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Foreword

On 1 July 2017, Dr Tedros Adhanom Ghebreyesus took office as the new Director-General of the World Health Organization (WHO). Among his five priority areas for action by WHO is addressing the health impacts of climate and environmental change. A changing climate and environment impact many aspects of life that are inextricably linked to health – food security, economic livelihoods, air safety and water and sanitation systems – and WHO estimates that 12.6 million people die each year as a result of living or working in an unhealthy environment. As noted by Dr Tedros, WHO has a key role to play in advancing both mitigation and adaptation strategies for climate and environmental change, working in close partnership with other United Nations agencies and stakeholders.

The health impacts of climate and environmental change in the WHO South-East Asia Region are the focus of this issue of the journal. In the collection of invited articles, progress to date towards mitigation and adaptation is discussed, and the remaining work needed in the region to meet the targets set by the Sustainable Development Goals is outlined.

Member States of the WHO South-East Asia Region are particularly vulnerable to a changing climate. Extreme weather events, undernutrition and the spread of infectious diseases are projected to increase the number of deaths attributable to climate change by 2030. As described in this issue, current trends in the region are towards higher ambient heat levels during large parts of each year, which will particularly affect low-income individuals and communities. With respect to occupational health, heat exposure is already a particular problem for working people in the region and thus strategies to address future health effects and productivity losses resulting from increasing heat levels will be essential.

Countries have started to include climate change as a key consideration in their national public health policies. However, further efforts are needed to increase the capacity of health systems to manage the health risks of climate change. One article describes how the steps taken by the health sector in Nepal to address the impact of climate change may serve as a good example for other low- and middle-income countries.

Access to adequate water, sanitation and hygiene (WASH) is essential for the health, well-being and dignity of all people. In general, the region made considerable progress in WASH provision over the past two decades' work towards the Millennium Development Goals. An article in this issue describes the significant work done to promote the use of water safety plans (WSPs), which are structured tools that help identification and mitigation of potential risks throughout a water-supply system, from the water source to the point of use. WSPs not only help prevent outbreaks of acute and chronic waterborne diseases but also improve water-supply management and performance. More than 5000 urban and rural WSPs have been successfully implemented in the region in the past 12 years, showing that supplying safe drinking water at the tap throughout the WHO South-East Asia Region is a realistic goal.

However, in contrast to increases in coverage of safe drinking water, access to adequate sanitation remains low in some parts of the region, with continued prevalence of open defecation. The most recent data indicate that 364 000 annual deaths from diarrhoea in the region are attributable to inadequate WASH. Although this represents a reduction in diarrhoea mortality since 1990, the level of diarrhoea morbidity has remained unchangingly high. Moreover, while the burden of health effects of inadequate WASH other than diarrhoea, such as undernutrition and soil-transmitted helminthiases, is more difficult to calculate, it is estimated to be at least as great as – and possibly much greater than – that of diarrhoea.

Putting the emphasis on the “S” in WASH is therefore a key priority. In this issue, authors describe the process by which the 2016 WHO manual on sanitation safety planning was developed, report on results of the extensive programme of pilots, and reflect on the opportunities for wider implementation in the region. Encouragingly, the authors note that lessons learnt during the piloting phase show how reducing health risks can be surprisingly easy, even in low-income settings.

In summary, the experts contributing to this issue have highlighted not only the challenges, but also the successes and opportunities that are relevant to health and climate and environmental change in the region. I hope this collection of articles will inform and encourage those working on this WHO priority area for action.

Dr Poonam Khetrapal Singh
World Health Organization
Regional Director for South-East Asia
Climate change and health in Maldives: protecting our common future

The term “sustainable development” was first defined in 1987, in the seminal report, Our common future, subsequently more commonly known as The Brundtland report.1 The report was the synthesis of 3 years’ work by the World Commission on Environment and Development, chaired by Dr Gro Harlem Brundtland, who would go on to be Director-General of the World Health Organization (WHO) from 1998 to 2003.

The Brundtland report was pivotal in establishing that the environment cannot be considered in isolation from human activity, and that development is not simply a niche activity whereby richer nations support their poorer counterparts through “development assistance”. As famously emphasized by Dr Brundtland, “… the ‘environment’ is where we all live; and ‘development’ is what we all do in attempting to improve our lot within that abode. The two are inseparable”.

Three decades since The Brundtland report was published, we are now in the era of the Sustainable Development Goals (SDGs), which are a universal call to action to end poverty, protect the planet and ensure that all people enjoy peace and prosperity.2 The SDGs provide clear guidelines and targets for all countries to adopt. Almost all the SDGs are directly related to health or contribute to health indirectly and, as highlighted in the articles of this issue of the WHO South-East Asia Journal of Public Health, a clear and present danger that imperils achievement of the SDGs is continuing climate change.

"… the ‘environment’ is where we all live; and ‘development’ is what we all do in attempting to improve our lot within that abode. The two are inseparable”

Dr Gro Harlem Brundtland, 1987

The launch of The Brundtland report in 1987 came at a pivotal time for Maldives, an archipelago of about 1192 small, low-lying coral islands that are grouped into 26 natural atolls in the Indian Ocean. Three years previously, as the result of two decades of tireless work, the last indigenous case of malaria was recorded.3 Maldives’ elimination of malaria represented not only a triumph in public health but also the inextricable link between a country’s malaria status and its potential for development; in the same time period, Maldives transitioned from a low-income to an upper-middle-income country.

Climate change now threatens these successes. Maldives remains free of malaria, and lymphatic filariasis was eliminated in 2016. However, other vector-borne diseases are re-emerging. Dengue became endemic in 2004 and data available indicate that the epidemic dynamics of dengue fever are influenced by climate variability.4

Maldives therefore can be seen as a case-study in how a changing climate not only threatens progress made to date in public health but also creates new challenges to sustainable development. Health threats include increases in heat-related illnesses, diarrhoeal diseases and respiratory illnesses. The infrastructures needed to deliver health services, such as electricity supply and water, sanitation and health-care facilities, are also vulnerable to climate change and extreme weather-related events. Indeed, as with other small island states, climate change endangers the very existence of Maldives into the next century and beyond. Being a low-lying island country, Maldives is highly vulnerable to hazards associated with a changing climate.5

Maldives has no rivers or streams, and only limited freshwater sources in the form of groundwater. In most of the islands, the freshwater lenses — where a thin layer of fresh water floats on top of dense salt water – are not potable, owing to intrusion from salt water and contamination by leachate from septic tanks. Despite these challenges, by 2015, the country had managed to provide improved drinking water to 99% of its population and improved sanitation to 98%.6 Most of the urban areas are supplied with desalinated water, while rainwater is the main source of drinking water in rural areas.

Air pollution is an emerging and pressing risk faced by many developing countries. The situation in Maldives is better than most, as there are fewer sources of pollution, except for the capital, Male’, where emissions are rising owing to the increasing number of vehicles being brought into the city. Since most of the population has access to electricity and liquefied petroleum gas for cooking, less than 5% of the population uses solid fuels for cooking.7 The reported range of annual PM$_{2.5}$ (i.e. particulate matter with diameter ≤ 2.5 µm) in Male’ city is 11 µg/m$^3$ and the modelled median PM$_{2.5}$ in both rural and urban areas is 16 µg/m$^3$, both of which are slightly above WHO guideline values for ambient air quality.8

An estimated 313 900 tonnes per year of solid waste are generated in Maldives, of which 21% is attributable to tourism.9 In addition, about 510 tonnes of medical waste are generated per year. The country is therefore faced with significant challenges in sustainably managing these huge amounts of waste. The bulk of the waste generated in the Male’ region is transported daily by boat to Thilafushi, an artificially built industrial island, and then burnt in an uncontrolled manner.

As with many countries in the WHO South-East Asia Region, the health trends in Maldives are shifting from communicable to noncommunicable diseases (NCDs). For Maldives, epidemiological transition has been swift – cardiovascular diseases moved from being the tenth-leading cause of death in 1990 to the leading cause in 2010, and NCDs were estimated to account for 81% of total deaths in 2012.10 Accordingly, the Multi-sectoral action plan for the prevention and control of
noncommunicable diseases in Maldives (2016–2020) targets the four key modifiable risk factors of tobacco use, diet, physical inactivity and alcohol use, and has a specific focus on cardiovascular diseases, diabetes, chronic obstructive pulmonary diseases and cancer.11 The action plan is supported by recognition from non-health government sectors that prevention and control of NCDs is a cross-sectoral issue.11 Key aspects of NCD prevention, such as production of fresh vegetables at affordable prices and good urban planning, will be affected by a changing environment.

Although the prevalence of mental disorders in Maldives is still largely unknown, there is growing evidence that it is increasing. The national mental health policy and strategic plan for 2016–2021 aims to create robust governance to ensure integration of mental health services with the existing health-care system, and to establish multisectoral collaboration for promotion, prevention and management of these disorders.12 Development of a resilient mental health system for Maldives is especially important, since appreciation of the mental health effects of climate change is growing, especially within communities that are vulnerable to extreme weather events.

For 2012, the overall proportion of deaths attributable to environmental factors in Maldives was estimated at about 13%.13 The country has made impressive progress in addressing environmental health risks; however, much more needs to be done to ensure that water supplied to houses is safe to drink, and to ensure safe management of wastewater. To address environmental degradation and protect human health, a rigorous system for management of solid waste, based on the “3 Rs” principle of reduce, reuse and recycle, has been introduced. Enhanced efforts are needed to maintain air quality within WHO guideline values and to reduce emissions of greenhouse gases in line with the commitment submitted to the United Nations Framework Convention on Climate Change.14 All of these actions require concerted efforts from different line ministries.

The Ministry of Health in Maldives has plans to strengthen the resilience of its health system to cope with and adapt to climate change. An assessment to check the feasibility of providing solar panels in health-care facilities has been conducted. A study of the quality of drinking water has also been carried out and guidelines developed for managing groundwater. A policy and strategy on managing health-care wastes has also been developed and will be implemented.

Vigilance needs to be maintained to sustain the elimination status of both malaria and lymphatic filariasis. This will be done by progressively reinforcing the six building blocks of health systems, namely governance, health workforce, health information system, health technologies, service delivery and health financing. An exemplary project, the Low Emission Climate Resilient Development (LECReD) programme, is being implemented in Laamu island, through partnership with various ministries, communities and United Nations agencies, and is contributing to health-system resilience. The programme mainstreams LECReD issues into local-level development planning and service delivery, with the aim of greater community-level ownership and sustainability of benefits. Through this project, surveillance and control of dengue has been initiated countrywide.

Maldives will continue to address climate change to ensure the well-being of the generations to come. But climate change does not respect borders and, as noted by Dr Brundtland three decades ago,10 sustainable development requires cooperation and action by everyone worldwide, to ensure that our common future is protected.

HE Abdulla Nazim Ibrahim
Minister of Health
Government of the Republic of Maldives
Male’, Maldives
Arvind Mathur
WHO Representative to Maldives
Office of the WHO Representative to the Republic of Maldives
Male’, Maldives

Correspondence to: Dr Arvind Mathur (mathura@who.int)

References

Health risks of climate change in the World Health Organization South-East Asia Region

Kathryn J Bowen¹, Kristie L Ebi²

¹Research School of Population Health, Australian National University, Canberra, Australia, ²Center for Health and the Global Environment, University of Washington, Washington DC, United States of America

Correspondence to: Dr Kathryn Bowen (kathrynjbowen@gmail.com)

Abstract
Countries in the World Health Organization (WHO) South-East Asia Region are particularly vulnerable to a changing climate. Changes in extreme weather events, undernutrition and the spread of infectious diseases are projected to increase the number of deaths due to climate change by 2030, indicating the need to strengthen activities for adaptation and mitigation. With support from the WHO Regional Office for South-East Asia and others, countries have started to include climate change as a key consideration in their national public health policies. Further efforts are needed to develop evidence-based responses; garner the necessary support from partner ministries; and access funding for activities related to health and climate change. National action plans for climate change generally identify health as one of their priorities; however, limited information is available on implementation processes, including which ministries and departments would be involved; the time frame; stakeholder responsibilities; and how the projects would be financed. While progress is being made, efforts are needed to increase the capacity of health systems to manage the health risks of climate change in South-East Asia, if population health is to be protected and strengthened while addressing changing weather and climate patterns. Enhancing the resilience of health systems is key to ensuring a sustainable path to improved planetary and population health.

Keywords: climate change, extreme weather events, health systems, infectious diseases, undernutrition

Projected impacts of climate change on health outcomes

Climate variability and change can affect the population burden of any health outcome whose occurrence and geographical range is affected by weather and climate variables, a rise in sea level, or ocean acidification. Changing weather patterns can affect the magnitude and pattern of morbidity and mortality from extreme weather and climate events and from changing concentrations of ground-level ozone, particulate matter and aeroallergens; can create environmental conditions that facilitate alterations in the geographical range, seasonality and incidence of climate-sensitive infectious diseases in some regions; and can affect the burden of undernutrition due to changes in water availability and agricultural productivity associated with a changing climate. This is particularly true in some parts of Asia.¹ In addition, mental health, migration and other factors affecting well-being can be affected by the consequences of a changing climate. While climate change will probably benefit some health outcomes in some locations in the short term, the overall balance will be detrimental, particularly in low- and middle-income countries that experience higher burdens of climate-sensitive health outcomes.¹ The pathways between climate change and health outcomes are often complex and indirect, making attribution challenging, as shown in Fig. 1.²

A recent study modelled the impacts of climate change on selected health outcomes in 2030 and 2050, under different projected development scenarios.³ Table 1 summarizes the estimate for additional deaths due to climate change in south and south-east Asia in 2030, assuming a future world of mid-range emissions of greenhouse gases, very rapid economic growth, global population peaking mid-century and then declining, and rapid introduction of new technologies that emit fewer greenhouse gases.³

There are large uncertainties in these projections, inherent to projecting how climate could change over coming decades. All projections are statistically significant except for undernutrition, indicating that additional efforts are needed to ensure health systems are prepared to protect population health. Further, these projections are for only five selected health outcomes and there are many more climate-sensitive health outcomes whose prevalence is expected to increase with climate change.¹

Issues related to climate change and health risks in Asia

The Fifth assessment report of the Intergovernmental Panel on Climate Change notes that it is very likely that the mean annual temperature increased over the past century over most of Asia.⁴ It is likely that the numbers of cold days and nights have decreased, and the numbers of warm days and nights have increased since the middle of the 20th century. For most of south-east Asia, annual temperatures over the past 100 years
increased by approximately 0.6 °C per decade. The projected temperature for Asia in the middle and at the end of the century depends on the pathway for emission of greenhouse gases, with an upper estimate of more than 6 °C.4

The pattern for precipitation is more mixed and uncertain. Most areas of Asia lack sufficient observational records to determine trends in annual precipitation over the past century. Even with this uncertainty, heavy precipitation events are increasing and light rainfalls are decreasing. In south Asia, seasonal mean rainfall has declined, with more frequent deficit monsoons. Projected changes in precipitation are highly variable, with increasing and decreasing trends observed in different parts and seasons of Asia. Precipitation extremes related to the monsoon are projected to increase in south and south-east Asia, with precipitation likely to become more extreme near the centres of tropical cyclones making landfall.4

An analysis of scientific and technical evidence on the impacts, adaptation and vulnerability of populations, completed as part of the Fifth assessment report of the Intergovernmental Panel on Climate Change, evaluated how patterns of risks and benefits are shifting due to climate change.4 Fig. 2 summarizes the key risks from climate change in Asia identified in this analysis and the potential for risk reduction through mitigation and adaptation. Levels of risk are presented for the near-term era of committed climate change (2030–2040), in which
Projected levels of increase in global mean temperature do not diverge substantially across emission scenarios. Risk levels are also presented for the longer-term era of climate options (2080–2100), for global mean temperature increases of 2 °C and 4 °C above pre-industrial levels. For each time frame, risk levels were estimated for the current state of adaptation and for a hypothetical highly adapted state. Adaptation issues and prospects are indicated for each key risk. Relevant climate variables are indicated by symbols. The key risks for health identified include food insecurity, water shortage, flood-related injuries, malnutrition, infectious diseases, mental disorders, deaths and heat-related mortality. While adaptation can reduce health risks, considerable residual risks are expected by the middle and end of the century.

Activities related to climate change and health outcomes in the WHO South-East Asia Region

For more than 10 years, the World Health Organization (WHO) has been advocating, supporting and guiding Member States to address the impacts of climate change on health. In the WHO South-East Asia Region, regional meetings, high-level conferences and national meetings have been, and continue to be, conducted. Since climate change and its health effects are highly specific to the local context, country-specific features and determinants of the health risks of climate change have been a focus. Countries such as Bangladesh, Bhutan, Nepal, Indonesia and India (two districts) have carried out assessments of health vulnerability and adaptation. Regional and national training on the subject has been provided. Between 2010 and 2015, Bhutan implemented a health adaptation to climate change project, resulting in a permanent focus on climate change and health outcomes. New projects to adapt to climate change, focusing on resilient water and sanitation services, were started in Bangladesh and Nepal in 2013. Bangladesh, Bhutan, Nepal, Maldives and Timor-Leste have prepared National Adaptation Programmes of Action (NAPAs) and submitted them to the secretariat of the United Nations Framework Convention on Climate Change. NAPAs provide a process for least-developed countries, as defined by the United Nations, to identify priority activities that respond to their urgent and immediate needs to adapt to climate change – those for which further delay would increase vulnerability and/or costs at a later stage. All countries have developed some sort of national plan and strategy for addressing the health risks of climate change.

Awareness of and capacity to manage climate-sensitive health outcomes in the WHO South-East Asia Region

In 2015, in 10 of the 11 countries of the WHO South-East Asia Region (the Democratic People’s Republic of Korea was not included, for operational reasons), a review explored awareness levels and understanding of the capacity of health systems to prepare for and manage the health risks of a changing climate. Interviews with 35 key informants in ministries of health, environment, agriculture, water resources, finance and treasury, planning, rural development and other related sectors strongly indicated that their countries were vulnerable to weather events, and most agreed that these weather events would become severe in the next 25 years. The majority of stakeholders could nominate at least one climate-sensitive health outcome in their respective countries, and many accurately identified the full range of health outcomes of concern. Most stakeholders agreed that these health outcomes could increase over the next 25 years with climate change, although some noted that further research was needed to better understand the magnitude and pattern of possible increases in risks in their countries. There was some degree of optimism, with a small number of stakeholders indicating that effective health systems and programmes could reduce the health risks of a changing climate. However, there was a low level of awareness of measures being taken to address the health risks from climate change. Where key informants were aware of measures, most indicated that current measures are inadequate and that additional and supportive measures are needed to prepare for any projected changes in health burdens due to climate change. With support from the WHO Regional Office for South-East Asia, country ministries of health are working to incorporate climate change into national health policies and plans.

All countries demonstrated a large array of partnerships with different organizations, including meteorological and environmental ministries and organizations, which bodes well for future collaborations. Engagement beyond sectoral and organizational silos is mandatory, to be able to understand the multiple drivers of adverse climate-sensitive health outcomes and to effectively design and implement programmes to manage those risks. There are significant opportunities for improving population health now, by using the rich meteorological and environmental information being generated to, for example, develop early-warning and response systems to dengue and heat waves.

Action plans for climate change, including NAPAs, of all the countries identified health projects as one of their priorities. However, there was generally very little information on crucial implementation processes, including (i) the people who were going to be involved as key implementers; (ii) the time frame of the projects; (iii) the responsibilities of different stakeholders; and (iv) how the projects were to be financed. Providing specifics on each of these issues is vital to monitor the progress and success of activities for climate change and health outcomes.

Urgent sourcing and securing of financial support, and subsequent implementation of prioritized projects for climate change and health outcomes identified in country plans, is a priority, in order to build resilience to the health risks of climate change in the region. Related to this is the gap in understanding at both country and regional levels of the main funding opportunities available, including the mechanisms for applying for such funding and associated time frames.

Lessons learnt and next steps

There have been many substantial advances in the activities of Member States of the WHO South-East Asia Region to respond to the health risks of climate change, particularly in relation to partnership building. These advances are promising
**Fig. 2. Key risks from climate change in Asia and the potential for risk reduction through mitigation and adaptation**

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<tr>
<td><strong>Increased risk of crop failure and lower crop production (medium confidence)</strong></td>
<td>Present</td>
<td>Present</td>
<td>Autonomous adaptation of farmers on-going in many parts of Asia.</td>
<td>Present</td>
</tr>
<tr>
<td><strong>Water shortage in arid areas of Asia (medium confidence)</strong></td>
<td>Present</td>
<td>Present</td>
<td>Limited capacity for water resource adaptation; options include developing water saving technology, changing drought-resistant crops, building more water reservoirs.</td>
<td>Present</td>
</tr>
<tr>
<td><strong>Increased marine, coastal, and urban flooding leading to widespread damage to infrastructure, livelihoods, and settlements in Asia (medium confidence)</strong></td>
<td>Present</td>
<td>Present</td>
<td>Exposure reduction via structural and non-structural measures, effective land-use planning, and selective relocation • Reduction in the vulnerability of lifeline infrastructure and services (e.g., water, energy, waste management, food, business, mobility, local ecosystems, telecommunications) • Construction of monitoring and early warning systems; measures to identify exposed areas, assist vulnerable areas and households, and diversify livelihoods • Economic diversification</td>
<td>Present</td>
</tr>
<tr>
<td><strong>Increased risk of flood-related deaths, injuries, infectious diseases and mental disorders (medium confidence)</strong></td>
<td>Present</td>
<td>Present</td>
<td>Shatter preparedness including early warning systems and local coping strategies.</td>
<td>Present</td>
</tr>
<tr>
<td><strong>Increased risk of heat-related mortality (high confidence)</strong></td>
<td>Present</td>
<td>Present</td>
<td>• Heat health warning systems • Urban planning to reduce heat islands; improvement of the built environment; development of sustainable cities • New work practices to avoid heat stress among outdoor workers</td>
<td>Present</td>
</tr>
<tr>
<td><strong>Increased risk of drought-related water and food shortage causing malnutrition (high confidence)</strong></td>
<td>Present</td>
<td>Present</td>
<td>• Shatter preparedness including early warning systems and local coping strategies • Adaptive integrated water resource management • Water infrastructure and reservoir development • Diversification of water sources including water re-use • More efficient use of water (e.g., improved agricultural practices, irrigation management, and resilient agriculture)</td>
<td>Present</td>
</tr>
<tr>
<td><strong>Increased risk of water and vector-borne diseases (medium confidence)</strong></td>
<td>Present</td>
<td>Present</td>
<td>Early warning systems, vector control programs, water management and sanitation programs.</td>
<td>Present</td>
</tr>
<tr>
<td><strong>Exacerbated poverty, inequalities and social vulnerabilities (high confidence)</strong></td>
<td>Present</td>
<td>Present</td>
<td>Insufficient emphasis and limited understanding on urban poverty, interaction between livelihoods, poverty and climate change.</td>
<td>Present</td>
</tr>
<tr>
<td><strong>Coral reef decline in Asia (high confidence)</strong></td>
<td>Present</td>
<td>Present</td>
<td>The limited adaptation options include minimizing additional stresses on marine protected areas, especially where sea surface temperatures are expected to change least and reef resilience is expected to be highest.</td>
<td>Present</td>
</tr>
<tr>
<td><strong>Mountain-top extinctions in Asia (high confidence)</strong></td>
<td>Present</td>
<td>Present</td>
<td>Adaptation options are limited. Reducing non-climate impacts and maximizing habitat connectivity will reduce risks to some extent, while assisted migration may be practical for some species.</td>
<td>Present</td>
</tr>
</tbody>
</table>

and it is important to continue to support them. Many ministries of health and their staff in the region are pursuing activities for climate change and health outcomes with energy and enthusiasm. There are, however, areas for further support and investigation, including: (i) better understanding of how climate change and health outcomes can be linked with country-level activities related to the Sustainable Development Goals (SDGs); (ii) policy integration and framing; and (iii) monitoring, evaluation, and learning. These challenges are briefly discussed next.

