events differed making it
impossible to use cluster sampling within any of the countries. Thus, the actual characteristics of the events could not be subdivided into component areas for more detailed analyses of what occurred in each of the countries. For example, the earthquake caused damage, as best can be determined, in only two countries: Indonesia and India. There was the belief that damages created by the earthquake primarily occurred in Aceh province (and perhaps in adjoining areas on the west coast of Indonesia) and in the Andaman and Nicobar Islands that are far distant from mainland India. While the onset of the earthquake and the arrival of the tsunami occurred within minutes in Aceh province, there was a longer interval between the primary and secondary events in the Andaman and Nicobar Islands. Yet, for the most part, little information could be gathered about the damage due to the earthquake in either country, including those areas of Aceh province that experienced the earthquake, but not the tsunami. This has made it difficult to compare the effects of the earthquake with those of other earthquakes of similar magnitude. For the most part, the events were considered as one—“the tsunami”? Thus, much valuable information was missing and no comparisons between earthquakes and their respective amounts and types of damage and loss of societal functions related to earthquakes were possible.

The descriptors used for the earthquake were also sketchy and inconsistent. For example, it is unclear how long and where the earth shook. The rupture along the fault was one of the longest ever recorded, and therefore, had an enormous intensity. But, unfortunately, it is not common to describe the duration of earthquakes—this impairs our ability to compare damage created by earthquakes, as the damage created is as much a function of duration as is the amplitude (often described as the magnitude) of the shaking. It has been assumed that the damage sustained in Aceh province and the Andaman and Nicobar Islands was related entirely to the tsunami, but there is evidence that the earthquake also caused substantial damage. Again, valuable information about vulnerability was lacking (or not found) as the evaluations did not include damage that occurred in the areas outside of the regions of Aceh province not directly impacted by the tsunami.

Because many factors combined to create the damage, it was not possible to correlate the damages either with the wave height, the number of waves, or the run-up of the tsunami with the number of persons injured, killed, or displaced. Factors related to the damage included the vulnerability of the structures impacted and the population density (not available for the regions impacted except for the city of Banda Aceh). Similarly, other than for the victims of drowning, the mechanisms of injuries were not clear. Most of the autopsies were conducted for victim identification purposes; the dynamics of the injuries incurred and the mechanisms that produced them could only be conjectured. The medical records of those victims who survived their injuries or who died later of complications from their injuries were not accessible. With rare exceptions, there was no accessible inventory of the injuries sustained. The records that could be accessed or the inventories that were assembled were not necessarily representative of the injuries that were responsible for the sudden deaths that occurred during or immediately following the tsunami. This lack of information has made it difficult to recommend necessary changes for medical care preparedness or for the public health mitigation efforts for future events. Further, it has not been possible to determine the impact of chronic diseases on the vulnerability of the victims to succumb to the forces exerted by the earthquake or the tsunami and the respective abilities of the national healthcare systems to provide care for the most vulnerable of its citizens or visitors.

Lastly, it was not possible to identify those who died of causes not directly related to injuries from the events, including how many died due to lack of insulin, cardiac medications, acute myocardial infarction, etc. In general, the indirect deaths related to the events have not been accounted.
Different health structures and pre-event status
Each of the countries studied had a different health structure and public health profile prior to the precipitating and secondary events. However, detailed descriptions of the systems were not available to accurately define these differences and no comprehensive inventory or set of indicators were used that would facilitate comparisons. Information/data had to be assembled from multiple sources using multiple descriptors.

Difficulty fitting information into the structure
It was determined at the beginning of this project that the WADEM Guidelines for Evaluation and Research would be used to structure the information and analysis in this work. Detailed application of the entire set of Guidelines had not been done prior to this project. Some of the information did not naturally fit into any one of the longitudinal phases or into a specific Basic Societal System. Thus, some of the assignments into specific elements of the Guidelines were subjectively chosen. However, in order to be useful, it was mandatory that such assignments be made. While most of the information seemed to fit easily into the structure, in some instances, specific assignment of data/information seemed to impair the analyses. Clearly, the usefulness of this structure depends on the input, judgment, and abilities of the investigators.

Summary
This retrospective study of the health aspects of the earthquake and tsunami was hampered by several barriers. Standardized methods, terminology, and structure should be used in future reporting, and all information obtained/reported must be archived and indexed in a common resource centre to allow for future analyses and comparisons.

References
Figure 25.1: Percentage of the first 167 articles in terms of the number of articles regarding the tsunami that were contained per source.
Part IV
Synthesis
Chapter 26
Putting It Together—1
The goal of this and the following chapters is to bring the material already presented together in a meaningful way that will provoke enhancements of the absorbing, buffering, and/or response capacities for all hazards not only in the five countries studied, but that could be applied generally to actions related to relief, recovery, and/or development including preparedness. The synthesis also should help to establish the validity of the use of the methods/structures employed.

In some instances, fitting what could be accessed into the longitudinal and transectional structures of the Guidelines for Evaluation and Research described in Chapter 2 and in the conceptual framework that follows was arduous, and the assignment into the most appropriate, specific longitudinal phase may be controversial. However, use of the process helped in the development of understanding what actually occurred and facilitated the ability to bring the findings together in what follows. In addition, the use of this format may serve as a model for future research and evaluations.

Conceptual framework
The progression of a hazard to a disaster is diagrammed in Figure 26.1. This framework has been described briefly in Chapter 2. The primary hazard (the fault) that resulted in the earthquake, and the secondary event, the tsunami, carried a risk that it would rupture, but the exact probability of how, when, and where the rupture would occur could not have been quantified. Nor could the expected magnitude of the energy released been estimated with accuracy. Importantly, no human actions could have prevented or even mitigated the risk that the earthquake would occur, nor could human actions have modified the location or amount of energy released by the rupture. There exist mathematical models to predict such risks, but these predictions have no relevance to this work.

Magnitude of the events
In order to compare the damage created by events, specific indicators of the magnitude of the events must be defined. Ideally, some indicators that are common to all events could be defined, such as the total energy released, or the forces exerted by the event on a structure (including living beings). Currently, this is not possible. But, the amplitude and intensity of the earthquake or the respective waves could serve as indicators, e.g., the differences in the heights and nature of the waves from the tsunami to which each of the five countries were exposed. However, although indicators of the amplitude of the earthquake seem to have been well-established, it has not been possible to determine the duration or cycles of the shaking, and therefore, it has not been possible to determine the intensity or the overall magnitude of the energy released. Wave heights,
Absorbing, buffering, and response capacities

Of particular significance for analyzing the varied effects of the events are the relative absorbing, buffering, and response capacities, as changes in any of these capacities alter the risk for a hazard resulting in a disaster. Changes in these capacities are part of preparedness (risk management/resilience). Therefore, analyses of what occurred in the five countries have relevance in enhancing resilience and preparedness.

Damage and absorbing capacities ($risk_{\text{damage}}$)

As discussed in Chapter 2, the absorbing capacity is the ability to absorb the forces applied so that minimal, if any, damage results from an event. The absorbing capacity is a part of the overall resilience of a society and its environment; it can be affected by human actions undertaken before an event occurs. As the absorbing capacity of a structure increases, the probability of the structure sustaining damage from a specific event of a given magnitude decreases. Consequently, the probability that a structure (human-built and/or living beings and/or the natural environment their respective frequencies, run-up heights, and inundation created have been identified for the five countries, but, in general, they have not been identified for specific areas of the countries studied. No efforts were made to define these factors using cluster techniques to separate a large area into smaller components. Further, we have not been able to separate the effects of the earthquake from those of the tsunami even in areas that suffered from the earthquake, but were not inundated by the tsunami. However, there were no reported effects for the earthquake other than in Indonesia and the Andaman and Nicobar islands—thus, the effects in the other countries can only be attributed to the tsunami.

Area-at-risk and area impacted

In order to understand the burdens created by the damage that resulted from the occurrence of an event, it is necessary to know the area-at-risk, its geographical and societal characteristics, and the population-at-risk and the characteristics (demography) of the population. The area-at-risk for exposure to an event related to the hazard may consist of an entire region or country, or can be a small cluster within a larger area-at-risk. But, it is essential that the specific area-at-risk under discussion be defined. For example, the area-at-risk could have been Indonesia, Aceh province, Banda Aceh, or even a neighbourhood within Banda Aceh; it could have consisted of a single manufacturing facility or an element of a Basic Societal System, such as roads and bridges, airports, or medical facilities. The proportion of the area actually impacted in relation to the defined area-at-risk for an event is a major determinant of the burdens placed on the resources of that area-at-risk. Although 80% of Banda Aceh was not directly impacted by the tsunami, the 20% of Banda Aceh that was devastated by the earthquake and tsunami contained much of the health resources for the city. Thus, the damage to the medical facilities was severe. There was little if any, buffering capacity in the Medical Care System (the system was unable to meet the healthcare needs of the population before the events) and the only medical response capacity available was in the military that was not prepared to render medical aid. This likely have contributed to the extreme number of injured and loss of life in the areas impacted. Those health resources that were not damaged were inadequate to sustain the functional status (buffering capacity) of the health services of the population impacted by the tsunami. This information should be helpful in future planning of the Medical Care System for Banda Aceh.

Also, the population densities of the areas-at-risk and areas impacted would have helped to define the relative burdens on the societal systems. For example, the very high population density in Banda Aceh resulted in huge numbers of injured that resulted in extreme burdens on the Medical Care and Public Health Systems. This information could not be abstracted for the areas impacted, but the value of such data should be apparent.
and/or the economy) will be damaged may be reduced by improving the absorbing capacity of the society exposed to a hazard. For example, the mangroves along the coastlines in some areas impacted by the tsunami absorbed some of the energy of the tsunami, and thus, the damage to structures on the shore was decreased. As illustrated in Figure 26.2, some structures, such as the edifice that remained intact while all else around it was destroyed indicates that that particular structure had higher absorbing capacity for the energy of the earthquake and tsunami.

The probability that a given hazard will produce damage when it manifests as an event is less than is the probability that an event will occur from the specific hazard. Some events do not result in much damage. One objective of this work was to examine the relative absorbing capacities of the Medical Care and Public Health Systems of the countries and regions within the countries impacted by the earthquake and tsunami. While the magnitudes of the earthquake and tsunami differed for each of the countries affected, their relative absorbing capacities for the energy also differed. Some of the countries had little time to prepare for the impact of the tsunami while others had a substantial period in which they could have prepared. How much damage was sustained by the healthcare facilities of the countries affected, and what was different about their relative absorbing capacities?

**The earthquake vs. the tsunami**

The differences in wave height, number of waves, penetration inland (inundation), the population densities, the characteristics of the natural and built environment, and the geography of the shoreline seemed related to the level of damage sustained in each of the areas impacted by the tsunami. The magnitude of the earthquake that precipitated the tsunami also was a factor in the amount of damage sustained; but little information was uncovered regarding the amount of damage sustained by the built infrastructure in Banda Aceh. Generally, it has been assumed that the damage in Banda Aceh was related only to the tsunami. However, the subduction in the shoreline and elevations of the land mass provide evidence of the impact of the earthquake in Aceh province and the Andaman and Nicobar Islands. In the Andaman and Nicobar Islands, numerous schools collapsed, and the land mass in some areas sank several metres into the sea. The amount of damage sustained inland and away from the shore could not be obtained directly from the available reports. But, it seems that much of the damage to rail lines, highways, and bridges was the result of the earthquake. In addition, the earthquake may have damaged the supporting structure of bridges that later collapsed during the tsunami. On the other hand, since the earthquake was barely felt in any of the other countries, it must be assumed that the damage that occurred was created by the tsunami. The identification of the different properties of the events that caused the damage should be a high priority for seismologists and structural engineers, especially as they relate to health.

It is clear that many of the structures in Aceh province and the Andaman and Nicobar islands did not have the ability to absorb the combined energy released by the earthquake and the tsunami. There were differences in the structure of those elements of the built environment that remained standing (e.g., mosques). Compared to the structures that surrounded the mosques, the structure of the mosques had very high absorbing capacity for the forces exerted by the earthquake and tsunami (Figure 26.2). These are important findings and must be compared with those damaged and/or destroyed and with the damage created by other earthquakes.

Unfortunately, although 20% of the city of Banda Aceh was destroyed following the tsunami, there is little information that allows separation of the damage created by the earthquake from that created by the tsunami. It was not possible to find damage reports of the areas affected only by the earthquake. Although there is some footage that shows prolonged shaking and sounds associated with the earthquake as well as some of the damage that occurred prior to the arrival of the tsunami, it is not possible to distinguish the
damage caused by the earthquake even from before and after photographs (Figures 26.2a and 26.2b). The inability to distinguish areas inundated by the tsunami from those that were not is true not only for Aceh province and the Andaman and Nicobar islands, but also for the other coastal cities and villages along the exposed coastlines of Sumatra.

Some evidence was available that documented subsidence and upheaval of the shore line that presumably were related to the earthquake. Earthquake-triggered subsidence and uplift submerged some coastal communities and destroyed valuable coastal ecosystems. Changes in land elevation were particularly devastating in the Nicobar islands, where subsidence of up to four metres inundated mangrove forests and permanently swamped Nicobari villages with seawater. Also, land subsidence amplified the impact of the tsunami by dropping inland areas and placing them within easier reach of destructive waves. While the earthquake rupture created subsidence in the Nicobar islands, it caused mostly uplift in the Andaman Islands, the northern portion of the territory. Uplift of up to two metres destroyed coastal ecosystems as it lifted coral reefs out of the ocean and drained mangroves. Subsidence of about 1–1.5 metres is believed to have occurred more than 30 minutes after the occurrence of the earthquake. One report indicates that many of the schools on the islands collapsed due to the earthquake. However, given the paucity of information, it has not been possible to compare the damages created by this earthquake with those that occurred with other, high magnitude earthquakes.

Although attributed primarily to the tsunami, there was extensive damage to all of the Basic Societal Systems in each of the countries studied. In Indonesia and the Islands, it remains unclear as to how much of the damage was created by the earthquake or how much of the damage attributed to the tsunami resulted because the earthquake had damaged the absorbing capacity of structures before the tsunami struck. From some of the descriptions, i.e., movement of structures inland from the shore, some of the damage to structures definitely can be attributed to the forces exerted by the tsunami. However, bent rails, collapsed bridges and buildings may have been the result of the earthquake.

**Damages and changes in functions (buffering capacity; risk \(\Delta\text{function}\))**

Just as not all events necessarily result in damage, not all damage necessarily disturbs the functions of the affected society. Some functions may become compromised while others will not. The buffering capacity is the ability of a society to cope with the damage sustained from an event and to continue to function in spite of the damage. It is the ability of a society to minimize the changes in an essential function or functions for a given change in available resources (goods and/or services).\(^2\) The disturbances in the functions of a society as a whole or in the Basic Societal Systems of the society are always judged against the functional status of that society or its Basic Societal Systems before the event (pre-event status). The risk (probability) that the damage will result in a disturbance(s) of a function(s) (risk \(\Delta\text{function}\)) is dependent upon the buffering capacity of the society that has sustained damage from an event. The greater the buffering capacity of the Basic Societal Systems of a society-at-risk, the greater is the likelihood that the society and its Basic Societal Systems will continue to function despite the damage sustained. Often, this requires the use of alternatives to sustain the functions. Some of the functions (or components) of a Basic Societal Systems may fall below their respective functional and/or critical thresholds.

The buffering capacity for the functioning components of the society-at-risk may vary; some components have less ability to buffer the effects of the damage sustained than do other components. The vulnerability of a function depends on which structures are damaged and the extent of the damage to the respective structures. Depending on the amount and type of damage sustained from the hazard, some aspects of the function may be able to continue unabated while the functioning level of others falls below
their respective critical thresholds.

Societies with substantial luxuries may lose the luxuries, but may continue to operate at or above their respective functional thresholds. For example, damage sustained by a hospital may compromise its ability to continue to provide non-emergency surgery, but it may be able to provide emergency and other needed surgeries to injured victims. The death/injury of laboratory personnel may compromise the ability of the medical staff to obtain laboratory tests or to type and cross-match blood essential for the survival of some of the victims. The lack of available blood may result in the inability to successfully resuscitate victims with traumatic injuries or to perform needed surgery, and result in increases of the crude mortality rate (CMR). Damage to the components of some of the affected societies that were operating just above their critical thresholds, as were many within the areas plagued by civil strife, had little buffering capacity for any of the damages sustained. This lack of buffering capacity resulted in profound increases of the crude mortality rate (CMR) due to damage to the critical infrastructure of the Medical Care System.

The effectiveness of the buffering capacity of a single function or subfunction may be compared between societies or segments of a society. The buffering capacity of the atoll medical facilities in the Maldives was substantially less than that of the tertiary care hospital in Malé. There was almost no buffering capacity in the medical facilities in Aceh province or in the conflict-torn areas of Sri Lanka. However, the buffering capacity available in India and Thailand was sufficient enough for them to dispatch staff into the field (relief responses).

**Response capacity**

The response capacity is the ability to respond to the needs created by the changes (disturbances) in function(s) created by the damage(s) sustained from the event. The response capacity includes relief and/or recovery responses to the changes in function that have resulted from the damage or are likely to result with ongoing damage. Buffering includes all of the interventions required to prevent the level of function from decreasing from its pre-event functional state. Response capacity includes all interventions directed to correcting the changes in function or preventing further declines. It contains what is required to respond to the needs, including the personnel, equipment, and supplies, as mandated by the Operational Disaster Response Plan. Responses are human actions (interventions) that utilize resources (human and material) that are contained in the response capacity. Thus, the response capacity provides the goods and services necessary for the responses.

When the responses (interventions) of the local response capacity are unable to restore the level of functions to pre-event levels, outside responses are required to supplement the available local response capacities to contain the loss of function(s) or to prevent the further deterioration of function, the disturbances in function and the resultant needs are called a disaster.

**Damage to healthcare systems and changes in functions**

The damage to a healthcare systems Medical Care, Public Health may be structural and/or to the staff. Structural damage includes not only the physical structure, but also the equipment and supplies essential for its operation. Thus, physical damage to either or both ultimately may lead to the inability of the damaged facility to provide any or some of the health services (functions) that it had made available before the events. The ability to provide services requires staff. Loss of staff due to injuries, inability to gain access to the facility, the need to provide care for loved ones, losses of family members and/or friends, grief, and survival guilt—each contribute to the failure to have adequate staffing to carry on the functions of the facility. The bottom line is whether and to what extent the facility is able to provide its day-to-day services and is able to meet the surge of injured victims during and/or following the event.
Healthcare facilities may range from a single service facility to the entire patient care and public health infrastructure. Clearly, the district hospitals in the Maldives had a greater exposure to the forces of the tsunami than did the tertiary care facility in Malé, which was not significantly damaged structurally, and for the most part, its staff was unharmed and reported for work, and its equipment and supplies were left essentially uncompromised—it was able to continue to provide major healthcare functions. On the other hand, the regional health centres in the atolls had weak absorbing capacities for the forces imposed, and hence, were damaged or destroyed, and did not have sufficient buffering capacity to continue to function. The facilities were rendered non-functional, especially the primary healthcare facilities. Unlike the hospitals in Aceh province, where substantial damage was sustained by the healthcare facilities and staff (little absorbing capacity for the forces imposed by both the earthquake and tsunami), the hospitals in Thailand and India sustained little damage to infrastructure and staff—the forces to which they were exposed were several times less than were those that hit Aceh province, and the absorbing capacities for the forces to which they were exposed were sufficient to minimize the damage sustained. In addition, the buffering and response capacities were sufficient to allow them not only to continue to function, but they also had sufficient response capacities to be able to manage the surge and even to send staff to the field to provide assessments, triage, and medical care. Thus, providing triage in the field prevented part of the surge of the injured and dead from reaching the hospitals.

The latter apparent successes must be viewed with caution. The reasons for this disparity despite the buffering and response capacities could not be determined, but deserves further scrutiny. The differences in the proportion of the injured who succumbed to their injuries raise substantial issues. In Tamil Nadu, three-quarters of the injured died. Only 12% of those injured in the Maldives succumbed to their injuries while 50% or more died of their injuries in the other four countries. The reasons for these profound differences are not clear. The lower forces that struck the Maldives may have produced less severe injuries. However, the proportion of the injured who died in Tamil Nadu far exceeded the proportion of the injured who succumbed even in Aceh province or the Andaman and Nicobar islands. This difference occurred despite the relatively rapid influx of support from the neighbouring Indian states and the dispatch of field teams from the affected hospitals in Tamil Nadu. It is not clear whether the injuries sustained in Tamil Nadu were more severe or whether the medical care delivered was less substantive than in the other countries, but no such differences could be demonstrated. On the other hand, the available data from India included only the public healthcare facilities. The private services were not required to report. It may be that the more skilled staff and the better equipment gravitated to the private healthcare sector, and the results there are not factored into the above assumptions. These observations deserve further study.

**Supplies, equipment, and personnel**

The damage and inability to provide even routine medical care in Aceh province was caused not only by damage to the structural integrity of the medical facilities, but also to the staff, equipment, and supplies. Adequate buffering to the damage was not available. At least in part, this may have been related to the fact that access to the facilities was severely compromised due to damage and dysfunction to the Public Health and Transportation and Logistic Systems upon which the medical facilities were heavily dependent. Roads were blocked, bridges were down, rail lines were disrupted, and vehicles were not available. In addition, the functions of the Transportation and Logistic Systems were compromised due to lack of fuel (Energy Supply) and of staff required to operate the available vehicles. The response capacity of these two Societal Systems was severely compromised and created major difficulties in meeting the supplies and equipment required by the healthcare facilities to be able to continue to
function. There was insufficient transportation to move incoming goods and responding personnel from their point of entry to where they were needed. Staffing was compromised due to deaths, injuries (including emotional), and the need to care for families and/or search for missing family members. Many of the surviving staff and the injured were unable to reach the healthcare facilities. Further, supplies of electricity, water, and food were compromised. Many of the care and warehousing facilities were inundated by water, sludge, and debris.

This constellation of problems was present to some degree in each of the countries studied. Essential components to allow continuation of the provision of health services must have contributed to deaths that may have been preventable. The impact of this constellation of failures on preventable deaths is not clear. Moreover, these factors demonstrate the heavy dependency of the Medical Care System on other Basic Societal Systems, i.e., Transportation and Logistics, Public Works and Engineering, Energy, Water and Sanitation, Food and Nutrition. At least early on, many of these facilities either were destroyed or not able to provide even routine care much less able to cope with the surge of patients and dead bodies. However, in India and Thailand, with their abundant medical and public health resources, no international help was requested to meet the relatively small burdens compared to those countries that sustained heavier damage and could not mobilize the resources required. In Indonesia, Sri Lanka, the Maldives, and the Andaman and Nicobar islands, medical supplies were rapidly depleted as there was little buffering capacity available in the areas impacted. Due to damage and destruction, there was little in the way of backup medical equipment to buffer the losses. Much of the available equipment was rendered non-operational. This was complicated further by acute shortages of skilled personnel who either were injured, killed or did not report to work due to losses of family members and friends, or the inability of the injured to reach a medical facility.

**Prehospital and local emergency medical services**

Prehospital emergency medical services were not available or were poorly developed in the areas impacted. But, it seems clear that even if any of the areas had robust pre hospital emergency medical care services available, they would have been rendered insignificant given the respective burdens created by the earthquake and tsunami.