**Linking with the Sustainable Development Goals**

The signing of the SDGs in 2015 signalled an unprecedented international policy window for addressing global sustainability and human development. The SDGs differ from their predecessor – the Millennium Development Goals – in that they concern all countries (not just least-developed countries) and aim to comprehensively link human development goals and environmental sustainability under a single global agenda. The SDGs therefore provide an opportunity to synergize global efforts to tackle climate change and its health impacts, as well as providing the framework to do this in a manner that is collaborative among countries. The integral systems approach that the SDGs necessitates means that planetary health (human health and the natural systems that underpin it) can also link with and adopt this framework. In addition, global health efforts have the potential to be stronger if they can be connected to a process such as the SDGs, with clear targets, indicators, and time frames.

**Policy integration and framing**

One clear policy lever to promote appropriate and effective responses to the health risks of climate change is the inclusion of climate change as a key consideration in national public health policies. Unless the health risks arising from climate change are clearly articulated in policies, it is difficult to (i) develop appropriate responses; (ii) garner the support from partner ministries (such as water, agriculture, etc.) for activities for climate change and health outcomes, the bulk of which are inherently cross-sectoral; and (iii) access funding for activities for climate change and health outcomes. Issues related to climate change have often been identified indirectly in public health policies, such as via disaster risk management and food security measures; however, it is imperative that these concerns are linked (where possible) to issues of weather and projected climate change. Unless this is clear, then there are likely to be many missed opportunities to coordinate and collaborate with such programmes to ensure policies and programmes promote health and well-being, and to seek joint adaptation funding. There is an opportunity here to encourage and bolster countries to explore different and culturally appropriate advocacy pathways for such policy integration to occur.

**Monitoring, evaluation and learning**

Indicators for monitoring, evaluation and learning (traditionally termed M&E) are needed, to assess and track over time the ability of health systems to prepare for and effectively respond to the health risks of a changing climate. M&E indicators can also facilitate identification of good practices for replication and scaling up, key barriers to progress, and enabling conditions. This information can enhance understanding of the past performance of given activities and help ensure that future adaptation actions are appropriately designed and executed. Health systems have a long history of monitoring health-outcome-specific morbidity and mortality, and of identifying which individuals, communities and regions are particularly vulnerable to an exposure. What is different is that climate change is likely to change where and when cases of climate-sensitive health outcomes occur. Surveillance systems may need to be modified to ensure data are collected in new locations and at new times of year. In some countries, surveillance systems may need to begin collecting data on emerging or re-emerging threats. Doing so proactively will help to prevent outbreaks before they occur.

In addition to outcome indicators of climate-sensitive health outcomes, indicators are needed to monitor resilience to the health risks of climate change. It would be helpful to develop a common set of indicators for countries in the WHO South-East Asia Region, to track and facilitate quantification of the effectiveness of adaptation policies and measures over time. In addition, each country may have unique indicators to track specific issues of concern.

**Conclusion**

Gaps in preparedness to manage the health risks of climate change are evident in Member States of the WHO South-East Asia Region. At the heart of the challenges lies the importance of genuine collaboration, within and between health and related ministries, as well as across levels of governance (local to national) and types of organizations. Climate change and health outcomes is an issue that demands collaboration to develop the synergies needed to produce powerful responses. A variety of actors outside the public sector and the health sector already respond to the threats posed by climate change, and inclusive decision-making processes and policy and programme development will harness the energies of these important organizations.

Critically, climate change must be robustly included in health policies and planning processes, with detailed timelines and identification of the required human and financial resources and partners. For many countries, additional capacity-building on climate change is needed within their ministry of health, and within other ministries, on the health risks of climate variability and change. Opportunities should be promoted to improve the visibility and representation of the health sector on national- and regional-level working groups and committees for climate change. Reporting frameworks are needed to support all ministries to report on activities for climate change and health outcomes. Addressing these gaps would not only improve population health now but also increase resilience to a changing climate.

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Health-sector responses to address the impacts of climate change in Nepal

Meghnath Dhimal1,2, Mandira Lamichhane Dhimal2,3, Raja Ram Pote-Shrestha4, David A Groneberg2, Ulrich Kuch2

1Nepal Health Research Council, Kathmandu, Nepal, 2Institute of Occupational, Social and Environmental Medicine, Goethe University, Frankfurt am Main, Germany, 3Faculty of Social Sciences, Goethe University, Frankfurt am Main, Germany, 4World Health Organization Country Office for Nepal, Kathmandu, Nepal

Correspondence to: Dr Meghnath Dhimal (meghdhimal@gmail.com)

Abstract

Nepal is highly vulnerable to global climate change, despite its negligible emission of global greenhouse gases. The vulnerable climate-sensitive sectors identified in Nepal’s National Adaptation Programme of Action (NAPA) to Climate Change 2010 include agriculture, forestry, water, energy, public health, urbanization and infrastructure, and climate-induced disasters. In addition, analyses carried out as part of the NAPA process have indicated that the impacts of climate change in Nepal are not gender neutral. Vector-borne diseases, diarrhoeal diseases including cholera, malnutrition, cardiorespiratory diseases, psychological stress, and health effects and injuries related to extreme weather are major climate-sensitive health risks in the country. In recent years, research has been done in Nepal in order to understand the changing epidemiology of diseases and generate evidence for decision-making. Based on this evidence, the experience of programme managers, and regular surveillance data, the Government of Nepal has mainstreamed issues related to climate change in development plans, policies and programmes. In particular, the Government of Nepal has addressed climate-sensitive health risks. In addition to the NAPA report, several policy documents have been launched, including the Climate Change Policy 2011; the Nepal Health Sector Programme – Implementation Plan II (NHSP-IP 2) 2010–2015; the National Health Policy 2014; the National Health Sector Strategy 2015–2020 and its implementation plan (2016–2021); and the Health National Adaptation Plan (H-NAP): climate change and health strategy and action plan (2016–2020). However, the translation of these policies and plans of action into tangible action on the ground is still in its infancy in Nepal. Despite this, the health sector’s response to addressing the impact of climate change in Nepal may be taken as a good example for other low- and middle-income countries.

Keywords: adaptation plan, climate change, diarrhoeal disease, gender, public health, vector-borne disease

Background

There is a global consensus that the climate change we are experiencing worldwide is natural and anthropogenic but mainly accelerated by the anthropogenic emission of so-called greenhouse gases into the atmosphere. The published literature continues to focus mainly on the effects of climate change in high-income countries. The effects on the most vulnerable populations of low- and middle-income countries have been grossly underreported in the past, and that imbalance is improving only slowly. These low- and middle-income countries are historically least responsible for emissions of greenhouse gases but most vulnerable to the impacts of climate change, an imbalance that has been described as a “growing ethical crisis”. The largest health risks are observed, and will continue to occur, in populations that are most affected by climate-sensitive diseases, such as vector-borne and waterborne diseases, and in those that are deprived of economic development. Thus, climate change disproportionately affects people with less power or those who are discriminated against because of factors such as their gender, ethnicity or socioeconomic status. Hence, poor people, members of minority groups, women, children, elderly people, people with chronic diseases and disabilities, those residing in areas with a high prevalence of climate-sensitive risks and diseases, and workers exposed to extreme heat or increased weather variability are the most vulnerable to the adverse impacts of climate change.

Despite Nepal’s very low contribution to global emissions of greenhouse gases (0.027%), it is one of the countries that is most vulnerable in the world to the impacts of climate change. In the Global Climate Risk Index, published by the nongovernmental organization Germanwatch, which is an analysis of the quantified impacts of extreme weather events, Nepal was the seventh-most affected country in 2014, with 1.90 deaths per 100 000 inhabitants, losses of US$ 143 million in purchasing power parity and 0.21% loss per unit of gross domestic product. Nepal’s particular vulnerability to climate change is a result of its geographical position in the “third pole” of this planet (the Himalayan mountains and Tibetan...
plateau), complex topography with steep mountain slopes and many rivers, and low socioeconomic status of the people, who largely depend on climate-sensitive sectors, such as agriculture.9

Several studies have shown a trend of increasing temperatures in Nepal in recent decades, with higher warming rates in the hill and mountain regions than in the lowlands (Siwalik and Terai).10–13 Changes in precipitation do not show such distinct trends in Nepal. However, there have been changes in the frequency and severity of extreme weather events, such as heavy rainfall, droughts, heat waves and cold waves.13,14 The combined effects of increased temperature and diminished snowfall, followed by the rapid retreat of the majority of glaciers, have resulted in a depletion of the amount of water available for drinking, livestock and irrigation in the hill and mountain regions of Nepal.12,15,16

The Climate and Health Country Profile Project, a joint collaboration between the World Health Organization (WHO) and the Secretariat of the United Nations Framework Convention on Climate Change, compared the effects of the highest and lowest of the emissions pathways defined by the Intergovernmental Panel on Climate Change with a situation in which the extent of climate disruption is limited for each country.17 For Nepal, the project estimated that, under the high-emissions scenario, the mean annual temperature is projected to rise by about 6 °C; the number of days with very heavy precipitation (20 mm or more) could increase by about 6 days, leading to a higher risk of floods; and the longest dry spell could increase by about 14 days, from an average of about 80–90 days, with large year-to-year variability from 1990 to 2100.18 Hence, climate change and climate-induced extreme events will continue to accelerate the loss of lives and property and increase the burden of diseases in Nepal, unless timely corrective actions are taken. The aim of this paper is to provide a perspective on climate-sensitive health risks, vulnerability, research evidence and health-sector responses to address the health risks of climate change in Nepal.

Current climate-sensitive health risks in Nepal

The Government of Nepal has identified public health as one of the sectors that is most vulnerable to the negative effects of climate change. The potential health impacts of climate change in Nepal include vector-borne, waterborne, airborne and foodborne diseases, nutrition-related diseases, injuries and mental illnesses.3,4,10 Climate change impacts directly on human health and indirectly via its effects on disease-transmitting agents. Based on global evidence and scientific consensus, Nepal will observe the changes summarized in Box 1 if climate change continues as projected.20,21

In order to avoid or prevent these health risks of climate change in the near and distant future, appropriate strategies are essential for early planning and strengthening of the country’s health system. The inclusion of the health sector in adaptation planning can yield synergies in actions to protect population health and result in the policies and programmes of other sectors contributing to health co-benefits.20 Hence, multisectoral collaboration and coordination is of utmost importance for addressing the health risks of climate change in Nepal.

Box 1. Projected effects on Nepal of unabated climate change

- Greater risk of injury, disease and death, owing to more-intense heat waves, cold waves and forest fires
- Increased risk of undernutrition, resulting from diminished food production in resource-poor regions
- More negative health consequences of lost work capacity and reduced labour productivity in vulnerable populations
- Increased risk of vector-borne, waterborne and foodborne diseases, especially in mountain areas, and leading to perennial occurrence in the lowlands
- Increase in cardiorespiratory diseases, owing to higher ambient air pollution and haze in urban areas, resulting from climate change
- Increase in mental health problems, owing to extreme climatic events such as droughts, floods and landslides
- Modest reductions in cold-related mortality and morbidity in the highlands, owing to fewer cold extremes
- Increased morbidity and mortality related to cold waves in the southern Terai lowlands
- Reduced disease-transmission capacity of vector insects in the Terai, owing to higher temperatures exceeding their thermal thresholds

Vulnerable populations and gender

The vulnerability of a population to a health risk related to climate depends on exposure, the availability of local resources, the effectiveness of governance and public institutions, the quality of public health infrastructure, and access to relevant local information on extreme weather threats and early-warning systems.4 Although all populations are vulnerable to the adverse health impacts of climate change, those living in flood-prone areas, mountain regions, water-stressed regions and densely populated urban areas are exposed to the greatest risks. Analyses carried out in Nepal have shown that men and women differ with respect to climate vulnerability and impacts, owing to sociocultural factors, differential access to and control over resources, and institutional arrangements.9 For example, the depletion of water resources causes particularly serious problems to women, especially with respect to sanitation, health and safety. Limited access to water resources for women, girls and children increases their workload and walking distances, which can contribute to adverse health effects, such as on personal hygiene or aspects of reproductive health, including uterine prolapse.22 Similarly, other health impacts of climate change, such as epidemics, increase the workload for women, since women in Nepal are culturally responsible for taking care of family members who are ill, children and elderly individuals. Furthermore, there are concerns that the impacts of climate change in Nepal are contributing to outbound migration of men seeking employment overseas, thereby increasing the health impacts of climate change on the women left behind mainly in the rural areas. Hence, continuing climate change may exacerbate gender differences in health outcomes in Nepal.
Evidence on the health impacts of climate change in Nepal

There are limited etiological studies on the health impacts of climate change in Nepal. Challenges to conducting such research in mountainous low- or middle-income countries include a lack of trained human resources, financial resources, long-term data and information, and suitable methods that are applicable to the local context.23 Despite these challenges, a number of research studies focusing on the effects of climate factors on vector-borne and waterborne diseases have been carried out in Nepal.

Vector-borne diseases

Nepal is endemic for seven major vector-borne diseases, namely malaria, lymphatic filariasis, Japanese encephalitis, visceral leishmaniasis, dengue, chikungunya and scrub typhus. A systematic review of the literature found evidence for a pronounced warming in the highlands, an expansion of autochthonous cases of vector-borne diseases to previously non-endemic highland areas including mountain regions, and significant relationships between climatic variables and vector-borne diseases and/or their vectors.24 Despite a significant decline in the number of cases of malaria in Nepal over the last decade, the distributions of malaria cases and malaria mosquitoes (Anopheles spp.) have expanded in hill and mountain regions that had previously been considered non-endemic.26–27 A study conducted in two districts that are highly endemic for malaria showed that a 1 °C increase in minimum and mean temperatures increased the incidence of malaria by 27% and 25%, respectively.28

The first reported case of dengue virus infection in Nepal was a Japanese volunteer in 2004, and the first local transmission of dengue virus in Nepal was confirmed during a 2006 outbreak in urban areas of the lowlands; dengue fever has subsequently extended its geographical range in the Terai and hill regions of Nepal.24,25 Similarly, cases of chikungunya fever have been reported from different districts of Nepal, including the hill regions, with a first report of confirmed indigenous cases in 2013.30,31 The mosquito vectors of these two viral diseases (and of Zika virus), Aedes aegypti and Aedes albopictus, have established populations up to at least 2000 m above mean sea level in Nepal.27,32 Significant effects of the climatic factors of temperature, rainfall and relative humidity on the abundance of these vector species has been reported from central Nepal.32,33 Although infections with Japanese encephalitis virus have been reported from 24 districts of the Terai region only in the past, Japanese encephalitis virus has recently been shown to have extended its distribution to hill and mountain regions of Nepal.24,34 Its principal vectors, Culex tritaeniorhynchus mosquitoes, have established populations at least 2000 m above mean sea level in Nepal. The spatio-temporal distribution of lymphatic filariasis caused by Wuchereria bancrofti is now also endemic in additional hill and mountain regions of Nepal.24 The principal vectors of lymphatic filariasis in Nepal, Culex quinquefasciatus mosquitoes, have established populations up to at least 2100 m above mean sea level in Nepal (the highest sampled altitude in Nepal in that study).33 Moreover, significant effects of the climatic factors of temperature and relative humidity on the mean abundance of C. quinquefasciatus per trap have been reported, indicating likely effects of climate change on the transmission of lymphatic filariasis.32 Spatio-temporal analysis of visceral leishmaniasis in Nepal shows an expansion of autochthonous cases and of the principal vector (Phlebotomus argentipes sand flies) towards the hill and mountain regions over the last decade.24 A recent outbreak investigation confirmed local transmission of visceral leishmaniasis in hill districts of eastern Nepal.35 A positive association of cases of visceral leishmaniasis with the climatic factors of temperature and rainfall has been observed, with reports of disease outbreaks 2–3 months after heavy rainfall in Nepal.25

Both climatic and non-climatic factors have played a significant role in epidemics and the control of vector-borne diseases, but the net effects depend on socioeconomic development and the capacity of the health system to control vectors and provide timely diagnosis, management and effective treatment of affected individuals.36 Hence, climate change is expected to increase the risk of epidemics of vector-borne diseases in highland regions of Nepal that had previously been considered non-endemic, if other non-climatic drivers of vector-borne diseases remain constant.

Waterborne diseases

Although case-fatality rates of diarrhoeal diseases are declining in Nepal, the incidence among children under 5 years of age has been increasing in the last decade.37 Frequent outbreaks of diarrhoeal diseases, including cholera, have been reported from different districts of Nepal in recent years.37 An analysis of data on temperature and diarrhoea from July 2002 to June 2014 estimated that, for a 1 °C increase in ambient temperature, the incidence of diarrhoeal diseases in Nepal rose by 4.39%.38 The same study also estimated that, for a 1 cm increase in annual rainfall, the incidence of diarrhoeal diseases rose by 0.28%. In the same time period, coverage of water supply and sanitation in Nepal, as well as the economic status of the population, has improved, and the community-based integrated management of childhood illness programme was scaled up.39 Nevertheless, the United Nations Children’s Fund Nepal Multiple Indicator Cluster Survey for 2014 found 82.2% of samples of household drinking water and 71.1% of samples of source water were contaminated with Escherichia coli bacteria (risk level ≥1 colony-forming units [cfu]/100 mL).39 Hence, climate change and climate variability may be contributing to increasing risks for diarrhoeal diseases.

Policies and programmes: work to date

The health sector has recently started to mainstream climate change into health-sector plans, policies and programmes in Nepal. The Nepal Health Research Council (NHRC), with the support of the WHO Country Office for Nepal, identified and prioritized climate change as one of its research areas in 2006. Then, NHRC and the WHO Country Office for Nepal convened a national workshop on climate change and human health in December 2007. This was possibly the first health-sector workshop on climate change in Nepal and it sensitized more than 80 participants, including government programme managers, policy-makers, academics, researchers, members of civil society and journalists.40 The workshop recommended generating country-level evidence on climate change and health through research, and raising awareness on this
emerging issue at various levels, from the public in general to policy-makers. Thereafter, a number of studies on these topics were carried out in Nepal, with major support from WHO.

**National Adaptation Programme of Action (NAPA) to Climate Change, 2010**
The National Adaptation Programme of Action (NAPA) to Climate Change of Nepal identified health as one of the sectors that were most vulnerable to climate change. A Public Health Thematic Working Group was formed under the leadership of the Ministry of Health and contributed to identifying the adaptation needs of the health sector. The following are the prioritized activities for public health adaptation to climate change:

- reducing public health impacts of climate change through evidence-based research and piloting;
- empowering communities through education for responding to the adverse effects of climate change in public health;
- investing in disease-outbreak and emergency response;
- scaling up programmes on vector-borne, waterborne and foodborne diseases and disasters;
- strengthening forecasting/early-warning and surveillance systems for climate change and health.

**Nepal Health Sector Programme – Implementation Plan II 2010–2015**
The Nepal Health Sector Programme – Implementation Plan II (NHSP-IP 2) 2010–2015 was the first health-sector plan that included a component on climate change. This plan had the objective to improve the health system to achieve universal coverage of essential health services, including control of communicable disease. The plan added sanitation and hygiene for communities as one of the health-promotion activities, and environmental health (water, air quality, sanitation, hygiene, waste disposal) as one of the components of essential health services for piloting and scaling up through intersectoral partnership. This plan also included establishment of a knowledge network with academia and practitioners on climate change, and a public health response team for climate change.

**Climate Change Policy 2011**
The Climate Change Policy 2011 aimed to form a sector-wide working group and integrate policy on climate change in the sector policies. After the introduction of this policy, sectoral thematic groups were formed and climate change units have been established in various ministries, including the Ministry of Health. In some ministries, existing units such as policy and planning are designated as focal units for climate change. The policy has emphasized the implementation of preparedness programmes for disasters and epidemics; regular implementation of public-awareness and capacity-building programmes; preparation and regular updating of appropriate climate-forecasting models for Nepal, based on regional climate models; and allocation of at least 80% of available adaptation funds to programmes at the community level related to climate change. Many provisions of this policy are reflected in health-sector policies and plans, such as the National Health Policy 2014 and the Nepal Health Sector Strategy Implementation Plan (2016–2021).

**National health policy, strategy and implementation plan**
The main objective of the National Health Policy 2014 is universal coverage of health services for all. The policy has one objective to gradually mainstream health into all policies, by further strengthening collaboration with stakeholders in health across all sectors. In order to achieve this objective of health in all policies, the following strategies have been adopted:

- the health agenda will be included in all concerned policies;
- for the overall management of the negative effects of climate change on health, a multisectoral action plan will be developed in collaboration with all stakeholders, with proper utilization of national networks and mechanisms or opportunities;
- the action plan will be prepared and implemented in such a way that there will be multisectoral coordination on various aspects, such as safe drinking water, sanitation, energy, food security, climate, environment, education, accommodation, and infrastructure development (including roads that affect access to health services).

Guided by the National Health Policy 2014, the Nepal Health Sector Strategy 2015–2020 prioritizes multisectoral collaboration to address the social determinants of health. The strategy articulates the nation’s commitment towards achieving universal health coverage and emphasizes the need to establish a multisectoral response to climate change.

Key interventions identified in the Nepal Health Sector Strategy Implementation Plan 2016–2021 are: (i) generation of evidence on the impact of climate change on human health; (ii) implementation of the NAPA to Climate Change with respect to planning and preparedness for disasters induced by climate change; (iii) monitoring changes in vector- and disease-distribution patterns; (iv) expansion of water-quality surveillance; and (v) collaboration with other sectors to enforce standards for air, water and food quality.

The Ministry of Health of Nepal, with support from the WHO Country Office for Nepal, carried out a vulnerability and adaptation assessment of the health sector. Based on the results of this assessment and other research evidence, the Health National Adaptation Plan (H-NAP): climate change and health strategy and action plan was developed and was approved in 2016. The H-NAP has a vision to develop climate-resilient health systems to protect human health from climate change in Nepal. This plan aims to develop national strategies on climate change and health, with an adequate focus on the health sector and intersectoral collaboration to protect health from the adverse effects of climate change. Furthermore, it aims to ensure that health issues are considered in the ongoing formulation process of the National Adaptation Plan, so that policies and programmes in other sectors contribute to health co-benefits.

As a part of institutional reform, a dedicated Disease Control, Climate Change and Environmental Health section was established in the Ministry of Health in 2016, which works as a focal point for environmental health and climate change in Nepal. Several research projects on climate change and health have been carried out by the NHRC, academic institutions and
individual researchers. Awareness-raising programmes on climate change and health are carried out by the National Health Education, Information and Communication Centre, through district public health offices. A component on climate change is incorporated in regular induction training sessions of the National Health Training Centre. The Epidemiology and Diseases Control Division (EDCD) of the Department of Health Services is working on control of vector-borne disease; strengthening early-warning and reporting systems; surveillance of water quality; and disaster risk management. Based on research evidence and surveillance data, the EDCD has, for example, scaled up the programme for control of visceral leishmaniasis in hill districts of Nepal.37 The WHO Country Office for Nepal has been supporting the Ministry of Health to build a climate-resilient health system. A multidisciplinary thematic working group on public health and water, sanitation and hygiene has been formed under the leadership of the Ministry of Health and is working to align health-specific components in the National Adaptation Plan formulation process.47 In conclusion, Nepal is making good progress towards mainstreaming climate change in its plans, strategies and policies, although enforcement of these provisions and translation to tangible action on the ground is still in its infancy.

Policies and programmes: next steps

There is an urgent need to conduct more research studies on vector-borne and waterborne diseases and other climate-sensitive diseases and risks, including noncommunicable ones, to inform evidence-based health-adaptation planning and programming for climate change in Nepal. This requires strengthening of data recording and reporting in the disease surveillance and health management information systems. Multisectoral preparedness plans are needed, to address the impacts from climate-related extremes such as heat waves, cold waves, droughts, floods, fire and storms. As health is directly and indirectly affected by climate change via various pathways, there should be a focus on health in national adaptation plans for the medium- and long-term adaptation needs of all sectors, including agriculture, energy, water, forestry and infrastructure. Enhancement of awareness is required, from grass-roots to policy-maker levels, and medical and health sciences curricula should be updated where content on climate change and health is missing or minimal. The health-sector policies and planning should focus on developing climate-resilient health systems.48 For this, climate change should be considered as an important determinant of health within each of the six core components or “building blocks” of the WHO framework for health systems: (i) service delivery; (ii) health workforce; (iii) health information systems; (iv) access to essential medical products, vaccines and technologies; (v) financing; and (vi) leadership/governance.49 Finally, existing policies, strategies and plans on climate change and health should be prioritized for implementation now, rather than waiting for more evidence and policies.

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References


Climate conditions, workplace heat and occupational health in South-East Asia in the context of climate change

Tord Kjellstrom¹, Bruno Lemke², Matthias Otto²
¹Australian National University, Canberra, Australia, ²Nelson-Marlborough Institute of Technology, Nelson, New Zealand

Correspondence to: Professor Tord Kjellstrom (kjellstromt@yahoo.com)

Abstract

Occupational health is particularly affected by high heat exposures in workplaces, which will be an increasing problem as climate change progresses. People working in jobs of moderate or heavy work intensity in hot environments are at particular risk, owing to exposure to high environmental heat and internal heat production. This heat needs to be released to protect health, and such release is difficult or impossible at high temperatures and high air humidity. A range of clinical health effects can occur, and the heat-related physical exhaustion leads to a reduction of work capacity and labour productivity, which may cause substantial economic losses. Current trends in countries of the World Health Organization South-East Asia Region are towards higher ambient heat levels during large parts of each year, and modelling indicates continuing trends, which will particularly affect low-income individuals and communities. Prevention activities need to address the climate policies of each country, and to apply currently available heat-reducing technologies in workplaces whenever possible. Work activities can be adjusted to reduce exposure to daily heat peaks or seasonal heat concerns. Application of basic occupational health principles, such as supply of drinking water, enforcement of rest periods and training of workers and supervisors, is essential.

Keywords: climate, heat stress, occupation, South-East Asia, wet bulb globe temperature

Background

Climate conditions of direct importance to human health include air temperature, humidity, air movement (wind speed) and heat radiation.¹ These have been known as occupational hazards for more than a century, based on evidence from field observations, epidemiological studies and physiological laboratory experiments. They were described in a detailed World Health Organization (WHO) technical report series in 1969,² and in the first substantive WHO/World Meteorological Organization/United Nations Environment Programme review of the impacts of climate change on human health in 1996.³

The ongoing and projected future climate change⁴ has given new impetus to the study, analysis and prevention of climate-related occupational health hazards. The WHO South-East Asia Region is an area with substantial future threats to health from the changing climate.⁵ As the environmental heat levels slowly increase, it is clear that working people are a vulnerable group.⁶ This paper briefly discusses the special risks to, and the health policies and strategies to protect, the populations living in this region of the world.

Occupational health hazards related to climate

Any occupational health hazard that is associated with climate factors can naturally also be linked to climate change. Table 1 summarizes the most likely hazards and their effects in vulnerable groups, based on a recent review of a large number of epidemiological and laboratory studies.⁷,⁸ The most predictable impact of climate change is an increase in environmental heat levels,⁴ because the modelling of future climate starts from the influence of greenhouse gases on air temperature. Health effects, such as heat exhaustion, heat stroke, chronic kidney disease and chemical poisoning (see Table 1), are therefore part of the occupational health impacts occurring in countries of the WHO South-East Asia Region. Thus, countries or areas with very long periods of hot weather are at particular risk for the heat effects. All of the tropical countries of the region are in this category. The risks of kidney disease⁶,⁹ and chemical poisoning¹⁰,¹¹ will depend on other factors at the workplace, but the local heat levels are a key feature. Extreme weather, particularly strong storms or heavy rainfall, can create serious injury and drowning hazards (see Table 1) and emergency workers are a vulnerable group,¹² as the frequency and strength of extreme weather events is likely to increase with climate change.⁴

The other health effects mentioned in Table 1 (vector-borne diseases, infectious diseases, noncommunicable diseases and mental health issues) are indirectly linked to climate change via factors such as ecological conditions, local food-production possibilities, worsened clinical status and displacement from home locations. Climate change involves effects on access to water and water quality, as well as changes in the ecology that may bring disease vectors to new locations. Local changes in climate conditions may be so extreme that continued habitation becomes difficult, as exemplified by a 21-year longitudinal study of weather-related displacement in rural Pakistan.¹³
Table 1. Climate-related occupational health hazards, vulnerable groups and health effects

<table>
<thead>
<tr>
<th>Climate hazard</th>
<th>Vulnerable groups</th>
<th>Health effects</th>
</tr>
</thead>
<tbody>
<tr>
<td>High heat exposure (temperature and humidity)</td>
<td>Workers carrying out physically demanding tasks; outdoor workers exposed to direct sun</td>
<td>Heat exhaustion, heat stroke</td>
</tr>
<tr>
<td></td>
<td>Workers in heat-stress situations who do not hydrate enough</td>
<td>Chronic kidney disease</td>
</tr>
<tr>
<td></td>
<td>Workers exposed to highly evaporative chemicals, e.g. organic solvents; high heat leads to higher workplace chemical exposures</td>
<td>Chemical poisoning</td>
</tr>
<tr>
<td>Extreme weather, wind</td>
<td>Outdoor workers in affected areas; emergency workers; all workers when their workplaces are closed due to weather</td>
<td>Injuries, drowning</td>
</tr>
<tr>
<td>Ecological conditions indirectly related to climate</td>
<td>Outdoor workers, particularly farmers needing to work at dawn and dusk</td>
<td>Vector-borne diseases, diseases related to ecological change</td>
</tr>
<tr>
<td>Other indirect climate-related hazards</td>
<td>Low-income groups with limited health protection; workers with existing non-climate health problems affected by heat</td>
<td>Infectious diseases, noncommunicable diseases, mental health issues, etc.</td>
</tr>
</tbody>
</table>

*Further details are provided in Kjellstrom et al., 2013 and 2016.*

**Specific risks related to workplace heat**

High heat exposure creates a risk of heat exhaustion and heat stroke and is subjectively perceived as unpleasant or dangerous. People working or involved in heavy physical activity are particularly affected because physical activity produces additional intra-body heat that must be dissipated. A working person’s natural reaction to heat is to reduce physical activity, which reduces the body’s internal heat production. This may be called “self-pacing” or “autonomous adaptation.” An outcome of this preventive reaction is reduced hourly work capacity and reduced economic productivity during exposure to heat.

Fig. 1 outlines the different components of heat stress and its impacts, as well as the different pathways for different health and social effects, most of which can affect working people. The starting point is heat exposure due to environmental/workplace heat. In addition, physical activity leads to internal heat production, which adds to the heat stress. Tight-fitting work clothing reduces the possibility for sweat to evaporate and cool the body, so clothing is a factor in heat stress (see Fig. 1). The pathways to the ultimate negative impacts of heat follow physiological and psychological tracks. This explains the variety of effects of heat that have been reported in reviews.

![Fig. 1. Population health and social impacts of heat: components and pathways](image-url)
Physiological heat strain is not only the result of high air temperature, but is also affected by air humidity, air movement (wind speed) and heat radiation (in outdoor work mainly from the sun). The human body needs to keep an internal temperature close to 37 °C, and when the external temperature is higher, the body temperature may increase. Heat radiation also increases the heat load on the body.

The main mechanism for maintaining a healthy body temperature at high heat loads is evaporation of sweat. This evaporation is reduced when air humidity is high (even if sweating is profuse), while air movement over the skin increases the evaporation. Thus, in order to quantify heat exposure that is linked to the physiological heat strain, an index that combines temperature with the other heat variables is of great importance. In the 1950s, the United States (US) Army developed the wet bulb globe temperature (WBGT) as a tool for protecting army recruits from heat stress, and this has become the most widely used index for occupational heat stress at global level. A WBGT value of 37 °C corresponds to an air temperature of 37 °C if the relative humidity is 100%. At lower humidity, the WBGT level will be lower than the value of the air temperature.

A key question for prevention of heat effects is “what level of WBGT is dangerous?” Table 2 summarizes the maximum WBGT values recommended by different occupational health agencies and organizations in the United States of America (USA), the standards of the International Organization for Standardization (ISO), and proposed limits in India. It is seen that an hourly WBGT of 30 °C or higher will create health risks in some workers, and at a WBGT of 27–28 °C, people in moderate work are at risk. These levels are already exceeded during parts of the year in several countries of the WHO South-East Asia Region. With climate change, the situation will get worse.

An enterprise can compensate for the effects of workplace heat by carrying out heat-sensitive work during the cooler night hours, or by scheduling such work into the cooler season. However, as climate change continues, the availability of “cool periods” is likely to diminish. Another factor influencing heat stress is the humidity level, which often goes up during night hours, reducing the impact of cooling. Many jobs have to be carried out during daylight, which reduces the availability of “cool hours”. For instance, many agricultural workers need to work outdoors in the sun and their pay is based on their product output. In order to maintain income, they may work beyond safe heat-exposure limits and a few die of heat stroke each year, as has happened even in the USA.

Climate conditions in the WHO South-East Asia Region

The WHO South-East Asia Region already experiences particular problems with heat exposure for working people. Currently, a monthly mean WBGT as high as 30 °C occurs in Bangladesh, the Ganges valley of India and Nepal, but generally not outside that area in the region. This can be seen in the heat maps in Intergovernmental Panel on Climate Change (IPCC) reports. The mean WBGT, in the shade, of the hottest month until the end of this century (2071–2099 average) has been modelled. This modelling presents the mean of two widely used models, the Hadley Centre Global Environment Model (HadGEM) from the United Kingdom of Great Britain and Northern Ireland (UK), and the Geophysical Fluid Dynamics Laboratory (GFDL) model from the USA, while the future pathway is the Representative Common Pathway (RCP) 6.0, which has been estimated based on current global policies for mitigation of climate change. The estimates of heat levels would be 2–3 °C higher in the sun during the middle of a day. Thus, most of Bangladesh, India and Thailand, and large parts of other Member States of the region reach heat levels that will have negative effects on working people, unless they are protected with air conditioning. As noted above, an hourly WBGT level above 30 °C would create a risk of health effects in moderate-intensity work, unless the worker takes regular rest within every hour, as per the USA or ISO guidance (see Table 2). Records of the monthly mean levels reaching such high levels imply that a large proportion of the work hours are too hot to carry out continuous work.

The past and projected heat conditions in the WHO South-East Asia Region are summarized in Table 3. It shows the afternoon air temperatures (monthly means of daily maximum temperatures, T max) during the coolest and hottest months in the geographical grid cell (0.5 × 0.5 degrees) around the capital city of each Member State of the region. In most of these countries, this area is one of the most populated, but there are, of course, other grid-cell areas with different climate from the capital. The climate in Bhutan is relatively cool (see Table 3), and the afternoon WBGT value (WBGT max) in the hottest month does not reach close to the risk values listed in Table 2. In the Democratic People’s Republic of Korea, the

Table 2. Examples of occupational hourly heat-exposure limits (WBGT, OC)†

<table>
<thead>
<tr>
<th>Work intensity</th>
<th>Metabolic rate (W)</th>
<th>ACGIHb</th>
<th>AIHAb</th>
<th>NIOSHb</th>
<th>OSHAb</th>
<th>ISO</th>
<th>India, Nag, 1996c</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resting</td>
<td>117</td>
<td>—</td>
<td>32</td>
<td>—</td>
<td>—</td>
<td>33</td>
<td>37</td>
</tr>
<tr>
<td>Light</td>
<td>118–233</td>
<td>30</td>
<td>30</td>
<td>30</td>
<td>30</td>
<td>30</td>
<td>35</td>
</tr>
<tr>
<td>Moderate</td>
<td>234–349</td>
<td>27</td>
<td>28</td>
<td>28</td>
<td>28</td>
<td>28</td>
<td>33.5</td>
</tr>
<tr>
<td>Heavy</td>
<td>350–465</td>
<td>—</td>
<td>26</td>
<td>26</td>
<td>25</td>
<td>25</td>
<td>31.5</td>
</tr>
<tr>
<td>Very heavy</td>
<td>466–580</td>
<td>25</td>
<td>—</td>
<td>25</td>
<td>—</td>
<td>23</td>
<td>28</td>
</tr>
</tbody>
</table>

ACGIH: American Conference of Governmental Industrial Hygienists; AIHA: American Industrial Hygiene Association; ISO: International Organization for Standardization; Geneve, Switzerland; NIOSH: National Institute of Occupational Safety and Health, United States of America (USA); OSHA: Occupational Safety and Health Administration, USA; WBGT: wet bulb globe temperature.

†Heat-exposure limits to prevent health risks among 90% or more of acclimatized workers at different work intensities.
‡USA data from NIOSH, 2016.
§Proposed in Nag, 1996; these values are higher than all the others, owing to different prevention criteria. The Indian Factories Act governs standards, and each state may prescribe a standard of adequate ventilation and reasonable temperature for any factory. Although the use of WBGT in India has been advocated, there are no standard values for India, and states do not prescribe WBGT levels.
WBGT value reaches the limit for heavy labour (see Table 2). All the other countries reach higher values, which implies that workers’ health may be threatened unless protective measures are implemented. The range of estimates of the hottest month in 2017–2099 for the five models used in the ClimateCHIP website are usually 2–5 °C hotter than the heat levels in 1981–2010. 

### Threats to occupational health and productivity in the WHO South-East Asia Region

The heat effects on working people in the WHO South-East Asia Region were already the focus of research at the National Institute of Occupational Health in India decades ago. In their more recent work, Nag et al. produced very important analysis of the heat concerns in relation to climate change. Most studies have been conducted in India, but Thailand and Nepal are also represented among the other countries outside this region. These data represent the potential annual loss of work hours for five countries in the region (see Table 4) and for a number of other countries outside this region. These data represent the modelling results for the policies of the Paris Agreement (similar to RCP 6.0) and the situation for moderate-intensity work (300 W). Losses as high as 5–9% may have major impacts on the annual economic outputs from local enterprises and could reduce a country’s gross domestic product in a significant manner. Such analysis for the countries in South-East Asia is lacking.

### Prevention policies and strategies

A fundamental strategy to reduce the risk of health effects and productivity losses in workplaces in the WHO South-East Asia Region is to ensure that future emissions of greenhouse gases from the largest emitters are constrained beyond the current national plans. Prior to the United Nations Framework Convention on Climate Change meeting in Paris in December 2015, countries published their post-2020 climate plans, known as their intended nationally determined contributions (INDCs). However, adherence to the INDCs would still result in average GTC reaching 2.7 °C, which is higher than the goal of a maximum increase in GTC of 2.0 °C adopted by the assembled governments. Thus, additional efforts towards

### Table 3. Past and projected heat conditions in the WHO South-East Asia Region

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Dhaka, Bangladesh</td>
<td>T_max</td>
<td>T_max</td>
<td>WBGT_max</td>
<td>T_max</td>
<td>T_max</td>
</tr>
<tr>
<td>Thimphu, Bhutan</td>
<td>25</td>
<td>33</td>
<td>29</td>
<td>27–30</td>
<td>35–38</td>
</tr>
<tr>
<td>Thimphu, Bhutan</td>
<td>7</td>
<td>17</td>
<td>14</td>
<td>8–13</td>
<td>18–20</td>
</tr>
<tr>
<td>Pyongyang, Democratic Republic</td>
<td>-3</td>
<td>28</td>
<td>25</td>
<td>0–2</td>
<td>31–33</td>
</tr>
<tr>
<td>New Delhi, India</td>
<td>20</td>
<td>38</td>
<td>30</td>
<td>22–25</td>
<td>38–43</td>
</tr>
<tr>
<td>Jakarta, Indonesia</td>
<td>31</td>
<td>32</td>
<td>29</td>
<td>32–34</td>
<td>34–36</td>
</tr>
<tr>
<td>Male’, Maldives</td>
<td>31</td>
<td>32</td>
<td>29</td>
<td>32–33</td>
<td>33–35</td>
</tr>
<tr>
<td>Nay Pyi Taw, Myanmar</td>
<td>28</td>
<td>37</td>
<td>29</td>
<td>30–32</td>
<td>38–40</td>
</tr>
<tr>
<td>Kathmandu, Nepal</td>
<td>18</td>
<td>29</td>
<td>25</td>
<td>20–22</td>
<td>32–35</td>
</tr>
<tr>
<td>Colombo, Sri Lanka</td>
<td>30</td>
<td>33</td>
<td>28</td>
<td>32–33</td>
<td>34–35</td>
</tr>
<tr>
<td>Bangkok, Thailand</td>
<td>32</td>
<td>36</td>
<td>31</td>
<td>33–36</td>
<td>37–40</td>
</tr>
<tr>
<td>Dili, Timor-Leste</td>
<td>30</td>
<td>31</td>
<td>26</td>
<td>31–32</td>
<td>32–34</td>
</tr>
</tbody>
</table>

*Monthly afternoon temperatures (Tmax and WBGTmax, °C) in grid cells (0.5 °C x 0.5 degrees) containing the capital city for each Member State of the WHO South-East Asia Region. Data from the ClimateCHIP website.
further reductions of emissions of greenhouse gases are needed to reduce the impacts described above and protect working people in the countries of the region.

Many workplaces in hot tropical countries need heat monitoring at some stage, in order to assess the level of health risk. Reductions of workplace heat stress can be achieved by providing shade covers for people who need to work outdoors. Reduction in the work intensity via use of mechanical devices would also reduce heat stress, as a result of reduced internal heat production. Indoor work environments can be air conditioned or cooled in other ways, and fans that increase air flow are often the simplest initial approach to protection. In many countries, advice on heat protection in workplaces is available in local languages from government agencies.

Basic occupational health management should also be applied to work that may involve heat stress. This includes access to sufficient clean drinking water to replace the body liquid lost via sweating. Daily dehydration is a serious health threat, and rehydration is essential for occupational health. It is also essential that work supervisors and the workers themselves receive training on the risks of heat stress, the symptoms to look out for, and the methods for prevention. Further details can be found on a number of websites, or in the handbook by Parsons.

**Table 4. Potential percentage annual daylight work hours lost due to environmental heat levels for moderate work (300 W) in the shade**

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Bangladesh</td>
<td>161</td>
<td>1.1</td>
<td>2.5</td>
<td>4.6</td>
<td>8.6</td>
<td></td>
</tr>
<tr>
<td>India</td>
<td>1311</td>
<td>2.0</td>
<td>3.6</td>
<td>5.2</td>
<td>8.0</td>
<td></td>
</tr>
<tr>
<td>Indonesia</td>
<td>258</td>
<td>0.33</td>
<td>1.2</td>
<td>2.6</td>
<td>5.5</td>
<td></td>
</tr>
<tr>
<td>Maldives</td>
<td>0.4</td>
<td>0.42</td>
<td>1.9</td>
<td>4.5</td>
<td>9.2</td>
<td></td>
</tr>
<tr>
<td>Nepal</td>
<td>29</td>
<td>0.61</td>
<td>1.3</td>
<td>2.0</td>
<td>3.4</td>
<td></td>
</tr>
</tbody>
</table>

GFDL: Geophysical Fluid Dynamics Laboratory; HadGEM: Hadley Centre Global Environment Model. The RCP equivalents in global mean temperature change since 1995 are shown on the x axis and annual percentage loss on the y axis. These are shown for three levels of work intensity: light (200 W, \( y = 0.172x - 0.0023 \)); moderate (300 W, \( y = 0.0318x + 0.0204 \)); and heavy (400 W, \( y = 0.0387x + 0.0585 \)).
There are also publications that report health-protection effects of “self-pacing”, in which workers have freedom to choose their own work pace. However, in many work situations, self-pacing will reduce the hourly work output for each heat-affected worker, and this may create negative conflicts between maintaining output and income on the one hand and protecting health from heat on the other hand. There is a need for further research on how these different protective approaches can best be implemented.