**Medical relief responses**

As has been demonstrated repeatedly during other disasters, the initial health-related responses (response capacity) in each of these countries came from the lay public or the military, few of whom were skilled in the provision of first aid, including life-supporting first aid. The local health response capacities were uniformly overwhelmed and initially were provided from neighbouring, non-impacted areas—outside assistance was required. The responses provided from the respective augmented health response capacities from surrounding provinces/states were adequate in India and Thailand, but international assistance for health relief responses was requested by and provided to each of the other three countries.

In most instances, it took days for backup health/medical personnel, supplies, and equipment from outside of the impacted areas or from other countries to reach the areas in need. The international humanitarian community mounted huge relief responses to supplement the local responses. Field hospitals were established and many of the responders supplemented (or took over) many of the activities required by the local/national health community. As has been noted following many disasters caused by sudden-onset events, most of these “outside” medical personnel, equipment, and supplies were used to support the day-to-day activities of the Medical Care Systems, as they arrived too late to provide lifesaving care for those with life-threatening injuries that were able to reach the medical facilities.

The only healthcare response capacities available in Aceh province immediately following the
earthquake and tsunami were provided by the resident military. However, the members of the military had little (if any) education, training, or material required to provide medical care. The response capacity of the Indonesian government was much greater than it was for Aceh province—but this capacity was not available for one to two days following the events. The situation was similar in Sri Lanka and the Maldives. However, although the local response capacity was less than optimal, the response capacity of the states surrounding the affected areas of India and in Thailand implemented a greater response capacity than was available in the areas directly impacted. But, the response capacity in those areas impacted was too low to meet the respective burdens, and each needed to tap into the response capacities of the surrounding area—and most often required the use of the response capacity of international organizations. The latter was not the case for India or Thailand. However, Thailand had to recruit forensic services from the international community.

Some of these humanitarian organizations arrived without adequate means of transportation to the areas in which they were needed. Many conducted their own assessments of the disturbances in health functions necessary for identifying the healthcare needs of the affected population. Generally, the distribution of these relief responses was not coordinated resulting in unnecessary duplication.

Medical and support supplies, equipment, and personnel flooded into the Maldives, Sri Lanka, and Indonesia. Much of what arrived was needed, and assisted in providing relief and in promoting recovery. However, some of the supplies, equipment, and even personnel were not needed and were unwanted. Supplies piled up in warehouses, especially at their point of entry. Even needed supplies piled up as there was little transportation available for distribution to where they were needed. The competition for transportation with the other Basic Societal Systems was substantial. There were no operational mechanisms in place in Indonesia, Sri Lanka, and the Maldives to prevent the entry of unneeded and unwanted personnel, supplies, and equipment. On the other hand, India and Thailand attempted to limit the influx of unneeded assistance—these two countries had better coordination and control mechanisms in place to accomplish this feat. There were no mechanisms in place to screen the credentials of persons who arrived to assist. India and Thailand shunned outside support as they were able to manage with their own resources. The government of the Maldives quickly realized the problem, and began to coordinate and control the influx (even given its relatively huge burdens).

Coordination and control is not possible without assessments and the determination of needs. In Indonesia, Sri Lanka, and initially in the Maldives, there was little done in the way of conducting organized and coordinated assessments, and there was little training on how to conduct the required assessments of damage and losses to the medical and public health functions. Prior to the event(s), the governments had charged governmental units as responsible for the conduct of such assessments and to synthesize needs from such assessments, but the policies under which they operated were out of date, had not been practiced, or were non-existent. The governments of each of the five countries studied have made substantial progress towards closing this major gap. This was demonstrated in Indonesia following the Yogyakarta earthquake in May 2006 in which 42,081 persons were injured of whom 5,762 (14%) died. The responses were much improved as was the coordination and control. The Indonesian government limited entry to those that could provide the assistance needed.3

Dependence on other BSF systems
A recurring theme throughout this work has been the extreme dependence of the healthcare system (Medical Care and Public Health) on other Basic Societal Systems. Compromise of any of these functional systems results in the impaired integrity of the healthcare system. Some of these dependencies are outlined below.

1. Transportation and Logistics—healthcare
facilities essentially were not prepared to deal with the lack of available transportation for required supplies, equipment, and personnel. In many instances, adequate transportation equipment was not available due damage/destruction; it was not possible to obtain adequate supplies of fuel, personnel were injured and many of the injured transportation personnel had succumbed, and/or there was competition with other BSF systems for the equipment and supplies that were available. Incoming medical and public health supplies, equipment, and personnel were not inventoried or triaged to where they could do the most good. As has been demonstrated during previous disasters, a substantial proportion of the medical supplies (e.g., drugs) that reached the affected countries were inappropriately labeled or expired, and could not be sorted. Personnel, equipment, and supplies arrived without any means of providing transport and warehouses overflowed. Healthcare facilities soon exhausted whatever supplies they had on hand before the events, and were unable to resupply.

2. Public Works and Engineering—the dependency of the healthcare facilities on the operational functional status of the Public Works and Engineering Systems was not only related to the access of the transportation and logistics systems to the healthcare facilities and to the victims, but also to the removal and appropriate disposal of liquid and solid wastes (especially medical wastes). This system was responsible for the collection, storage, and disposal of the corpses, many of which were transported by survivors to the healthcare facilities. Heavy equipment was required for removal of debris.

3. Energy—almost all of the functions of healthcare facilities require energy. All the healthcare facilities in the areas impacted were at least transiently without electrical power. Few had backup generators, and those that had such backup systems in place ran short of fuel for their operations. Refrigeration was not possible, and thus, the cold chain was interrupted. Blood and blood products were lost. Medical gas supplies ran short or were interrupted. Lighting and air handling equipment failed. Operating theatres could not function. Sterilization systems did not function leaving only the use of cold sterilization techniques. The contributions of such failures on the death toll have not been quantified.

4. Water and Sanitation—similarly, healthcare facilities cannot function without adequate supplies of potable water are needed for sanitation, irrigation of wounds, etc. Water delivery systems were interrupted and water had to be imported into the areas affected. Also, water collection and storage facilities were damaged, swept away, or contaminated.

5. Food and Nutrition—adequate food supplies are important for patients and staff, and often the families of the staff. Inadequate staffing led to long working hours with obvious need for nutrition. Although persons may survive for weeks without food, those working (e.g., medical staff), require food in order to function effectively.

6. Security—healthcare facilities generally are considered safe havens. Survivors flocked to the healthcare facilities and interfered with the ability of the facilities to deliver care. Security of the healthcare facilities is key to the ability of the medical facilities to deliver care to those in need.

**Recovery**

The process of recovery is the return of the functional state to its pre-event level of functioning. Generally, this is accomplished by repairing the damage or by replacing the infrastructural elements damaged or destroyed.

**Evaluation of responses**

It should be apparent that throughout the country
reports and the analysis section, no essential specific interventions were identified or the impacts of any responses defined or discussed. It is in this respect that major gaps in the information exist. Little is known about specific interventions provided, including the nature of the interventions provided and their respective costs, or the outcomes and contributions to the health and well-being of the affected populations. However, more is known about the public health interventions, the effects of which were sufficient to prevent the outbreaks of diseases.

**Summary**
The damage caused by the events of 26 December severely compromised the abilities of the healthcare facilities in the areas directly impacted. Many healthcare facilities were unable to provide the functions that they had provided before the events. These disturbances in functional levels were due not only to structural damage and inundation by water, mud, muck, and debris, but by severe shortages of personnel required to deliver these services. It is not known how many lives could have been saved had the buffering and response capacities been more robust pre-event or if reinforcements had arrived more quickly. Paramount to this problem was the lack of education and training of the lay public and military in life-supporting first aid. The value of such preparedness, education and training has been demonstrated in Bangladesh. Lastly, the reasons for the huge disparities in the proportion of the injured who died of their injuries remain unclear, and deserve further study.

**References**
2. Ibid, 146.
Figure 26.1: Conceptual Framework (revised 01 August 2012)

Figure 26.2: Photography of massive destruction related to the earthquake and tsunami. The absorbing capacity of the mosque was much greater than it was for the surrounding structures.
Part IV
Synthesis

Chapter 27
Putting It Together—2
Introduction

In order to appreciate the needs that resulted from the damages caused by the earthquake and tsunami in the five affected countries, the relative burdens on the respective societies must be understood (Table 27.1). Even though all the estimates of burdens could not be triangulated, and, depending on the sources, varied some in absolute values, the differences, even if over- or under-estimated, provide useful information. The burdens faced by each of the governments are defined using the best estimates available for the total number of persons injured/10,000 population, the number of the injured who died/10,000 population, the number of IDPs initially accounted, and the costs incurred relative to the country’s national Gross Domestic Product (GDP).

Examination of Table 27.1 provides an answer as to why Thailand and India did not request outside assistance. The impact of the earthquake and tsunami had little impact on the central governments of Thailand and India relative to the other countries; in other words, given the comparative loads on the respective total resources of these two countries, India and Thailand could buffer the changes in functions and respond to the needs related to the disturbances in functions without needing outside assistance. For India and Thailand, this simply required shifting of their relatively robust resources from other parts of the country into the areas impacted by the tsunami. The economic impact was low as responses consumed only a very small proportion of the total financial resources in these two countries.

The relative burdens experienced by the Maldives, Indonesia, and Sri Lanka were several orders greater than were those for India and Thailand. As noted in Table 27.1, the burdens on the small population of the Maldives truly were overwhelming. This is evidenced by the extraordinarily high number of persons per unit of the population who were injured and/or internally displaced (and not the absolute numbers) especially relative to the total available resources. Even though the actual associated economic costs varied widely, the economic burden consumed much of the gross national product of the Maldives. Sri Lanka also experienced a huge burden of IDPs and deaths: it experienced an even higher death burden than did Indonesia, and injury and economic burdens second only to those experienced by the Maldives. Thus, it seems clear that the societal burdens on the respective governments of the Maldives, Sri Lanka, and Indonesia were of an order such that they could not cope without outside assistance.

The burdens on Aceh province and the Andaman and Nicobar islands (Table 27.2) were even more striking than were those on their respective countries. In Aceh province, each of the burdens was many times greater than
for the entire country, and the burdens for the Andaman and Nicobar Islands far exceeded those for mainland India. Yet, none of the countries or their respective components exceeded the IDP burden experienced by Sri Lanka. Similarly, the economic burdens on the governments of the Maldives, Aceh province, and the Andaman and Nicobar Islands were profound.

It would have been helpful if more of the damage and changes in function of the coastal provinces/states could have been factored out of those for the countries as a whole and correlated with the energy released by the events. However, it has not been possible to correlate the severity of the events with the burdens faced. Perhaps, the extraordinary burdens experienced by Aceh province and the Andaman and Nicobar Islands not only can be attributed to the forces brought to bear by the tsunami, but also to extremes in the scope of the primary event, the earthquake, that these areas experienced. There is some evidence from the Andaman and Nicobar Islands that the earthquake, and the aftershocks, destroyed a number of buildings before the tsunami arrived. For example, the earthquake that preceded the tsunami leveled 119 schools and killed 64 teachers. Unfortunately, this is the only report of infrastructure damage caused by the earthquake alone.

Initially, increases in the aforementioned burdens above the pre-event burdens had to be met with the resources that were being used in the response capacities of the specific areas of the countries directly impacted. The civil conflicts that had plagued Aceh province and the northeastern areas of Sri Lanka had utilized much of the response capacities of those areas—little was available to meet the challenges created by these burdens. In Aceh province, prior to the earthquake and tsunami, governmental functions had all but ceased and the province was under military rule that not only limited access to the province, but drove out many of the non-governmental organizations—the military assumed that some of the NGOs were supporting the insurgency. Essentially, progress was forestalled—there was little absorbing capacity, no ability to buffer the effects of the damage sustained, and the little, non-military response capacity present before the events, was diminished even further by the loss of personnel, supplies, equipment, and infrastructure that were operational prior to the events. The burden in Aceh province was overwhelming. Resources were sent from Jakarta, but access was difficult and many areas could not be reached. The marginal Public Works and Engineering System that was barely able to stay up with the collection and disposal of trash prior to the earthquake and tsunami, now was faced with an overwhelming burden with even fewer resources.

In the area of Sri Lanka impacted by the tsunami, there already was a huge internally displaced population related to the insurgency. Available resources in that area to meet the burdens created were minimal, and dangers to the population were pervasive. Thus, little in the way of resources was available to cope with the additional burdens created by the tsunami.

Although as evidenced by pre-event data in many areas of India before the tsunami, conditions in the states that were impacted by the tsunami were a bit better than for India as a whole, except for the proportion of the population under the poverty level that rendered them more vulnerable to events from hazards. Moreover, abundant resources were available in the states neighbouring the impacted area, and they were brought to bear within the first 24-48 hours of the tsunami. However, this was not the case in the Andaman and Nicobar Islands. Although the military had a very strong presence in the Port Blair area, many of the islands were not readily accessible and the trip from the mainland by ship required at least five days plus additional time to distribute materials and personnel to the islands impacted. Yet, using its military, India possessed sufficient resources to provide assistance rapidly to Aceh province in Indonesia.

Of the five countries, Thailand was the best prepared for the disaster. Thailand did not
experience the earthquake. It was able to mobilize resources quickly (within 24 hours) to assist the stricken areas. It also had the lowest overall burden. In addition, Thailand had just exercised its disaster plan prior to the events of 26 December. Thailand did not request outside assistance, except for supplemental personnel, equipment, and supplies for disaster victim identification. The tourist areas struck by the tsunami comprise an important part of Thailand’s economy and the tourist areas were devastated.

As noted, the overall burdens created by the tsunami in the Maldives were monumental. The Maldives were facing a water crisis before the tsunami struck. The sources of water were being depleted and contaminated, and there was little or no absorbing capacity to protect the water sources on many of the islands. Logistics were a major problem in meeting the extraordinary burdens created by the damage from the tsunami. For example, bottled water had to be imported. Unfortunately, the islands became littered with empty plastic water containers.

**Damage to humans**

Much of the information that would have helped to define the epidemiology of the human damage caused by the events of 26 December could not be obtained. Generally, not all of the population-at-risk was exposed to the events. This had major implications on the respective countries’ ability to respond to the injured. A remarkably small proportion of the total population of India and Thailand was exposed to the earthquake and tsunami. Thus, the resources available in India and Thailand to cope with the human damage were much greater than were those that were available in the areas of Indonesia, Sri Lanka, and the Maldives impacted by the events. But, definition of the proportion of the population-at-risk who actually were exposed to the event could not be defined, nor were the reasons that the population was or was not exposed identified.

Not all of the population exposed was affected by the event(s). The term “affected” carries multiple definitions and the definitions used in the reports accessed remained unclear. Consequently, there is no common set of indicators that define “affected”. The reasons that portions of the population were or were not affected could not be identified. The proportion of the population affected would have helped to define the relative health burdens created by the event.

It would have been helpful to have been able to identify the proportion of the affected population that actually was injured by the event(s). In addition, the reasons that the proportion of the exposed population were injured should have been identified. This would have facilitated a comparison of the outcomes from injuries with those of other victims who suffered the same complex of injuries, as well as with the human damage that had been caused by other events. It is in this way that identification of measures that can mitigate the damage sustained from an event of a given magnitude could be identified, implemented, and tested even at a smaller scale than is created in a mass-casualty situation.

The reasons for the reversal of the ratio of the numbers killed to the total number of injured (including the number who succumbed to their injuries) that was associated with the tsunami as it crossed the Maldives compared to the ratio in other countries now seems apparent. The tsunami did not crash against the Maldives, but instead the event was more like a flood—it did not carry the profound energy released on the population in the other countries. In addition, the onset was more gradual. Thus, it seems that the majority of the Maldives’ population was able to survive the impact, but many were injured by the forces released by the tsunami and by the debris mobilized by the flooding water. In the other countries, the forces exerted by the waves were far in excess of those sustained by the Maldives, and the force of the water moved persons and debris at extreme velocities that resulted in non-survivable injuries, that on retreat, pulled victims and debris into the sea. In addition, the forces and velocities involved primarily were devastating to the children and elderly. Women
and those with chronic, debilitating diseases who had less strength to hold onto fixed objects (e.g.,
trees) that remained stationary, or the ability to
swim in the fast and treacherous currents were
more vulnerable than were the adult males,
many of whom were out at sea. In future events,
it is essential to identify, as much as possible,
the mechanisms involved in producing the
injuries and the types of injuries sustained. For
the most part, this information was not possible
to determine given the massive numbers of
injured, and attempts to identify the causes of
death often were abandoned in favour of victim
identification or the cultural need to rapidly
bury those who had succumbed. Thus, for the
most part, we can only guess as to the causes
and types of mortal (life-terminating) injuries
sustained. This information could not be obtained
even from those who died from complications
of their initial injuries. We do know that some
of the delayed deaths were caused by tetanus
(only in Indonesia, where the immune status
pre-event was poor) drowning, pneumonia due
to aspiration of contaminated sea water, infected
wounds, and sepsis and multi-organ system
failure. It seems that many of the delayed deaths
could be attributed to aspiration pneumonia and
lack of immediately available ventilatory support,
but the numbers remain unknown. This has
major implications for the stockpiling of ventilators
within regions so that they could be accessed
within the appropriate time frame. However, the
ability to move equipment to the areas in which
they would be needed may be compromised by
the inability of the Transportation and Logistics
System to convey them, to gain access to the
area, or to have sufficient energy to make the
trip.

Both physical and psychological injuries must be
considered as both result in substantial morbidity.
Physical injuries impair the functional status of the
victim and for some, full recovery of function may
never be achieved. The psychological stresses
encountered were a conglomeration of observing
people in the process of dying, the inability to
protect other members of the family or their
friends and to prevent their death, the inability to
access the remains of those killed either because
they were washed out to sea or were buried in
mass graves, the loss of homes and all of their
worldly possessions, the need to seek shelter
in over-crowded camps and temporary shelters
or imposing on non-displaced family or friends,
loss of livelihood, dependency, and the terror
associated with the possibility for the occurrence
of subsequent events, survival guilt, and feelings
of helplessness and for many, having a near-death
experience. Estimates of emotional morbidity
 ranged from as high as 65% of the population
directly affected. The impact of these factors
has been profound, and for many, psychological
recovery is far from complete and may never
be attained. Compensatory strategies (part
of buffering capacity) must be augmented for
populations-at-risk.

**Massive numbers of dead**

Following the tsunami, dead bodies were almost
everywhere within the areas directly impacted.
Urgency in body retrieval was fueled by the myth
widely disseminated by the media, that another
secondary event caused by the spread of diseases
from the decomposing bodies was imminent.
The urgency was fueled further by cultural and
religious factors that dictated that the dead must
be buried within 24 hours of the time of their
death. This was true particularly in Aceh province
where the ICRC and the military were enlisted
to participate in body retrieval. In Indonesia and
Sri Lanka, many of the bodies were dumped
unceremoniously into mass graves, some of
which contained 50 000 to 70 000 bodies.3

In Thailand, Sri Lanka, and the Maldives, many of
those killed were expatriate tourists. In an effort
to minimize the damage to its important tourist
industries, Thailand went to extreme measures
to identify the remains of many of the victims
so that the remains could be repatriated to
their respective country of origin. However, the
burden created by those killed also was by far the
smallest in Thailand than for the other countries.

The decomposing corpses did present substantial
problems. Decomposing flesh produces a stench
and serves as an ongoing reminder of the huge losses sustained by the population. These factors combined to further the mental stress on those who had survived.

**Health burdens**

The respective burdens on the public (societal) and individual health of the populations affected by the earthquake and tsunami are in Tables 27.1 and 27.2. Indicators that reflect the initial burdens thrust upon the Public Health and Medical Care Systems include the number of injured survivors and the number of IDPs generated. The numbers of dead are not included in the health burden. The number of injured survivors was an indicator of the surge in the number of persons seeking medical care for their injuries. The burdens on the Public Health and Medical Care Basic Societal Systems that were created by the IDPs were extensive. The public health implications of crowding people into limited spaces in shelters and camps are also apparent.

**Physical injuries**

Physical injuries to humans are the damage sustained related to the forces exerted by the events and/or the impact of persons onto fixed objects, and/or being crushed by moving debris, and/or injuries sustained during responses (stepping on metal, wood, or glass fragments) during clean-up activities. The injuries sustained may not have been survivable (life-terminating), life-threatening (at least initially), or may have created complications that may or may not have been survivable, or were not life-threatening or minor.

**Life-threatening injuries**

As noted previously, the human body has a very low absorbing capacity to external physical forces. To gain an understanding of the effects of the earthquake and tsunami on the affected population, it is helpful to classify the injuries along the lines of the generally accepted trimodal distribution of deaths due to injuries: (1) life-terminating (mortal)—the injuries had caused death during or immediately following the time of the injury; (2) life-threatening injuries that untreated or inadequately treated result in death within the first few hours of the time of the injury (“golden hour”); and (3) complications that develop from the initial injury that may result in death after the first three days of being injured.4–7 Little can be accomplished medically for those who were killed during or in the immediate aftermath of sustaining the injuries. Most often, these deaths are related to asphyxiation, head injuries, and/or a cardiovascular catastrophe such as cardiac rupture and/or a disruption of the aorta. Persons who survive the initial, life-threatening injuries for periods up to 72 hours often have the capacity to survive if they receive life-supporting and surgical interventions promptly. Without such interventions, this group of patients will succumb to their injuries. Patients who survive for hours after their injury may develop secondary, life-threatening problems related to their initial injuries and/or treatment. They may develop bacterial or other forms of pneumonia, the respiratory distress syndromes, renal failure, sepsis, and/or multi-organ system failure. They often require prolonged ventilatory support and life-support treatment in an intensive care unit. These stages are elements of the relief phase of a disaster.

Unfortunately, from the information available, it has not been possible to determine how many, or what proportion of those who died did so in which of the respective phases for deaths from trauma-induced injuries following the events of 26 December 2004. However, in order to enhance our knowledge in a way that will be beneficial for victims of future catastrophic events, using these basic stages for organization of the medical care and public health aspects associated with these events will be useful. This is especially relevant to future responses to similar events.

**Life-terminating injuries**

(mortally wounded; non-survivable)

It is not known how many (or what proportion) of the deaths occurred within minutes of sustaining the physical injuries responsible for the deaths. Causes of these immediate deaths were related to asphyxiation due to drowning,
burial under collapsed structures or objects, blunt injuries (non-penetrating) due to impact with or by debris or by being thrown against fixed objects, i.e., head injuries with loss of airway or spontaneous ventilation, rupture of one or more viscous organs with massive exsanguination (e.g., heart, aorta), or penetrating injuries from contact with sharp objects. Even during stable times in the best of medical care scenarios, little can be done for the survival of these victims.5–7 Therefore, those that were killed by the forces associated with the earthquake and/or tsunami would have died from their injuries regardless of the setting in which the injuries occurred.

However, several observations associated with these deaths are worthy of note. These include: (1) the disproportionate number of deaths that occurred in the most vulnerable sectors of the impacted society; (2) management of massive numbers of dead; (3) psychological trauma due to loss of loved ones and the horrors associated with witnessing the awful deaths; (4) a personal near-death experience; and (5) the ongoing questions about whether more could have been done. The corpses of many of those who were mortally wounded often were brought to medical facilities, and thus, contributed to the surge of activities required of the medical personnel staffing the facility—a task that must not occur during surges of living victims.