Analysis of national impacts as a tool in prevention

Climate change and the related increasing environmental heat situation will not develop in the same way in all countries, and will impact on health and social conditions in different ways, depending on workforce distributions and currently applied approaches to heat protection. An important way forward towards effective prevention of workplace heat stress and its effects is therefore a detailed assessment of the problem and its most feasible solutions in each country. A national analysis and report on the impacts of climate change should ideally include the following information:

- a background statement and listing of any publications on the topic of heat effects on work, including materials from WHO and the World Meteorological Organization, International Labour Organization and International Organization for Migration;
- a quantitative description of the current and future heat-index levels (e.g. WBGT) during different months and in different parts of the country (or province), including maps (such material is available on the ClimateCHIP website);\(^{27}\)
- analysis of the health risks and productivity impacts at the identified heat-index levels, using exposure–response relationships or heat-prevention guidelines or standards;
- listing of potential heat-effect prevention methods and discussion of how best to develop interdisciplinary strategies and actions to deal with the heat threats (involving the health sector, labour authorities, enterprises, trade unions, meteorology service, and other likely partners);
- a step-by-step plan for country-level policies and programmes.

Conclusion

Climate change will create a variety of direct and indirect occupational health hazards. These include effects of environmental heat, injuries during extreme weather events, risks of vector-borne diseases, and other indirect effects as the climate is changing. The most prominent hazard is heat stress, and the underlying mechanisms and pathways of the health impacts are well known from thermal physiology. The WHO South-East Asia Region is a vulnerable area because the current heat situation in many countries is already creating important occupational health risks. Climate change will make the situation worse and each country is recommended to develop a local occupational health impact analysis and prevention plan to protect their workers.

Acknowledgements: We appreciate the research on this topic carried out in the region, and have been inspired by many local scientists to carry out analysis and produce reports on the climate and occupational health issues in South-East Asia. We acknowledge the valuable analysis work contributed by Ms Lauren Lines for this project, and are grateful to the two anonymous reviewers who provided valuable comments and some missing information.

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Conflict of interest: None declared.

Authorship: TK developed the design of the work, interpreted results and drafted and finalized the manuscript. BL contributed expertise in heat physiology, collected climate data from the web, developed analysis methods and contributed text. MO developed the database for the analysis, designed software applications for the work, carried out analysis for different locations and contributed text.

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Water, sanitation and hygiene: the unfinished agenda in the World Health Organization South-East Asia Region

Indira Chakravarty, Animesh Bhattacharya, Saurabh K Das

Public Health Engineering Department, Kolkata, Government of West Bengal, India

Correspondence to: Professor Indira Chakravarty (indiracal@hotmail.com)

Abstract
Access to adequate water, sanitation and hygiene (WASH) is essential for the health, well-being and dignity of all people. The World Health Organization South-East Asia Region has made considerable progress in WASH provision during the past two decades. However, compared with increases in coverage of improved drinking water, in some parts of the region, access to adequate sanitation remains low, with continued prevalence of open defecation. The Sustainable Development Goals (SDGs) have set ambitious targets for WASH services to be achieved by 2030. Examples of major health outcomes that would benefit from meeting these targets are diarrhoea and nutrition status. Although the total number of deaths attributable to diarrhoea declined substantially between 1990 and 2012, inadequate WASH still accounts for more than 1000 child deaths each day worldwide. And, despite the reductions in mortality, diarrhoea morbidity attributable to diarrhoea remains unchanged at around 1.7 billion cases per year. It has been known for decades that repeated episodes of diarrhoea increase a child’s risk of long-term undernutrition, reduced growth and impaired cognitive development. Nutritional effects of inadequate WASH also include environmental enteropathy, leading to chronic intestinal inflammation, malnutrition and developmental deficits in young children. Inadequate WASH also contributes to iron deficiency anaemia resulting from infestation with soil-transmitted helminths. The cross-sectoral emphasis of the SDGs should act as a stimulus for intersectoral collaboration on research and interventions to reduce all inequities that result from inadequate WASH.

Keywords: diarrhoea, hygiene, sanitation, South-East Asia, undernutrition, WASH, water

Background
Access to adequate water, sanitation and hygiene (WASH) is essential for the health, economic and social well-being, and dignity of all people. This paper reflects on the unfinished agenda on childhood diarrhoea and undernutrition attributable to inadequate WASH in the World Health Organization (WHO) South-East Asia Region. Although diarrhoea and undernutrition are the focus, it is important to emphasize the growing consensus on evidence for inadequate WASH having a much wider-ranging impact on diseases, conditions and issues of equity. As explored in a recent review, examples include: food hygiene; violence against women and psychosocial stress, e.g. where poor access to WASH services can lead to vulnerability, rape and assaults, and fear of such assaults can prevent women and children from using sanitary facilities outside of the home at night; maternal and neonatal health; management of menstrual hygiene; school attendance; the efficacy of oral vaccine; and the health and well-being of people with disabilities.1 While noting that more robust data are needed, another review estimated the effects of inadequate WASH on health outcomes other than diarrhoea, including undernutrition; soil-transmitted helminthiasis; neglected tropical diseases, such as schistosomiasis and trachoma; and vector-borne diseases.2 The estimates indicated that the adverse health effects of inadequate WASH may be at least as great as – and possibly much greater than – those of diarrhoea (see Table 1).2

Table 1. Health outcomes (excluding diarrhoea) and range of the fraction of disease globally attributable to inadequate water, sanitation and hygiene

<table>
<thead>
<tr>
<th>Contribution of WASH not quantified at global level</th>
<th>0–33%</th>
<th>33–66%</th>
<th>66–100%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hepatitis A, E, F; scabies; arsenicosis; fluorosis; methaemoglobinemia</td>
<td>Onchocerciasis</td>
<td>Lymphatic filariasis; malaria; undernutrition and its consequences; drowning</td>
<td>Ascariasis; hookworm; trichuriasis; dengue; schistosomiasis; Japanese encephalitis; trachoma</td>
</tr>
</tbody>
</table>

WASH: water, sanitation and hygiene.
*Estimates are based on the source-document authors’ previous assessments, combining systematic literature review with expert opinion.
Source: Preventing diarrhoea through better water, sanitation and hygiene: exposures and impacts in low- and middle-income countries. Geneva: World Health Organization; 2014.2
Water and sanitation in the World Health Organization South-East Asia Region

The WHO South-East Asia Region, in general, made considerable progress in WASH provision during the past two decades’ work towards the Millennium Development Goals (MDGs). However, compared with increases in coverage of improved drinking water, some countries still lag behind in sanitation coverage. In the 2015 MDG assessment, the proportion of the population using improved sanitation facilities varied widely among the 11 countries of the WHO South-East Asia Region – from 40% to 98%. By contrast, the proportion of population using an improved drinking-water source in the region was 81–100%; Timor-Leste was the only exception at 72%. Notably, although use of improved drinking water was quite high in India (94%), the country also had the lowest proportion of its population using improved sanitation, at 40%.3

Arguably, the strategy of targeting the provision of improved water sources without parallel progress in providing safe water and hygiene and adequate sanitation has been a limiting factor in achieving expected improvements in health outcomes. The commitment made by world leaders in September 2015 to achieve 17 Sustainable Development Goals (SDGs) by 2030 strengthens calls for investment to achieve SDG Goal 6, to “ensure availability and sustainable management of water and sanitation for all”.

Burden of diarrhoea attributable to inadequate water, sanitation and hygiene

The overall burden of disease related to unsafe WASH was first examined at the global level two decades ago. Although different methodological approaches have been proposed and used since then, there is international consensus that much of the global burden of diarrhoea can be attributed to inadequate WASH.

The most recent data were compiled by an expert group of scientists from 14 collaborating research institutions. This group was convened by WHO in 2013 to provide an updated assessment of the burden of diarrhoeal disease resulting from inadequate WASH, and to reassess the effectiveness of WASH interventions. For this analysis, the burden of WASH-attributable diarrhoeal disease in 2012 was estimated for 145 low- and middle-income countries. The proportions of mortality from diarrhoeal disease attributable to inadequate WASH were calculated both separately and in combination.

The main findings for all 145 countries and for the WHO South-East Asia Region are summarized in Table 2. The project estimated that 842 000 deaths (361 000 of which were in children aged under 5 years) in low- and middle-income countries worldwide were caused by inadequate WASH, representing 58% of the total number of deaths attributable to diarrhoea. Within that total, the number of deaths in the WHO South-East Asia Region that were attributable to inadequate WASH was 364 000, which was 56% of all deaths attributable to diarrhoea in the region.

With respect to trends over time, the number of deaths in the 145 low- and middle-income countries that were attributable to inadequate WASH reduced by more than 50% from 1.8 million in 1990, to 842 000 in 2012. Globally, the total number of deaths that were attributable to diarrhoea declined from 2.9 million in 1990 to 1.5 million in 2012. Although the data indicate substantial reductions in mortality attributable to diarrhoea in recent years, the results also underscore that tackling the continuing burden of diarrhoea due to inadequate WASH remains an urgent global health priority.

By WHO region, the greatest decreases between 1990 and 2012 in deaths in low- and middle-income countries from diarrhoeal disease attributable to inadequate WASH were in the WHO Region of the Americas (87% reduction), the WHO European Region (80%) and the WHO Western Pacific Region (79%). These regions had similarly large improvements in access to improved drinking water and sanitation over the same time period. Decreases in WASH-attributable diarrhoea mortality during 1990–2012 in the WHO African Region and the WHO South-East Asia Region were 55% and 35%, respectively.

The number of deaths worldwide in children aged under 5 years that were attributable to diarrhoea has greatly reduced: from 1.5 million in 1990 to 622 000 in 2012. The authors of the multicountry analysis note that it is likely that improvements in water and sanitation have played a significant role in this marked reduction, in addition to improved access to health care and oral rehydration and reduced child undernutrition.

Within the WHO South-East Asia Region, these global trends have been seen at the national level in Bangladesh, where mortality in children aged under 5 years reduced between 1990 and 2015, from 144 to 38 deaths per 1000 live births. Diarrhoea accounted for 6% of these deaths in 2015. The proportion of the population using an unimproved source of drinking water reduced from 26% in 1990 to 13% in 2015; the proportion using unimproved sanitation facilities similarly reduced from 16% to 10% in the same time period. These data accord with research projects on the impacts of drinking water and sanitation on health and nutrition in Bangladesh, which have indicated that progressive increases in coverage

<table>
<thead>
<tr>
<th>Population</th>
<th>Deaths attributable to inadequate WASH (as proportion of total diarrhoeal deaths)</th>
<th>Deaths/DALYs attributable to inadequate water</th>
<th>Deaths/DALYs attributable to inadequate sanitation</th>
<th>Deaths/DALYs attributable to inadequate handwashing</th>
</tr>
</thead>
<tbody>
<tr>
<td>WHO South-East Asia Region</td>
<td>364 000 (56%)</td>
<td>208 000/11 000</td>
<td>123 000/6000</td>
<td>132 000/7000</td>
</tr>
<tr>
<td>All LMICs</td>
<td>842 000 (58%)</td>
<td>502 000/34 000</td>
<td>280 000/19 000</td>
<td>297 000/20 000</td>
</tr>
</tbody>
</table>

DALY: disability-adjusted life year; LMIC: low- and middle-income country.

*All data are rounded to the nearest thousand.

*Exposures to faecal-oral pathogens through drinking water, sanitation or hygiene are not independent; thus, the total burden is not the sum of the separate burdens of those risks; it is slightly lower.

*145 LMICs worldwide.

of drinking water from protected sources have coincided with a gradual reduction in rates of both infant mortality and mortality in children aged under 5 years. A recent report by WHO, UNICEF and the United States Agency for International Development summarized the current evidence on the benefits of adequate WASH for improving nutritional outcomes, especially in young children, by integrating WASH interventions into national nutrition policies and programmes. Despite the significant reductions in recent years in deaths in children aged under 5 years, discussed above, the burden of morbidity attributable to diarrhoea remains unchanged at around 1.7 billion cases per year. A 2013 systematic review of studies worldwide concluded that rotavirus, calicivirus and enteropathogenic and enterotoxigenic Escherichia coli cause more than half of all diarrhoeal deaths in children aged under 5 years. Recent research, published in 2015, aimed to identify the pathogens associated with diarrhoea in the community, i.e. in cases not seen at a health-care facility, in eight low- or middle-income countries.

Pathogens associated with non-severe diarrhoea in children aged 0–24 months varied substantially between the study sites and, in addition to pathogens commonly associated with more-severe diarrhoea, Campylobacter spp., norovirus genogroup II and astrovirus were also associated with a substantial number of the diarrhoea episodes.

For children in low- and middle-income countries, repeated episodes of diarrhoea resulting from high exposures to enteric pathogens have a negative effect on their nutritional status for several reasons, including reduced appetite, increased loss of nutrients and impaired intestinal absorption. Long-term consequences include undernutrition and impairment of normal growth and cognitive development. For example, a review of global data available for 2010–2011 estimated that 25% of stunting could be attributed to five or more episodes of diarrhoea before 2 years of age. In turn, the undernutrition resulting from diarrhoea increases the frequency and duration of subsequent episodes of diarrhoea, thereby creating a vicious cycle.

Undernutrition is directly related to inadequate dietary intake and infectious disease. However, it has been recognized for many years that effective programmes to combat undernutrition in children include not only interventions such as exclusive breastfeeding, complementary feeding and micronutrient supplementation, but also access to adequate WASH. Easy accessibility of water has a significant impact on saving loss of energy from the body, by reducing the burden of carrying water, as well as saving time spent accessing water. Women and girls benefit especially from better water accessibility. For example, a study supported by the United Nations Children’s Fund (UNICEF) conducted in the three geographical regions of Nepal – mountainous, hilly and Terai – showed that use of gravity flow (UNICEF) conducted in the three geographical regions of Nepal – mountainous, hilly and Terai – showed that use of gravity flow provided safe sources of drinking water resulted in significant savings in the time and energy spent in collecting water, together with improvements in the nutritional status of children.

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The role of water, sanitation and hygiene in nutritional outcomes

WASH interventions are critical to breaking the links between undernutrition associated with diarrhoea, environmental enteropathy/ environmental enteric dysfunction and soil-transmitted helminthiases.

Undernutrition

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ingestion of faecal bacteria. Children living in poor sanitary conditions are exposed to high quantities of enteric pathogens. The pathogens damage the wall of the small intestine, reducing its ability to absorb nutrients. The resulting gut hyperpermeability also evokes energy- and protein-consuming immune responses to subsequent infections. The condition is subclinical and difficult to measure. Thus, the nutritional and health significance of many non-diarrhoeal faecally transmitted infections has also been masked by their diversity, their multiple presences in the same child, and their often subclinical nature. In 2009, Humphrey argued that “prevention of tropical [environmental] enteropathy, which affects almost all children in the developing world, is crucial to normalize child growth, and that this will not be achievable without provision of toilets”.25

Soil-transmitted helminthiases and anaemia

More than 2 billion people globally are estimated to be infected with soil-transmitted helminths – parasitic diseases caused by nematode worms that are transmitted to humans by faecally contaminated soil.26 The soil-transmitted helminths of major concern to humans are Ancylostoma lumbricoides and Trichuris trichiura, and the hookworms Necator americanus and Ancylostoma duodenale. Soil-transmitted helminthiases are most prevalent where sanitation is inadequate and water supplies are unsafe. Heavy-intensity infections with soil-transmitted helminths result in impaired physical growth and cognitive development in children. They also cause micronutrient deficiencies, including iron deficiency anaemia, leading to poor school performance and absenteeism in children, reduced work productivity in adults, and adverse pregnancy outcomes.26

Hookworm infection results from the ingestion or skin penetration of the hookworm larvae in soil. Larvae develop in soil through the deposit of faeces containing eggs from infected persons. Hookworm infection is not transmitted from person to person but is associated with poor sanitation and hygiene. Intervention studies have shown the effectiveness of adequate WASH in prevention of hookworm infection.7,27–29 An in-depth study conducted in several districts of West Bengal, India, on hookworm and other parasitic infections, indicated that hookworm infection is universal in all age groups of both sexes, with a higher prevalence in areas with a limited number of latrines, or poor rates of sanitation use. Hookworm infection exacerbated pre-existing dietary iron deficiency.30

The public health intervention recommended by WHO for the control of morbidity associated with soil-transmitted helminthiases in endemic areas is preventive chemotherapy – the periodic administration of anthelmintic medicines.31 WHO has set the goal that at least 75% of preschool and school-age children in all endemic countries should be treated by 2020.31 Preventive chemotherapy is not required in only three countries the WHO South-East Asia Region: Maldives, Sri Lanka and Thailand. In 2015, preventive chemotherapy was administered to more than 56 million preschool children, equivalent to a regional coverage of 52.1%. The Democratic People’s Republic of Korea, Myanmar and Timor-Leste reached their national coverage target of ≥75%.31 Also in 2015, 214.8 million school-age children received preventive chemotherapy, equivalent to a regional coverage of 86.8%. Bangladesh, Bhutan, Democratic People’s Republic of Korea, India, Myanmar and Timor-Leste reached >75% national coverage.31 It is anticipated that future reports will show a marked increase in regional coverage, owing to the introduction in 2015 of an annual countrywide deworming day in India.

However, preventive chemotherapy with regular administration of anthelmintic drugs to at-risk groups does not stop rapid reinfection. A systematic review and meta-analysis has shown that the availability of sanitation facilities is associated with significant protection against infection with soil-transmitted helminths, indicating a need to prioritize improved sanitation in parallel with preventive chemotherapy and health education.32

Conclusion

Although considerable advances have been made, sustained work is still needed to close the gaps that preclude people from accessing adequate WASH in the WHO South-East Asia Region. Although hindered by lack of attention from the health research community, evidence of the importance of adequate WASH to health and social outcomes beyond the challenge of childhood diarrhoea is growing.1 The emphasis of the SDGs on intersectoral collaboration and cross-sectoral goals and targets raises awareness of the wide-ranging benefits that can accrue through providing people with access to adequate WASH.

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4. Sustainable Development Knowledge Platform. Sustainable


Observations and lessons learnt from more than a decade of water safety planning in South-East Asia

David Sutherland, Payden

World Health Organization Regional Office for South-East Asia, New Delhi, India

Correspondence to: Dr David Sutherland (dcsuth@gmail.com)

Abstract

In many countries of the World Health Organization (WHO) South-East Asia Region, drinking water is not used directly from the tap and faecal contamination of water sources is prevalent. As reflected in Sustainable Development Goal 6, access to safer drinking water is one of the most successful ways of preventing disease. The WHO Water Safety Framework promotes the use of water safety plans (WSPs), which are structured tools that help identify and mitigate potential risks throughout a water-supply system, from the water source to the point of use. WSPs not only help prevent outbreaks of acute and chronic waterborne diseases but also improve water-supply management and performance. During the past 12 years, through the direct and indirect work of a water quality partnership supported by the Australian Government, more than 5000 urban and rural WSPs have been implemented in the region. An impact assessment based on pre- and post-WSP surveys suggests that WSPs have improved system operations and management, infrastructure and performance; leveraged donor funds; increased stakeholder communication and collaboration; increased testing of water quality; and increased monitoring of consumer satisfaction. These achievements, and their sustainability, are being achieved through national legislation and regulatory frameworks for water supply, including quality standards for drinking water; national training tools and extensive training of sector professionals and creation of WSP experts; model WSPs; WSP auditing systems; and the institution of long-term training and support. More than a decade of water safety planning using the WSP approach has shown that supplying safe drinking water at the tap throughout the WHO South-East Asia Region is a realistic goal.

Keywords: impact assessment, South-East Asia, water quality partnership, water safety planning

Background

Access to safe drinking water is essential to health, a basic human right and a component of effective policy for health protection. Yet an estimated 1.8 billion people worldwide use a source of drinking water that is faecally contaminated, and this contamination is most prevalent in the World Health Organization (WHO) African Region and South-East Asia Region. The delivery of safer drinking water, as well as safely managed sanitation and hygiene, are among the most successful ways of preventing disease. In line with these aims, for more than a decade, the WHO Regional Office for South-East Asia has worked in a water quality partnership (WQP) with the WHO Regional Office for the Western Pacific and WHO headquarters in Geneva, with financial support from the Australian Government. This partnership has the vision of increasing continuous access to the safest drinking water attainable. Central to this strategy has been the sustainable implementation of water safety plans (WSPs). The Australian Government supported WHO on updating the Guidelines for drinking-water quality, published as the third edition in 2004. These guidelines, for the first time, promoted WSPs as a proactive risk-based tool to help prevent outbreaks of acute and chronic waterborne diseases. WSPs are now used worldwide and are legally mandated in several countries. They are a key component of the Water Safety Framework promoted under the fourth edition of the Guidelines for drinking-water quality, which aims to set health-based targets for the quality of drinking water and monitor compliance with them through effective surveillance (see Fig. 1).

For more than a decade, WHO and the Australian Agency for International Development (AusAID, now under the Department of Foreign Affairs and Trade, DFAT) have worked together (often with the International Water Association) to help put the Water Safety Framework into practice, through normative work and technical guidance from WHO and the two regional offices, and through implementation of WSPs and support measures in countries across the two regions. This partnership has seen significant advances in the context and practice of supply of drinking water. This progress has helped to increase the awareness of water safety as a health issue and ensure that the safety of drinking water has been included as a Sustainable Development Goal (SDG) target (target 6.1 “By 2030, achieve universal and equitable access to safe and affordable drinking water for all”), with WSPs as a key measure for meeting the target. In total, 15 countries have made significant advances on water safety planning, through the direct support of the WQP. Six of these are in...
the WHO South-East Asia Region (with three additional countries indirectly supported) and this paper focuses on the development of water safety planning in these countries and the lessons learnt from the process and implementation of the WSPs themselves.

**Purpose and description of water safety plans**

A WSP delivers safer water to consumers by identifying potential risks in the entire water-supply system, from the water source to the point of use, and dealing with them before they become problems. First, the ways in which hazards are introduced to the water-supply system are examined, hazardous events are identified and their risks to health are assessed. The risks are then prioritized, focusing on the hazards (microbiological, chemical and physical) and hazardous events that pose the highest risk. A plan is then developed to manage the risks, using barriers to stop contamination of water.

The process of WSP development involves bringing together professionals, technicians and stakeholders to gain a thorough understanding of the water system and work out realistic and responsible ways to make sure the system works as it should, with the lowest level of risk possible. This is achieved by preventing contamination at source; removing or reducing contamination by treatment; and/or preventing recontamination in distribution and handling in the home.

A WSP is developed through a structured process involving 10 steps:

- **Step 1**: preparation – assembly of a WSP team and definition of the scope and objectives;
- **Steps 2 to 4**: system assessment – system description, hazard identification, selection of control measures;
- **Step 5**: system improvement – development of an improvement plan;
- **Steps 6 and 7**: operational monitoring of control measures, WSP verification;
- **Steps 8 to 10**: management plans – management procedures, supporting programmes and WSP review.

**Water safety planning versus operation and maintenance**

Traditionally, water suppliers fix problems in the system reactively when they arise, for example, if a pipe breaks and people complain about an unusual colour or smell detected in their water because of cross-contamination from sewage. However, the preventive water safety planning approach looks at potential problems that could arise and aims to fix them before they become a problem; for example, hazard analysis would detect risk areas of sewage cross-contamination in the distribution system and alert the supplier to measures to be taken. One of the reasons given initially by the Asian Development Bank for their interest in WSPs was not the improved health impacts but the improved management and performance they delivered, demonstrated by a reduction in non-revenue water – through a reduction in leakage and illegal connections.

By providing a structure and process for developing new operating procedures or revising existing procedures for standard or emergency situations, WSPs are helping to institutionalize good practice in the operation and maintenance of water-supply systems. This is one of the most challenging aspects of sustainable and effective management of water supply. Once a WSP has been completed, improvements need to be made to address the risks identified; many of these may be directly operational, while others that appear to be technical may ultimately be found to be managerial, with organizational strengthening required.

A flexible approach is needed; thus, WSPs can be as simple or as complex as the systems to which they apply, so this partnership has dealt with WSPs for systems as diverse as single hand-pumps, community-managed pond systems, community-managed piped systems for 50 households, small-scale urban systems with small numbers of staff, or major water-supply systems in capital cities. Catering for this diversity of physical and management systems is complex and requires different manuals, training materials and methods, technical solutions and regulatory frameworks.

**History and current status of water safety planning in South-East Asia**

The WQP has focused on countries with government commitment to water safety planning, as well as capacity and commitment among water suppliers; with some availability of WSP education and trained trainers; with commitment of significant country donors and nongovernmental organizations (NGOs); and with a completed country WSP scale-up strategy. Both the WHO South-East Asia Region and the WHO Western Pacific Region have been part of the water safety planning. The countries of the WHO South-East Asia Region involved in the water safety planning have changed slightly over the many years of the partnership but the core countries were Bangladesh, Bhutan, Indonesia, Myanmar, Nepal and Timor-Leste, with some regional office support to India, Maldives, Sri Lanka and Thailand. The WQP evolved over three phases as follows:

- **Phase 1, 2005–2009**: focused on setting the foundations for WSPs and piloting early WSPs;
• Phase 2, 2010–2011: sought to scale up WSPs in those countries that had succeeded in Phase 1 (Bangladesh, Bhutan and Nepal), through policy, increased training and WSP implementation;
• Phase 3, 2011–2017: sought to consolidate WSP sustainability in existing countries, through regulatory frameworks, model WSPs, WSP experts, institutional development for long-term training and support, and piloting of surveillance activities; and to expand WSPs to newly committed countries (Indonesia, Myanmar and Timor-Leste).

Quality impact of water safety planning in the region

The WQP’s activities have been complex. The partnership has delivered safer water for millions of people in in the WHO South-East Asia Region, through more than 1000 WSPs implemented directly through the partnership, and more than 5000 WSPs implemented by other government agencies, projects and NGOs. In addition, the WQP has sought to achieve a change in mindset in the sector, from one of limited responses to disease outbreaks or incidents of poor water quality resulting from poorly managed water-supply systems, to one of effective proactive management based on sound risk-based approaches to water-supply management. This was reflected in a national meeting of state engineers and secretaries organized by the Ministry of Drinking Water and Sanitation in India in 2016. The joint secretary who was chairing the WSP advocacy session stated that people tend to forget the “public health” part of public health engineering departments, which are the state-level implementers, and only focus on engineering, thus neglecting water quality. This change in mindset has required a significant amount of work to ensure that:

• water safety planning is embedded within national legislation and regulatory frameworks for water supply, including quality standards for drinking water;
• training tools are locally appropriate in local languages, and extensive training of sector professionals and community representatives has resulted in good knowledge among a significant proportion of sector staff;
• model WSPs of a high standard have been created to act as field-based training centres and examples of good practice;
• key sector professionals have been trained to such a level that their understanding and confidence enables them to train and advise on WSPs and also to carry out audits of water safety planning, to identify strengths and areas for improvement;
• WSP auditing systems have been piloted to assess the WSP quality and enhance the sustainability of the water safety planning process;
• institution of long-term training and support of WSPs has ensured that the next generation of engineers and sector professionals will be immersed in water safety planning before starting service;
• the impact of WSPs on management of drinking-water supply and water quality is understood in depth, and available for advocacy purposes.

Auditing of water safety plans

One of the key measures to ensure the sustainability of individual WSPs, and of the water safety planning process as a whole, is surveillance. In its 2011 Guidelines for drinking-water quality, the WHO defines surveillance as both the direct assessment of water quality, for compliance against national water quality standards, and the auditing of WSPs to ensure quality is maintained. In countries with advanced regulatory systems and capacity, like Australia and the United Kingdom of Great Britain and Northern Ireland (UK), WSPs are a regulatory requirement and are audited to ensure compliance. Incentives for compliance and/or penalties for non-compliance may be part of the process called “external formal” auditing. The auditing that has been carried out thus far in the WHO South-East Asia Region is called “external informal” auditing and is concerned with training potential auditors but also with identification of how good the WSPs that have been implemented are and what systemic or specific WSP improvements may be required. This is part of the process of continuous improvement promoted by WHO.

In 2014, the WHO Regional Office for South-East Asia supported two 2-week training sessions for some of the best, most available, WSP experts in the region, to develop their skills in WSP training, analysis, advice and auditing, and provide a pool of “master trainers” qualified to serve as regionally based resource persons to sustain and further develop WSPs in the region and beyond. The training was based on the urban WSP training materials subsequently published by the WHO Regional Office for South-East Asia in 2016. Most of these experts have continued to be actively involved in WSP work since the training, both within their own countries and internationally.

In 2016, the WHO Regional Office for South-East Asia commissioned a programme of international WSP audits led by the master trainers and observed by international experts from Australia. The international auditing work was designed to challenge the master trainers to review types of systems that are different from those seen in their own countries. They have responded well and have become valuable national and international WSP resources. Master trainers from:
(i) Bhutan and Nepal carried out six WSP audits and trained future auditors in Sri Lanka; (ii) Bangladesh and Sri Lanka audited Bangkok Metropolitan Waterworks Authority’s WSP in Thailand; (iii) Bhutan and Sri Lanka audited two small schemes in Nepal; (iv) Bhutan, Nepal and Sri Lanka audited two urban model WSPs in Bangladesh; and (v) Nepal undertook audits of all pilot WSPs in Timor-Leste and completed follow-up progress visits.

Impact assessment of water safety plans

In 2016, a largely independent impact assessment was commissioned by WHO to quantify some of the key impacts that the WSPs are having on management of drinking-water supply and consequent outcomes. All analysis and reporting for this study was done by the NGO Aquaya, with data collection done by either government staff, NGOs or consultants, depending on the country. Given the complexities and costs associated with attributing health benefits to the improved quality of water supplied, especially in the short term, the impact assessment focused on 36 performance indicators. These indicators were based on a United States Centers for Disease Control and Prevention conceptual framework for evaluating the impacts of WSPs, which distinguishes shorter-term system-level changes (“outcomes”) from longer-term service-delivery and societal...
improvements ("impacts") and provides a comprehensive evaluation tool covering institutional, operational, financial, policy, water-supply, health, and socioeconomic aspects.\textsuperscript{12} The study collected pre- and post-WSP data from 99 WSPs in 12 countries in the WHO South-East Asia Region and WHO Western Pacific Region: Bangladesh, Bhutan, Cambodia, Cook Islands, Lao People's Democratic Republic, Mongolia, Nepal, Philippines, Samoa, Sri Lanka, Timor-Leste and Vanuatu.

All of the 99 WSPs included in the impact assessment were first audited for quality. While 99 sites were audited, only the urban sites ($n = 59$) were scored and categorized (see Fig. 2). Audits of rural sites result in a set of actions agreed to by the auditors and the WSP team. The urban audit categories (see Fig. 2) show a normal distribution around the “average” category, with four WSPs classified as “very good” and only one requiring “priority attention”. The data from eight districts in Bangladesh (see Fig. 3), suggest that there may be a relationship between WSP maturity and audit score, reflecting the principle of continuous improvement over time, although this relationship is less pronounced in other countries. Further analysis of factors affecting the quality of water safety planning is in process. The major benefits across the 12 countries have been identified as improved system operations, management, infrastructure and stakeholder communication and collaboration; leveraging of donor funds; reductions in unaccounted for water; and increased testing of water quality and monitoring of consumer satisfaction.

The impact assessment noted that challenges, including coordination of team meetings and capital for infrastructure, can limit the efficacy of WSPs.\textsuperscript{11} Nevertheless, positive effects were also identified. For example, there was more supplier interest in water quality, with more microbial and turbidity tests done by utilities and an average increase of 11\% in the number of tests complying with microbial standards. Utilities paid increased attention to consumers, with the proportion conducting customer satisfaction surveys increasing from 14\% to 38\%, and recording of consumer complaints increasing from 38\% to 63\%. Most countries noted that new knowledge had been acquired, with changes in mindsets and more attention to water quality.

One example from Bhutan illustrates the improvements that WSPs have delivered. Bajo, a town in Wangdue Phodrang District, had such serious problems of poor water quality that the residents started to protest. Following WSP training and identification of key improvements to achieve impacts on water safety, the municipality submitted their WSP to government. They won a competition for best WSP and received financial support from the government and from the Organization of the Petroleum Exporting Countries Fund for International Development, as well as technical support from WHO; this resulted in improvements enhanced by operator capacity-building and support, and monitoring of water quality. As a result, operators were empowered and trained to collect and analyse data on water quality and make decisions on chlorination, based on the analysis. They became active WSP team members and are now trainers to other towns. More recent audits confirm that the WSP team is active and that improvements continue to be made to improve water safety. Surveillance data on water quality from the hospital in Bajo suggest that there has been increased compliance with microbiological standards and reduced contamination in non-compliant samples (see Table 1). A customer survey also shows a high level of satisfaction with the quality, although much remains to be done.

**Evolution of the water safety planning process and priorities**

In the years since publication of the third edition of WHO’s *Guidelines for drinking-water quality*\textsuperscript{1} and *Water safety plan manual*,\textsuperscript{13} the WSP agenda has evolved and expanded. New hazards and solutions are being identified and developed all the time. This is one of the successes of the process itself, as governments and organizations have seen the relevance and

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{fig2.png}
\caption{Fig. 2. Categorization of the quality of water safety plans included in the impact assessment\textsuperscript{11}}
\end{figure}

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{fig3.png}
\caption{Fig. 3. Audit score\textsuperscript{*} and duration of water safety plans in eight districts in Bangladesh}
\end{figure}

\textsuperscript{*}Maximum score possible is 120.
importance of WSP approaches in managing not just drinking water but all facets of water, sanitation and hygiene (WASH).

The original manual and training programmes were designed mainly for urban, corporately managed systems and demand grew for training and reference materials for smaller-scale, community-managed systems; these have now been produced.14,15 Many of the examples and case-studies in the original manual were from countries like Australia and the UK, where water safety planning was already advanced. Since then, numerous examples of hazards, associated control measures and WSP management have been collected from across the globe, including many from the WHO South-East Asia Region. The manual is now being updated and will include many of these examples.

For the first seven or so years of the WQP, the training and support covered all 10 steps of the WSP, but in reality water suppliers focused on the preparation and system assessment and the early steps in operational monitoring. In more recent years, there has been much more of a demand for support on the later steps, especially on developing operating procedures for standard or emergency situations; long-term training for sector and utility staff; effective operational monitoring and treatment; and WSP verification and review, through auditing, compliance monitoring and assessment of customer satisfaction. These are encouraging signs of progress and the WHO Regional Office for South-East Asia has supported countries with training support, culminating in the publication of training manuals and materials on operational monitoring and chlorination for small urban systems.16,17 as well as on auditing.

Climate change resilience
One of the most significant emerging issues for WASH has been the impact of climate change on water sources and on WASH infrastructure, so WSPs have been modified to include risks that result from more extreme weather events such as drought, more intensive rainfall events and heat waves, and rises in sea levels, and the control measures needed to mitigate these new risks. This is having an impact on water supplies during both normal and emergency operating conditions, with new responses required to ensure water security as well as water safety. Some of the largest issues relate to spring sources in mountain areas, groundwater sources in coastal areas and cross-contamination in urban areas.

Sanitation safety planning
The same risk-based approach and WSP structure is now being applied to operationalizing WHO’s guidelines for the safe use of wastewater, excreta and greywater, as well as addressing some sanitation-management issues through the development of a manual for sanitation safety planning.18 These are now being piloted in the region.19

Safety managed services to achieve Sustainable Development Goals
All of these developments, and the associated advocacy on water and sanitation safety, have led to the development of SDG WASH targets 6.1 and 6.2. Target 6.1 seeks to achieve, by 2030, universal and equitable access to safe and affordable drinking water for all – the indicator is the proportion of the population using safely managed drinking-water services.6 Target 6.2 seeks to achieve access to adequate and equitable sanitation and hygiene for all by 2030, and to end open defecation, paying special attention to the needs of women and girls and those in vulnerable situations – the indicator is the proportion of the population using safely managed sanitation services, including a handwashing facility with soap and water.6

WSPs, sanitation safety plans, the WHO Water and Sanitation for Health Facility Improvement Tool (WASHFIT)20 and other interventions and approaches are key tools for achievement of these targets.

Technical lessons learnt from the water quality partnership
In the WHO South-East Asia Region, while audits have shown that WSP development, and implementation of improvement plans, are performing better than ongoing activities of operationalization, monitoring and verification, the agenda is definitely moving towards the latter activities. So many WSPs are in place that the focus is now on improving existing ones before extending to new ones.

Most corporate- and community-run WSPs are much better in practice than on paper and in most cases, documentation is a real challenge. In the auditing, this was the area that brought many of the WSP audit scores down. Continuous support is needed in this area and there is a particular need to adapt community-managed WSPs to maximize the benefits for minimum effort for the communities, with more prescriptive hazard sections and checklists that require less writing.

The proactive, risk-based approach of WSPs is now being adapted for sanitation and wastewater management,19 and for institutions (such as WASH in health-care facilities). The approach is proving to be flexible and the WSP format is adaptable and able to accommodate extra hazards from climate change (especially water security) and to enhance equitable access through including equity lenses to WSP preparation, system assessment, operational monitoring and management planning.

At a community/system or policy/strategic level, the integral role that WSPs play in every aspect of WASH, not just water quality, is becoming clearer. Sanitation, clean environment (including management of solid waste), treatment and storage of household water, and handwashing are increasingly being understood as legitimate control measures for water safety. Linked to this, more are realizing that introducing WSPs may not require any (or very few) additional physical control measures but rather improvements in operational and maintenance practices. Therefore, WSPs can easily be introduced at any stage of WASH or environmental health activity and there is no need to start anew. However, if they are being introduced

<table>
<thead>
<tr>
<th>Year</th>
<th>Number of samples</th>
<th>% of samples complying*</th>
<th>Average faecal coliform counts in non-complying samples (CFU/100 mL)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2012</td>
<td>36</td>
<td>0</td>
<td>35</td>
</tr>
<tr>
<td>2013</td>
<td>58</td>
<td>0</td>
<td>29</td>
</tr>
<tr>
<td>May–Dec 2014</td>
<td>37</td>
<td>41</td>
<td>9</td>
</tr>
<tr>
<td>Jan–July 2015</td>
<td>67</td>
<td>66</td>
<td>8</td>
</tr>
</tbody>
</table>

CFU: colony-forming unit.
*Faecal coliform = 0 CFU/100 mL.
where WASH programmes are already running, WSPs are a chance to review and consider emerging hazards.

At a utility level, the impact assessment showed that where investment is already secured, WSPs can add essential value and sustainability and that successful WSPs can attract investment. As with community-run systems, utilities introducing WSPs may not require any additional control measures but may just need to improve management of existing controls. WSPs can easily be introduced at any stage of current work and, as with WASH programmes, are an opportunity to review and consider emerging hazards.

Programmatic lessons learnt from the water quality partnership

Throughout the WHO South-East Asia Region, commitment to WSPs is high at the policy-maker level but, unlike at the operational level, they are often looked at in isolation. More focused advocacy is needed to clarify how WSPs fit in with other utility-management approaches, such as asset management, and the framework they provide for all WASH interventions. There is still a need for significant advocacy nationally and internationally, to promote WSPs in the light of the SDG target for safely managed drinking water. 6 There is now much stronger evidence to support this advocacy, from the impact assessment and other work done in individual countries. In addition, the increased monitoring of water quality in the region provides a valuable data set for monitoring the SDG indicators for water quality,6 but much more work is needed to strengthen methods of data collation and quality assurance.

A post-Phase 2 comprehensive review of the programme was carried out in all three countries participating in Phase 2 (plus the three countries from the WHO Western Pacific Region, Lao People’s Democratic Republic, Philippines and Viet Nam) and this was fundamental to the redesign of Phase 3, where development of model WSPs and WSP master trainers and longer-term support to WSP implementers was introduced. Longer-term support to water suppliers is needed to complete all aspects of water safety planning; further, to fully understand the continuous process promoted within WSPs and ensure sustainability requires a deeper knowledge and resource base, with more systematic national and regional training that is supported locally in the longer run. To this end, the WQP has worked with the International Water Association to create a website for global collation and sharing of key WSP resources developed; this can be found at www.wsportal.org. 21

Conclusion

In many countries of the WHO South-East Asia Region, it is very common to see people either treating water at home with household filters or using bottled water, with the majority not drinking water directly from the tap. The reason for this is either that people are not confident of the safety of water supplied or that the water supplier does not have adequate measures in place to provide safe water. Water-supply systems in many cities and towns have ageing infrastructure with huge leakages, have illegal connections, often crisscrossing sewer lines, or have intermittent supplies. In addition, a reactive approach to managing the system, and lack of regulatory frameworks for water quality, compound the problem. Supplying safe water at the tap, which is the aim of SDG target 6.1,6 is not impossible. The WSP approach helps to address these issues in a comprehensive continuous incremental process. If WSPs are implemented adequately and audited independently on a regular basis, the dream of safe water at the tap can become a reality.

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Sanitation safety planning as a tool for achieving safely managed sanitation systems and safe use of wastewater

Mirko S Winkler1,2, Darryl Jackson3, David Sutherland4, Payden4, Jose Marie U Lim5, Vishwanath Srikantaiah6, Samuel Fuhrimann7, Kate Medlicott8

1Department of Epidemiology and Public Health, Swiss Tropical and Public Health Institute, Switzerland, 2University of Basel, Basel, Switzerland, 3Independent consultant, Brisbane, Australia, 4World Health Organization Regional Office for South-East Asia, New Delhi, India, 5LCI Envi Corporation, Quezon City, Philippines, 6Biome Environmental Solutions Pvt. Ltd, Bangalore, India, 7School of Public Health and Family Medicine, University of Cape Town, Cape Town, South Africa, 8Department of Public Health, Environmental and Social Determinants of Health, World Health Organization, Geneva, Switzerland

Correspondence to: Dr Mirko Winkler (mirko.winkler@unibas.ch)

Abstract
Increasing water stress and growing urbanization force a greater number of people to use wastewater as an alternative water supply, especially for irrigation. Although wastewater irrigation in agriculture has a long history and substantial benefits, without adequate treatment and protective measures on farms and in markets, use of wastewater poses risks to human health and the environment. Against this background, the World Health Organization (WHO) published Guidelines for the safe use of wastewater, excreta and greywater in agriculture and aquaculture, in 2006. The Sanitation safety planning: manual for safe use and disposal of wastewater, greywater and excreta – a step-by-step risk-based management tool for sanitation systems – was published by WHO in 2016 to put these guidelines into practice. Sanitation safety planning (SSP) can be applied to all sanitation systems, to ensure the systems are managed to meet health objectives. This paper summarizes the pilot-testing of the SSP manual in India, Peru, Portugal, Philippines, Uganda and Viet Nam. Also reviewed are some of the key components of the manual and training, and an overview of SSP training and dissemination efforts and opportunities for implementation in the WHO South-East Asia Region. Lessons learnt during the piloting phase show how reducing health risks can be surprisingly easy, even in a low-income setting, especially when combining many smaller measures. The SSP approach can make an important contribution towards Sustainable Development Goal target 6.3, by reducing pollution, eliminating dumping and minimizing the release of hazardous chemicals and materials, thereby halving the proportion of untreated wastewater and substantially increasing recycling and safe reuse globally.