Vulnerable segments of the population—In each of the countries, there was a disproportionate number of deaths in the most vulnerable segments of the affected population. More than half of those killed from the tsunami were children, and there was a disproportionate number of women and elderly who succumbed. In most of the coastal communities impacted; the males were fishing at sea where, for the most part, they were safe from both the earthquake and the tsunami. Furthermore, survival seemed to be related to the strength and the skills of those impacted. Women and some of the men did not have the strength to hold on to their children who were swept away by the forces of the moving water, and the children did not possess the strength or the skills to battle the currents. The culture in some of the areas impacted did not allow women to learn to swim, and in some instances, the clothing worn limited their freedom to swim (if they were skilled) and battle the currents. Women who had remained at the shore awaiting the return of the fishermen were in harm’s way when the water came ashore. Similarly, the elderly and those who were chronically ill could not battle the currents. Also, there were several indicators of malnutrition in each of the countries that could have been associated with decreased strength. In Indonesia, 42% of the children <5 years of age were stunted, as were 45% in India. Forty-seven percent of the children in India were underweight; 88% of pregnant women were anaemic, and 45% of children <5 years in the Maldives were underweight.

Little is known about the number of persons killed by the earthquake as information relative to the damage created by the earthquake from areas struck by the largest and most prolonged earthquake of the century has not been found. It is known that children and teachers in the Andaman and Nicobar Islands were killed by the collapse of schools due to the earthquake. It can be surmised that many more persons were killed in the Andaman and Nicobar islands and in Aceh province due to the earthquake. But, there is little evidence to support this assumption.

Preventable deaths—Once an immediately fatal injury has been inflicted, medical care has nothing to offer to prevent the inevitable, especially in the setting of mass casualties. Even in a stable setting with superb pre-hospital emergency medical service systems providing care for only one person who has sustained such injuries, survival is rare.4 In the latter setting, on occasion, life-supporting first aid may contribute to the remarkable survival of a victim. In mass-casualty settings, the best of all the pre-hospital emergency medical services systems contributes little to the survival of those who have sustained such immediately fatal injuries. Instead, the efforts of pre-hospital emergency medical services
personnel are best concentrated on the living with life-threatening injuries rather than those who had sustained life-terminating injuries. Therefore, in the setting of massive numbers of injured who survived their immediate injuries, it is unreasonable to second guess the results using the best available trauma systems providing care to only a few life-threatened victims as the reference for what could have been done for an individual victim. Criticism using this measure is inappropriate. Most of those who succumbed immediately could not have been saved regardless of the expertise and the availability of a superb trauma system.

The only measure that may make a difference for the next time, is to avoid sustaining such injuries. All persons should be skilled in swimming and should not be encumbered by their clothing. Given any suspicion that a tsunami is possible, the vulnerable population must flee rapidly to higher ground! This may require a tsunami warning system, and/or better communications between governments; the population along the sea coast must be educated to move to higher ground in the event of an earthquake.

**Life-threatening injuries**

Stage 2 in the trimodal distribution of deaths due to physical injuries is related to victims with life-threatening injuries who survive through Stage 1. In triage systems, these victims are labeled as “red” (urgent), and require life-supporting treatment in the field and rapid evacuation from the scene to a medical facility with the capability to adequately diagnose and treat them for their injuries.6–7 If not diagnosed and treated appropriately within hours to 2–3 days of sustaining their injury, these victims will succumb. If they survive to reach a medical facility, they comprise the most clinically significant component of the surge of injured patients on the receiving medical facility.

The numbers of victims who survived their injuries for hours after sustaining their injuries following the earthquake and tsunami remain unknown as do the number of victims who arrived at a medical facility only to succumb to their injuries. The medical records, if any, during the first day were inaccessible or were poor.

Many patients who reached a medical facility alive succumbed due inadequate numbers of skilled personnel and/or lack of essential life-supporting equipment and supplies. It is known that in Thailand, despite the general impression that little changes occurred in the Medical Care System, when a hotel was commandeered as an alternative site to a severely damaged hospital, the only life-saving treatment that could be provided consisted of attempts to control haemorrhage. There was limited ability to provide ventilatory support for patients who had survived a near-drowning experience. Further, the surge of patients with non-life-threatening injuries competed for the limited resources available. Thus, during the mass-casualty circumstances produced by the tsunami and/or earthquake, many victims whose death may have been averted during “normal” times, died of their injuries during the first 1–2 days following the events. This includes those who survived their initial injuries, but died before they could reach a medical facility.

Further, the medical facilities in many of the areas in Indonesia and Sri Lanka directly impacted by the tsunami generally were barely able to meet the daily patient loads prior to earthquake and tsunami, much less the surge that occurred following the tsunami. There were no trauma centres located in these regions and the emergency medical services, where they existed, were far from robust. The destruction/damage to many of the medical facilities coupled with the deaths of staff, staff members who were missing, and staff who were unable to report for duty for personal reasons, including injuries or due to loss of family members, took the immediate capacity of the medical facilities, in each of the countries to levels that were lower than before the events. Staff shortages were particularly problematic for the nursing staff.8 Furthermore, it was not possible for reinforcements of medical personnel to reach the medical facilities...
in the stricken areas in time to provide the life-supporting care required by those who had sustained life-threatening injuries. By the time that expatriate medical personnel reached the areas impacted, they were too late to provide the life-supporting surgical care required by the injured who had succumbed to their injuries. There was little need for emergency trauma surgery personnel when these teams arrived. Most of the teams were relegated to the provision of intensive care for patients in Stage 3, or to incise and drain infected wounds, revise surgeries performed in the acute phase, or supplement the delivery of primary care to the crippled primary care systems in each of the countries. As has been demonstrated repeatedly following sudden-onset events,9–11 expatriate surgical teams arrive too late to be of assistance to survivors who have sustained life-threatening injuries, but may function to decrease the probability of death or morbidity from complications of initial injuries.

In Thailand and India, some of the skilled personnel that did reach medical facilities were dispatched into the field as teams. These teams triaged less severely injured victims away from the hospitals or treated them in the field, thus minimizing the surge of patients reaching the hospitals and attenuating the competition for scarce resources at the hospitals. This was possible in India and Thailand because the burden created by the injured was minimal compared to that experienced in the other countries, and sufficient numbers of skilled personnel were imported into the stricken areas. Such reinforcement was not possible in Indonesia, Sri Lanka, and the Maldives, where the burden of the injured was huge, or in the Maldives and Andaman and Nicobar Islands where the geography limited access. But, it is of interest that India had the highest proportion of deaths of all the countries. The reasons for this observation are not apparent, and require further examination.

None of the countries included in this study had a robust pre-hospital emergency medical services system. But, given the circumstances, such a system would have been able only to assist a very limited number of victims with life-threatening injuries. This applies to all sudden-onset events that generate huge numbers of life-threatened victims. Even in the best pre-hospital EMS system, it is unrealistic to believe that in the situation of massive numbers of severely injured victims that the EMS system will be of substantial value—the systems will become over-run.

It has been demonstrated repeatedly that primary rescue efforts are provided by lay survivors,11–13 but the effectiveness of the lay public who provide life-supporting first aid in these circumstances has not been demonstrated. In preparedness activities for future events, perhaps the cause would be better served by educating and training the lay public in the provision of life-supporting first aid and survival skills, and using the EMS personnel for the provision of life support in casualty collection points.13

Another major issue in the circumstances associated with the earthquake and tsunami was the inability to gain access to the medical facilities due to the damage sustained by the Public Works and Engineering and the Transportation and Logistics Basic Societal Systems. Those countries with the lowest burdens of injury and the least amount of damage to the infrastructure and transportation systems (i.e., Thailand and India), were able to transport victims and provide supplemental staff to the medical facilities. Relatively rapid reinforcements of public works and engineering staff and equipment, and the import of transportation capacities undoubtedly contributed to the survival of many victims during Phase 2. Roadways were cleared and abundant transportation capabilities were made available often using the military. The impact on survival of these reinforcements and evacuation of victims with life-threatening injuries to external facilities on survival is not known, but must be accounted in future events. Such reinforcements were not possible within the first 24 hours in Indonesia and Sri Lanka, and many victims with potentially survivable injuries died as a result of their injuries and the inability to reach adequate medical care.
This was further accentuated by the extensive damage/destruction of many of the healthcare facilities and the profound loss of medical staff.

During this stage of care of the severely injured victims, the use of military resources may play an important, but limited medical role. The capabilities and capacities of the military to mobilize transport resources for the movement of victims from the site of injury to medical facilities, the conveyance of supplemental personnel, equipment, and supplies, and the evacuation of critically ill victims constitute an important resource. However, given the massive nature of the human damage sustained from the earthquake and tsunami, it seems that the mobilization of these resources had little overall impact on the survival of victims during Stage 2. Furthermore, the capacity of the medical facilities to provide needed lifesaving services were compromised further by the loss of electrical power and clean water; loss of electrical power was experienced in each of the hospitals in the directly affected areas in each of the countries.

Lastly, the impact on the medical personnel’s inability to help all of the injured was associated with feelings of profound helplessness. Watching people die of injuries who possibly could have been saved during normal times, results in severe psychosocial trauma—“Should we have done more?”

Several lessons seem apparent. During disasters with massive numbers of casualties who have sustained life-threatening injuries caused by sudden-onset events, most of these victims will succumb to their injuries. With superb medical care, only a very small proportion may survive. Furthermore, it is inappropriate to believe that the surge capacity can be provided by augmenting the staff with off-duty personnel; these personnel may never materialize due to injuries (physical and psychological) of the staff or their inability to reach the medical facilities. Alternative means of meeting the surge of life-threatened victims must be sought and integrated into the disaster plans. Furthermore, it seems that depending on pre-hospital emergency medical services personnel to triage and manage massive numbers of victims with life-threatening injuries in the field will not be adequate, no matter how robust the system is. Transportation capabilities for the injured will be inadequate to meet the demands on the transportation resources, and there will be substantial competition for these limited resources. During situations in which there are massive numbers of persons who sustained life-threatening injuries, most of them that survive immediate death will die before reaching a medical facility. It remains unknown as to how many lives could be saved by lay rescuers educated and trained in the provision of life-supporting first aid.

The management of the bodies of victims who succumbed during Stage 2, presented the same issues as did those who died immediately following being injured. Victims who have sustained life-threatening physical injuries and who have had their injuries repaired within hours of their injury may develop complications related directly to their injuries or to damage to other organ systems, and may develop life-threatening complications despite treatment for their injuries.

**Complications—delayed deaths**

Delayed deaths that occur ≥48 hours following injury generally are related to complications from the injuries or lack of appropriate treatment. They occur days to months (or longer) following the injuries. The complications may include the development of pulmonary failure related to the respiratory distress syndromes or pneumonia (in this situation from the inhalation of contaminated water by near-drowning victims — “tsunami lung”), sepsis, renal failure, multi-organ system failure following shock or a ruptured organ, wound infections, dehydration, and/or suicide.

Treatment of patients during Stage 3 consisted largely of the administration of fluids and antibiotics, ventilatory support, incision and drainage of abscesses, amputations of infected extremities, and other interventions provided in critical care environments. When possible, such
patients merit treatment in an intensive care unit. Obviously, in the areas directly impacted in each of the countries studied, for the most part, this was not possible. Therefore, when such services could not be provided locally, some of these patients were evacuated to distant, higher level facilities often with the use of land or airborne military transportation resources or via boat as occurred in the Maldives and the Andaman and Nicobar Islands. Some of the foreign, injured, critically ill victims were repatriated using military aircraft. It is in this stage that expatriate medical teams and facilities may be of valuable service in field hospitals to supplement the functional status of damaged or destroyed hospitals or providing expatriate physicians, nurses, and other healthcare personnel to work in the local hospitals. Some of these services in Indonesia were provided by hospital ships from India, the USA, and Germany. Again, related to poor-record-keeping or inaccessible records, the numbers who died from complications related to their injuries, as well as the numbers who survived life-threatening injuries or complications from non-life-threatening injuries could not be accounted.

As noted, when possible, patients were evacuated to hospitals that could provide the most appropriate care. For example, the only tertiary care facility in the Maldives was in Malé, which was not severely damaged by the tsunami. Evacuation of patients requiring complex critical care services was quite prompt in Thailand and India. In the Andaman and Nicobar Islands, patients were transferred using the transportation resources that had delivered supplies and personnel.

Of particular interest was the outbreak of tetanus in Aceh province. At least 101 patients with tetanus were reported to have reached medical facilities. It is not known how many victims who developed tetanus died before reaching a medical facility. The incidence of tetanus seems related to the low vaccination rates in Aceh province prior to the earthquake and tsunami. A shortage of tetanus immunoglobulin contributed to the death rate. There were some reported attempts to modify the course of tetanus by the inappropriate administration of tetanus toxoid to patients who had already developed tetanus.

**Non-life-threatening injuries**

Adding to the injury burden in the countries were the survivors with non-life-threatening injuries who presented to a medical facility for diagnosis and treatment. These injuries consisted of lacerations (often deep) without severe haemorrhage and shock, fractures of extremities, sprains and strains, concussions, and/or eye injuries. Some of the lacerations became infected and some of these were treated with antibiotics and/or incision and drainage. On occasion, extremities had to be amputated in an effort to remove the potential source for sepsis. When available and indicated, tetanus booster injections were provided. Most extremity fractures were treated using routine splinting, casting, and when indicated and available, surgical fixation. Importantly, patients with non-life-threatening injuries may go on to develop life-threatening complications. Follow-up of these patients has not been done or their records have not been accessible.

**Psychological injuries**

The psychological stressors experienced by the survivors were extreme. The feelings of grief at the loss of a loved one(s) were compounded by guilt often related to the inability to protect loved ones from certain death, the horrors associated with witnessing and hearing the screams of the awful, agonizing deaths, feelings of helplessness, and those associated with their own near-death experience. This was compounded further by the inability to find lost family members, to gain closure with the identification of the bodies of missing family members (of which many never will be found), and the inability to meet the religious and cultural demands of a prompt and appropriate ceremonial burial, as so many were buried in mass graves with no capability to identify the remains or pay their respects. Many lost not only all of their belongings and many family members, but also the means of earning
a livelihood. They became displaced with no means to support their families; they became dependent, and with the dependency also came their loss of pride. The psychological agony was huge and crippled many of the survivors for the rest of their lives regardless of the heroic efforts to provide the survivors with psychological first-aid and support. Alcohol consumption increased.\textsuperscript{19} For the most part, changes in suicide rates have not been available. One study indicated a localized rise in tsunami-related suicides with none after the first month.\textsuperscript{20} Another report found no significant change in the suicide rates in Sri Lanka.\textsuperscript{21}

The impact on the medical personnel of the inability to help all of the injured was associated with the feelings of profound helplessness. Watching people die of injuries who possibly could have been saved during normal times resulted in severe psychological trauma.

The exact burden of the psychological traumas suffered following the tsunami is not known and probably never will be known. It has been estimated that more than one-third of the survivors suffered severe psychological problems following the events.\textsuperscript{22–25} In India, it has been estimated that >50% of the exposed population developed psychological dysfunctional states.

Except for Thailand, the available psychological support was meagre prior to the tsunami. In the other countries, prior to the earthquake and tsunami, psychosocial support was provided primarily by the social support systems of religion and culture. However, many of the religious leaders and support personnel were injured/killed by the earthquake and/or the tsunami. For the most part, resources were not available at the community level. However, Thailand had thousands of trained volunteer mental health workers in place at the community level. Furthermore, many of the traditional resources used for the prevention and treatment of these disorders were not available in most of the impacted areas following the tsunami.

For the most part, the psychosocial burdens created were not only recognized, but substantial efforts were initiated to identify individuals suffering from psychological dysfunction, and major efforts were implemented to support those affected. Such efforts were directed towards treating/preventing depressive reactions and the ravages associated with the development of the post-traumatic stress disorder (PTSD).

Substantial efforts/investments in the mental health of the survivors were provided by the NGOs, and in some instances, by lone expatriates who tried to provide support. The character and outcomes from these interventions have not been quantified, but the issues associated with reactions to such stressors were recognized. There is evidence that some of the interventions provided were inappropriate and may have contributed to psychosocial dysfunctions rather than to abating them.\textsuperscript{26–27} For example, some therapy was begun while the grieving process was at its peak. Psychotropic drugs were provided to persons who did not need them. Some individuals were providing interventions who had no credentials to do so. However, the problem was recognized and attempts were made to attenuate the amount of psychosocial dysfunction that resulted.

Unfortunately, despite the often heroic efforts to assist in the recovery of those afflicted, the psychological scars associated with the events will be ever-present for generations. For many, it will never be possible to reintegrate with their society or even with their family. The toll is and will remain huge. It will be decades or longer before the pre-event mental health status will be recovered. As noted, other than two studies, it has not been possible to obtain the suicide rates following the tsunami. A significant study could be implemented to compare the psychological morbidity in those who had received psychological first aid with those who did not.

**Disease states not related to injuries**

It was expected that the conditions following the earthquake and tsunami would breed disease
states and deaths not related directly to injuries (indirect effects/deaths). Anticipated problems included the development of: (1) dehydration; (2) infectious diseases; (3) non-infectious diseases including exacerbation of chronic conditions; and (4) development of psychological disease states and social maladjustments. These problems were thrust onto the healthcare systems that, in some of the areas impacted, barely could meet the day-to-day healthcare needs, and a public health infrastructure that had been neglected.

**Dehydration**

Given the extensive damage incurred by the water and sanitation systems and the massive destruction of the infrastructure of the Public Works and Engineering System in each of the countries, it was anticipated that an immediate problem facing the public health and medical care systems would be a lack of the minimum supplies of potable water required to survive. The potable water supplies in India and the Maldives had been in critical short supply before the tsunami. The tsunami contaminated water sources in each of the countries; wells became salinated or contaminated with sludge; water storage systems were whisked away or fractured by the earthquake and tsunami in Aceh province, the Andaman and Nicobar islands, and the Maldives; and rain water collection systems (a primary source of potable water) were damaged, destroyed, or carried away by the surging currents.

As noted, the critical threshold for water averages 2.5 litres/day/person. If this minimum is not attained, people will begin to succumb to dehydration within 2-3 days. It was not possible to identify reports of persons who succumbed due to dehydration following the tsunami. The absence of reports of persons who succumbed due to dehydration following the tsunami. The absence of reports of persons who succumbed due to dehydration following the tsunami. The absence of reports of persons who succumbed due to dehydration following the tsunami.

As part of the recovery processes, wells were cleaned, water storage containers were replaced, rainwater collection systems restored, and, in some instances, desalination facilities were installed. An important issue arose with the installation of sea water desalination facilities in the Maldives as the facilities consumed fuel that had to be imported, and often, the “beneficiaries” were not trained in the operation and maintenance of these facilities; replacement parts were not provided. Further, the plants raised significant cultural issues in these settings and subsequently, fell into disrepair. Lastly, much of the supply of water was provided in plastic containers that eventually littered the landscape, as the severely compromised Public Works and Engineering Systems could not deal with the litter.

Major causes of dehydration could have resulted from nausea, vomiting, and/or diarrhoea. However, the reported incidence of diarrhoea post-event was no greater than it was prior to the earthquake and tsunami. It was not a prominent cause of death reported in any of the countries. Other than for a few reports, such outbreaks were rare, and those that did arise were limited
by treatment of the contaminated water sources using chlorine tablets.

The cases of dehydration that were detected were treated with the administration of rehydration salts provided by WHO. It is a remarkable testament to the Public Health, Transportation and Logistics, and Public Works and Engineering Systems that few if any deaths were caused by lack of sufficient supplies of water. The efforts of these Societal Systems prevented deaths from dehydration, and also highlighted the essential role that can be filled by the appropriate use of military resources during disasters.

### Infections and infectious diseases

Following the tsunami, conditions were ideal for the development of infections and contagious diseases. Despite the evidence that indicates that unless the initial event was related to infectious diseases, infections and infectious diseases rarely are associated with disasters, it was believed by some that there was a very high potential that infectious diseases would kill more people than did the earthquake and tsunami. The media jumped onto that bandwagon and fanned the flames that a secondary disaster was imminent.

Several diseases were endemic (prevalent in or restricted to a particular region, community, or group of people) in the affected countries prior to the events of 26 December 2004. Malaria was prevalent in each of the countries except for the Maldives, where it had been eliminated. The prevalence of malaria was greatest in Indonesia and India, less so in Thailand, and even less in Sri Lanka. The prevalence of HIV/AIDS was highest in Thailand followed by India. The remaining three countries had prevalence rates that ranged from 33–44 cases/10 000 population. Tuberculosis was also prevalent in the same countries: its prevalence was substantially greater than for HIV/AIDS and for either malaria or HIV/AIDS in Indonesia, the Maldives, and Sri Lanka. Minor outbreaks of diarrhoea, acute viral fever, dengue and dengue fever, shigellosis, and typhoid fever occurred sporadically throughout the region following the events, but no evidence of an epidemic was identified. The few minor outbreaks (chickenpox, measles) that occurred were contained by public health measures.

Pre-event immunization rates varied substantially between the affected countries. Children in the Maldives, Thailand, and Sri Lanka had excellent coverage rates (96%–99%) for measles, diphtheria, pertussis, tetanus (DPT), BCG (tuberculosis), hepatitis B, and polio, with the exception of only 79% for hepatitis B in Sri Lanka. This was not the case for children in India and Indonesia where immunization coverage rates ranged from 51%–79%, except for 88% coverage for BCG in Indonesia. Significantly, the immunization rates for Aceh province (where available) were dismal; only 31% of the children had received measles vaccine; 35% of the one-year olds received the third dose of DPT; and only 6% had received the third dose of polio vaccine. This latter finding is consistent with the poor pre-event healthcare services that were available in Aceh province prior to the earthquake and tsunami due largely to the ongoing civil conflict and military rule. This became manifest in the outbreak of tetanus that occurred in Aceh province following the tsunami. It is probable that the immunization rates of adults in India and other areas of Indonesia were even poorer.

Furthermore, conditions following the tsunami were fertile ground for the development and spread of diseases. Internally displaced persons were forced into crowded living conditions that were ideal for the spread of the diseases: sanitary conditions were poor with open-field defecation commonplace, and the collection and disposal of garbage and refuse were limited causing the wastes to pile-up in the streets. The latter problem was due, in part, to the damages suffered by the already limited abilities of the Public Works and Engineering System services. Thus, it was reasonable to believe that outbreaks and even epidemics were likely to occur. There was some fear that an outbreak of cholera was imminent. Furthermore, as noted above, there were several indicators of malnutrition in each of the countries that could
have been associated with decreased resistance/immunity to infections.

Remarkably, even with marked enhancement of reporting associated with the augmentation of the public health surveillance capabilities implemented in each of the countries (with the assistance of WHO-SEARO, UNICEF, and several NGOs), other than for a few minor outbreaks that were quickly contained, there were no major outbreaks of any infectious diseases. The reasons for this remarkable accomplishment by the Public Health Systems are not clear. Several factors may have played a role. As described above, concerned efforts were directed toward the provision of adequate supplies of potable drinking water. Non-bottled drinking water was processed by boiling or with the use of chlorine tablets. One minor outbreak of diarrhoea was terminated by chlorination of the water. Minor outbreaks of measles and mumps, especially in the IDP camps in Sri Lanka and the Maldives were contained. Many of the displaced persons rapidly left the camps to move to the homes of unaffected family or friends, or as in the Maldives, to islands that had not sustained severe damage and continued to function, or, when possible, returned home.

Regardless of the reasons, and much to the credit of the actions of the augmented Public Health Systems, and regardless of the factors outlined above, it seems that good public health measures contributed to the outcome, as there was no epidemic or even a major outbreak of infectious diseases.

Non-infectious and chronic diseases
A host of other conditions may have contributed to the deaths of the victims. There is some evidence that the numbers of indirect deaths may have been significant, especially in areas where there was civil strife (conflict), but there are no available reports relative to the earthquake and tsunami to substantiate this claim. The impact of chronic diseases has already been considered, but the additional medical burden created by persons with these diseases also cannot be quantified. For example, how many persons with diabetes or chronic cardiovascular-pulmonary problems were unable to access life-supporting medications? These conditions existed before the earthquake and tsunami and were part of the burden on the public health and medical care systems. Pre-event, cardiovascular diseases were responsible for an average of 28% of the deaths in four of the five countries, with only Thailand having rates less than the average (20%). On the other hand, Thailand had the highest percentage of deaths due to injuries and cancer, and Sri Lanka had the highest percentage of deaths caused by chronic respiratory diseases (11%). It is clear that
a major role played by the augmented expatriate medical care personnel was to facilitate the continued care of those with chronic conditions, and to provide primary care for those with the usual health problems, in addition to caring for those with exacerbations of their chronic conditions due to the circumstances created by the events. Field hospitals (national and international) primarily functioned to supplement the damaged medical facilities (structural and functional including dead, injured, ill, and absent staff) and not for the acute treatment of injuries due to the earthquake and/or tsunami. In fact, the majority of medical and surgical interventions provided by expatriate medical units (including the hospital ships anchored off the coast of Banda Aceh) were for routine primary health care and the provision of surgical services (cancer, corrective) not available pre-event. Unfortunately, the provisions of such care raised the standards and such levels of care could not be sustained.

Migration
The social and economic burdens created by the more than 2 million persons who fled from the impacted areas initially were huge. Reasons for this sudden, massive movement of people included loss of their homes and belongings, fear that another earthquake and/or tsunami was imminent, searching for missing family members/friends, and/or to find a new source of income/job. Some fled to makeshift camps or flooded into those already established (especially in Sri Lanka); some to structures that had adequate absorbing capacity to survive the forces of the earthquake/tsunami, such as mosques, schools, and government buildings, and some to the homes of relatives/friends that were outside the areas directly impacted. Some headed to the cities or took refuge outside their homeland. The distributions to the respective destinations are unknown except for the 2 million who were accounted for in camps. Therefore, it is likely that the numbers displaced were far in excess of the 2 million that have been accounted for.

The standards for the IDP camps have been delineated by the Sphere Project and the problems encountered in such settings were well-known to the humanitarian community before the occurrence of the earthquake and tsunami. It is not known to what extent these standards were applied or enforced by the public health systems. Initially, the camps and other shelters were heavily overcrowded, and raised substantial public health concerns. Many IDPs had moved from fairly secure quarters and livelihoods to crowded tent villages in which they were insecure and totally dependent for food, water, shelter, and clothing.

Due to the continued social unrest in Sri Lanka and Aceh province, there was ongoing migration of the populations from the areas of conflict in efforts to escape the violence. For example, it was estimated that some 400 000 persons in Sri Lanka were in IDP camps before the events of 26 December.35 People migrated from place to place in search of security. They lived in makeshift shelters that were highly vulnerable to the forces of the earthquake and tsunami. It was not possible to distinguish how many of those that perished were migrant.

Many IDPs found temporary quarters with families and/or friends and avoided the trauma associated with being contained in camps with strangers. In the Maldives, survivors who could not stay in their places of residence went to islands that were not severely damaged by the tsunami. Importantly, many of the IDPs quickly extricated themselves from the camps and some were forced from the buildings in which they had sought “temporary” shelter and sustenance. It is not clear exactly to where they migrated. But, it is most likely they sought “temporary” shelter and support from relatives and friends who had not been directly affected by the events. They arrived with what they had on their backs and the little that they could carry. Few had any resources—they had lost everything—personal belongings and often loved ones; hard working, independent, self-reliant, proud persons found themselves dependent on the good will of the hosts. New livelihoods were difficult to establish in the new environments. Some of those who had left the camps returned to them during the
day in order to gather supplies being provided in the camps by relief organizations, and left again with what they were able to gather. Essentially, at least initially, no such relief supplies were provided to the host families. Furthermore, the construction of temporary shelters was relatively slow and stays often became prolonged.

As was evidenced in the Maldives, the IDPs were initially welcomed with open arms. But, the stay was to be only temporary—and as the time passed, what was intended to be temporary looked as if it was going to become permanent. Uneasiness grew and benevolence began to fade—many of the “intruders” became unwelcome and eventually, violence erupted. They had outstayed their welcome. Resources that were short pre-event, became thinner as they had to support more people. But, for many of the survivors, there was nowhere to go, no way to make their own way—they were trapped. Undoubtedly, this picture of increasing unwelcome was repeated in each of the countries, and the migrants and hosts suffered the same stressors—the issues were the same.

Pressure increased for the provision of temporary shelters to bide these unfortunates over until they could find a new livelihood and return home or into permanent new housing. However, few if any of the construction programmes for the provision of temporary or permanent shelters were completed on time—there were too few available, leaving many in a dependent state. This was all superimposed on the profound psychosocial trauma and its toll on the well-being of those affected. Some of the IDPs refused to move into the new housing, which they deemed unsatisfactory, e.g., the dwellings provided were located too far from the seashore for fishermen. Many of the damaged fishing boats were replaced, but some of the “replacements” were not seaworthy or would not serve the purposes for which they were built. Achievement indicators such as the number of houses built or boats provided does not define the impact of such interventions on the beneficiaries.

The impact of such massive migrations on the medical care and public health systems requires further scrutiny. Migration of huge numbers of people requires shifts in the locations of healthcare facilities and personnel and creates new public health dilemmas. Thus, not only were many healthcare facilities damaged and personnel killed or injured, but the service areas changed abruptly. Some NGOs established clinics in the camps or elsewhere where they were needed in support of the migrants.

In terms of recovery, many of the IDPs gradually were placed into temporary or permanent housing. Some areas (especially in the Maldives) received temporary shelters made of corrugated metal, while elsewhere, temporary buildings were erected to house the displaced while permanent homes were being constructed. At the time of this writing, many remained in temporary housing or in camps. Unfortunately, only rarely were the intended beneficiaries included in the decisions as to the design and location of the permanent structures provided. Consequently, some of the permanent structures constructed still remain unoccupied.

**Functional changes in medical facilities**

The damage to a medical facility may be structural and/or to the staff. Both ultimately led to the inability to provide any or some of the health services (functions) that were available pre-event. The bottom line is whether and to what extent the facility was able to carry on day-to-day services and meet the surge of victims during or following the events. Structural damage includes not only the physical structure, but also the equipment and supplies essential for its operation. But, the ability to provide services requires staff. Loss of staff due to injuries, inability to gain access to the facility, or the need to provide care for family and loved ones contributes to the failure to have adequate staffing to carry on the functions of the facility.

What facilities were at risk? Clearly, the district hospitals in the Maldives had a greater exposure
to the forces of the tsunami than did the tertiary care facility in Malé. The tertiary care facility was not significantly damaged structurally and was able to continue to provide major healthcare functions. For the most part, its staff was unharmed and reported for work; its equipment and supplies were left essentially uncompromised. On the other hand, the regional centres were destroyed and rendered non-functional as were many of the clinics. Unlike the hospitals in Aceh province, where substantial damage was sustained, the hospitals in Thailand and India generally sustained little damage to infrastructure and staff. For the most part, they were able to absorb the surge and were able to send staff to the field to provide assessments and care. However, it also has been noted that the staff of one hospital had to evacuate and set up a temporary facility in a hotel where they did not have adequate supplies and ventilators.

The damage and inability to provide even routine medical care was not only caused by damage to the medical facilities and their contents, but also to the staff, equipment, and supplies. In addition, access to the facilities was severely compromised due to damage and dysfunction of the Public Works and Engineering and the Transportation and Logistics Systems upon which the medical facilities are heavily dependent. Roads were blocked, bridges were down, rail lines were disrupted, and vehicles were not available. There was little ability to re-supply facilities with needed supplies and equipment. Staffing was compromised due to injuries (including emotional), deaths, and the need to care for families and/or search for missing family members. Surviving staff and the injured were unable to reach the facilities. In addition, the functions of the transport and logistics system were compromised due to lack of fuel (Energy Supply System) and staff. These problems extended well into the recovery phase—there was insufficient transportation to move incoming goods and services to where they were needed. Further, supplies of electricity, water, and food were compromised. These are essential components to allow continuation of the provision of health services. These factors demonstrate the heavy dependence of the Medical Care System on other Basic Societal Systems, e.g., Public Works and Engineering, the Transportation and Logistics, Energy Supply, Water and Sanitation, Food and Nutrition. The impact of this constellation of failures on preventable deaths was not clear. At least early-on, these facilities either were destroyed or not able to provide even routine care much less able to cope with the surge of patients and dead bodies. However, in India and Thailand, with their abundant medical and public health resources, no outside help was required to meet the rather small burdens compared to those that sustained heavier damage and could not mobilize the resources required. Hospitals also were invaded by uninjured persons seeking security, shelter, food, water—normally recognized functions of the community hospitals. Further, in many instances, the corpses were brought to the hospitals. These demands increased the burdens on the depleted staff of the hospitals. In addition, in some instances, incoming international medical personnel essentially took control of the healthcare facilities, often to the exclusion of local professionals.

**Supplies, equipment and personnel**

In Indonesia, Sri Lanka, the Maldives, and the Andaman and Nicobar islands, medical supplies were rapidly depleted as there was little buffering capacity in the areas impacted. There was little in the way of backup medical equipment to buffer the losses due to damage and destruction. Much of the available equipment was rendered non-operational. This was complicated further by acute shortages of skilled personnel who either were killed, injured, or did not report to work.

Most of the initial responses came from the lay public or the military, few of whom were skilled in the provision of first aid, including life-supporting first aid. In most instances, it took days for backup personnel, supplies, and equipment from outside the impacted areas or from other countries to reach the areas in need. The international humanitarian community mounted huge relief responses that supplemented the local responses. Field hospitals were established and many of the responders supplemented (or
took over) many of the medical care activities required by the community. As has been noted following many disasters caused by sudden-onset events, most of these personnel, equipment, and supplies were used to support the day-to-day medical care operations, as they arrived too late to provide lifesaving care for those with life-threatening injuries that were able to reach the medical facilities.

Some of these humanitarian organizations arrived without adequate means of transportation to the areas in which they were needed. Many conducted their own assessments that drove their responses. Generally, the distribution of these relief responses was not coordinated resulting in unnecessary duplication and competition. Supplies, equipment, and personnel flooded into the Maldives, Sri Lanka, and Indonesia. Much of what arrived was needed and assisted in providing relief and in promoting recovery. However, some of the medical supplies, equipment, and even personnel were not needed and were unwanted. Medical supplies piled up in warehouses, especially at their point of entry. Even needed supplies piled up as there was little transportation available for their distribution. The competition for transportation with the other Basic Societal Systems was substantial. There were no operational mechanisms in place in Indonesia, the Maldives, or Sri Lanka to prevent the entry of unneeded and unwanted personnel, supplies, and equipment. Nor were there mechanisms in these countries to screen the credentials of persons or their competencies or the capabilities and capacities of the responding agencies that arrived to assist. India and Thailand shunned outside support as they were able to manage with their own resources. The government of the Maldives quickly realized the problem, and began to coordinate and control the influx (even with its relatively huge burdens).

Coordination and Control

The competition for transportation with the other Basic Societal Systems was substantial. There were no operational mechanisms in place in Indonesia, the Maldives, or Sri Lanka to prevent the entry of unneeded and unwanted personnel, supplies, and equipment. The governments of each of the five countries studied have made substantial progress towards closing this major gap. This was demonstrated in Indonesia following the Yogyakarta earthquake that struck Indonesia less than one year following the tsunami.

Cooperation and Control

The world responded to the damage and loss of function sustained in the countries as it never had before. Enormous amounts of money were raised, and country after country sent massive quantities of supplies, equipment, and personnel to help the stricken populations. Humanitarian organizations poured into Indonesia, Sri Lanka, and the Maldives, but they were not welcomed into Thailand and India, where the relative societal burdens created by the tsunami could be managed without the assistance of the international community. People, supplies, and equipment came from all corners of the globe. These resources arrived by air and when possible, by sea. If they reached the sites where they were needed, generally they were useful and undoubtedly contributed to saving many lives and to the recovery of many of the damaged and dysfunctional systems that had comprised the affected societies before 26 December. This included the Public Health and Medical Care Systems.

Unfortunately, the amounts and types of supplies provided overall were excessive, often were not needed, not wanted, or not appropriate, or were misdirected to areas in which they were not needed. There were no standardized methods used for assessing what really was needed, and often, the data acquired from the assessments were not shared between the assessors and
those who could have benefitted from access to the data. Furthermore, in many areas, there were insufficient transportation resources available to transport the personnel and supplies to where they were needed. Damage to roads and bridges also impeded the delivery of the personnel and goods to areas in which it was believed they were needed. Societal systems competed for the transportation resources that remained functional. Consequently, medical supplies, equipment, and personnel piled up at points of entry. Medical supplies, often inappropriately labeled or outdated, overflowed warehousing facilities. Overall, many of the excellent and essential benefits that were achieved were overshadowed by the glut of “stuff” that was received, but could not get to where it could have been of benefit or should not have been sent. For the most part, there was no coordination and control of what was sent or received. United Nations agencies attempted to provide consultation and day-to-day planning and monitoring. Nevertheless, duplication of services continued. Many activities/interventions were not coordinated and were wasteful; much duplication occurred. Furthermore, in many instances, the potential beneficiaries had no input into what reached them. Similar problems arose in the other societal services as well.

However, the government of the Maldives quickly learned to limit the responses by outside agencies and began to refuse what it did not request. This demonstrated the efficacy of appropriate Coordination and Control of humanitarian assistance.

The principal functions of a coordination and control entity are to identify and prioritize needs and to ensure that the responses are coordinated with the identified needs and the activities of and between each of the Basic Societal Systems. Failure to provide adequate Coordination and Control results in confusion, unnecessary duplication, inefficiencies, unnecessary costs, and activities that may be counterproductive to the society for which it is responsible. This is what occurred in Indonesia (despite apparent enabling legislation), Sri Lanka, and initially in the Maldives. Pre-event, in these countries, there was no legal mechanism that was responsible for the provision of Coordination and Control. Each country had at least a titular agency charged with the mandate to coordinate responses during a disaster, but these agencies generally only had the mandate but lacked the authority or resources to implement the mandate. There were no laws that assigned them the authority to implement disaster response plans. For example, in Indonesia, one organization was charged with the responsibility for preparedness and response, but another agency controlled the resources. Although Sri Lanka had assigned the responsibility for disaster preparedness and response to a national Disaster Management Centre, it did not have the authority or resources to provide the needed Coordination and Control. Instead, the actual responsibility was shared by multiple organizations, none of which had all of the essential components to carry out the mandate, authority (power), and the resources required to act. In addition, there was no requirement for accountability by any of the agencies. Consequently, Coordination and Control was not possible; if there was any semblance of such an agency, it was dysfunctional at best. In addition, Indonesia, the Maldives, and Sri Lanka did not have a cogent and up-to-date strategic Disaster Response Plan. All in all, these countries were besieged by well-doers, and exemplify what can happen without a well-developed disaster response plan and a Coordination and Control entity that has the mandate, resources, and authority to regulate the responses.

At one time, there were more than 200 NGOs operating within Aceh province. Each conducted its own assessments, determined its own perception of what was needed that they could provide, developed its own plan, and implemented its own interventions. Often, the information obtained from the assessments and the interventions that were generated were not shared with other agencies. Eventually, Indonesia tried to register incoming personnel, equipment, and supplies, but it seems that this effort fell short—but it was a start.
In contrast, India and Thailand had the essential elements for Coordination and Control in place before the tsunami struck. Each country had a national Disaster Response Plan in place, and Thailand had exercised its plan less than one month before the tsunami. Each had control over relief activities within its borders, especially during the relief phase. However, this must be tempered by the fact that the respective burdens generated by the events were many times less than those of Indonesia, Sri Lanka, and the Maldives. It can only be surmised that this apparent competency in the provision of Coordination and Control would have been adequate if the respective burdens had been equivalent to those suffered by the other countries.

It must be realized that some of the areas with no or dysfunctional Coordination and Control mechanisms had been engaged in civil conflict for years preceding the tsunami. Essentially, military rule existed in Aceh province at the time of the tsunami. Most of the resident NGOs had pulled-up stakes and departed—only four remained at the time the earthquake and tsunami struck. The military was in charge. However, military personnel did not possess Life-Supporting First Aid (LSFA) skills and were unable to provide assistance to many victims who potentially could have survived their injuries. Foreign military personnel, equipment and supplies also responded to the disaster contributing to a relentless struggle to identify who actually was in-charge and who was responsible and accountable. This did not occur in Thailand, India, or the Maldives, where the military became an important element in the responses and assumed responsibility for assisting many of the Basic Societal Systems in these countries.

It appears that the shortcomings associated with the lack of coordination and control were most prominent and detrimental primarily during the relief phase of the responses, at least in terms of the medical care system. The ability to control medical assistance seemed to improve as time passed and seemed better as the relief phase came to an end. Mechanisms gradually evolved that provided the necessary control and continued to improve as recovery progressed.

Recognizing the needs for enhanced Coordination and Control, UN agencies attempted to assist the governments with the provision of Coordination and Control of relief and recovery interventions. The UN-OCHA and UNDP initiated a Humanitarian Relief Centre in Aceh province. In addition, UN agencies established meetings of the stakeholders to enhance coordination. Observations of the devastating effects of inadequate Coordination and Control ultimately led to the humanitarian reform movement within the UN.

From a health perspective, the inadequacies of Coordination and Control related mostly to the provision of medical care services to the injured and other individuals with health problems. Despite the relatively weak public health infrastructure present in Indonesia, Sri Lanka, and the Maldives prior to the tsunami, the international responses in support of the Public Health Systems in each of the countries were much better than in the Medical Care System. The goals of the Public Health System before, during, and after disasters include: (1) detect and contain disease outbreaks; (2) replace/procure needed health supplies and equipment; (3) coordinate and control public health surveillance and interventions; and (4) support the needs of persons with chronic disease states. It was not responsible for the operation of healthcare facilities or for the care rendered to individual patients.

WHO-SEARO became the focal point for the Coordination and Control of the public health activities of WHO-SEARO following the earthquake and tsunami. The primary mission of WHO following the tsunami was to bolster and support the country governments in meeting the aforementioned goals. As such, through the operations of a 24X7 Ops Room in SEARO, and through the WHO country offices, it coordinated efforts to detect and contain outbreaks of disease
through the provision of expertise and technical assistance, and provided/procured supplemental personnel, equipment, and supplies and the supply chains to get them to the right places at the right time. It deployed assessment teams to assist the affected countries in identifying the public health needs and bolstered the abilities of the countries to conduct syndromic surveillance and responses to outbreaks or anticipated outbreaks of disease. WHO-SEARO provided the countries with the public health expertise required. In addition, through the WHO country offices, it assisted the countries and WHO with the recruitment of additional staff and facilitated the transition of public health from relief into recovery and recovery into development.

Although no one intervention provided by WHO-HQ, WHO-SEARO, and the WHO country offices can be attributed solely to the success of the programmes, no epidemics occurred and the minor outbreaks of disease that were detected were contained using public health measures. Many of the programmes initiated with the assistance of WHO-SEARO and directly by the WHO country offices have evolved into sustainable programmes and the Public Health Systems in each of the affected countries now are vastly improved compared to pre-event states. Much of the confusion that occurred in the Medical Care System was avoided by the Public Health System.

The apparent failures in coordination and control of the responses to the relief and recovery interventions ultimately led to UN-OCHA conceiving and implementing the “humanitarian reform” movement. In efforts to enhance coordination and control, the UN-OCHA Interagency Standing Committee (IASC) established a set of clusters with the aim of bringing the stakeholders to the table to enhance communications, coordination, and stimulate collaboration. WHO was designated as the lead agency for health. In turn, WHO established the Global Health Cluster, and is participating in the development of health clusters at the country levels. The country health clusters have been implemented in several countries, and evaluations of their effectiveness, benefits, and costs in enhancing Coordination and Control is ongoing.

Role of the military
In none of the countries studied did the mission of its military include disaster relief activities. Yet, in each of the countries, the military filled key roles in the provision of relief even though such missions were not in consort with the usually recognized mission of the military. The organizational capabilities, capacities, and readiness of the military exceeded those of civil society. In Thailand, the military was used to supplement the Public Works and Engineering Systems to help to clear roads and to re-establish transportation routes and communication to and from the areas impacted. In Indonesia, the Indonesian military was supplemented by foreign military. Of special significance was the use of rotary-wing aircraft to transport supplies into otherwise inaccessible areas. This was particularly significant for relief in Aceh province where many areas were not accessible by other means. The military also augmented medical capabilities and capacities with the provision of hospital ships and transport capabilities for personnel, equipment, supplies, and on return trips, with patients. As previously noted, few of the military had been trained in the provision of life-supporting first aid.

Aceh province was under military rule before the tsunami. There is some evidence that the Indonesian military distrusted the NGOs as it suspected that they were in league with the insurgency in the battle for control of the natural resources within Aceh province. Thus, at the time of the earthquake and tsunami, only four NGOs remained within the province. In addition, the government of the province basically was dysfunctional pre-event and was further disrupted given the damage caused by the earthquake and tsunami. With the arrival of the military units from other countries, the command role of the Indonesian military command became more difficult. Conflicts arose as to who was in charge.
Similarly, the tsunami impacted the areas of Sri Lanka that were involved in civil strife. This conflict added to the vulnerability of the population to the effects of the tsunami. At the time of the tsunami, some 400,000 people were living in IDP camps, while others had no permanent residence and migrated in attempts to escape harms. Shelters often were makeshift and were unable to absorb the energy of either the earthquake or tsunami. Many, many of these nomads were killed by the forces of the earthquake and tsunami.

Importantly, the military has the supplies, equipment, communications, logistical, and command and control capabilities and capacities to respond rapidly to the losses of function that occur from the damage created by high magnitude events that precipitate disasters. Their resources stand in a state of readiness. But, disaster response generally has not been a recognized component of the mission of the military. There were no formal Disaster Response Plans nor were there any legal commitments in place designating the roles of the military during disaster except perhaps for the provision of security. The military in each of the countries rose to the occasion and demonstrated its ability to quickly provide support during disasters. The development of formal arrangements between civil society and the military must have priority. The role of the military in future relief activities requires further study, and perhaps, defined actions, in addition to routine mission of the military, will be realized.

Social structures
Following the earthquake and tsunami, there occurred severe disruptions in the social fabric of the societies directly and indirectly impacted by the forces of the events. The psychosocial costs to the affected societies included the loss of: (1) family members and friends, including children; (2) leaders and symbols of their respective religions; (3) faith in their religion(s); (4) livelihoods; (5) all worldly possessions; and (6) security. In addition, they experienced: (1) inability to follow religious traditions, such as traditional ceremonial burial procedures; (2) inability to recover the remains of lost family members; (3) witnessing the horrible deaths of family and friends; (4) a near-death experience; (5) feelings of helplessness; (6) dependency; and (7) guilt.