Keywords: agriculture, aquaculture, excreta reuse, sanitation safety planning, Sustainable Development Goals, wastewater reuse

Background
In many regions of the world, the scarcity of freshwater sources is accelerating, making wastewater an increasingly attractive alternative resource.1,2 Wastewater can be a valuable sustainable resource for irrigation.3 Not only does it contain important nutrients for agricultural production but it is also available from a variety of different sources, such as domestic wastewater, industrial effluents and polluted surface waters.4 In 2012, it was estimated that, worldwide, about 20 million hectares of agricultural land were irrigated with treated, partially treated or untreated wastewater.5 Wastewater is also used for aquaculture, landscape irrigation, urban and industrial uses, recreational and environmental uses, and artificial groundwater recharge.5 The importance of safe wastewater and excreta disposal and reuse is also reflected in Sustainable Development Goal (SDG) target 6.3, which aims to improve water quality by reducing pollution, eliminating dumping and minimizing the release of hazardous chemicals and materials, thereby halving the proportion of untreated wastewater and substantially increasing recycling and safe reuse globally by 2030.7,8

Without adequate treatment and protective measures on farms and in markets, workers and the public are exposed to pathogens and hazardous contaminants that pose risks to human health.9–11 Diarrhoeal disease and helminth infections are considered the greatest risks to human health transmitted by consumption of wastewater-irrigated products or through contact with contaminated soils and irrigation water.12–15 There are also concerns about wastewater being a potential contributor to antimicrobial resistance.16 In 2006, the World Health Organization (WHO) published updated Guidelines for the safe use of wastewater, excreta and greywater in agriculture and aquaculture.17 The main objective of these guidelines is to maximize the environmental benefits associated with the use of wastewater, excreta and greywater in agriculture and aquaculture, while minimizing potential health risks. The overall objective of the guidelines is to ensure that wastewater is used safely with minimal risks to health, through microbial-reduction targets for diverse pathogens and a code of good
management practice. The WHO guidelines assist with the selection of economically feasible and technically sensible methods of wastewater treatment and suggest comparatively low-cost on-farm measures to limit exposure, which can be applied in developed and developing countries alike.

In order to put the principles into action, a sanitation safety planning (SSP) manual was recommended in 2010, with the objective of providing a hands-on approach to assessing, managing and monitoring risks along the entire sanitation chain. The SSP manual seeks to ensure that the quality and reduction targets for wastewater set by the WHO 2006 guidelines are reached through incremental improvement and by applying a multi-layered approach (i.e. combining different control measures available, such as treatment practices, irrigation methods and measures for food handling and preparation).

This paper describes: (i) the development process for the SSP manual, which comprised an extensive piloting phase in locations in most regions of the world; (ii) key features of the final version of the SSP manual; and (iii) an initial SSP training programme held in Kolkata, India. Following the manual’s publication in 2016, lessons have been learnt from piloting and application of the manual and initial training activities. These are reported here and suggestions on future dissemination in the WHO South-East Asia Region are outlined.

Development of the sanitation safety planning manual

The draft SSP manual drew on the Stockholm framework for guidelines for microbial contaminants in water, which creates a harmonized framework for developing guidelines and standards for water-related microbiological hazards and provided the conceptual framework for the 2006 WHO guidelines. Its basic elements are the assessment of public health and risks; health targets; and risk management, based on informed environmental exposure and acceptable risk. The draft SSP manual also drew on the hazard analysis and critical control point (HACCP) approach that is common to WHO’s guidelines for drinking water, recreational water and food safety. The safety planning approach has been described and successfully implemented globally through water safety plans (WSPs), which assist water suppliers and regulators to apply the WHO guidelines for the quality of drinking and recreational water. In contrast, it was recognized that the main users of the SSP manual would be: (i) health authorities and regulators (to introduce health-risk-based approaches to the sanitation sector and to verify their effectiveness); (ii) local authorities (for planning investment in sanitation, especially in low-resource settings); (iii) wastewater utility managers (for managing effluent quality and safeguarding public and occupational health); (iv) sanitation enterprises and farmers (to introduce/complement quality-assurance procedures for the safety of workers, local communities and consumers or users of the product); and (v) community-based organizations, farmers’ associations and nongovernmental organizations. SSP and WSPs have several similarities and differences (see Table 1).

The first draft of the SSP manual comprised a broad set of tools, methods and procedures that followed a structured approach to achieving preset health targets at individual and community levels in a range of contexts. WHO’s 2006 guidelines, the Water safety plan manual, and the textbook on Microbial exposure and health assessments in sanitation technologies and systems were the key sources for the tools featured in the first draft of the SSP manual.

Table 1. Similarities and differences between sanitation and water safety planning

<table>
<thead>
<tr>
<th>Similarities</th>
<th>Water safety planning</th>
</tr>
</thead>
</table>
| Derived from WHO Guidelines for the safe use of wastewater, excreta and greywater | Derived from WHO Guidelines for drinking-water quality
| Uses risk management, hazard analysis and critical control point (HACCP), The Stockholm framework for guidelines for microbial contaminants in water, Note 1 | Uses risk management, HACCP, The Stockholm framework for guidelines for microbial contaminants in water
| Core components: (i) system assessment; (ii) monitoring; and (iii) management | Core components: (i) system assessment; (ii) monitoring; and (iii) management
| Follows the entire sanitation chain | Follows the entire supply chain for drinking water
| Considers multiple exposure groups for microbiological, physical and chemical hazards | Considers a single exposure group (consumers of drinking water) for microbiological, physical, chemical and radiation hazards
| Expands from waste generation (source) to its uses and discharge into the environment | Converges from catchments (sources) to the drinking-water delivery point
| Usually no clear regulatory framework – roles and responsibilities are shared over different sectors and levels | Operates in a clear regulatory framework in high- and middle-income countries, and an increasing number of low-income countries
| Objectives – to reduce negative health impacts of using wastewater, excreta or greywater, while maximizing the benefits of their use | Objectives – to consistently ensure the safety and acceptability of a drinking-water supply and to reduce the risk of drinking-water contamination
| Implementing agency – varies depending on objectives, skills and resources | Implementing agency – water utility or a community association for small supplies

In 2012, with support from the Swiss Agency for Development and Cooperation, WHO started to work in collaboration with the Swiss Tropical and Public Health Institute (Swiss TPH), the International Water Management Institute, the Swiss Federal Institute for Aquatic Science and Technology and the International Centre for Water Management Services, to draft the SSP manual and testing process as part of an initiative for safe resource recovery and reuse.28

The draft manual was developed during 2013–2014, drawing on expertise of the WHO water quality and health technical advisory group and experiences from pilot sites in India, Peru, Philippines, Portugal, Viet Nam and Uganda, representing a wide range of contexts (see Table 2). In each case, national authorities responsible for implementing SSP worked with local experts to develop sanitation safety plans for the pilot site. WHO and Swiss TPH provided training and remote technical support to the process over a 6-month period.29

The findings and experiences from the pilots were shared in a 2-day workshop involving all stakeholders, who gave suggestions on how to improve the SSP manual and provided case-studies and some key learning on institutional mechanisms to support and sustain SSP.

Some of the key features of the sanitation safety planning manual and training materials

The final SSP manual22 comprises the following key sections:

- a detailed description of the six SSP modules (see Fig. 1) and expected outputs;
- guidance notes for each of the main tasks listed under each module, as well as relevant background information;
- specific tools for SSP and examples illustrating the application of the tools;
- guidance notes based on the experience gained in the piloting sites;
- a worked example of SSP in a fictional town in a middle-income country with a tropical climate;
- annexes including; (i) more than 50 control measures and their effectiveness in risk reduction for wastewater treatment;

**Table 2. SSP pilot countries and sites with their lead organizations**

<table>
<thead>
<tr>
<th>Location</th>
<th>Characteristics of SSP pilot site</th>
<th>Lead organization(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bangalore, India</td>
<td>Sanitation wastes (combined with the open-drain stormwater system) and solid-waste-disposal sites include small-scale agricultural production and formal and informal sanitary waste dumping</td>
<td>Devanhallli Town Municipal Council; and Karnataka Urban Water Supply and Drainage Board</td>
</tr>
</tbody>
</table>
| Lima and Lurigancho District, Peru | Lima site: treated wastewater irrigation in a public park (Parque Zonal Huáscar)  
Lurigancho District site: indirect agricultural use of wastewater from a river contaminated with wastewater from upstream cities; uses included fish farming and agriculture | Lima site: park service of Lima  
Lurigancho district site: Rimac River Users' Board |
| Baliwag and Quezon City, Philippines | Faecal sludge waste collection, treatment, reuse and disposal at two sites; uses included vermiculture using faecal sludge bio-solids                                                                                                       | Baliwag Water District; and Maynilad Water Services Inc. |
| Benavente, Portugal  | Inter-town sanitation and drainage system including: on-site septic systems, sludge management system, stormwater collection system, sewage system, wastewater treatment plants, agriculture effluents (slurry/manure) reuse | Municipality of Benavente, and Águas do Ribatejo (inter-municipal company responsible for the water supply and sanitation system, serving seven municipalities in Portugal) |
| Kampala, Uganda      | Sanitary waste collection, treatment, wastewater collection and discharge into a wetlands farming area using the effluent and combined raw wastewater for irrigation                                                                                   | Kampala Capital City Authority and the National Water Supply and Sewage Corporation |
| Hanoi, Viet Nam      | Hanoi site 1: wastewater use in agriculture and conveyance system  
Hanoi site 2: municipal organic composting plant using treated sewage                                                                                                        | Hanoi site 1: Hanoi Water Supply and Drainage Board  
Hanoi site 2: municipal organic composting plant using treated sewage |

**Fig. 1. Sanitation safety planning modules**

SSP: sanitation safety planning.

wastewater in agriculture and aquaculture; and excreta, urine and greywater use; (ii) a summary of microbial health risks from the use of wastewater in irrigation; and (iii) a list of wastewater chemicals in agriculture and aquaculture.

Some of the key features of the manual and supporting training materials include:

- a comprehensive exposure-group assessment, since the variety of groups exposed is greater than for water safety planning, and may be directly or indirectly impacted; typically, exposure groups would include:
  - workers who maintain, clean, operate or empty the sanitation technologies;
  - farmers who use the untreated, partially or fully treated wastewater, bio-solids or faecal sludge, usually on a farm or in a factory;
  - local communities living near to or downstream from the sanitation technology or farm on which the material is used and who may be passively affected;
  - consumers who eat or use products (e.g. crops, fish, compost) that are produced using sanitation products.
- the training starts with an entertaining and thought-provoking role-play activity, which not only acts as an ice-breaker but also sets the scene for the identification of risks and exposure groups in a typical sanitation system in Asia;
- the training provides an introduction to relevant pathogens and infection pathways and guidance on compiling biological, chemical and physical hazard information; information on types of hazard during normal and/or emergency operating conditions, which may be weather/climate related; exposure and transmission routes; and control measures that could be used to mitigate the risks. Several videos and visual aids are used in this interactive training.

**Lessons learnt from the pilots and regional workshop**

**Regional workshop on sanitation safety planning in Kolkata, India**

Reuse of wastewater in agriculture and aquaculture is practised in several countries of the WHO South-East Asia Region, generally informally with no proper regulation of reuse activities. To highlight the health risks, and at the same time to build capacity, the WHO Regional Office for South-East Asia organized the first South Asia regional workshop on SSP in August 2016, in Kolkata, India. The main objective of the training was to establish a pool of key people in the region with an in-depth understanding of key SSP concepts and principles, who would become SSP champions in the region.

The training was attended by 34 participants from Bangladesh, India, Indonesia, Nepal, Sri Lanka and Thailand, representing sanitation and health officials from government ministries, sanitation practitioners from nongovernmental organizations, and representatives from development partners, including the Asian Development Bank. Facilitation was done by a team of eight trainers selected to be ready to support future upscaling of SSP internationally. An additional workshop objective was to trial the first draft of a new training package for the SSP manual. All trainers had prior knowledge of the manual and some had contributed technical input.

The training included a field visit to the East Kolkata Wetlands (fields, ponds and a sewage-treatment plant), which recycles almost 90% of the city’s waste for aquaculture and agriculture, and a visit to the State Pollution Control Board for a briefing. Three days of training followed, covering the six modules of the SSP training. SSP processes were outlined by the trainers, and participants practised their application using the Kolkata wetlands. Based on the learning and skills developed in the workshop, work has commenced on SSP for the East Kolkata Wetlands, with an initial risk assessment now completed. The Kolkata SSP will initiate longer-term environmental surveillance in the region.

At the end of the training, participants: (i) were able to explain the SSP concept and process to other sanitation stakeholders; (ii) knew where to locate further technical information to assist SSP preparation, especially in relation to hazards, hazardous events, control measures and their effectiveness; and (iii) were able to develop peer-group relations and links to international SSP experts and peers from around the globe. Each country team also developed a provisional SSP action plan.

**Pilot sanitation safety plan in the Baliwag, Philippines**

The pilot sanitation safety plan of Baliwag Water District underscored the need for proper procedures and standards for the reuse of faecal sludge in agriculture in the interest of public health. The sanitation safety plan identified practical control measures designed to manage risks produced by improper handling of sludges from faecal sludge-treatment plants when used as agricultural fertilizer. Simple and practical measures included restriction on the use of treatment-plant sludges for non-food crops, crops processed before consumption, or crops that have to be cooked; improvement of farmers’ handwashing hygiene; and promotion of protective clothing for farmers during application of bio-solids to farms. As the water utility started its formal licence application for the use of its bio-solids as soil conditioners, immediate improvement plans were implemented, based on the results of the risk analysis in the pilot sanitation safety plan.

Building on the lessons learnt in the Baliwag SSP, and with assistance from the Asian Development Bank, the water utility developed a business model for reuse of its bio-solids to optimize environmental benefits through safe bio-solids treatment and reuse, and by reducing the financial costs of disposal, through third-party uses of treatment-plant by-products processed as soil conditioners. With the increasing investments by the local government units and water utilities on sewage management in the Philippines, an increase in the volume of bio-solids that will be generated is anticipated. The SSP approach will complement these investments by establishing stronger demand for the end-products of bio-solids processing, with the private sector scaling up the business of sludge reuse; by promoting greater understanding among farmers about the benefits of bio-solids as soil conditioners or fertilizers; and by advocating more research and academic work on the fate of residuals and by-products of sewage treatment.

**Sanitation safety plan in Karnata, India**

A sanitation safety plan was applied in Devanahalli town, Karnataka, India, to complement the draft liquid-waste management plan prepared by the Karnataka Urban Water Supply and Drainage Board (KUWSDB). The SSP process
identified hazards associated with the management of open drains collecting wastewater and storm water. Clearing solid waste in those drains was identified as the highest risk to workers and local communities. Improvements to reduce risk included changes in management and improved coordination with the workers, resulting in lower capital investment needs than had been anticipated in the original liquid-waste management plan.

The SSP process was understood and run by the three staff available at the Devanahalli Town Council, with very little outside assistance. No extra budget was required for the improvements identified by the SSP process.

The KUWSDB has a specialized training institute for its own staff and other stakeholders in the area of water and wastewater management. This centre plans to take up SSP as a training programme and replicate it across the 270 small and medium-sized towns in the state of Karnataka.

Optimizing support for the sanitation safety planning process

Among the challenges for successful SSP implementation are the need for effective broad-ranging stakeholder engagement, which is often achieved through appropriate composition of the SSP team. The SSP team should include people with complementary health and technical skills, so that members are collectively able to define the system, identify all hazards and hazardous events, and understand how the risks can be controlled (e.g. it should include relevant agricultural and/or aquacultural expertise). SSP is often initiated by the sanitation service provider, such as a sewage company. However, users of the effluent or bio-solids (e.g. farmers), and consumers of their produce, face significant potential health risks, and also have major roles to play in protecting public health.20 The roles of these stakeholders are as important as that of the service provider. Without the commitment and involvement of users, SSP can lead to suboptimal health gains. To help address these challenges, the SSP manual includes guidance on stakeholder analysis, to help the lead organization effectively engage all stakeholders.22

Often there is a natural initial reluctance by the service provider to extend the SSP boundary beyond the traditional limits of the sewage-treatment plant. This is because areas downstream of the treatment plant are generally outside their normal operational or regulatory limits. Operational experience in SSP has shown, however, that when the service provider puts effort into meaningful discussions with stakeholders, as encouraged in SSP, stakeholder engagement is significantly improved. One outcome of this engagement is greater understanding of the actual use of the effluent and bio-solids processes downstream of the treatment plant. This engagement and understanding not only leads to better stakeholder communication and understanding of health impacts, but directly supports improved development and implementation of SSP.

In the course of the SSP piloting and early application, a number of success factors for SSP have been identified, namely: (i) support by multinational donors and funding agencies can “kick-start” local interest and raise awareness; (ii) support by international and national consultants experienced in SSP helps to avoid SSP teams “doing it alone”; (iii) a keen sense of ownership of SSP by the lead agency’s young professionals has been shown to be significant in developing SSP champions; and (iv) appropriate partnerships with civil society organizations should be developed and nurtured, in order to strengthen the ownership and impact of SSP.

Opportunities and challenges for wider application of sanitation safety planning in the WHO South-East Asia Region

The amount of wastewater produced in the WHO South-East Asia Region is increasing every year, with rapid development, urbanization and population growth. Hence, proper management of wastewater becomes increasingly important, mainly to protect public health and the environment. Lack of resources, capacity and regulation are some of the factors that affect proper treatment of wastewater and safe disposal or use of wastewater in agriculture or aquaculture. However, initiatives have been commenced, like that in India through the Swachh Bharat Abhiyan (Clean India Mission), spearheaded by the prime minister, designed to declare India free of open defecation by 2019, while at the same time addressing management of liquid waste.31 In support of this initiative, the Ministry of Urban Development issued a policy in 2008, with a vision to make all cities and towns “sanitized, healthy and liveable”. To achieve this, many cities have started developing city sanitation plans. SSP is central to such initiatives and efforts are being made to use SSP in ongoing programmes.

The National Water Supply and Sewerage Board in Sri Lanka is scaling up water safety planning in several parts of the country and they are exploring opportunities to implement SSP in catchment areas of drinking-water sources where WSPs are implemented as a means of protecting the water catchment area from contamination by wastewater.

Conclusion and outlook

Working towards SDG target 6.3, i.e. “by 2030 … halving the proportion of untreated wastewater and substantially increasing recycling and safe reuse globally”,7 countries worldwide need to ensure robust planning of new sanitation systems with end-use in mind, and to put in place ongoing management and surveillance to ensure the system protects public health at all steps of the sanitation chain and can adapt over time to a changing environment (e.g. population growth or climate variability). The SSP manual22 and the WHO 2006 guidelines17 have potential to become an important vehicle for promoting safely managed sanitation and safe use of wastewater and excreta. Through its flexible step-by-step approach, combined with clear guidance and a broad toolset, the SSP manual22 allows SSP to be readily adapted to local, societal, financial and ecological systems. A limitation of the manual is the proposed semi-quantitative risk-assessment approach, using a matrix of likelihood and severity. While such a method can be applied by people with varying backgrounds, it may not result in a fully objective risk quantification. Therefore, as recommended in the SSP manual, the semi-quantitative risk assessment needs to be undertaken by several individuals, in order to produce consolidated ratings.

Experience in the WHO South-East Asia Region shows that SSP is contributing to more efficient and safer sanitation
systems. In particular, its focus on operational and verification monitoring helps operators and regulators to concentrate on key issues affecting the health of sanitary workers, farmers and consumers. In areas like the Philippines, where there is increasing investment in management of faecal sludge, SSP has been shown to complement the investment by maximizing its return, especially in terms of ongoing management and health protection. In addition, experience in India has shown that the collaborative stakeholder SSP process itself can lead to improved investment decisions, especially in resource-scarce areas. Given the expected growth in the use of waste products in agriculture, principally to recover nutrients and increase production to supply growing populations in urban and peri-urban areas, SSP offers a very useful tool to improve sanitation systems and meet public health targets. Against this background, WHO will continue to promote SSP in the WHO South-East Asia Region, through (i) increased training capacity within regional and national organizations; (ii) partnerships with governments, nongovernmental organizations and other stakeholders to expand SSP implementation; and (iii) learning exchanges to improve the quality of risk assessment and management of sanitation systems.

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References


Online media coverage of air pollution risks and current policies in India: a content analysis

Nandita Murukutla1, Nalin S Negi2, Pallavi Puri1, Sandra Mullin1, Lesley Onyon2

1Vital Strategies, New York, United States of America, 2World Health Organization Regional Office for South-East Asia, New Delhi, India

Correspondence to: Dr Nandita Murukutla (nmurukutla@vitalstrategies.org)

Abstract

Background Air pollution is of particular concern in India, which contains 11 of the 20 most polluted cities in the world. Media coverage of air pollution issues plays an important role in influencing public opinion and increasing citizen demand for action on clean air policy. Hence, this study was designed to assess news coverage of air pollution in India and its implications for policy advancement.

Methods Articles published online between 1 January 2014 and 31 October 2015 that discussed air pollution in India were systematically content analysed. From 6435 articles in the national media and 271 articles in the international media, a random selection of 500 articles (400 from national and 100 from international media) were analysed and coded by two independent coders, after high inter-rater reliability (kappa statistic above 0.8) was established.

Results There was an increase in the number of news stories on air pollution in India in the national media over the study period; 317 (63%) stories described the risk to health from air pollution as moderately to extremely severe, and 393 (79%) stories described the situation as needing urgent action. Limited information was provided on the kinds of illnesses that can result from exposure. Less than 30% of stories in either media specifically mentioned the common illnesses resulting from air pollution. Very few articles in either media mentioned the population groups most at risk from air pollution, such as children or older people. Vehicles were presented most often as the cause of air pollution in India (in over 50% of articles in both national and international media). Some of the most important sources of air pollution were mentioned less often: 6% of national and 18% of international media articles mentioned unclean sources of household energy; 3% of national and 9% of international media articles mentioned agricultural field burning. Finally, the majority of articles (405; 81%) did not mention any specific institution or organization – such as the government or industry groups – as the primary responsible stakeholder, thus leaving ambiguous the organizations whose leadership was necessary to mitigate air pollution.

Conclusion Gaps exist in the current media discourse on air pollution, suggesting the need for strengthening engagement with the media as a means of creating citizen engagement and enabling policy action. Through greater elaboration of the health burdens and evidence-based policy actions, the media can play a critical role in galvanizing India’s action on air quality. These data may suggest opportunities for media advocacy and greater public and policy engagement to address issues around air quality in India.

Keywords: air pollution, content analysis, India, media advocacy, news coverage

Background

Air pollution, a global public health threat, is of particular concern in densely populated rapidly developing countries. Premature deaths from air pollution have been estimated as 6.5 million annually,1 and it has been further estimated that two thirds of deaths attributable to air pollution occur in low- and middle-income countries.1 In India, which is home to 11 of the 20 most polluted cities in the world,2 over one million individuals die annually as a result of exposure to household air pollution alone.3 Policy action to address air pollution in India is urgently needed.3,4 Public opinion and citizen demand play a crucial role in building political will and mobilizing policy action in health matters.5 Informed populations may make healthier personal choices and can also demand health-promoting policies from their governments. In public health, the mobilization of public opinion through mass media, and coordinated action from governments and other key stakeholders, has been critical to advancing policies in such diverse areas as tobacco control and HIV.5–7 Historically, public opinion and citizen demand have also been critical to advancing environmental health agendas, including for air quality, in a number of countries around the world.8–12
The news media can play a powerful role in shaping public opinion and setting agendas for clean air. News reporting can build an understanding of the causes, consequences and potential solutions for air pollution, and, through frequent and prominent reporting, it can help to establish certain issues as urgent public priorities. Conversely, when news reporting is inaccurate, it can perpetuate misunderstandings and misdirect the public’s support for solutions. Hence, to ensure that the public is appropriately informed and provided with the necessary information to be effectively engaged and to demand evidence-based policies, it is important to understand the current state of news media reportage and to engage with the news media, as a critical stakeholder, to advance evidence-based public policy.