Losses are met with grief. Loss of family members often was accompanied by major changes of roles within the family structure—male survivors suddenly had to manage the family, especially the children. Female survivors found it necessary to generate the livelihood to support their families. There was nowhere to go or persons to help them cope with their shaken faith in their religion. They had little means of earning a livelihood, and were forced to accept help, and thus, became dependent upon support from others—a position generally not part of their respective culture. They had lost their homes and all of their family possessions—they were destitute. Many wound up in camps with others they did not know or with whom they had not had any social relationships. Many were alone. Their social structure had collapsed.

The mental health needs were augmented further by the destruction of many family units due to death or incapacitation of one or more family members. Some children had lost both parents and were orphaned. More women were killed than men, and, in many instances, this resulted in fathers having sole responsibility for the children, thereby creating a conflict for the males: care of the children versus earning a livelihood. In some circumstances, the role of the surviving women changed from family care and gatherers to sole supporters for the family. Lone partners often had difficulty obtaining compensation, since, in many instances, they were unable to produce documentation of their losses as the bodies were never recovered or identified. Such major shifts in roles added substantially to the stress.

Major efforts were made to care for those left without parents or partners. Efforts were directed to place or absorb the orphans into the
family structure of relatives. Especially in India, efforts were directed to finding new partners for those whose partners were lost. In some instances, this entailed marriages of fathers to very young women who could assume the family responsibilities and enabled the fathers to earn a living to support the family.

The collapse of the educational system added further to the society’s social burden. Students did not attend school and increased the burden on the surviving family members or on the host families. In addition, many of the youth were pressed into helping to meet the survival needs of the family and were withheld from attending school.

These factors, coupled with the perception that they no longer were in control of their lives and destiny, provoked feelings of helplessness. These perceptions were coupled with guilt; guilt associated with an inability to protect their loved ones and even guilt that they had survived while others did not (survival guilt). Thus, psychological factors devastated many and depression became rampant. Large portions of the population were vulnerable to the development of the post-traumatic stress disorder. Grief and depression were rampant and made it difficult to recover and move on.

For the first time, it was clear to the medical community that massive psychosocial problems affected the surviving population. Remarkable responses were mobilized to assist the stricken population cope with these stresses. At one time, there were 130 organizations in Aceh province attempting to help those psychologically stricken. The task was daunting in each of the countries as the psychosocial burdens were extreme. Although much of the support seems to have been helpful to the stricken, some was not. In endeavouring to assist the population to cope with the stresses, many questionably qualified to do so also appeared. In some instances, psychotropic drugs were provided to those still in the process of grieving their losses. Efforts to validate the credentials of many were impossible.

There was little increase detected in the suicide rate or in the consumption of alcohol and other drugs. This is testimony to the remarkable resilience of the affected societies.

One other factor is relevant. Initially, there was a huge migration of the affected populations into existing or spontaneously erected camps. In addition, many who were displaced from their homes were absorbed into the homes of their unaffected family or friends. Orphans were absorbed by other members of their extended families. The numbers of persons absorbed into the extended family circumstances is not known, and generally could not be accounted for in the reported numbers of IDPs. It seems that the numbers of IDPs that have been accounted for does not represent the actual numbers of those displaced. In addition, the attrition of the numbers who originally gathered in IDP camps was remarkable. It is not clear where they went.

In some instances, major problems arose as the survivors who were welcomed by host families and settlements eventually outstayed their welcome. What initially was believed to be a temporary arrangement seemed to be evolving into a permanent situation and this caused tension in the community. This was fueled by some inordinate delays in the provision of temporary shelters and inability to gain employment. Nerves became frayed and sometimes violence erupted.

One last aspect of this huge problem entailed the fact that generally, at least initially, there was no support provided to the host families who had to support newly-arrived relatives or friends on their relatively meager resources. The “intruders” frequently reappeared in the camps to gather what they could to help with the burdens. In addition, even in India, compensation for the losses sustained was slow and was hampered further by the inability of the survivors to present proof of their respective losses. These issues eventually were recognized by each of the governments and adjustments were made.
Except for Thailand, there was little in the way of support for downtrodden persons in need of psychosocial support. As noted, the traditional support by the institutes of religion were severely disrupted. Essentially, other means of support within the communities were not available. Thailand had community mental health workers prior to the tsunami. The efforts of these workers were a substantial element in blunting the psychosocial effects created by the tsunami.

However, several positive developments have occurred. Due to apparent successes in Thailand and elsewhere, each of the countries followed the example of the services operational in Thailand before the tsunami. Consequently, each country has established mental health services at the community level. For example, Indonesia has trained community health workers in the recognition of mental illnesses and the provision of basic psychosocial care including psychosocial first aid. With the assistance of WHO-SEARO, Sri Lanka has upgraded the knowledge and skills of its midwives to include the provision of psychosocial support. India has established a National Institute for Mental Health, and has charged its states with the responsibility for the education and training of persons to provide services at the community level. Moreover, it has embedded these programmes in the Social Structure System rather than as part of Medical Care System. At the time of this writing, each of the five countries had psychosocial services available at the community level. These are welcome and needed developments and should serve as models for other nations.

Summary
Much has been learned from the medical and public health aspects of the disasters that resulted from the earthquake and tsunami of December 2004. Of greatest importance is to realize that the main focus of efforts has to be at the community level. It will take decades for many to recover and return to their respective pre-event levels of functioning. For some, this will not be realized within their lifetime.

References


Table 27.1: Societal burden on the five countries produced by the earthquake and tsunami (total injured = number of injured who died + injured survivors)

<table>
<thead>
<tr>
<th>Societal burden</th>
<th>India</th>
<th>Indonesia</th>
<th>Maldives</th>
<th>Sri Lanka</th>
<th>Thailand</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total injured/10 000 population</td>
<td>0.168</td>
<td>13.540</td>
<td>30.333</td>
<td>19.940</td>
<td>2.304</td>
</tr>
<tr>
<td>Deaths/10 000 population</td>
<td>0.1</td>
<td>6.9</td>
<td>4.0</td>
<td>18.0</td>
<td>1.0</td>
</tr>
<tr>
<td>Injured survivors/10 000 population</td>
<td>0.068</td>
<td>6.540</td>
<td>26.333</td>
<td>11.940</td>
<td>1.304</td>
</tr>
<tr>
<td>IDPs/10 000 population</td>
<td>5.89</td>
<td>20.66</td>
<td>985.90</td>
<td>4663.21</td>
<td>0.92</td>
</tr>
<tr>
<td>Economic costs (US$ billions)</td>
<td>1.2*</td>
<td>4.0*</td>
<td>0.304–1.0*</td>
<td>1.5*</td>
<td>0.5–0.8**</td>
</tr>
<tr>
<td>GDP (US$ billions)</td>
<td>906.268</td>
<td>364.458</td>
<td>0.206</td>
<td>29.996</td>
<td>206.247</td>
</tr>
<tr>
<td>Costs/GNP (%)</td>
<td>0.13</td>
<td>1.10</td>
<td>147.6–485.4</td>
<td>5.0</td>
<td>0.2–0.38</td>
</tr>
</tbody>
</table>

**estimates: http://www.tdri.or.th/reports/published/n75.pdf; 10 Mar 09

Table 27.2: Societal burden on Aceh province, Andaman and Nicobar islands, and the state of Tamil Nadu, India (total injured = number of injured who died + injured survivors)

<table>
<thead>
<tr>
<th>Societal burden</th>
<th>Aceh province</th>
<th>Indonesia</th>
<th>Andaman &amp; Nicobar islands</th>
<th>Tamil Nadu</th>
<th>India</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total injured/10 000 population</td>
<td>707.83</td>
<td>13.54</td>
<td>140.50</td>
<td>1.73</td>
<td>0.168</td>
</tr>
<tr>
<td>Deaths/10 000 population</td>
<td>314.71</td>
<td>6.9</td>
<td>98.7</td>
<td>1.24</td>
<td>0.1</td>
</tr>
<tr>
<td>Injured survivors/10 000 population</td>
<td>393.12</td>
<td>6.540</td>
<td>41.80</td>
<td>0.49</td>
<td>0.068</td>
</tr>
<tr>
<td>IDPs/10 000 population</td>
<td>1025.6</td>
<td>20.66</td>
<td>1217.19</td>
<td>38.89</td>
<td>5.89</td>
</tr>
<tr>
<td>Economic costs (US$ billions)</td>
<td>4.1+</td>
<td>4.0*</td>
<td>0.8</td>
<td>0.8</td>
<td>1.2*</td>
</tr>
<tr>
<td>GDP (US$ billions)</td>
<td>1.4</td>
<td>364.458</td>
<td>1.435</td>
<td>700.</td>
<td>906.268</td>
</tr>
<tr>
<td>Costs/GNP (%)</td>
<td>292.9++</td>
<td>1.10</td>
<td>55.7</td>
<td>0.114</td>
<td>0.13</td>
</tr>
</tbody>
</table>

+ www.fao.org/docrep/008/j6992e/j6992e00.htm; 10 Mar 09
++ www.sudestasiatico.cpm/2007/03/06/aceh-una-spiranza-fallace/; 10 Mar 09
Part IV

Chapter 28

Conclusions and Recommendations
Conclusions and Recommendations

Introduction

Using the Frameworks outlined in Chapter 2 for this analysis helped to identify major gaps in the data available at the initiation of this project. The principal goals of this project were to discuss, as comprehensively as possible, the health aspects associated with the earthquake and tsunami of 26 December 2004, and to summarize this information in a book that could have value in developing future preparedness measures. It is important to emphasize that this discussion focuses on the perspectives of public health and medical care. Despite the many barriers described, a substantial amount of information has been accessed and analyzed. The processes and format selected have facilitated the comprehensiveness and synthesis of the available information. Prior to this project, many of the findings would never have been integrated.

During the analyses, two general aspects of the evaluation and research of disasters became apparent: (1) disaster epidemiology; and (2) disaster interventions. The study of the epidemiology of disasters requires research and should elucidate the pathophysiology of disasters so that they can be compared, while the evaluations of interventions should elucidate the achievement of the goals of the interventions as well as their effect and impact. Much was learned regarding the pathophysiology/epidemiology of disasters but, for the most part, little information could be obtained regarding the impacts of specific interventions/responses. However, it is clear that the supplemental supplies of potable water early after the events were successful in preventing deaths from dehydration. It also is clear that the public health interventions directed at prevention, detection of outbreaks, provision of immunization, and responses were very effective in preventing epidemics.

The conclusions reached from this analysis and the recommendations related to these conclusions follow. They are organized by major categories; the manner in which they are listed is not ranked by relative importance or priority.

Data, information, indicators, and reporting

Conclusions

1. No uniform definitions exist.

2. There was (and is) no universal repository for data/information collected; the material collected was widely dispersed. No annotated bibliography of important sources of data/information exists.

3. The mechanisms employed for the assessments, reporting, and storage of data/information were inadequate and not standardized. These factors limited the analysis and synthesis of the data and
information, and hence, the findings. A minimum, standardized set of indicators for the health aspects of this disaster was not used for the collection of data/information, thereby limiting the ability to compare what happened relative to established, pre-event baselines, differences between the five countries evaluated, changes related to interventions, or comparison with similar and/or non-similar events.

4. Although some sets of indicators have been proposed (HeRAMS, Sphere, TRIAMS, Initial Rapid assessment (IRA)), none have achieved universal endorsement or have been validated through multiple applications. No standardized format was used for the reporting of data/information acquired from assessments, and standardized, minimum sets of indicators were not used. Some of the data/information generated following the tsunami were collected by untrained persons using non-standardized tools/indicators and did not have any uniform structure.

5. Much important data were not accessible, thereby impairing the acquisition of some of the data essential for defining the epidemiology of the disaster.

6. Much of the data/information gathered initially following the earthquake and tsunami rapidly perished and became inaccessible. This necessitated the conduct of structured interviews to obtain information no longer available in written form or reports.

7. Much of the assessment data/information gathered by the NGOs was not shared.

8. A lack of coordination of data-gathering efforts led to repeated attempts to gather the same information by different assessors. This led to informant burnout and probably to inaccurate information.

9. There are no available indicators for describing absorbing, buffering, surge, or response capacities.

---

**Recommendations**

1. A uniform set of standardized definitions must be developed through the consensus of stakeholders and endorsement by the disaster/medical communities.

2. Minimum, standardized sets of indicators for the Medical Care and Public Health Systems must be developed, or currently available indicators must be validated, endorsed, and used for documentation in all phases (including pre-event) of every disaster. Endorsement should be achieved by consensus in a method similar to that used by the Sphere Project.

3. The endorsed minimum set of indicators should be incorporated into standardized forms (paper/electronic) that become part of a database for the specific disaster and become part of a comprehensive disaster health repository, such as or similar to that used by the Centre for Research on the Epidemiology of Disasters (CRED).

4. A disaster health repository must be established and maintained. It should contain all data acquired by governmental, inter-governmental, and non-governmental agencies that have relevance to any phase of the disaster. This repository should be linked to various repositories such as CRED (Centre for Research on the Epidemiology of Disasters), Regional Disaster Information Center (CRED) of the Pan American Health Organization and, the National Library of Medicine.

5. A readily accessible pre-event inventory should incorporate information on all societal functions according to the orientation of Basic Society Systems (BSSs) defined by the Guidelines. This pre-event inventory is required for potential responders and must include sub-national (including community) information.

6. A standardized structure must be developed and endorsed for reporting studies into...
disasters according to: (1) epidemiology; and
(2) interventions.

7. An agreement that open sharing of
assessment data/information must be a
pre-condition to the deployment of any
organization into disaster areas.

8. To prevent unnecessary duplication and
informant burnout, sampling strategies for
the collection of data/information must
be endorsed by a legislatively established
coordination and control agency.

9. Disaster collection templates should
become standard operating procedures for
data/information collection during every
longitudinal phase of a disaster. The templates
should be used repetitively for assessments
and identification of gaps in the available data
and information.

Use of data collection templates
In order to enhance the future collection
of epidemiological data before, during, and
following a disaster, several templates have been
devised using the experience obtained from
this project. The use of these templates should
help to fill the important gaps in the information
that became apparent during this analysis.
These templates (Figures 28.1–28.4) expand
the conceptual framework of the Guidelines
that was used in this analysis. Collation of the
data collected using these tools will facilitate the
development of a better understanding of the
pathophysiology (epidemiology) of disasters, and
can help to link some of the indicators essential to
comprehensive data collection. The format used
in these templates is in the style of the Utstein
Templates that have been applied for the analyses
of cardiopulmonary arrests as promulgated by
the European Resuscitation Council\textsuperscript{7} and the
American Heart Association,\textsuperscript{8} and the consensus
template for physical injuries caused by external
forces.\textsuperscript{9} Their routine use could form the basis
for the organization of the data/information that
is necessary to gain an understanding of disasters.
Use of these suggested supplemental templates
(Figures 28.1–28.4) will provide greater detail
in the application and use of the frameworks.

During this analysis, attempts to insert the
available data for the indicators in each step of
the respective templates highlighted some of
the major gaps that impeded analysis and the
subsequent development of conclusions and
recommendations. It also became apparent
that a more comprehensive set of indicators is
required for future analyses. A compendium of
the indicators used herein is in the Appendix.
As one fills in the information required in these
templates, reasons for the entry should be
annotated in a form such as that suggested in
Table 28.1.

Hazard to loss of infrastructure functions
(Template I)—The first of these Utstein-style
templates uses indicators that describe the
progression of a hazard through the structural
damage to the losses of function of any
infrastructure (Figure 28.1). This Infrastructure
Template follows the progression from a hazard
and examines the impact of an event caused by
the hazard on a particular infrastructure exposed
to the hazard. It may be valuable for assessing an
entire area-at-risk, a small area within the area-at-
risk, or even a solitary structure such as a hospital
or clinic. Its use should help to define the impact
of an event upon an infrastructure of the area-at-
risk and help to define potential burdens created
by a similar future event. Thus, if the magnitude
of the event is known (or estimated), it should
be possible to assess the absorbing capacities of
the natural environment and built infrastructure.

Using this Template for Data Collection for
any of the Basic Societal Systems (BSS) or their
component(s) could assist in identifying the
differences between damaged and non-damaged
infrastructure. Its use also could assist in assessing
the proportion of the irreparable infrastructure
compared to repaired/damaged infrastructure.
Lastly, use of this Template should provide
estimates of the functional status of infrastructure
that was not destroyed, and estimations of the
respective buffering capacities for a given amount
of structural damage. Its use could be applicable
in assessing any area or sub-area of interest
and could facilitate the identification of existing differences between them.

**Progression of hazard to loss of function of healthcare facilities**—The Infrastructure Template (Figure 28.1) is expanded for the documentation of the impact of an event on a specific medical facility or a portion of the medical facility (e.g., an intensive care unit, operating suite, or an emergency department), a group of medical facilities in the areas impacted, or at a country or region impacted (Figure 28.2).

The capacity of a healthcare facility to resist structural damage from an event of a given magnitude provides important information about the absorbing capacities of the structure(s). The template outlined in Figure 28.2 should be useful for understanding the ability of a medical facility(ies) to continue to function following or during an event. However, the ability of the impacted healthcare facility to continue to function not only is related to the absorbing capacity of the physical structure (including equipment and supplies), but also to the impact of the event on the staff and their ability to report for duty. Numerous examples of the inability of medical facilities to provide necessary services occurred in the countries affected by the earthquake and tsunami. This was true even prior to the events, and was exacerbated after the events when they were unable to manage the surge associated with the numbers of injured victims. Injured staff may be physically or mentally unable to function in their respective roles. Uninjured or minimally injured staff may not be able to reach the medical facility due to failures in the Transportation and Logistics System and/or the Public Works and Engineering System and/or they may have other obligations such as caring for their families or searching for missing or dead loved ones. Regardless of the functional condition of the physical structure of the medical facility, its functional status may be compromised without adequate staff.

Use of this template also should facilitate documentation of the impact of the surge of patients on the functional state of the facility and the effectiveness of its response capacity. Services that could be provided before the surge of patients may not be available for all of the patients in the surge due to shortages of personnel, equipment, and/or supplies.

**The Injury Template**—The third in this series of Utstein-type templates should be helpful for defining the medical burdens on the affected population and provides a structure for evaluating the human toll from the event (the Injury Template, Figure 28.3). This template could be used to assess injuries for any region, the country as a whole, the area-at-risk, or even for an individual healthcare facility, as diagrammed in Figure 28.2. In this template, the “area/facilities-at-risk”, was replaced by the “population-at-risk” and “Infrastructure” was replaced by “population”. Generally, not all of the population-at-risk is exposed to the event. The population-at-risk defines the potential burdens that could result from an event and the population exposed defines the potential burden on the society. The population “affected” is the proportion of the population exposed, while the population “injured” provides the burden of injuries on the population-at-risk. For example, a remarkably small proportion of the total population of India and Thailand actually was exposed to the earthquake and tsunami. Thus, the resources available in these countries to cope with the human damage were much greater than were those available in the impacted areas of Indonesia, Sri Lanka, and the Maldives. Therefore, the proportion of the population-at-risk that was exposed to the event or in the cluster being studied must be defined, and the reasons that the population was or was not exposed identified.

Additionally, not all of the population exposed is affected by an event. A set of indicators that define “affected” remains to be identified; the term carries multiple, conflicting definitions that must be resolved. The reasons that some populations were or were not affected by an event should be defined during data collection. The proportion of the population affected helps to define the relative health burdens created by the event.
It is essential to identify the proportion of the affected population that actually was injured by the event, and it is imperative that the reasons that the proportion of the exposed population was injured be identified. This should facilitate a comparison of the outcomes from the injuries with those of other victims as well as those caused by other events. It is in this way that measures that can mitigate the damages sustained from an event of a given magnitude can be identified, implemented, and tested.

Some of the injured population die almost immediately after sustaining their injuries, while others survive; the reasons for these differences in outcomes are important. Even from sudden-onset events, not all of the deaths occur immediately. Of those victims who initially survived their injuries, some will have sustained life-threatening injuries; the survival from such injuries is an indicator of the functional status of the components of the existing Medical Care System. It is important to assess the delayed deaths and the complications from injuries as well as the deaths and morbidities indirectly related to the event. Identifying the level of morbidity related to the event is essential and can be a reflection of the care delivered and the robustness of the Public Health and Medical Care System of the impacted society. All of these factors must be compared with the pre-event status of the Public Health and Medical Care Systems as well as the other systems upon which they are dependent or interdependent.

The available data following the earthquake and tsunami were entered into the Injury Template as depicted in Figure 28.4. Much information could not be found and entered into this template, and reveals major gaps in the available data. However, they should be part of future data collection efforts. It should be clear that these gaps significantly impaired the ability to understand the epidemiology of the disaster.

Despite the inability to retrospectively gather all of the data required to complete each of the templates for each of the areas impacted by the events of 26 December 2004, the use of these templates facilitated the organization of the information available and helped to identify the gaps in information that are crucial to comparing the damage and losses of functions created by future events. These templates resulted from the attempts to bring this material together, and it is suggested that they be used as part of standard data collection instruments and that as the data/information are collected, they should be maintained in a secure database that is readily accessible.

The lack of information has made it difficult, if not impossible, to project some of the findings into recommendations for the preparedness of the Public Health and Medical Care System, or for the measures that will be necessary to mitigate the severity of injuries that could result from the next events, nor has it been possible to determine the impact of chronic diseases on the vulnerability of the victims to the forces exerted by the earthquake or the tsunami. The respective abilities of the national healthcare systems to provide care for the most vulnerable of its citizens or for the visitors to the respective countries are not apparent.

**Events Conclusions**

1. The indicators used to describe the magnitude of the events that occurred were not adequate to provide an understanding of what actually occurred. The amplitude of the earthquake using the Richter Scale and the wave height and run-up of the tsunami provided only a portion of the required information of the actual forces involved. Furthermore, the terms that were used were too broad and did not reflect the variations in the forces that occurred at different sites. In general, information regarding the actual number of waves and their respective heights for specific areas impacted could not be found.

2. Other than the overall view of the events, it was not possible to identify the forces involved in smaller segments of the whole
event. Thus, it was not possible to separate the major events into smaller units for a more in-depth analysis.

**Recommendations**

1. A comparative scale that represents the magnitude of an event that correlates with the amount of structural damage that occurred should be developed. Such a scale would facilitate comparisons between events.

2. Continued efforts should be directed towards identifying the effects of the earthquake in those areas that were not directly impacted by the tsunami.

**Structural Damage**

**Conclusions**

1. Other than the Richter Scale and duration of earth movement, none of the available indicators of the magnitude of the events correlated with the structural damage sustained, or facilitated a comparison of these events with other similar events.

2. Overall, it was not possible to identify the amount/type of structural damages that were the result of the massive earthquake. For the most part, damage data/information have been related only to the tsunami. The only information of the structural damage from the earthquake was a minor report from the Andaman and Nicobar Islands. Data were not available from areas of Indonesia impacted by the earthquake, but not by the tsunami (e.g., areas of Banda Aceh away from the shore). A window of opportunity was missed that would have facilitated identification of the effects of the largest earthquake in more than 40 years.

3. Cluster sampling techniques (each affected country comprising a cluster) were used in the application of the Modified Mercali Scale for estimating the magnitude of the shaking from the earthquake between the countries. The Mercali Scale indicated that the earthquake was only a major contributor to the damage in Indonesia and the Andaman and Nicobar Islands of India; the damage created in the other countries was the result of the tsunami.