**News media coverage and environmental policy in India**

India has a thriving newspaper business, with circulation growing each year. While Hindi newspapers dominate, English newspapers are the second largest in number. With the growth of Internet penetration in India, Indian newspapers have invested in digital media, and most major newspapers now publish an online version of their paper. The Indian media plays an important role in shaping social norms, policies and politics. Indeed, recent studies have demonstrated how media content in India has shaped discussions around issues such as climate change.

Management of air quality in India is primarily the responsibility of the Ministry of Environment, Forest and Climate Change and is regulated under the Air (Prevention and Control of Pollution) Act 1981. The Central Pollution Control Board, along with its state counterparts, is the designated authority for the management of air quality. However, as the harmful health effects of air pollution have become increasingly clear, the role of the Ministry of Health and Family Welfare as an active advocate for clean air in the interest of human health has increased. Indeed, there has been some recognition of this in India, as the Ministry of Health and Family Welfare has established an innovative high-level multisectoral steering committee on air pollution, which has formulated a set of recommendations for coordinated actions to reduce the major sources of air pollution and to strengthen the existing health infrastructure and capacity to mitigate its health impacts.

**Rationale for this study**

The impetus for this study was an apparent significant increase in the volume of news reporting on air pollution in India during 2014–2015. It was hypothesized that this increase may be linked to the significant number of key global events that were relevant to air pollution during this time period, as listed next.

- May 2014: the World Health Organization (WHO) updated its database of ambient air pollution in cities. Reporting of these data caused commentators to replace Beijing with New Delhi as the most polluted city in the world, thereby attracting both media attention and controversy.
- May 2015: the World Health Assembly adopted a resolution (WHA68.8) that recognized air pollution as the world’s largest environmental health risk and provided ministries of health with a mandate to redouble their efforts to identify, address and prevent the health impacts of air pollution.
- September 2015: the United Nations General Assembly adopted the 2030 Agenda for Sustainable Development, which identified air pollution as integral to the achievement of Sustainable Development Goals related to health (SDG3), affordable and clean energy (SDG7) and sustainable cities and communities (SDG11).
- November 2015: the 21st Conference of the Parties to the United Nations Framework Convention on Climate Change (COP21) resulted in adoption of a legally binding treaty to address atmospheric pollutants, including those that create air pollution, to protect people and the environment.
- December 2015: the Paris Agreement on climate, which builds on COP21, for the first time, brought all nations together to undertake ambitious efforts to combat climate change and adapt to its effects, with enhanced support to assist developing countries to do so.

India’s agreement to the World Health Assembly Resolution 68.8, the Agenda for Sustainable Development, and the COP21 global agreements was significant, given its population size, the current levels of health and environmental burden, and its projected economic growth.

Given the role of news media in shaping policy actions, a systematic content analysis of news stories published online in the period 2014–2015 was undertaken, to assess the news media’s prioritization of air pollution in India, its perception of severity and urgency for action, and the reported sources and policy solutions.

**Methods**

The study was conducted between 1 October and 15 December 2015. Relevant articles in English published between 1 January 2014 and 31 October 2015 were included. This time frame was chosen purposively to encompass the key global events relevant to air pollution listed above, plus relevant national events such as the Indian national elections in May 2014 and the launch of a new Indian National Air Quality Index in April 2015.

**Sampling of news articles**

Articles for analysis were identified through two news-monitoring services that were available to the authors – Google News and Meltwater – using the search terms “air pollution” and “India”. Alternative search terms like “smog”, “haze” and “air quality” were not used for this study, since air pollution was found to be the more frequently used term. Additionally, terms like “haze” and “smog” tended to co-occur with the term “air pollution”, and, given the high volume of articles already obtained with the term “air pollution”, the decision was made to not further expand the search terms, in order to keep the scope of the study manageable.

Articles were obtained from online versions of papers, since it was established that all prominent newspapers simultaneously publish web and print versions of their papers daily. Articles from both Indian national and international media were included; the latter were included only if issues of air pollution in India were specifically mentioned.

Once retrieved, all articles were carefully cleaned and sorted. Personal blogs, aggregators and non-relevant articles that were mistakenly captured in the search were excluded.
Articles for analysis were classified by source as web news (if only printed online with no print version available); articles posted on web pages of television news stations; web versions of print newspapers; or web versions of print magazines. The final cleaned sample of articles was 6706, comprising 6435 articles from Indian national media and 271 articles from international media.

Sampling of a subset for content analysis
Given the large volume of articles, a subset of 500 articles was systematically selected for content analysis. To provide for an analysable subset, it was determined that 100 articles would be selected from the international media, and the remaining 400 from Indian national media. To ensure systematic random selection of articles for coding, the complete set of articles identified was separately ordered by date, and in each list every nth article was selected to achieve the desired 400 articles from the Indian national media and 100 from the international media.

In addition to presenting the findings in total across all 500 articles, the findings in this study are also presented separately by international and national media in all tables and within the text, as appropriate. This was done as both a point of interest to compare the national and international media reportage and because the subsets comprised very different proportions of the national (6.2%) and international (36.9%) complete sets.

Coding frame for content analysis
A coding frame for content analysis was developed and included the following topics: section in which the article was published; article theme or aspects of air pollution described; health risks mentioned; sources and solutions mentioned; primary responsible stakeholder (e.g., government) mentioned; and overall tone towards the issue of air pollution in India.

To reduce errors due to subjectivity, questions were intentionally designed to require objective assessments, such as recording the presence/absence of mention of specific issues. In a few instances, the coders were called upon to make subjective assessments: in particular, in a series of questions that used five-point Likert scales, they were asked to gauge aspects, including the article’s tone (where 1 = very negative, 2 = somewhat negative, 3 = mixed, 4 = somewhat positive and 5 = very positive); its presentation of the severity of the health risks from exposure to air pollution (1 = not at all severe, 2 = somewhat severe, 3 = moderately severe, 4 = very severe, 5 = extremely severe); the perceived urgency of action required (1 = not at all urgent, 2 = somewhat urgent, 3 = urgent, 4 = very urgent and 5 = extremely urgent); and the expressed imminence in experiencing health effects from exposure to air pollution (to be experienced right away or in some distant future).

Two independent coders coded the articles after an intense 3-day training on the coding frame and after any ambiguities in question wording or meaning were resolved. To ensure uniform implementation of the coding frame, particularly on the subjective assessments, a methodology established in the literature was used. Specifically, both coders simultaneously but separately coded the same 77 articles (15% of articles), and once inter-rater reliability, using kappa statistics, was found to be high (over 0.8) on all questions, including the subjective assessments, coding continued on the remaining articles separately and simultaneously.

Data analysis
The complete set of 6706 articles, comprising 6435 from national media and 271 from international media, were examined for month-wise frequency. Content analysis was restricted to the subset of 500 articles. The coders’ observations were entered into SPSS (IBM Corp. Released 2013. IBM SPSS Statistics for Windows, Version 22.0. Armonk, NY: IBM Corp.). Frequencies on all questions were computed.

Results

Frequency of articles
There were clear time trends in reporting of issues related to air pollution in both national and international media (see Fig. 1). In the national media, there was variability but the linear trend indicated a steady increase from January 2014 to October 2015 in the frequency of articles that reported on air pollution. The variability around this trend included a peak from around April to May 2015. In the international media, the linear trend was constant but there was substantial variability, including two distinct peaks in May 2014 and in April 2015. The trend lines for the national and international article sets and their respective subsets mirrored one another closely (data not shown), indicating that the systematic sampling procedure was successful in creating two reliably representative subsets of articles for coding.

Article characteristics
Results of the content analysis are presented in the text that follows and, unless stated otherwise, refer to the total set (n = 500) of articles analysed; selected results are summarized in the tables. With respect to article characteristics, most of the 500 articles were obtained from news sites – primarily online versions of print newspapers, and, secondarily, websites of television news channels. The articles were most often news stories (n = 455, 91%; see Table 1). Traditionally, print publications have clearly marked sections, such as Editorial, News, Opinion, etc. With the online articles in this study, section placement could not be determined in most cases (n = 370, 74%); however, in the few cases where placement could be determined, less than 4% of the articles were found on the front page. In 208 articles (163 national and 45 international) where the section of the newspaper/magazine could be determined, the stories appeared most often in the City (national: n = 29, 18%; international: n = 15, 33%) or in the Environment sections (national: n = 18, 11%; international: n = 7, 16%).

A total of 225 (45%) articles were accompanied by an illustration, of which 88% (n = 198) were photographs. With respect to the emotional tone conveyed by the illustrations (negative, positive or neutral), 110 (49%) had a negative tone (national: n = 66; international: n = 44). Examples of negative images included those that elicited negative emotions through depictions of heavy and disgusting pollution in places where people reside.

In addition to India, the countries most often mentioned were China and the United States of America (USA). The countries other than India were more likely to be mentioned in international
than in national articles. Among the 400 national articles, 62 (16%) mentioned China and 37 (9%) mentioned the USA, whereas in the 100 international articles, China and the USA were mentioned in 23 (23%) and 7 (7%) articles, respectively. New Delhi was the city most often referred to in both national (n = 173, 43%) and international (n = 62, 62%) media; Beijing and Mumbai were the cities next most frequently mentioned.

**Air pollution topics, causes, terms and solutions reported**

The most common primary theme of articles was the extent of air pollution in India (n = 139, 28%), followed by the health effects of air pollution and solutions to address air pollution (see Table 2). Far more articles highlighted or opined about possible strategies to address issues of air pollution than its causes: in the national media, 19 (5%) articles described the causes of air pollution, while 74 (19%) raised possible solutions; in the international articles, 10 (10%) described the causes of air pollution, while 14 (14%) raised possible solutions to the issue.

Terms used most often to describe or characterize air pollution were “PM$_{2.5}$” (i.e. particulate matter with diameter $\leq$ 2.5 µm) in 160 (32%) of the articles, “PM$_{10}$” (i.e. particulate matter with diameter $\leq$ 10 µm) in 80 (16%) of the articles, and “air quality index” in 59 (12%) of the articles. Constituents of air pollution like sulfur dioxide, nitrogen dioxide and carbon dioxide were rarely mentioned. Additionally, outdoor (ambient) sources of air pollution were more often mentioned than were indoor (household) sources, such as cooking with unclean fuels or cooking with inefficient cooking stoves.

In the total set of 500 articles, vehicles were most frequently mentioned (n = 279, 56%) as the source of air pollution in India. This was followed by power plants (n = 104, 21%) and diesel-powered electricity-generation sets (or “gen-sets”, which are

![Fig. 1. Month-wise publication of articles containing the terms “air pollution” and “India”](image)

<table>
<thead>
<tr>
<th>Characteristics and categories</th>
<th>Total articles (N = 500), n (%)</th>
<th>National articles, (N = 400), n (%)</th>
<th>International articles (N = 100), n (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type of article</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>News</td>
<td>455 (91)</td>
<td>364 (91)</td>
<td>93 (93)</td>
</tr>
<tr>
<td>Feature</td>
<td>13 (3)</td>
<td>10 (3)</td>
<td>3 (3)</td>
</tr>
<tr>
<td>Opinion</td>
<td>24 (5)</td>
<td>21 (5)</td>
<td>3 (3)</td>
</tr>
<tr>
<td>Editorial</td>
<td>6 (1)</td>
<td>5 (1)</td>
<td>1 (1)</td>
</tr>
<tr>
<td>Countries other than India mentioned (multiple results)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>China</td>
<td>85 (17)</td>
<td>62 (16)</td>
<td>23 (23)</td>
</tr>
<tr>
<td>United States of America</td>
<td>44 (9)</td>
<td>37 (9)</td>
<td>7 (7)</td>
</tr>
<tr>
<td>Cities mentioned (multiple results)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>New Delhi</td>
<td>235 (47)</td>
<td>173 (43)</td>
<td>62 (62)</td>
</tr>
<tr>
<td>Beijing</td>
<td>45 (9)</td>
<td>24 (6)</td>
<td>21 (21)</td>
</tr>
<tr>
<td>Mumbai</td>
<td>21 (4)</td>
<td>16 (4)</td>
<td>5 (5)</td>
</tr>
</tbody>
</table>
used during power outages; \( n = 72, 14\% \)). While the second-most often cited source of air pollution in both national and international articles was power plants (\( n = 86, 22\% \) and \( n = 18, 18\% \), respectively), national articles less frequently mentioned cooking with unclean fuels than the international media (\( n = 24, 6\% \) in national versus \( n = 18, 18\% \) in international media). Finally, while among national articles, diesel-powered gen-sets were the third most frequently mentioned source, among international articles, factories, and inefficient cooking stoves were the next most frequently mentioned. International articles were also more likely to mention dust and construction; agricultural, wood and waste burning; and brick kilns than were the national articles (see Table 2).

**Health effects**

While negative health effects of air pollution were mentioned in general terms, most articles did not describe the specific kinds of health effects that one might experience as a result of exposure to air pollution (see Table 3): 164 (33\%) described general health effects and 121 (24\%) described deaths or mortality attributable to air pollution. When a specific illness was mentioned, it was most likely to be cardiovascular disease (\( n = 67, 13\% \)). Lung diseases were mentioned less often. Overall, articles in international media were more likely than those in national media to mention a specific health effect. Finally, very few articles mentioned populations that are particularly at risk from air pollution, such as children and the elderly.

The overall tone of most articles (\( n = 385, 77\% \)) towards air pollution in India was negative, with international articles more likely to be negative in tone than the national ones (see Table 3). The articles’ tone towards specific burdens created by air pollution was likewise negative: 365 (73\%) articles described the environmental burdens created by air pollution in a negative tone; 313 (63\%) articles described the health burdens created by air pollution in a negative tone. A total of 317 (63\%) articles presented the health risks of exposure to air pollution as moderately to extremely severe.

The articles also suggested a need for urgent action: 393 (79\%) articles presented the issue of air pollution as requiring urgent action, with a higher proportion of the international media than the national media suggesting urgent action (\( n = 89, 89\% \) versus \( n = 304, 76\% \)). However, while air pollution was frequently presented as a severe and urgent issue, few articles reported that the health effects were imminent or likely to be experienced in the short term. Only 26 (7\%) articles in the national media and 3 (3\%) in the international media suggested that some of the negative health effects could be felt immediately.

**Policy and individual actions to address air pollution**

Policy measures to address air pollution that were most frequently mentioned in all articles included monitoring of air pollution (\( n = 73, 15\% \)), establishment of emission and testing standards for vehicles (\( n = 42, 8\% \)), and traffic restrictions (\( n = 33, 7\% \); see Table 4). Among national articles, increased taxes on polluting sources was mentioned in only 14 (4\%) articles and increased availability of clean energy sources was mentioned in only 23 (6\%) articles. In both national and international media, the following policy solutions were

### Table 2. Reporting of air pollution topics, terms and sources

<table>
<thead>
<tr>
<th>Characteristics and categories</th>
<th>Total articles ((N = 500), n(%))</th>
<th>National articles ((N = 400), n(%))</th>
<th>International articles ((N = 100), n(%))</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Primary theme/topic of the article (top five)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Extent of air pollution</td>
<td>139 (28)</td>
<td>103 (26)</td>
<td>36 (36)</td>
</tr>
<tr>
<td>Health effects</td>
<td>132 (26)</td>
<td>107 (27)</td>
<td>25 (25)</td>
</tr>
<tr>
<td>Solutions to address air pollution</td>
<td>88 (18)</td>
<td>74 (19)</td>
<td>14 (14)</td>
</tr>
<tr>
<td>Monitoring of air pollution</td>
<td>34 (7)</td>
<td>27 (7)</td>
<td>7 (7)</td>
</tr>
<tr>
<td>Causes of air pollution</td>
<td>29 (6)</td>
<td>19 (5)</td>
<td>10 (10)</td>
</tr>
<tr>
<td><strong>Terms used to describe or characterize air pollution (multiple results)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PM(_{2.5})</td>
<td>160 (32)</td>
<td>125 (31)</td>
<td>35 (35)</td>
</tr>
<tr>
<td>PM(_{10})</td>
<td>80 (16)</td>
<td>66 (17)</td>
<td>14 (14)</td>
</tr>
<tr>
<td>Air quality index</td>
<td>59 (12)</td>
<td>48 (12)</td>
<td>11 (11)</td>
</tr>
<tr>
<td>Smog</td>
<td>54 (11)</td>
<td>29 (7)</td>
<td>25 (25)</td>
</tr>
<tr>
<td><strong>Sources of air pollution mentioned (multiple results)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vehicles</td>
<td>279 (56)</td>
<td>216 (54)</td>
<td>63 (63)</td>
</tr>
<tr>
<td>Power plants</td>
<td>104 (21)</td>
<td>86 (22)</td>
<td>18 (18)</td>
</tr>
<tr>
<td>Diesel-powered electricity-generation sets</td>
<td>72 (14)</td>
<td>62 (16)</td>
<td>10 (10)</td>
</tr>
<tr>
<td>Factories</td>
<td>56 (11)</td>
<td>39 (10)</td>
<td>17 (17)</td>
</tr>
<tr>
<td>Cooking with unclean fuels</td>
<td>42 (8)</td>
<td>24 (6)</td>
<td>18 (18)</td>
</tr>
<tr>
<td>Cooking with inefficient cooking stoves</td>
<td>29 (6)</td>
<td>15 (4)</td>
<td>14 (14)</td>
</tr>
<tr>
<td>Agricultural field burning</td>
<td>21 (4)</td>
<td>12 (3)</td>
<td>9 (9)</td>
</tr>
<tr>
<td>Waste burning</td>
<td>21 (4)</td>
<td>12 (3)</td>
<td>9 (9)</td>
</tr>
<tr>
<td>Dust and construction</td>
<td>20 (4)</td>
<td>12 (3)</td>
<td>8 (8)</td>
</tr>
<tr>
<td>Wood burning</td>
<td>16 (3)</td>
<td>9 (2)</td>
<td>7 (7)</td>
</tr>
<tr>
<td>Brick kilns</td>
<td>7 (1)</td>
<td>3 (1)</td>
<td>4 (4)</td>
</tr>
<tr>
<td>Others</td>
<td>36 (7)</td>
<td>31 (8)</td>
<td>5 (5)</td>
</tr>
</tbody>
</table>

PM\(_{2.5}\): particulate matter with diameter \( \leq 2.5 \mu m \); PM\(_{10}\): particulate matter with diameter \( \leq 10 \mu m \).
mentioned in 5% or less of the articles: removal of subsidies, increasing the price of diesel, and reducing the price of compressed natural gas. Less than 1% of articles mentioned the co-benefits, like reduced road injuries, increased physical activity or mitigation of climate change, which could accrue from the implementation of policies to address air pollution.

Individual actions for protection from air pollution were cited only infrequently. These included reducing vehicle use (n = 33, 7%), increasing public transport (n = 26, 5%), purchasing better grade fuels (n = 24, 5%) and the use of clean cooking stoves (n = 18, 4%).

**Responsible and accountable authorities**

The majority of articles (n = 405, 81%) were silent on the issue of who should be held responsible or most accountable on air pollution in India but also important gaps and missed opportunities that may guide future engagement with the media by parties – including the government – who are interested in seeing increased citizen engagement and strengthened policy action on air quality.

This study found a significant volume of reporting on issues related to air pollution in India but also important gaps and missed opportunities that may guide future engagement with the media by parties – including the government – who are interested in seeing increased citizen engagement and strengthened policy action on air quality.

The study found a steady increase in reporting on issues around air pollution in the national media between 2014 and 2015. In the international media, the linear trend in reporting over the period of study was at a constant level but the month-wise variations included two peaks around May 2014 and around April 2015, probably coinciding with the release by WHO of data on deteriorating air quality in cities and the announcements of a new Indian National Air Quality Index and the plan to install new monitoring stations across the country, which were suggestive of increased government intent to act on air pollution in India.