4. The absorbing capacity of the areas impacted was inadequate to mitigate much of the structural damage from the extreme magnitude of the energy released by the events. The absorbing capacities were the poorest in areas plagued by civil unrest (Aceh province and northeastern Sri Lanka), but the magnitude of the events also was the greatest in Aceh province. In addition, there was no warning. No indicators are available to describe the absorbing capacity of impacted structures.

5. There were remarkable differences in the absorbing capacities of some of the structures that remained standing compared to those that were destroyed by the events.

6. Some work by WHO indicates differences in structural damage in the various districts and cities in Aceh province. There were substantial differences in the damage produced within the same province of Indonesia. Unfortunately, cluster sampling of damage was not available. Thus, the clusters used in this work consisted of the different countries and the magnitude of the events. More could have been learned if the countries had been evaluated using smaller areas within each country (cluster approach) that would have facilitated separating a single large event into multiple smaller events. Cluster analysis may have allowed linking the magnitude of the forces from the events with structural damage.

7. It was difficult, and often impossible, to gather data on structural damages to medical facilities other than in Indonesia—no standard damage assessment tools were used.

8. Again, it was demonstrated that initial rescue efforts were provided by bystanders and that, for the most part, international search
and rescue teams arrived too late to recover many living persons trapped in the rubble.

9. It was not possible to establish the mechanisms or causes of death; findings had to be generalized from small inventories and extrapolation. Autopsies conducted in Thailand primarily were for the purpose of victim identification and not for the determination of causes of death. In part, this was due to the fact that substantial decomposition of the bodies had occurred by the time the forensic examinations were performed, although a heroic effort to provide refrigeration facilities was made by Normeca.10

10. Regarding the physical damage to humans:
   • It was not possible to determine how many of the deaths were due to life-terminating or life-threatening injuries in victims who were unable to reach definitive care in time to be saved;
   • Neither the lay population nor the military were educated/trained in life-supporting first aid. It is not known whether the application of such training would have saved more lives given the circumstances;
   • Individuals with chronic diseases, children, the elderly, and women were more vulnerable to the forces exerted by the events. In part, this vulnerability was related to their relative overall strength and the inability to hang onto fixed objects;
   • It remains unclear as to the number of deaths that were related to the damage/destruction and losses of function of the healthcare facilities;
   • Many of the dead were transported to the medical facilities, which unnecessarily increased the surge demands on the medical facilities; and
   • It has not been possible to determine the number of deaths that were related to complications of injuries that were inadequately diagnosed or treated due to compromised staffing and/or experience or insufficient amounts and types of equipment and/or supplies, and/or the inability to evacuate injured victims to higher level medical facilities.

Recommendations

1. Attempts should be made to link geographical or functional clusters of structural damage (human and built) to the magnitude of the events.

2. Future analyses should encompass cluster sampling in order to partition a single event into multiple events.

3. A set of indicators to define absorbing capacity should be developed. Such indicators could be most useful in the development of preparedness measures.

4. Future analyses of disasters should attempt to identify the mechanisms of injuries and the causes of deaths associated with the event.

5. Standardized indicators of damage should be developed, and their respective construct validity should be tested. Perhaps the PAHO Hospital Safety Assessment Inventory could serve as a source of such indicators for health facilities.11

6. Disaster response plans must include measures for handling dead victims in order to prevent the dead from being conveyed to medical facilities.

7. Education and training of the lay public, in particular school children, in life-supporting first aid (LSFA) and measures to protect oneself from harm has a high probability of averting many deaths. Therefore, the education and training of the lay public and public servants in these skills should be mandated by every country. This training should be matched with the findings from the hazard-vulnerability assessments.
8. Information should be gathered about how and when the deceased victims succumbed. Efforts then can be directed to developing potential mechanisms (including LSFA) to minimize the numbers of preventable deaths.

9. Complications from injuries in Stage III of the longitudinal stages of death (see Chapter 27) must be accounted, and the causes of death must be recorded. Use of the templates suggested in this document should assist in this process. Accurate record-keeping must be mandated and supported, included in the disaster response plan (DRP), and prioritized as a mandate to incoming relief agencies.

10. Strict building codes for hazards must be established and enforced.

11. Permanent structures must be located sufficiently distant from the shore.

12. Mechanisms for the easy documentation of information must be developed and tested during actual disasters.

Burdens

Conclusions

1. The determination of the burdens (numbers/10 000 population) highlighted the differences in the burdens that occurred between countries and between areas within countries. Four major types of burdens were identified: (a) societal: (i) care of the dead; and (ii) psychosocial; (b) medical: (i) injured; (ii) primary health care; and (iii) complications; (c) public health: (i) migrations/IDPs; and (ii) detection and response; and (d) economic.

2. Although the dead present a burden to the affected society, they should not constitute a medical burden. Following the earthquake and tsunami, the dead presented a huge psychosocial dilemma and created a major burden in terms of victim identification, particularly in areas with high tourist densities. While it was not possible to preserve the bodies for post-mortem analysis, post-mortem identification of the victims could be performed. Thailand was particularly active in disaster victim identification processes and requested substantial forensic help from the international community. There was no evidence that the corpses created a public health burden.

3. The determination of burdens helped to identify the full impact of the events on the affected country. Even though the actual numbers of people injured and the numbers of injured who were killed or permanently missing were the lowest in the Maldives, Aceh province of Indonesia, and the Andaman and Nicobar Islands of India, they experienced the highest medical burdens.

4. The greatest burdens created by IDPs occurred in Sri Lanka; Sri Lanka had 400 000 IDPs before the tsunami arrived.

5. Changes in specific burdens may be a useful method for evaluating the impact of interventions. Unfortunately, it was not possible to determine the impacts of specific interventions in this analysis.

6. Although it appeared that Thailand handled the medical and public health aspects of the disaster the best of the five affected countries, it also experienced the lowest burdens of any of the countries studied.

Recommendations

1. Corpses should be managed away from medical facilities and should not constitute a burden on the medical facilities.

2. The determination of burdens (numbers/10 000 population) rather than the use of absolute numbers should be used in analyses and prioritization of interventions.

3. Relative burdens should be incorporated into assessments of the impact and performance of responses (interventions).
Assessments

Conclusions
1. In general, there were few records of assessments performed and the subsequent interventions implemented based on the needs determined from such assessments.

2. No standardized assessment forms/databases were available or were used.

3. Results of conducted assessments often remained parochial and were not shared with other stakeholders, including Coordination and Control (when and where it existed). This resulted in unnecessary duplication of efforts, and in some instances, interventions that did not match the needs of the affected population.

Recommendations
1. The assessments and determination of needs and the documentation of the impact(s) of the interventions in achieving the objectives and contributing to the stated goals must be shared with Coordination and Control and with other stakeholders.

2. Minimum standardized data collection forms must be developed, validated, tested, and their use mandated.

3. Donors and aid agencies must be educated in the value of assessments regarding their ability to contribute to quality improvement. All stakeholders as well as beneficiaries, can profit from well-done assessments.

4. Some assessments of damages and changes in levels of functions must be conducted concurrently with responses.

Evaluations of interventions/responses

Conclusions
1. In general, little information could be obtained relative to specific public health or medical care interventions provided.

2. Those outcomes of interventions that could be accessed generally consisted of achievement indicators (e.g., the number of immunizations achieved, number of procedures performed, number of persons who responded), and did not include the impact(s) on the affected society.

3. Little information that could be tracked was available on the processes used before or during the interventions. Critical points of success/failure in the processes used could not be identified.

Recommendations
1. Evaluations of each intervention implemented must be performed, documented, and available for review or the lessons observed will not be learned.

2. Evaluations of interventions must focus on measures of impact on the intended beneficiaries, and not on achievement indicators.

3. Donors must insist that evaluations of the impact of every intervention be a part of the projects that are funded.

4. Process analysis for each intervention is essential in order to identify critical points of success and critical points of failure. Successful processes must be codified and added to the science, and critical points of failure should be noted or the process should be abandoned. These analyses must be documented and added to the science of disaster health.

5. Independent evaluators should be used to conduct evaluations of interventions.

6. Donors should support the conduct of evaluations in an effort to ensure that their respective investments are cost-effective.

7. The success of any intervention should be determined relative to the objectives for which it was implemented, whether it contributed
to attainment of the established overall goal(s), and documentation of the other effects of the intervention, and whether they were beneficial or detrimental to the affected society.

Public Health Systems

Conclusions

1. The application of the principles of public health was successful in preventing the development of public health emergencies. No epidemics were detected; minor outbreaks of diseases that were related to the earthquake and tsunami were contained.

2. Regional coordination of public health activities by WHO-SEARO was outstanding. Its efforts resulted in the matching of resources (human and material) with the needs and available resources (human and material) of the national governments.

3. As best as can be determined, the actual incidence of infectious and chronic diseases decreased below baseline levels following the tsunami. This may have been a function of the public health activities and/or may have been related to the earthquake/tsunami-caused deaths of many with these diseases.

4. Indirect deaths were not accounted.

5. A very rapid exodus of persons who initially sought refuge in IDP camps occurred, thereby decreasing some of the burdens on the Public Health Systems.

6. Many of the improved public health services brought to bear following the tsunami have been sustained, and the public health capabilities and capacities of each of the countries are vastly improved.

7. Some public health interventions provided may not have been necessary, i.e., massive cholera vaccinations in Indonesia.

8. The tetanus outbreak in Indonesia was mainly a manifestation of the poor immunization rates that existed prior to the earthquake and tsunami. It remains unknown how many persons succumbed to tetanus who never reached medical facilities.

Recommendations

1. Regional, country, and local syndromic surveillance capabilities and capacities should be optimized. Regional resources should be made available to supplement national resources.

2. Policies and procedures should be in place to address all types of public health emergencies.

3. The incidence of diseases, injuries, and deaths, including deaths not directly related to the precipitating event, must be accounted so that the epidemiology can be defined, corrective actions taken; preparedness measures must become part of DRPs and public health actions.

4. Immunization of populations-at-risk must be optimized.

Medical Care Systems

Conclusions

1. Medical Care Systems are heavily dependent upon the services provided by other Basic Societal Systems.

2. The ability of medical facilities and hospitals to provide adequate medical care was difficult to assess. However, it is clear that the ability to provide medical care was related to several factors:

   a. Absorbing capacity—Structural damage/destruction of the healthcare facilities, damage to equipment, failure of vital systems, including loss of electrical power without backup generating equipment that led to the inability to provide energy for lighting and temperature control of the operating rooms, breaks in the cold chain and inability to store blood and blood products, vaccines, and pharmaceuticals, interruption or
contamination of life lines, damage to equipment and supplies, including water, pharmaceuticals, inability to sterilize equipment, etc. That compromised the functionality of the medical facilities. In each of the countries studied, the structural absorbing capacity of the primary care facilities was the lowest of all of the structures in the Medical Care Systems; and there did not seem to be any differences in the structural absorbing capacity of the primary care facilities in any of the countries studied. Few of the tertiary care centres were damaged as, generally, they were located further inland. The relative absorbing capacities of the secondary and tertiary care facilities also could not be differentiated. In each of the countries, medical facilities were damaged/destroyed, and patients and staff were killed by the events.

b. Buffering capacity—With the exception of Thailand, there was a shortage of essential medical personnel in the early period following the events. Many healthcare personnel sustained injuries from which they succumbed. In addition, many staff could not access the facilities due to lack of transportation or the destruction of roads etc. Some personnel stayed away from the medical facilities in order to provide care for their families, search for missing loved ones, or were psychologically unable to work. Thus, most of the healthcare facilities impacted were unable to function even at their pre-event levels, much less absorb the surge of patients requiring immediate medical care. Medical supplies were rapidly depleted, although the impact of deficient equipment and supplies on mortality could not be determined.

c. Response capacity—In Indonesia, Sri Lanka, and the Maldives, medical reinforcements from the outside arrived too late to provide urgent surgical trauma care to the victims; it seems that many victims with potentially survivable injuries may have succumbed by the time the reinforcements arrived. In Aceh province, Sri Lanka, and the Maldives, essential supplies could not be replenished as a result of failures of the Transportation and Logistics and the Public Works and Engineering Systems including damaged and destroyed infrastructure, as well as injured and killed drivers. These failures also compromised the distribution of abundant donated supplies that piled up at points of entry.

3. Medical facilities also were besieged by victims with less severe injuries whose care could have been delayed or diverted to other medical facilities or alternative care sites (failure of triage).

4. At least one alternative care site was established in Thailand; however, it was established before adequate supplies and equipment were made available. Thus, the staff of this facility was only able to provide rudimentary life-supporting first aid. India and Thailand sent medical personnel into the field to treat victims, and thus, diverted some of the less seriously injured away from the hospitals or treated their injuries in the field. These countries also experienced the lowest injury burdens.

5. Triage conducted by the Indian and Thai medical personnel in the field diverted injured victims with non-life-threatening injuries (yellow) away from the hospitals; victims were treated and released in the field or sent to clinics or alternate care sites. However, given the extraordinarily high percentage of the injured victims in Tamil Nadu who succumbed to their injuries, the impact of such activities must be questioned.

6. The continuous functioning of the surviving medical facilities was compromised because of their heavy dependency on the functional
state of other Basic Societal Systems. Since coordination and control was not effective, at least early on, the medical facilities had to compete for the services of the other systems upon which they were dependent. Stockpiles were insufficient, and there was little available buffering capacity.

7. Other than the need for debridement and drainage of infected wounds, repair of fractures, and improvement of immobilization methods used, there was a rapid shift from the needs for trauma care to the needs for primary healthcare services. The field hospitals that were established assisted in providing primary care services that the local resident medical services were unable to provide. In some instances, the incoming medical personnel assumed control of the existing medical facilities to the exclusion of the locals.

8. The three hospital ships that responded arrived too late to provide initial, lifesaving care, and provided primary and secondary medical care services, some of which could not be sustained following their departure.

9. When possible, patients with serious, even life-threatening complications were evacuated to medical facilities outside the areas directly impacted. However, records of such evacuations were not obtained nor could the impact of such evacuations be discerned.

10. Limb amputations were performed in efforts to prevent life-threatening complications. The numbers, effectiveness, and impact of such amputations could not be defined in any of the countries.

11. Field hospitals mostly provided primary care services that could not be delivered at the local facilities. Local facilities could not maintain the level of services provided pre-event. The exact contributions of field hospitals could not be determined; surgical procedures were provided in an effort to prevent complications.

12. The numbers, arrival times, and nature of the injuries of the victims that arrived at functional medical facilities were difficult to ascertain. Therefore, the magnitude, time, and nature of the surge of injured on the Medical Care System could not be quantified. This prevented the ability to provide recommendations on how to do it better next time.

13. Migration of the populations shifted the catchment areas for the functional medical facilities. As populations shifted, alternate sites for the provision of medical care had to be developed and staffed. Initially, much of the care for these populations was provided by national/foreign field hospitals and clinics.

14. In the immediate period following the tsunami, there was a greater shortage of nurses than of physicians.

15. During disasters with massive numbers of casualties who have sustained life-threatening injuries caused by sudden-onset events, most victims will succumb to their injuries. With superb medical care, only a very small proportion may survive. Furthermore, addressing the surge capacity with off-duty personnel may be impossible due to injuries (physical and psychological) to supplemental staff or their inability to reach the medical facilities.

Recommendations

1. Responding organizations should only provide the levels of care that were standard in the region during the pre-event phase. They should not provide care that will not be sustainable after their departure.

2. The absorbing capacities of the structures of all medical facilities must be optimized for the hazards to which they are exposed. This includes not only the physical structure, but the equipment and supplies as well. Special attention must be directed to preventing damage to essential services, i.e., lifelines,
electrical power, environmental control, sterilization procedures, shelters, and sustenance for personnel (staff) and their families.

3. The integrity of the components of the buffering capacity must be maintained including the functional state of generators, oxygen supplies, anaesthetic gases, water, food, etc.

4. Internal backup supplies must be available to support the essential functions of a medical facility including those required for the anticipated surge (surge capacity) for a period of at least one week. Just-in-time methods of supplying essential supplies must be modified to exclude essential supplies needed to meet the demands in accordance with known hazards. Mechanisms must be developed to sustain the capacity of the facility for continued, uninterrupted provision of essential services that also will meet the needs generated by the surge of injured/ill victims.

5. Disaster response plans must include the identification and preparation of alternate care sites.

6. The criteria for shifting from "usual care" to "crisis care" must be defined, as well as when and how the shift should occur. This requires education and training of staff and the ability to task-shift to personnel with lower overall competencies, e.g., manual ventilation when a shortage of available mechanical ventilators occurs.

7. Victims with non-life-threatening injuries should be diverted from hospitals to alternate care sites.

8. When needed, field hospitals should be established to provide primary healthcare services that no longer can be provided by a damaged medical facility. Field hospital staff should be prepared to provide primary care services and be able to mitigate life-threatening complications rather than provide life-saving services.

9. The Coordination and Control Centre within a medical facility must keep the local Coordination and Control Centre (Emergency Operations Centre) informed of its current functional state (including capabilities and capacities).

10. Medical facilities should establish an internal Coordination and Control entity.

11. Accurate and comprehensive medical records must be initiated and sustained for every patient assessed. These records must contain the time of arrival of rescuers (if applicable) following the injury, the time of initial assessment (pre-hospital and in-hospital), time of arrival at the facility, and how the victim accessed the facility.

12. The development and use of a Medical Reserve Corps consisting of retired medical and other personnel should be considered.

13. All medical facilities should take measures to provide for the health and comfort of their staff and their families in times of crisis. Such preparations will enhance the willingness of staff to work long hours when deemed essential.

14. When possible, personnel with pre-hospital triage and life-supporting first aid competencies should be dispatched into the field to triage survivors with non-life-threatening injuries away from the hospitals to alternate care facilities, or to treat and release those with minor injuries.

15. Plans should include the probability that expatriate medical personnel will provide primary health care and most likely will not arrive in time to provide life-saving surgical interventions.
16. Local medical staff must remain in control of all medical activities unless they voluntarily relinquish control to external medical staff. Local staff should be involved in all medical actions.

17. The DRP must identify a realistic process for the discharge of less severely ill inpatients and/or the transfer of such patients to other medical facilities. As the transfer of patients requires transportation, facilities for such actions (e.g., provide own transport facilities) should be part of the normal functioning of medical facilities.

18. Patients with potentially life-threatening or actual life-threatening complications should be transferred from the impacted areas as soon as their conditions permit. The military may have the resources available to perform this task; arrangements to mobilize these resources should be part of the DRP.

19. The capacity and capability to provide care at alternate care sites must be available to meet demands caused by population migration.

20. Disaster response plans must include the likelihood that shifts in the locations of the population are likely and victims may not be able to access fixed sites.

21. Given that considerable portions of the staff may be unable to reach a given medical facility, alternative means of meeting the surge of life-threatened victims must be sought and integrated into the disaster plans.

22. The medical care provided should be consistent and appropriate to the culture in which it is delivered and with pre-event medical practices.

Mental Health

Conclusions

1. The stresses on the affected survivors were extreme and resulted in depression and, in some instances, the development of the Post-Traumatic Stress Disorder. In addition, the support mechanisms usually available to the population were severely compromised due to injuries, deaths of religious leaders, and the loss of the religious symbols including mosques. Extraordinary attention was paid to those suffering from the psychosocial consequences related to the damages; this included efforts on the part of many expatriate mental health workers. However, the credentials of some of these responders could not or were not verified, and several actions by some of these “volunteers” may have contributed to increased emotional distress of the affected victims.

2. Many individuals who were self-sufficient before the events of 26 December became dependent on others after the events.

3. Major role shifts within the family structure were required and added to the stress.

4. In Thailand, trained community mental health workers were distributed throughout the country prior to the tsunami. After the events, they were very successful in containing the emotional problems at the community level; the System has served as a model in each of the other countries and now each has developed community-level mental health resources. It is anticipated that many of those stricken will never return to normal lives. Potentially, this problem may take several generations to heal.

Recommendations

1. Communities should have the capabilities and capacities to provide emotional support to survivors and to recognize serious psychological problems. The Community Mental Health Workers in Thailand should serve as a model for enhancing the capabilities and capacities to provide emotional support and triage of those severely handicapped.

2. The competencies of responders attempting to provide mental health...
services should be confirmed before deployment.

3. Task-shifting (sharing) for specific assessments and interventions should be considered.

Coordination and Control

Conclusions

1. During the relief phase of the disaster, there was little, if any, provision of coordination and control of the Medical Care System by the governments of Indonesia, Sri Lanka, and the Maldives from the community through the national levels.

2. The Medical Care and Public Health Systems were highly dependent upon other Basic Societal Systems, i.e., Water and Sanitation, Shelter and Clothing, Energy Supply, Public Works and Engineering, Transportation and Logistics, Food and Nutrition, Communications; therefore, they were dependent upon coordination and prioritization of the resources needed for patient care and for the prevention of disease outbreaks/epidemics. This required an operational, high-level coordination and control structure that could ensure the availability of the resources needed to prevent unnecessary deaths, pain, and suffering. The damage to the other BS Systems and the absence of a single, designated coordination and control agency with the mandate, authority, and resources in Indonesia, the Maldives, and Sri Lanka prevented the Public Health and Medical Care Systems from operating optimally. The effects of this competition for resources on potentially preventable deaths remain unknown. Donors must insist that evaluations of the impact of every intervention be a part of the projects that are funded.

3. The performance of assessments by/for the Medical Care Systems in Indonesia, Sri Lanka, and the Maldives became haphazard, and often, some of the assessments performed by NGOs were not shared between NGOs or with governmental or inter-governmental agencies. Furthermore, there were no standardized assessment tools used and often, no trained personnel to perform the assessments or personnel with sufficient competencies to determine and prioritize the needs. Unfortunately, this led to uncontrolled aid and assistance, excessive supplies of resources that were not needed and/or piled up at points of entry, inappropriate supplies to meet defined needs, misdirected resources so that they were not available where they were needed, competition between responding organizations, duplicate responses, and unnecessary costs. A number of these responses actually were counter-productive. Some of the donated materials/supplies were not labeled or were labeled in languages that could not be interpreted, or had passed their date of expiration. Often it was impossible to gain access to the transportation resources needed to move personnel, supplies, and equipment to where they were needed most. Although responses in India and Thailand seemed better coordinated and controlled than in the other countries, this must be viewed with the consideration that the health burdens of these two countries were of a substantially lower order than were those in Indonesia, Sri Lanka, and the Maldives.

4. With the assistance provided by WHO-SEARO, Public Health Systems at the country and sub-country levels were able to augment the surveillance capacities and capabilities of the countries, assist in the assurance of the quality of water and food, the competence of the sanitary systems, the containment of the relatively minor outbreaks that occurred, and the enhancement of the immune status of many who were most vulnerable. The public health activities were coordinated through WHO-SEARO in association with the respective WHO country offices and national governments.

5. In Indonesia, Sri Lanka, and initially in the Maldives, no mechanisms were in place to
verify the credentials of individuals entering the countries or the capabilities and capacities of the aid agencies.

6. In general, representatives of the affected population (beneficiaries) were not included in the planning processes, and often, were excluded from participating in the responses. This resulted in many interventions that were wasteful or not in tune with the culture of those affected.

7. Prior to the tsunami, no single agency within the national government in Indonesia, Sri Lanka, and the Maldives was legally vested with the mandate, authority, AND the resources to provide the coordination and control of the responses. In addition, there were no established processes for demonstrating accountability for the responses; and responding organizations/persons were not required to register or to be accountable for their actions. Likewise, there were no consistent relevant policies or procedures in place before the tsunami in Indonesia, Sri Lanka, or the Maldives. However, such policies, procedures, and the legal designation of responsible agencies with the resources and authority were present in India and Thailand. Thailand had conducted a country-wide disaster exercise within a month of the tsunami.

8. Military rule existed in Aceh province prior to the earthquake and tsunami, and the military was present at the time of the events. Conflicts arose as to who was in charge, and became exacerbated with the arrival of foreign military units. Issues arose as to accountability and control. Support provided by the military was limited, as the personnel had not been educated and trained in the provision of life-supporting first aid.

9. Indonesia, Sri Lanka, and the Maldives have developed enhanced coordination and control mechanisms, legislation, and resources for better preparedness for future events.

**Recommendations**

1. Mechanisms for the provision of Coordination and Control including policies, procedures, mandate, authority, and resources must be part of preparedness at all levels.

2. The capabilities and capacities of Coordination and Control personnel must be optimized through education and training, including the use of drills/exercises. Table-top exercises should be conducted frequently at all levels. The development and use of standardized sets of exercises that deal with each of the hazards present in the areas may be helpful.

3. All arriving organizations must be registered and assigned locations for implementation of their activities by Coordination and Control.

4. Open entry for all who wish to assist must be eliminated.

5. Coordination and Control is responsible for all the assessments conducted and for the results of these assessments.

6. The activities of all incoming organizations must be assigned by the most appropriate level Coordination and Control agency so as to be able to meet identified or anticipated needs.

7. Data acquired from all assessments must become the property of Coordination and Control. Acceptance of this condition must be a requisite for the provision of all services, equipment, and supplies. Ultimately, Coordination and Control is accountable to the government for its actions while all responders are accountable to the appropriate Coordination and Control agency. Coordination and Control must have the authority to mandate the use of standardized data collection forms.

8. Coordination and Control must have access to the appropriate representatives of all stakeholders. Stakeholders include
the affected population, government, inter-governmental organizations, non-governmental organizations, and for-profit organizations operating or planning to operate in the disaster zone.

9. Performing evaluations of all interventions implemented must accompany each and every intervention; the agreement to conduct such evaluations must be a pre-requisite component for every intervention. The focus of the evaluations must be the short-, medium-, and expected long-term impacts as well as all other effects created by the specific intervention. The reasons for the success/failure of each intervention must be part of every evaluation.

10. A credentialing and accreditation process must be developed and implemented for all responders and responding organizations. Ideally, the responding organizations must be responsible for the competencies of their members. Responding organizations should be accredited to do what they propose to do.

11. There must only be one organization vested with the Coordination and Control function at each specific level of operations (on-scene, local, district, state/province, national). A hierarchy of Coordination and Control agencies must be part of every disaster response plan.

12. Disaster response must become a documented and practical part of the mission of the military. Responsibilities and relative authorities of the civil and military components must be defined by the respective governments prior to any emergency and appropriate military personnel must be trained in disaster response interventions.

13. Supplies from outside the affected country must be limited to those that will meet a defined need. Countries must be able to say: “Thank you, but no thank you.”

14. Coordination and Control is the responsibility of the national government and should be a functional, working unit on a 24 X 7 basis. Coordination and Control should be responsible for risk reduction as well as for planning/preparedness for recognized hazards and for coordinating responses. These responsibilities include the development and critiques (lessons learned) of drills and exercises.

15. The credentialing of responding individuals should be the responsibility of the responding organizations; organizations should be accredited by the national governments (or by an internationally appointed organization) for what they can provide, and, for international responses, by the WHO Regional/HQ offices before providing responses.

16. The education and training of the lay public in the provision of life-supporting first aid and self-safety must be mandated by the respective governments.

17. Agreements between civil society and the respective military organizations must be part of the disaster response plan for each country.

18. Disaster planning for Coordination and Control must be the legal responsibility of national governments.

19. For international health responses, the WHO Regional Offices should be the hub of activities within their Region and should provide Coordination and Control of public health and medical care activities within their respective regions. Countries should request international assistance through the Regional Offices.

**Communication systems**

**Conclusions**

1. As best as can be determined, there was no communication between the countries and the likelihood that they may be impacted before the Maldives notified WHO-SEARO that its islands were being flooded.
2. Initially, communications between and within each country were difficult. This, in part, was due to the lack of a Coordination and Control mechanism. Communication between the islands/atolls of the Maldives was not possible.

3. No tsunami warning systems were in place at the time of the tsunami. However, other than for Aceh province, and perhaps, the Andaman and Nicobar Islands, there was sufficient time to warn other countries of the impending tsunami, but there was no system for such communication in place in the Maldives, Sri Lanka, India, or Thailand. It seems that no warnings for the impending arrival of the tsunami were provided between the five countries. This failure could have been related to the profound damage suffered by the countries and that attention was directed to responding to the immediate damage and losses of functions caused by the tsunami. For example, Indonesia was struck first by the strongest earthquake in the world in the last 40 years; this was followed within minutes by the biggest tsunami. Both events caused destruction of the communications capabilities, and prevented the ability to warn the country or any of the other countries of the impending event(s).

4. Failures of the Communication Systems were commonplace following the events and occurred in the media, landlines, and mobile (cellular) telephones. Cellular systems were rendered non-functional.

5. The media promoted/perpetuated myths as to what would ensue, including the high probability that a second disaster related to the spread of infectious diseases (from dead bodies) would kill more persons than did the earthquake and tsunami. It focused primarily on the negatives and did not promote the positives that were implemented.

6. The media was a major driver for obtaining donations that resulted in the pledge of the most resources (financial, human, and other) ever provided during a disaster.

7. In each of the countries studied, the event(s) took down communications lines and the mobile telephone capabilities rapidly became overloaded. The only communications to the outside world were accomplished by satellite phones that were used by the military and the insurgents and/or using radios such as those used by fisherman. No communication backup systems were in place. It is relevant and has been demonstrated during many disasters that the cellular (mobile) telephone networks become overloaded and are not a dependable technology. Furthermore, there were no existing agreements between the countries as to whom to notify of an impending event.

8. Portable technology is heavily dependent on available electrical power. Batteries have limited life and recharging may not be possible.

9. At least temporarily, electrical power was interrupted in the areas directly impacted by the events. This, in turn, interrupted the media, and consequently, all channels of communication from the impacted areas were cut off.

10. Many of the responding agencies used their own communications network and did not communicate their assessments or actions to the authorities (Coordination and Control).

**Recommendations**

1. Alternative communication technologies must be addressed in DRPs and backup/alternative technology must be accessible and operational. Adequate supplies of batteries are essential, as are generators specifically used for recharging battery-equipped equipment.

2. The media must be coopted as partners in disaster preparedness and response.
They must be educated relative to the real world. The media is essential to good communications during times of crisis.

3. A communications network between the governments of countries-at-risk to facilitate warnings of impending events must be established and tested regularly. This network must be hardened and not vulnerable to the hazards likely to become events. Backup systems must be robust and supported. Perhaps, the WHO Regional offices should be the hub for regional health systems.

4. Emergency warning systems and backup systems should be installed and implemented. This may include manual methods of communications such as runners, public address systems, sirens, etc.

5. A tsunami detection system should be installed in the Indian Ocean and in the waters that are at risk for the development of a tsunami.

6. The media should be co-opted to warn the public of a potentially damaging event, and should be partners in the planning processes.

7. Emergency evacuation messages should be developed and the public educated and trained to use them.

8. Disaster myths must be dispelled.

**Impact of civil conflict**

**Conclusions**

1. The resilience of all the Basic Societal Systems (BSS) was profoundly weakened by the ongoing civil conflicts in Aceh province and northeastern Sri Lanka. This was manifested by the impaired absorbing, buffering, and response capacities in these areas. Substantial portions of the population migrated in attempts to stay out of harm’s way, and many lived in flimsy, makeshift structures that had little absorbing capacity for the forces brought by the earthquake (Aceh and the Andaman and Nicobar Islands only) and the tsunami. In Aceh province, little remained of the governmental infrastructure and most of the NGOs had departed. Areas were under control of the military, and, the military distrusted the NGOs. When the events of 26 December occurred, the area had little if any absorbing capacity to withstand the forces, and the military was unable to protect the population. In the areas directly impacted, large proportions of the population sustained immediate life-terminating injuries, and those who were able to flee were displaced. In Sri Lanka, existing violence had resulted in hundreds of thousands living in camps before the events occurred.

2. In Indonesia and Sri Lanka, there was little available to buffer the effects of the damages; however, as their functional state was so compromised before the events, little additional function was lost. There was little response capacity available.

3. The ongoing conflicts resulted in huge migrations of the population in Sri Lanka and Aceh province, which, in turn, increased their vulnerability to the forces exerted by the earthquake and tsunami. The areas involved in civil conflict suffered the greatest proportions of deaths and displacements from the events of 26 December.

4. In Aceh province, military rule resulted in the departure of all but four of the NGOs, which in turn, further compromised the resilience of the area.

5. The events of 26 December may have contributed to the development of solutions to the conflicts in both countries.

**Recommendations**

1. The fact that civil conflicts lessen the resilience of affected communities to natural hazards must be incorporated into the disaster response plans and integrated into preparedness measures.
Water and Sanitation Systems

Conclusions

1. Second only to access to life-saving medical care, potable water supplies above the critical threshold must have the highest priority; time without at least critical threshold supplies of water must be limited. Depending on the climate and amount of exertion, water supplies that are below the critical threshold will result in death in a matter of days.\textsuperscript{15}

2. In the Maldives and India, potable water supplies prior to the event were well below the functional threshold (not the critical threshold), and water availability was deteriorating progressively.

3. Collection and storage devices for water were destroyed, damaged, and/or swept away.

4. Remarkably, in none of the countries studied was there evidence that a shortage of water caused deaths from dehydration. This was due largely to mobilization of the military from several countries to distribute water using bottled water, tanker trucks, and rotary wing aircraft.

5. In the Maldives and Sri Lanka, water supplies were supplemented by the installation of desalinating plants. However, many of these installations were not sustainable. In addition, their operation required fuel, which in the Maldives, was difficult to obtain. Locals often were not trained in the operation of the plants, and maintenance and replacement parts were difficult to obtain. In some areas, desalination was not acceptable culturally.

6. Supplemental water in small containers helped to provide essential supplies of drinking water, but also created difficulty in terms of appropriate disposal of the containers.

7. Thirst is a powerful stimulus and may lead to competition and even violence over possession and distribution of available water supplies.

8. Substitutes for water, such as coconut milk, were used until the water supplies could be restored.

9. Many wells were contaminated by sea water and debris and had to be cleaned and decontaminated. Contaminated water often was treated with chlorine tablets and/or was boiled before consumption. However, the latter required fuel, which was in very short supply. Almost anything that would burn was used as fuel.

10. The use of military resources for the rapid provision of adequate water supplies was very successful following the events of 26 December.

11. Damaged rainwater collection systems had to be repaired or replaced. This was true especially in the Andaman and Nicobar Islands.

12. The disposal of wastes, especially medical wastes, was a challenge. United Nations agencies were involved in assisting with the disposal of medical wastes. The disposal of donated drugs that were inappropriately labeled, were past their expiration date, or were not needed presented a substantial challenge to the host nations.

13. Overall, sanitation was managed in accordance with good public health practices. Despite the often horrendous circumstances in the camps, including much open-field defecation, little fecal-oral contamination occurred.

Recommendations

1. The assurance of adequate supplies of water for periods of at least three days should be part of the buffering capacity in any area-at-risk.

2. The provision of adequate potable water supplies is part of preparedness and is the responsibility of the governing agency.
3. Additional supplies of potable water should be available on a regional basis as part of the regional response capacity and should be able to be transported quickly to where water is needed.

4. Arrangements for the provision (transport and distribution) of backup water supplies must be part of any DRP, including contractual agreements with the military.

5. Special arrangements for the appropriate disposal of medical wastes must be included in any DRP.

6. Any technology (such as desalination facilities) provided to maintain essential functions must be sustainable.

7. Local personnel should be charged with monitoring water quality and provided with the requisite knowledge, skills, and equipment to do so. Requirements for surveillance, including testing the quality of the water and reporting the results to public health officials must be mandated by law.

8. The impact, including all effects of interventions must be considered, e.g., disposal of plastic water bottles, unused drugs.

**Food and Nutrition**

**Conclusions**

1. Food is required to sustain life and strength. However, relative to time, access to food is less urgent than is access to potable water.

2. The overall nutritional state of the countries was poor and may have contributed to lack of strength, and hence, to the vulnerability of some of the individuals who were swept away by the tsunami. In many circumstances, the provision of micronutrients (i.e., vitamin A) was less than adequate. This was particularly true for the children and may be responsible, in part, for the high mortality rates of children.

3. No evidence was found to indicate that starvation was a principal cause of deaths.

4. Some of the relief foods supplied were culturally inappropriate.

5. Hunger is a powerful stimulus and may have contributed to competition and/or for violence over available food supplies. However, no evidence was found indicating violence was used to secure food.

6. In Sri Lanka, there were complaints that the relief food aid was not being distributed equitably.

7. Food production was severely compromised in the areas directly impacted by the tsunami. The soil became salinated, and home gardens, a principal source of food, were destroyed.

**Recommendations**

1. Relief foods provided must not only be adequate in amount and quality, but must be culturally appropriate.

2. Micronutrients should be included in food supplements.

3. Stores of non-perishable foods should be part of the buffering capacity.

**Transportation and Logistics**

**Conclusions**

1. In each of the countries studied, transportation and logistical support rendered were less than optimal due to the destruction of vehicles, loss of operators, destruction of routes, and in some areas, shortages of fuel.

2. Many responding organizations arrived without their own transport, and thus, added to the already existing transportation deficits. Eventually, many organizations arranged for their own transportation capabilities.

3. Inadequate transport capacities compromised access to the medical facilities by the ill
and injured as well as the staff and supplies available at the medical facilities. The impact of the compromised Transportation and Logistics may have contributed to the pain, suffering, and deaths of some of the injured who were unable to reach the medical facilities and/or as a result of inadequate quantities of essential supplies and/or personnel. It was not possible to assess the impact of the compromised transportation and logistics system on mortality or morbidity.

4. Difficulties were encountered in deciding where the limited transportation and logistics resources should be allocated and by whom. This was especially true in Sri Lanka and Aceh province. Logistics difficulties were encountered in getting appropriate supplies to the Maldives and the Andaman and Nicobar Islands as boats were required and the docking facilities were severely damaged. India and Thailand mobilized abundant transportation capabilities from neighbouring states and districts and from the military.

5. All transportation is heavily dependent upon the Public Works and Engineering for the integrity of the roads, bridges, airports, and harbours.

6. The airports were not severely damaged, but little priority was given to incoming personnel, equipment, and supplies, which arrived randomly. Some of the supplies, equipment, and personnel were not consistent with needs.

7. Essential supplies piled up at points of entry due to inadequate transportation required for their distribution.

8. Some of the injured could not be reached and may have succumbed to injuries that potentially were survivable.

9. The military possesses and can mobilize much of the transport and logistics resources required.

10. Patient care required urgent transport and evacuation of seriously ill or injured patients to hospitals outside the areas directly impacted.

11. Transportation resources were not available for the evacuation of the population. This may have had greatest significance in those areas impacted by the tsunami hours after the earthquake.

Recommendations

1. Priorities for the use of compromised transportation and logistics and energy systems functions should be assigned by Coordination and Control. High priority must be assigned to the transportation of victims and staff to and from medical facilities.

2. Incoming relief organizations should be required to provide their own transportation needs and cannot rely on the crippled Transportation and Logistics System within an affected area.

3. Responding organizations must be entirely self-sufficient including providing their own means for the transport of personnel, equipment, and supplies.

4. Relief and recovery goods and services that are not directed toward specifically defined needs should not be allowed into the disaster area.

5. Assistance offered in terms of goods and services should be screened prior to leaving their point of origin, not once they are being transported or received.

6. Arrangements for use of military transportation and logistics resources should be part of all DRPs. Such arrangements must specify who and how priority decisions will be determined and financed.

7. The DRP must have provisions for the evacuation of populations once a warning has been issued.
Public Works and Engineering

**Conclusions**

1. With the exception of Thailand, prior to the events of 26 December, some sub-functions of Public Works and Engineering were not well-developed in the areas directly impacted. This was especially true regarding the functions of trash collection, removal, and disposition.

2. The Public Works and Engineering infrastructure and personnel within all the areas directly impacted by the tsunami and in Aceh province and the Andaman and Nicobar Islands by the earthquake sustained heavy damage.

3. In Thailand, some public works and engineering sub-functions were assumed by the military, e.g., clearing of roads and restoration of communications.

4. Difficulties were encountered in deciding where the limited resources of Public Works and Engineering should be allocated.

5. Much of the heavy equipment required for search and rescue and recovery was the property of the private sector.

6. The management of medical wastes presented a major problem.

**Recommendations**

1. Priorities for the use of compromised resources of the Public Works and Engineering Systems should be assigned by Coordination and Control. High priority must be assigned to providing access to and from medical facilities.

2. Coordination and Control should make arrangements for assistance from outside the impacted area or country.

3. Methods for the management of medical wastes must be defined and be part of preparedness plans.

4. Arrangements for the use of military resources for assisting Public Works and Engineering should be part of all DRPs. Such arrangements must specify who and how priority decisions will be determined.

5. Arrangements for the use of private sector resources to assist Public Works and Engineering should be part of all DRPs and accessible by Coordination and Control.

Security

**Conclusions**

1. Medical facilities were besieged by uninjured victims looking for the missing or for resources, by mildly injured persons, and by persons bringing dead victims. Many came because they perceived the medical facilities as safe havens. This diverted limited resources away from those whose survival may have depended upon the availability of those resources.

2. In Meulaboh, the hospital was looted for mattresses as well as other equipment and supplies.

**Recommendations**

1. Security of the medical facilities must be assigned a high priority.

2. The DRP should designate mechanisms for providing security for the medical facilities.

3. Security must be able to divert persons with non-medical issues away from the medical facilities.

Energy Supply

**Conclusions**

1. Electrical power for the medical facilities was interrupted in each of the areas impacted. Where backup generating equipment was available, it was often inundated by sea water, sludge, mud, and debris.

2. Fuel required for transportation, public works, cooking, and powering electrical generators
was scarce, and various sectors competed for the limited supplies.

3. In some of the areas impacted (i.e., the Andaman and Nicobar Islands), reserves of fuel lasted until they could be replenished from the unaffected areas (e.g., the mainland for the Maldives).

4. In the Maldives, all fuel for the operation of generators and for the operation of desalinating plants had to be imported.

**Recommendations**

1. All medical facilities must be equipped with backup electricity generators located where they are not likely to be affected by events for which the facilities are at risk. The backup equipment (part of the buffering capacity) must be able to provide lighting, environmental control, operation of electrically driven equipment, and refrigeration.

2. Adequate supplies of fuel to allow medical facilities to continue to operate for several days must be held in reserve at the medical facilities.

3. Initially, priority must be given to the use of fuel required for the transportation of injured victims, those with chronic diseases, and those with new medical problems, as well as for the transportation of the equipment and supplies to medical facilities.

**Education**

**Conclusions**

1. With the exception of Thailand, neither the responsible officials nor the lay public had been educated or prepared adequately for protection from, or responses to the events of 26 December. Thailand had run a country-wide disaster exercise within a month of the occurrence of the tsunami.

2. The closure of damaged schools created an additional social burden on the survivors including the host families. In addition, undamaged educational facilities were used for shelter by IDPs, thereby displacing surviving students. Surviving parents had to look after children who normally would have been in school. This was a significant burden, especially for those parents who were unable to earn a living due to loss of the traditional caregivers.

3. Like the functional integrity of any of the other BS Systems, the educational system is dependent upon other BS Systems. The educational system failed to function not only as a result of structural failures, but also from losses of books, computers, records, and staff, including teachers.

**Recommendations**

1. As has been demonstrated in Bangladesh,\textsuperscript{16} disaster health should be a part of the curriculum in schools and the learning of life-supporting first aid should be essential at all levels. This would contribute to better preparedness for emergencies and disasters.

2. National surveys have shown that educational status relates to better levels of health.\textsuperscript{17} There also is a relationship between education and economic status, with higher levels of poverty among illiterates. In addition, there is a strong relationship between education and family size, which, in turn, relates to health. Therefore, in the assessments of the pre-event status of a community, assessment of the overall status of its education is important.

3. Teachers are an important resource and can assist in the provision of relief.

4. Educational institutions can serve as temporary locations for the provision of relief goods and services.

5. During the recovery phase of a disaster, schools should be re-opened as soon as possible in order to assist in preservation
of the economy, the ability to earn wages, the maintenance of mental health, and the provision of psychosocial support.

**Social Structures**

**Conclusions**

1. All disasters create major stresses for the affected population, and the stresses associated with the tsunami were extreme in each of the five countries studied. Except for Thailand, the citizens of each of the countries were poorly prepared to cope with the psychosocial impacts associated with the damage and functional collapse of the social structures that occurred. However, more than ever before, the potential psychosocial impact of the damage was appreciated, and for the most part, responders attempted to mitigate the effects of the stresses on the affected population.

2. Although no concrete evidence was identified that the psychosocial burden created was managed more comprehensively and with better results in Thailand than in the other four countries, it has generally been accepted that Thailand’s use of community health workers who were educated and trained to recognize, support, triage, and appropriately refer victims with psychological problems, minimized the morbidity. However, this conclusion must be viewed with caution, as the relative burdens created in Thailand were smaller than those created in Indonesia, the Maldives, and Sri Lanka. Since the earthquake and tsunami, each of the four countries has revised its respective laws that deal with persons with psychological disturbances, and has established a community health programme using the Thailand community health worker model.

3. Many international responders (e.g., more than 130 NGOs in Aceh province alone) attempted to provide psychosocial support to the affected populations in Indonesia, the Maldives, and Sri Lanka. No records of the nature and impact of the interventions used were found. However, the information acquired indicates that the credentials of those who provided psychological interventions generally were not checked and/or validated. In addition, information suggests that some responders provided affected persons with psychotropic drugs in situations in which they may not have been needed or even may have been counter-productive.

4. The livelihoods of many of those directly impacted by the tsunami were destroyed and family structures were devastated. These damages created conditions of dependence that were contrary to the cultures of the people in each of the affected countries. In Aceh province and in Sri Lanka, major, but uncoordinated efforts were directed to restoring the respective fishing industries; the fishing industry in Maldives was not particularly compromised. Generally, input from the intended beneficiaries of the recovery interventions (namely replacement of destroyed boats) was not obtained, and many were useless for the purposes for which they were constructed.

5. Social patterns were interrupted in each of the five countries; religious leaders were killed, edifices were destroyed, and persons who had lost everything, including their homes and personal belongings, were forced into IDP camps where their cultures were difficult to sustain. In addition, the rapid exodus from these camps into the homes of unaffected families or friends created a burden on these IDPs and augmented their feelings of helplessness and dependency. It remains unknown as to where many of these IDPs eventually relocated. At least early on, the host families were not provided with supplemental resources needed to accommodate the additions to their respective households. Many orphaned children were absorbed into the households of surviving/unaffected relatives.

6. The temporary collapse of the educational systems created an additional burden on
the surviving family members who now had to care for the children not in school; this impacted negatively on the ability of the parents to earn a living. In addition, many of the children had to be pressed into assisting with the support of the families.

**Recommendations**

1. The psychosocial consequences of the stresses produced during disasters have been well-documented, and the psychological impacts of exposure to these stresses should be anticipated, and the responses required to mitigate the psycho-physiological effects (morbidity) should be addressed in the respective DRPs.

2. Studies should be conducted that demonstrate the most effective means to minimize the morbidity from exposure to disaster-associated stresses—this will require structured evaluations of the assessments conducted, the interventions applied, and the impact of such interventions. Appropriate persons should be educated and trained to conduct the assessments and to implement specific interventions to address the needs detected by the assessments.

3. All countries should implement a community health programme that includes the ability to recognize, triage, treat, and appropriately refer persons who become, or are likely to become, impaired due to the stresses encountered.

4. A mechanism should be developed to credential appropriate individuals to provide psychological support. In particular, this applies to international responders. All incoming responders must be previously requested / invited by the Coordination and Control agency of the affected country, and each responding agency must be accredited to provide the services requested. The credentials of all responders and responding organizations must be validated prior to being assigned and deployed into the field.

5. All responders and interventions must be cognizant of the situation and the culture into which the interventions will be implemented.

6. All interventions implemented must be evaluated in terms of their respective impact on those to whom the intervention was directed. In addition, the processes used must be documented for subsequent evaluation of the process(es) employed, and the performance of those delivering the respective interventions.

7. All possible efforts must be employed to minimize the development of dependencies in the affected populations. The intended beneficiaries must provide inputs into all interventions/projects directed towards their benefit.

8. As soon as is possible, after the onset of the disaster efforts should be directed to the restoration of the religion(s) and customs of the affected population. Such actions will help to minimize the efforts required by outside persons/organizations to provide the support required.

9. The migration patterns of those IDPs who leave the IDP camps must be tracked so that appropriate support can be provided to them once they have left. Persons who migrated from their homes into those of host families also must be tracked. Relief supplies for the beneficiaries must include distributions to the host families to assist with the support of the IDPs for whom they are providing shelter, food, and other forms of support.

10. Any time the educational system has been interrupted, immediate mechanisms must be provided for the occupation of children so that the parents can endeavour to regain their respective livelihoods.

**Interventions/responses**

**Conclusions**

1. Little is known about the impact of specific interventions, including the medical
interventions provided. This was more notable for the interventions provided by the Medical Care System than for those provided by the Public Health System.

2. Many of the interventions provided by NGOs were not accounted and their impact has been impossible to obtain. Few of the available reports have included an evaluation of their effects, outcomes, and impacts. Reports of most of the interventions applied and their outcomes and impacts have not been made accessible by the responding organizations.

3. While the successes of the public health assessments and interventions are difficult to demonstrate, their impact is evident in that no public health crisis occurred—there were no epidemics despite conditions that were ripe for the development of a second disaster related to infectious diseases (cholera, typhoid, measles, polio, tuberculosis, etc.).

4. Some of the available information indicates that the provision of temporary and permanent housing was slower than expected. In addition, some of the permanent shelters constructed were built without input from the locals. Many still stand empty. Communities disputed the distances from the sea in which they were relocated as they did not support the livelihoods of the fishermen. In addition, although large numbers of replacement boats were constructed, some were not appropriate for the tasks they were intended to support.

5. Most of the information available from reports of interventions has focused on achievement indicators; the actual impact(s) of the interventions have not been accounted. For example, although the targeted number of replacement fishing boats eventually were built, they had little impact on the affected fishermen who found the boats unacceptable for their work.

**Recommendations**

1. Methods for defining the impact (i.e., achievement of the objective(s) and contributing to the overarching goal(s)) of preparedness interventions must be developed and tested. Such indicators can be determined best from evaluations of interventions that have been used in actual disasters or that have been applied elsewhere.

2. The attainment of achievement objectives is not synonymous with impact.

3. All interventions must be accounted and their effects and impact assessed.

4. Every effort must be made to facilitate the prompt removal of IDPs from the camps and into temporary or permanent housing. This will require the rapid provision of temporary housing in a safe location and will promote the return to jobs and support livelihoods.

5. The affected population must always be part of the planning processes for replacement/reconstruction/repair of infrastructure required for earning a livelihood and for shelters.

6. Assessment plans that will define the impacts and other effects of interventions must be included in response plans.

**Shelter and Clothing**

**Conclusions**

1. Adequate shelter is essential for protection from the climate, for the prevention of vector-borne diseases, and for privacy.

2. The absorbing capacity of most of the residences and lower-order health facilities directly impacted was not equal to the forces of the tsunami, and consequently, were destroyed. This was true particularly for the shelters cobbled together by those migrating out of harm’s way in areas in civil strife. More
than 750,000 homes were destroyed in the five countries. The proportion of houses destroyed varied greatly by districts, but the reasons for these differences remain unclear. It also remains unclear as to how much of the damage was caused by the earthquake and that caused by the tsunami.

3. People not killed or severely injured by the forces fled to shelters that had sufficient absorbing capacity to survive the forces exerted or to existing or spontaneously formed camps away from the shore, or to homes of relatives or friends. The numbers of people who shifted to families and friends are unknown, and have not been accounted in the number of Internally Displaced Persons. The greatest losses for 1000 population occured in Aceh province, the Maldives, and in Sri Lanka.

4. Woodframe structures seemed more capable of withstanding the forces than many of the shelters constructed of concrete, coral, or limestone. Those structures built to accommodate tourists were constructed using re-inforced concrete, and, generally, had sufficient absorbing capacity to withstand the forces brought to bear upon them.

5. Internally displaced persons who initially appeared in camps, tended to leave the camps relatively quickly; yet it remains unknown as to where they went.

6. The construction of temporary and permanent housing was much slower than predicted.

7. For the most part, the victims were not involved in the design or construction of the replacement dwellings, and some of the structures remain unoccupied.

8. Hospitals/medical facilities are considered as safe havens, and many fled to the area's medical facilities. These arrivals contributed to the burdens experienced by the medical facilities.

9. Movements of persons seeking shelter results in significant changes in the catchment areas for the medical facilities.

10. Clothing worn by some women may have impeded their ability to swim.

**Recommendations**

1. Strict building codes must be enforced, but the views and cultures of the potential occupants must be integrated into the location and design.

2. Shelters and supplies must be designated as part of preparedness and included in Disaster Response Plans.

3. Alternate medical facilities should be designated as part of the DRP. Preparedness plans must anticipate shifts in the location of their patient population.

4. Efforts should be directed to identifying where internally displaced persons/refugees move and how they integrate into and function within their new environment.

5. Internally displaced persons should be diverted from medical facilities.

6. Timelines for the completion of temporary/permanent housing must be realistic and achievable.

**Economy**

**Conclusions**

1. There was no clear correlation between the amount of money spent on healthcare/capita pre-event and the responses to the losses of functions. This also was seen in the requests for outside assistance. Actually, the countries with the highest budget for healthcare/capita were the countries that also requested outside assistance (except for Thailand, which refused outside help).

2. The fishing and tourist industries sustained a major share of the damage and losses
of functions and livelihoods in each of the countries.

3. It is clear that the overall financial burden and the burden of damages to the healthcare facilities sustained by the Maldives far exceeded that of any of the other countries. Although its burdens were many times greater than those suffered by Sri Lanka and Indonesia, the burdens on Sri Lanka and Indonesia were substantial.

4. Some of the funds donated were earmarked for specific interventions.

5. Delays in obtaining financial resources by countries impacted by the disaster impaired the ability to obtain needed resources in time to make an impact early in the disaster. The creation of the South East Asia Regional Health Emergency Fund (SEARHEF) for the Region was facilitated and is administrated by WHO-SEARO, and represents a major step forward in preparedness.

Recommendations
1. Healthcare financial resources should be prioritized based on the relative economic burdens suffered by the respective countries.

2. Economic support for rehabilitation of those who have lost their means of livelihood must be assigned a high priority in the use of resources during or following a disaster.

3. The distribution of resources should be according to needs determined from assessments and the priorities established by Coordination and Control, and not according to the objectives of the donors.

4. The SEARHEF funds available should be augmented progressively to facilitate more realistic disbursement of funds to countries with immediate financial needs. Mechanisms should be developed to recoup resources dispersed when the funds are used.

5. The process used for the creation of the SEARHEF should serve as a model for other WHO Regional Offices.

Other societal systems
Conclusions
1. The rapid mobilization of military resources contributed much to limiting the negative effects of the events. Involvement of the military during the relief phase of the disaster lessened the impact of the forces on the population.

2. The WHO-SEARO provided regional coordination of responses, recruitment of essential personnel, support of supply chains, etc.

3. Inappropriate materials, such as high-heeled shoes, evening gowns, soccer shoes, were donated as relief supplies. They clogged transportation facilities and required disposal.

Recommendations
1. Cash donations are superior to the donation of items. It is the responsibility of Coordination and Control to distribute funds or purchase what is needed with the donated funds.

2. The pre-event inventory should include all services provided by society.

Preparedness and planning
Conclusions
1. Of the five countries studied, only Thailand had a national Disaster Response Plan that had been tested. The exercise conducted less than one month before the events included health facilities. The remaining countries did not have a national DRP that had been tested. This was particularly evident by the lack of Coordination and Control entities with the mandate, power/authority, and resources required. Therefore, the bulk of the responses was uncoordinated, and in many instances, was counterproductive to the overall effort.
2. There were no established standards/benchmarks to facilitate preparedness and the prioritization of efforts to reach the standards prior to the events of 26 December. Major gains were achieved by efforts of WHO-SEARO by providing the leadership for the establishment of these standards and for setting benchmarks of progress for each of the countries impacted by the earthquake and tsunami as related to Public Health and Medical Care Systems.

3. Each of the countries involved has implemented legislation and plans to enhance responses to future events. The development and organization of Coordination and Control entities in the countries remains unclear.

4. Regional coordination of the public health responses by WHO-SEARO contributed substantially to the prevention of epidemics following the events. The functions of Regional Offices of the WHO in the acquisition, distribution, and coordination of international responses and in preparedness have been under-appreciated, and in some dimensions, have been bypassed.

5. The WHO Regional Offices have very good knowledge and understanding of context of the needs of the countries within their respective regions. This is an important aspect for better preparedness and response.

6. Many of the non-governmental and inter-governmental agencies upon which the Public Health and Medical Care Systems are dependent do not have regional offices.

7. As in almost all other disasters, initial relief responses were provided by lay persons. However, for the most part, the lay public had not been educated and trained in any life-supporting first aid procedures.

Recommendations

1. Every country must have a national DRP that has been tested and modified by exercises or actual experience. Such plans must be dynamic and updated in accordance with evaluations of the exercises/experiences and thus, incorporate lessons learned.

2. Coordination and Control entities should be mandated by the DRPs and provided with the authority/power and resources required. Coordination and Control entities should be provided at each level of government.

3. Based on the findings of this book and on experiences obtained from disasters that have occurred in the Region since December 2004, the standards/benchmarks identified in 2005 should be re-evaluated, updated, coordinated with the progress achieved, and expanded as appropriate.

4. Legislation and DRPs relative to disasters achieved by the respective countries should be collated and shared between the countries and these documents should be part of the database retained in WHO-SEARO.

5. The coordination functions of the Regional Offices should be expanded to include coordination of the medical care responses as well as the public health responses.

6. Governmental, inter-governmental, and non-governmental organizations should develop regional structures coordinated with those of WHO.

Military

Conclusions

1. The military played an essential role in the initial relief responses to the disasters in these countries.

2. The military possesses the logistical resources required to move essential supplies, equipment, and personnel. These resources can be mobilized immediately in times of crisis.

3. Military resources were vital in preventing deaths from dehydration by transporting
water to otherwise inaccessible areas.

4. Military resources were provided to move essential supplies and personnel to inaccessible areas and to evacuate victims from medical facilities impacted by the damage and losses of health functions to higher levels of care as needed.

5. Disaster responses are not part of the traditional missions of the military.

6. Most military personnel have not been trained in the provision of life-supporting first aid. Trained military personnel may have contributed to the survival of many who succumbed to life-threatening injuries.

7. Civil-military relations are not codified.

**Recommendations**

1. The mission of the military must be expanded to include disaster relief responses and the use of military resources must be included in DRPs.

2. Civil-military collaboration must be codified to include designated roles in disaster relief responses including designation of who is in charge.

3. Military personnel should be trained in life-supporting first aid and other basic emergency medical care skills.

The foregoing discussion provides only some of the conclusions and the recommendations based on these conclusions. The value of the process used should be apparent. Hopefully, you will continue to analyze and expand the information provided. The model can be applied prospectively and retrospectively into the study of future events so that the results will be readily compared with what has been discovered so far. This is the beginning of structured research into the epidemiology of disasters and to the evaluations of what we do for those in need. We need so many answers.

**References**


**Figure 28.1:** Infrastructure Template for the progression of a hazard to the losses of function of any infrastructure including the absorbing and buffering capacities.

**Figure 28.2:** Healthcare Facility Template for the progression of a hazard to the loss of function (including the absorbing and buffering capacities). *The SURGE of patients may further compromise functional status depending on the response capacity available for the facility. This template can be applied to an area with several medical facilities, to a single medical facility, or to a unit within a given medical facility.*
Figure 28.3: Injury Template for the progression of a hazard to loss of function including the absorbing and buffering capacities as applied to the injuries of the population in the area of the disaster.

Figure 28.4: Example of the use of the Injury Template to study the progression of the earthquake and tsunami to loss of function (including the absorbing and buffering capacities) as applied to healthcare facilities in Aceh Province. The stages of trauma care are denoted on the left. Available data are in parentheses. Much of the data required to complete this template were not available. Completion of the template would have provided a better picture of what actually occurred and would have facilitated comparisons with other countries or other disasters. (Data not available where numbers are not noted. (UNK = UNKNOWN) (Available data could be replaced with numbers/10,000 population to quantify burdens))
Table 28.1: Worksheet for entry of Data/information acquired to complete the Infrastructure Template !.

<table>
<thead>
<tr>
<th>Date</th>
<th>Time</th>
<th>Event</th>
<th>Area-at-Risk</th>
<th>Area Exposed</th>
<th>Damaged</th>
<th>Destroyed</th>
<th>Structurally Non-Functional</th>
<th>Structurally Completely Functional</th>
<th>Structurally Partially Functional</th>
</tr>
</thead>
<tbody>
<tr>
<td>4-Apr</td>
<td>1800</td>
<td>Earthquake</td>
<td>Banda Aceh</td>
<td>Banda Aceh</td>
<td>60%</td>
<td>20%</td>
<td>55%</td>
<td>15%</td>
<td>20%</td>
</tr>
</tbody>
</table>


Amnartyothin S, Ashkenasi I, Schwartz D, et al: Medical response of a physician and two nurses to the mass-casualty event resulting in the Phi Phi Islands from the tsunami. *Prehosp Disaster Med* 2006;21(3)


Carden P: Recycling and Reuse of Debris from the Tsunami Disaster. Mahidol University. Available at http://www.ict4dev.mahidol.ac.th/tsunami/Contents/%E0%B8%8A%E0%B8%94%E0%B8%84%E0%B8%A7%E0%B8%B2%E0%B8%A1%E0%B8%8A%E0%B9%80%E0%B8%81%E0%B8%A2%E0%B8%A7%E0%B8%B1%E0%B8%9A%E0%B8%AA%E0%B8%99%E0%B8%82%E0%B8%A1/tabid/71/ctl/Details/mid/397/ItemID/5/Default.aspx. Accessed 10 December 2008.


BIBLIOGRAPHY


**Globalis:** Number of Births Attended by Skilled Personnel. Available at http://globalis.gov.unu.edu/indicator_detail.cfm?IndicatorID=139&Country=MV


Gupta SK: Inadequate drinking water quality from tanker trucks following a tsunami disaster, Aceh, Indonesia, June 2005. Disaster Prevention and Management 2006;15(1):???


Khalakdina A: Technical field report, WHO. (limited distribution. See Tsunami information/Trine’s computer/Indonesia/Asheena Khalakdina)


McBeth J: Good deeds may help end Aceh’s insurgency. The Straits Times. 05 January 2005.


Ministry of Health and Family Welfare (India): NCMH Background Papers—Burden of Disease in India (New Delhi India), September 2005.


Montlake S: Tsunami priority: Homes; One year later, most survivors still do not have permanent shelter. Yet many have income again. The Christian Science Monitor. 27 December 2005, p 1.

Montlake S: Tsunami priority: Homes; One year later, most survivors still do not have permanent shelter. Yet many have income again. The Christian Science Monitor. 27 December 2005, p 1.


Rajesh P: Mental health and psychosocial relief efforts after the tsunami: Assignment report, 01 January–31 March 2006. SEARO.


Ravi D: Poverty and Health: Critically of Public Financing. Indian Journal of Medical Research. 2007. (Also available at http://findarticles.com/p/articles/mi_qa3867/is_200710/ai_n2127901/pg_1.)


SEARO: Moving Beyond the Tsunami, the WHO Story.


Simamora AP: Swiss government launches new project for tsunami victims in Aceh. The Jakarta Post. 05 February 2005.


Sundnes KO, Birnbaum ML (eds) and the Taskforce on Quality Control of Disaster Management, World Association for Disaster and Emergency Medicine: Health disaster management: Guidelines for evaluation and research in the Utstein style (conceptual framework). Prehosp Disaster Med 2003;17 (suppl 3).


Tharyan P: Aftermath of the tsunami on Black Sunday (December 26th 2004). JEPHC 2005;3


TRIAMS Workshop, Bangkok, 3-5 May 2006.


WGO: Earthquake and Tsunami Relief Aceh and Nias 2005 [What is this?!?]


WHO and Ministry of Public Health.: Lesson Learned from Dead Bodies Management In Tsunami Disaster. May 2006 (hard copy)


WHO: From Relief to Recovery, the WHO Tsunami Operation.[MORE]


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


WHO: Tsunami Recovery Programme Indonesia Final Report. (See tsunami info folder on G-Drive. Labeled TsunamiFinalReport0607…)


WHO-SEARO: 11 health questions about the 11 SEAR countries. Available at


World Health Organization: Regional Office for South East Asia: Regional Meeting on Health Aspects of Disaster Preparedness and Response. Prehosp Disaster Med 2006;21(5):s62-s78.


## Appendix A: Indicators

### Event
- Earliest tsunami wave arrival time
- Time elapsed between earthquake (00:59 UTC) and earliest wave arrival (min)
- Approximate distance from tsunami epicenter (km)

### Demography
- Impacted districts n (%)

### Population
- Total
- impacted n(%)
- Density/km²
- Injured n (n/10 000)
- Survived n (/10 000)
- Killed n (n/10 000)
- Causes of Death (%)
- Population Change (n, %)
- Religion (% pop
  - Muslim
  - Hindu
  - Christian
  - Buddhist
  - Islam
  - Jains
  - Misc Other
- Primary Languages

### Climate
- Rainfall/year (mm)
- Rainy (wet) Season
- Ambient Temperature °C
- Hottest months

### Sources of Electricity (%)
- Fossil
- Hydro-electric
- Other
- Wind
- Solar
- Nuclear

### Economic Indicators
- Rank by GDP
- GDP (millions)
- GDP/per capita
- Income category
- Pop < poverty line (%)
- % world’s poor
- Human Development Index
- Healthcare costs/capita
- Healthcare costs/GDP (%)
- Major Products
- Tourist arrivals
- Tourists/10 000 pop
- Estimate of costs of damage to healthcare system
  - US$ million
- Costs of damage to Healthcare facilities/capita
  - (US$)
- Costs of damage to Healthcare facilities/GPD (%)

### Education
- Literacy
- Ave Educational Level (yr)+
- Medical Schools
- Medical Schools/10 000 population

### Public Health
- Life expectancy in years,
- Crude mortality rate/1000 population/day
- Infant mortality rate/1000
- Maternal mortality rate/100 000 live births.
- Disease Incidence
Vector borne
Water borne
Direct contact

**Immunization rates (% population)**
- Measles
- Three doses of diphtheria, tetanus, pertussis (DTP)
- Three doses of Hepatitis B
- BCG (tuberculosis)
- Poliomyelitis

**Medical Care (n/10 000 population)**
- Physicians
- Nurses
- Midwives
- Laboratory technicians
- Health workers
- Dentists
- Number of beds
- Hospital Births attended by skilled personnel (%)
- Pop/facility

**Nutritional Status (%)**
- Children <5 years of age that are stunted (%)
- Children <5 years of age that are underweight (%)
- Children <5 years of age that are wasted (%)
- Newborns with low birth weight (%)
- Pregnant women with anemia (%)
- Per capita protein supply (grams/day/person)
- Per capita fat supply (grams/day/person)
- Per capita energy supply (calories/day/person)
- Calories from cereal (%)

**Household Energy and Fuel Uses**
- **Principal source of light**
  - Kerosene
  - Electricity
  - Solar
- **Principal source of cooking fuel**
  - Fire wood
  - Gas
  - Kerosene
  - Electricity
  - Saw dust/
  - Paddy husk

**Health Centres, clinics, hospitals, labs and offices (n, %,)**
- Destroyed
- Damaged
- Damage inUS$ million
- ICUs
- Pop/ICU

**Nature of injuries**
- Respiratory
- Trauma
- Musculoskeletal
- Dermatological
- Other
- Anemia

**Conditions**
- Respiratory
- Trauma
- Skin infections
- Musculoskeletal
- Fractures
- Near drowning
- Crush
- Head injury

**Outbreaks**
- Cholera
- Malaria
- Measles
- Tetanus
- Tuberculosis
- Dengue
- Resp Infect

**Epidemics**
- Mumps
- Diarrhoea

**Interventions**
- Mosquito netting
- Impregnated Plastic Sheets
- Chemical disinfectants
- Burial of remains
- Fogging w insecticides
- Weekly briefing
- Mosquito eating fishies
Clean water
Cholera detect kits
Personnel-Teams Dispatched
WHO
UNICEF

**Burdens**
CMR/10 000/day Pre-event
CMR/10 000/day for 1st 3 days
Deaths/Total population (%)
Deaths/10 000 population
#Injuries/#deaths-missing
Survivors Injured (%)
% Injured who survived
#Injured/10 000 population
Total injured/10 000 population
Deaths/10 000 population
Injured survivors/10 000 population
IDPs/10 000 population
Economic Costs (US$ billions)
GDP (US$ billions)
Costs/GNP (%)

**IDP**
Total # Displaced
% population displaced
#Displaced/10 000 pop
# in Camps
#Camps
% in camps
# in Residences
# in Shelters
# in temporary shelters
# tents

**Water**
Cost (million US)
Wells damaged/destroyed
Cost US$/10,000 population

**Shelter Houses**
Destroyed (%; number)
Damaged (%; n)
Houses repaired

**Pre-events**
Number of houses (Pre-events)
Houses/10 000 population (Pre-events)
Average occupants/house

**Post-events**
Houses destroyed (%)
Houses destroyed/10 000 population
Number of people with destroyed homes (est)
Number of people with damaged house**
Number of houses damaged/10 000 population
Costs (US$ millions)
Cost/capita (US$)

**Internally Displaced Persons (IDP)**
Number Pre-event
Population (millions)
Total number Displaced
% population displaced
Number Displaced/10 000 population
Number in Camps
Number of Camps
% in camps
DPs/houses damaged
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.