The media content was primarily focused on the extent of air pollution during this period; its tone was negative and the articles described India’s air pollution as a severe problem requiring urgent action. However, most coverage of the issue was in the form of news reports on the extent and relative scale of the problem of air pollution in India. There were few editorials from key influencers that could have served as opportunities for calling for decisive action. Furthermore, the focus on the national capital, New Delhi, neglected other parts of the country with similarly poor air quality. It has been noted

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**Table 3. Reported health risks of air pollution, perceived severity and urgency for action**

<table>
<thead>
<tr>
<th>Categories</th>
<th>Total articles (N = 500), n (%)</th>
<th>National articles (N = 400), n (%)</th>
<th>International articles (N = 100), n (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Health effects mentioned (top five)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>General effects</td>
<td>164 (33)</td>
<td>139 (35)</td>
<td>25 (25)</td>
</tr>
<tr>
<td>Deaths/mortality</td>
<td>121 (24)</td>
<td>87 (22)</td>
<td>34 (34)</td>
</tr>
<tr>
<td>Cardiovascular disease</td>
<td>67 (13)</td>
<td>41 (10)</td>
<td>26 (26)</td>
</tr>
<tr>
<td>Respiratory problems</td>
<td>60 (12)</td>
<td>42 (11)</td>
<td>18 (18)</td>
</tr>
<tr>
<td>Lung cancer</td>
<td>38 (8)</td>
<td>17 (4)</td>
<td>21 (21)</td>
</tr>
<tr>
<td>Health effects not mentioned</td>
<td>205 (41)</td>
<td>175 (44)</td>
<td>30 (30)</td>
</tr>
<tr>
<td>Vulnerable populations mentioned (multiple results)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>General population</td>
<td>322 (64)</td>
<td>249 (62)</td>
<td>73 (73)</td>
</tr>
<tr>
<td>Children</td>
<td>39 (8)</td>
<td>29 (7)</td>
<td>10 (10)</td>
</tr>
<tr>
<td>Elderly</td>
<td>13 (3)</td>
<td>9 (2)</td>
<td>4 (4)</td>
</tr>
<tr>
<td>With pre-existing health conditions</td>
<td>4 (1)</td>
<td>3 (1)</td>
<td>1 (1)</td>
</tr>
<tr>
<td>Lower socioeconomic status</td>
<td>4 (1)</td>
<td>3 (1)</td>
<td>1 (1)</td>
</tr>
<tr>
<td>Tone on health risk</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Severity of health risk = “moderately severe” or “extremely severe”</td>
<td>317 (63)</td>
<td>242 (61)</td>
<td>75 (75)</td>
</tr>
<tr>
<td>None</td>
<td>1 (0)</td>
<td>1 (0)</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Imminence of health risk = immediate</td>
<td>29 (6)</td>
<td>26 (7)</td>
<td>3 (3)</td>
</tr>
<tr>
<td>Article tone</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Overall tone = “very negative” or “somewhat negative”</td>
<td>385 (77)</td>
<td>295 (74)</td>
<td>90 (90)</td>
</tr>
<tr>
<td>Tone on environmental burden = “very negative” or “somewhat negative”</td>
<td>365 (73)</td>
<td>290 (73)</td>
<td>75 (75)</td>
</tr>
<tr>
<td>Tone on health burden = “very negative” or “somewhat negative”</td>
<td>313 (63)</td>
<td>243 (61)</td>
<td>70 (70)</td>
</tr>
<tr>
<td>Tone on government action = “very negative” or “somewhat negative”</td>
<td>75 (15)</td>
<td>54 (14)</td>
<td>21 (21)</td>
</tr>
<tr>
<td>Tone on urgency of action required = “extremely urgent” or “very urgent”</td>
<td>393 (79)</td>
<td>304 (76)</td>
<td>89 (89)</td>
</tr>
</tbody>
</table>
elsewhere that other parts of India have received insufficient policy attention and action.41

The prominent theme in the media was the general health burden and overall mortality resulting from exposure to air pollution. However, there was little specificity and detail on the kinds of health burdens, including the kinds of illnesses that could develop from or be exacerbated by exposure to air pollution. Likewise, there was rare mention of the groups that are most vulnerable to exposure to air pollution, such as the elderly and children. Thus, the news media missed an opportunity to educate the public on the health harms of exposure to air pollution, including the health effects of varied levels of exposure – namely, the varied health impacts of short-term versus seasonal spikes versus cumulative, chronic long-term exposures, with the last being the most responsible for the health burden attributable to air pollution.

There was limited reporting on what is meant by air pollution and the sources of air pollution in India. While PM$_{2.5}$ was most frequently referred to as a measure of air pollution, few articles discussed its constituents and their harmful effects. Additionally, the preponderance of articles described outdoor or ambient sources of air pollution. Both national and international articles focused on vehicles as the primary source of air pollution in India, followed by power plants. International articles were more likely than national articles to mention other sources of air pollution that have been found to be major contributors in some Indian cities, such as brick kilns, unclean fuels, inefficient stoves, agricultural field burning and waste burning.21 In some cases, this order of prominence is inconsistent with the known data on sources of pollution affecting human health.21 Most notably, while household air pollution has been found to be a major source of air pollution in India, followed by power plants. International articles were more likely than national articles to mention other sources of air pollution that have been found to be major contributors in some Indian cities, such as brick kilns, unclean fuels, inefficient stoves, agricultural field burning and waste burning.21

**Table 4. Actions to address air pollution and support policies**

<table>
<thead>
<tr>
<th>Characteristics and categories</th>
<th>Total articles ($N = 500$), $n$ (%)</th>
<th>National articles ($N = 400$), $n$ (%)</th>
<th>International articles ($N = 100$), $n$ (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Primary responsible stakeholder mentioned</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Government</td>
<td>84 (17)</td>
<td>56 (14)</td>
<td>28 (28)</td>
</tr>
<tr>
<td>Individual</td>
<td>9 (2)</td>
<td>9 (2)</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Industry</td>
<td>2 (0)</td>
<td>2 (1)</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Not specified</td>
<td>405 (81)</td>
<td>333 (84)</td>
<td>72 (72)</td>
</tr>
<tr>
<td><strong>Policy solutions mentioned (top five)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Monitoring air pollution</td>
<td>73 (15)</td>
<td>62 (16)</td>
<td>11 (11)</td>
</tr>
<tr>
<td>Vehicle emission and testing</td>
<td>42 (8)</td>
<td>35 (9)</td>
<td>7 (7)</td>
</tr>
<tr>
<td>Traffic restriction</td>
<td>33 (7)</td>
<td>22 (8)</td>
<td>11 (11)</td>
</tr>
<tr>
<td>Cleaner energy resources</td>
<td>32 (6)</td>
<td>23 (6)</td>
<td>9 (9)</td>
</tr>
<tr>
<td>Increased taxes on pollution sources</td>
<td>27 (5)</td>
<td>14 (4)</td>
<td>13 (13)</td>
</tr>
<tr>
<td><strong>Individual actions mentioned (top five)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reducing vehicle use</td>
<td>33 (7)</td>
<td>23 (6)</td>
<td>10 (10)</td>
</tr>
<tr>
<td>Increasing public transport</td>
<td>26 (5)</td>
<td>18 (5)</td>
<td>8 (8)</td>
</tr>
<tr>
<td>Better grade fuels</td>
<td>24 (5)</td>
<td>18 (5)</td>
<td>6 (6)</td>
</tr>
<tr>
<td>Clean cooking stoves</td>
<td>18 (4)</td>
<td>15 (4)</td>
<td>3 (3)</td>
</tr>
<tr>
<td>Air filter</td>
<td>5 (1)</td>
<td>4 (1)</td>
<td>1 (1)</td>
</tr>
<tr>
<td><strong>Authorities mentioned (top five)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Indian national government</td>
<td>98 (20)</td>
<td>87 (22)</td>
<td>11 (11)</td>
</tr>
<tr>
<td>WHO</td>
<td>86 (17)</td>
<td>55 (14)</td>
<td>31 (31)</td>
</tr>
<tr>
<td>India state government</td>
<td>71 (14)</td>
<td>62 (16)</td>
<td>9 (9)</td>
</tr>
<tr>
<td>Pollution control boards</td>
<td>36 (7)</td>
<td>29 (7)</td>
<td>7 (7)</td>
</tr>
<tr>
<td>National green tribunal</td>
<td>34 (7)</td>
<td>28 (7)</td>
<td>6 (6)</td>
</tr>
<tr>
<td><strong>Government department mentioned (multiple results)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Environment</td>
<td>25 (5)</td>
<td>24 (6)</td>
<td>1 (1)</td>
</tr>
<tr>
<td>Health</td>
<td>14 (3)</td>
<td>14 (4)</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Energy</td>
<td>5 (1)</td>
<td>5 (1)</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Others</td>
<td>53 (11)</td>
<td>50 (13)</td>
<td>3 (3)</td>
</tr>
<tr>
<td>None</td>
<td>414 (83)</td>
<td>318 (80)</td>
<td>96 (96)</td>
</tr>
<tr>
<td><strong>Instances where WHO was mentioned</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Air pollution level in various countries</td>
<td>79 (16)</td>
<td>60 (15)</td>
<td>19 (19)</td>
</tr>
<tr>
<td>Medically acceptable level of air pollution</td>
<td>24 (5)</td>
<td>19 (5)</td>
<td>5 (5)</td>
</tr>
<tr>
<td>Number of deaths and diseases caused by air pollution</td>
<td>19 (4)</td>
<td>10 (3)</td>
<td>9 (9)</td>
</tr>
<tr>
<td>Recommendation for policy</td>
<td>1 (0)</td>
<td>1 (0)</td>
<td>0 (0)</td>
</tr>
<tr>
<td>No mention</td>
<td>377 (75)</td>
<td>310 (78)</td>
<td>67 (67)</td>
</tr>
</tbody>
</table>

WHO: World Health Organization.
Second, the Smart Cities Mission, a major urban development strategy, is a well-known flagship government campaign to improve livability and economic progress of urban areas, with a strong emphasis on technology solutions. This emergency measure, versions of which have been used in New Delhi, first implemented from 1–15 January 2016, to reduce air pollution through reducing vehicular congestion. This emergency measure, versions of which have been used in other jurisdictions like Paris or Mexico City, restricts the ability of vehicles to drive on the roads based on their registration numbers: those with odd numbers are allowed on the roads on odd-number dates and those with even numbers on even-number ones.

Finally, most articles were either silent or unclear in calling for government leadership to address air pollution. The government was mentioned in less than 20% of the articles. Among these mentions, state governments and environment ministries rightly received the focus of attention, but health departments, which can provide the powerful public health justification for clean air action, were rarely mentioned. Well-funded, flagship government programmes that could address air pollution were also rarely mentioned. In particular, the link to two programmes that have otherwise received significant government backing, as well as media and public attention, was missed. First, Swachh Bharat Abhiyan (Clean India Mission) is a well-known flagship government campaign to address sanitation, particularly open-defecation and waste management, but it may also address air pollution. Second, the Smart Cities Mission, a major urban development programme to improve livability and economic progress of urban areas, with a strong emphasis on technology solutions, could have been called upon urgently to address air pollution as a core issue in the delivery of these programmes. Finally, very few articles called for the industry to show leadership in addressing air pollution.

The strengths of this study lie in the significant period of time considered for analysis, the large volume of articles analysed and the comprehensiveness and depth of the content analysis. Nonetheless, there were some limitations to the study. The search terms were restricted to “air pollution” and “India” and did not include articles that referred to air pollution as solely smog or haze. However, national articles tended to primarily use the term “air pollution”, and the alternative terms were more common in international media and most tended to co-occur with the primary term “air pollution”. Second, this study was restricted to only English language articles. While English media arguably hold influence in India, particularly among the higher socioeconomic groups, and while the government and other stakeholders are invested in the representation of India in the international media, the regional press – particularly in Hindi – is highly influential in the numbers it reaches and the influences it wields on local politics. Future studies may thus consider analysis of Indian regional media for the study of similar issues.

Conclusion
This study has identified the many positive developments in media reporting on air pollution: the issue had increasingly become salient in the national media, with appropriate communication of the severity of air pollution in India and the urgent need for action. The media had also rightly identified the need for policy measures to counter the poor air quality observed in India.

However, there were many gaps in reporting observed, as well as missed opportunities for further galvanizing public action. While the health harms of air pollution were generally reported, the varied illnesses resulting from air pollution were not specifically mentioned, and the populations that are particularly vulnerable were not mentioned or warned. There was limited understanding of the causes of air pollution, and the volume of reporting slanted towards vehicles and ambient sources, when other sources – particularly household ones – are significant contributors in India that require action. Likewise, discussion of policy options tended to focus on better monitoring of air quality and traffic restrictions to reduce emissions, which are an important part but not the whole or a balanced picture. Other recommended measures, such as taxes on polluting sources, subsidies and improved infrastructure for access to clean energy, were less often mentioned in the context of addressing air pollution. Not only does this represent a lost opportunity to address air pollution, but some of these measures – like improved public transport – have been recognized to have significant co-benefits, reducing the burden of noncommunicable diseases and reducing road injuries and deaths. For these cross-sectoral policies to be implemented, a strong and accountable government needs to be at the forefront, and health departments must play an active part in advancing the health perspective in policies for clean air.

Future engagements with the media must seek to redress many of the gaps identified in this study. Increased specificity about the burden of exposure to air pollution, including advice for the groups most vulnerable to the impacts of air pollution, would serve an important educational purpose. Greater elaboration in the media, particularly by key influencers, on the true sources of and solutions to air pollution can help trigger policy action. Calls on the government to play a leadership role...
role, through strengthening data systems and building an air-quality management system, which are evidence-based approaches found to be globally successful, would help trigger public support and enable strengthened policy action.

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Conflict of interest: None declared

Authorship: All authors worked on the study approach and design and NM, NSN, PP and LO contributed to the development of the research protocol and materials. NM, NSN and PP supervised the research work. NSN produced data tables, NM and NSN supervised the analysis, and SM and LO assisted in interpretation of the findings. All authors contributed to writing the paper.

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Original research

Rural recruitment and retention of health workers across cadres and types of contract in north-east India: a qualitative study

Preety R Rajbangshi¹, Devaki Nambiar¹, Nandini Choudhury¹², Krishna D Rao¹³
¹Public Health Foundation of India, Gurgaon (Haryana), India, ²Possible, New York, United States of America, ³Department of International Health, Johns Hopkins Bloomberg School of Public Health, Baltimore, Maryland, United States of America
Correspondence to: Ms Preety Rajbangshi (preety.rajbangshi@phfi.org)

Abstract

Background Like many other low- and middle-income countries, India faces challenges of recruiting and retaining health workers in rural areas. Efforts have been made to address this through contractual appointment of health workers in rural areas. While this has helped to temporarily bridge the gaps in human resources, the overall impact on the experience of rural services across cadres has yet to be understood. This study sought to identify motivations for, and the challenges of, rural recruitment and retention of nurses, doctors and specialists across types of contract in rural and remote areas in India’s largely rural north-eastern states of Meghalaya and Nagaland.

Methods A qualitative study was undertaken, in which 71 semi-structured interviews were carried out with doctors (n = 32), nurses (n = 28) and specialists (n = 11). In addition, unstructured key informant interviews (n = 11) were undertaken, along with observations at health facilities and review of state policies. Data were analysed using Ritchie and Spencer’s framework method and the World Health Organization’s 2010 framework of factors affecting decisions to relocate to, stay in or leave rural areas.

Results It was found that rural background and community attachment were strongly associated with health workers’ decision to join rural service, regardless of cadre or contract. However, this aspiration was challenged by health-systems factors of poor working and living conditions; low salary and incentives; and lack of professional growth and recognition. Contractual health workers faced unique challenges (lack of pay parity, job insecurity), as did those with permanent positions (irrational postings and political interference).

Conclusion This study establishes that the crisis in recruiting and retaining health workers in rural areas will persist until and unless health systems address the core basic requirements of health workers in rural areas, which are related to health-sector policies. Concerted attention and long-term political commitment to overcome system-level barriers and governance may yield sustainable gains in rural recruitment and retention across cadres and contract types.

Keywords: contractual health workers, health workers, India, permanent health workers, rural recruitment, rural retention

Background

Human resources are a critical component of health systems, and account for approximately 70% of recurrent expenditure in most countries’ health systems.¹ The World Health Organization (WHO) has described human resources as a crucial “building block in [a] health systems framework”.² Despite this, human resources remain a neglected component of health systems in low- and middle-income countries.³ Among these countries, India has been identified as one with significant shortage of qualified health workers.⁴

Of late, there have been considerable efforts within the country to address the shortage of human resources for health. After the launch of the centrally funded National Rural Health Mission (NRHM) in 2005 (currently known as the National Health Mission [NHM]), state governments have invested in health infrastructure and introduced various policies to attract health workers in rural areas.⁵-¹⁰ Key among these is the contractual appointment of health workers as per NHM norms, to supplement sanctioned state government posts.¹⁰ With the inclusion of these health workers, permanent (also called “regular” or “regularized”) and contractual health workers now provide care in India’s health systems, with similar scope of work, but distinct conditions of employment (see Box 1).

Existing studies in India have explored the attitudes of medical students and in-service health workers towards rural service, and the factors at the individual level that act in favour of retention of health workers in rural areas.⁷,⁸ Findings from
Box 1. Types of contract in public health systems in India

Health is under state authority in India; all the administrative matters of recruitment, remuneration and other benefits of permanent and contractual health workers are decided by the respective state government.

Regular or permanent health workers are on the state government payroll and are entitled to employee benefits, such as a provident fund, health benefits, paid leave, maternity benefits and retirement benefits.

Contractual health workers are hired by each state’s National Health Mission scheme, with funding from central government, under state contracts (not scheme based), and also by individual facilities. The respective state government decides the remuneration and other benefits. At present, beyond pay, contractual health workers are not entitled to any other social security benefits or perquisites (maternity benefits, pensions, earned leave, etc.) and their situation varies between states.

The study was located in Meghalaya and Nagaland states in north-east India, which are geographically remote, hilly, subject to insurgency on an almost continuous basis, and in many ways disconnected from the rest of India. Meghalaya and Nagaland are predominantly tribal, with about 80% of the population residing in rural areas. Meghalaya and Nagaland in 1972 and Nagaland in 1963 were relatively late entrants as states into the Indian union; have historically had poor economic and development indicators, and have, for many years, been dependent on central/federal government assistance. While some of the health-system challenges – including rural recruitment and retention of health workers – are shared with other states, the unique challenges faced by these states are less well understood.

What is known is that in both states there are large urban–rural differences in the density of health workers. Neither state has a medical school, but they both sponsor students to enrol in medical colleges across India. Each state has four government midwifery schools; Meghalaya has one government nursing school but Nagaland has no nursing school. Given the larger context, the World Bank initiated a programme to help strengthen health systems, with a focus on the health workers in Meghalaya and Nagaland. This study commenced in 2013 and was carried out at the behest of respective state governments, to better understand the challenges in health human resources for developing strategies to address rural recruitment and retention.

Methods

A combination of semi-structured interviews, observations and unstructured interviews were undertaken in Meghalaya and Nagaland. Field-based data collection was carried out between March and May 2014, by a team of three researchers, following approval from the institutional review board of the Public Health Foundation of India.

In each state, one rural/remote and one central district were selected based on state (NHM) categorization criteria of accessibility, in consultation with the authorities of the state health department. Within each district, inclusion of primary- and secondary-level health facilities was ensured; these were mostly primary health centres (n = 9), but community health centres (n = 5), district hospitals (n = 4) and one district maternity and child hospital (n = 1) were also included. In India, primary health centres are the first point of contact with a qualified doctor in rural areas and they provide a range of curative and preventive health care. According to the Indian Public Health Standards (IPHS), primary health centres are staffed by an allopathic doctor, a doctor from the Indian system of medicine known as an AYUSH (ayurveda, yoga and naturopathy, unani, siddha and homeopathy) doctor, and nurses, along with other paramedical staff. Primary health centres are not equipped to manage clinical complications and refer such cases to secondary-level health facilities. The community health centre is a secondary-level health facility that provides referral and specialist health care. As per IPHS, a community health centre is meant to be staffed by an allopathic doctor, AYUSH doctor and dentist, as well as specialists (surgeon, physician, obstetrician and gynaecologist, paediatrician, and anaesthetist), nurses and paramedical staff. The district hospital provides comprehensive secondary health-care services, which include basic specialty services. In addition to the manpower mentioned for community health centres, as per IPHS, a district hospital should also have the following specialists – ophthalmologist, orthopaedic surgeon, radiologist, pathologist, ear nose and throat specialist, dermatologist, psychiatrist, microbiologist and forensic specialist. The requirement for health workers varies somewhat, depending on the bed capacity of a district hospital.

In Meghalaya and Nagaland, it was rare to find community health centres with the entire complement of specialists recommended under the IPHS. Further, in all four district hospitals, a shortage of doctors and specialists was noted by participants, and was greater in remote districts. Moreover, unlike other Indian states, district hospitals in Meghalaya do not provide obstetrics and gynaecology services. Therefore, all specialists for maternity and child care were posted in the district maternity and child hospital.
Health workers interviewed, drawn from government registers, were selected based on purposive maximum variation criteria, to ensure a range in type of contract, level of experience and sex, using definitions and criteria applied by the states. They included specialists, allopathic doctors, ayurvedic and homeopathic doctors from the Indian system of medicine, and nursing (including midwifery) cadres. In each cadre, both permanent and contractual health workers (if available) at each facility were interviewed.

At each interview, procedures for informed consent were carried out and, based on their preference, participants gave written or verbal consent. Interviews were audio-recorded and, where permission for this was not given, handwritten notes were taken. Each interview lasted between 30 and 40 minutes. Following the interviews, unlinked transcripts were shared with a professional transcriber, to obtain verbatim transcripts. Data were preliminarily examined and field notes shared by the research team, to determine when saturation was being achieved within a particular cadre or contract type. At that point, no more interviews in that subcategory were undertaken.

Interviews were mostly undertaken in English. In Nagaland, four interviews undertaken mostly or completely in Nagamese were transcribed by a member of the research team who is a native speaker. Data were analysed using Ritchie and Spencer’s framework method of applied policy analysis (1994).\textsuperscript{21} Based on the research questions and WHO’s 2010 framework of factors affecting decisions to relocate to, stay in or leave rural and remote areas,\textsuperscript{22} a priori codes were encoded in the data. According to this framework, rural recruitment and retention are shaped by six groups of factors – personal origin and values; family and community aspects; working and living conditions; career-related factors; financial aspects; and bounding or mandatory service. These were applied to the study data and emerging codes added, based upon how the a priori codes were elucidated. Finally, codes and quotations were indexed and mapped, and the codes were clustered under themes that could be drawn into a narrative.

## Results

### Participant profile

A total of 11 specialists, 32 doctors, 25 nurses and 3 auxiliary nurse midwives from public-sector health facilities were interviewed (see Table 1). Out of these, 7 specialists, 18 doctors, 9 nurses and 3 auxiliary nurse midwives were from Nagaland and the remaining 4 specialists, 14 doctors and 16 nurses were from Meghalaya. In addition, a total of 11 key informants (6 in Meghalaya and 5 in Nagaland) were interviewed. Key informants in both states were senior health functionaries in the state and district health departments, and a representative of an international civil society organization in Nagaland. Participants with permanent contracts tended to be older than those with shorter-term contracts. The majority of health workers on short-term contracts reported being employed under an NHM contract, with some others being funded by the state government or health facility.

### Motivations for rural service

Table 2 summarizes motivations for rural service for both permanent and contractual doctors and nurses.

#### Shared motivations

Across all cadres and contract types, there was a desire to serve in rural areas, with a preference to work in one’s own native village or district; rural service allowed workers to serve their own people. Participants also reported seeing family members suffer because of non-availability of doctors and health services in local health facilities. Such experiences influenced their decision to become a doctor or nurse, and also to continue

### Table 1. Profile of study participants

<table>
<thead>
<tr>
<th>Participants</th>
<th>n (male/female)</th>
<th>Average age (range), years</th>
<th>Average years (range) in government service</th>
<th>Average years (range) in primary health centre</th>
<th>Average years (range) in current post</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Doctors</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NHM contract</td>
<td>5 (4/1)</td>
<td>30 (26–35)</td>
<td>2.6 (0.4–4)</td>
<td>1.5 (0.3–3)</td>
<td>1.7 (0.4–3)</td>
</tr>
<tr>
<td>State contract</td>
<td>3 (3/0)</td>
<td>34 (29–40)</td>
<td>5.7 (3–9)</td>
<td>4.3 (2–8)</td>
<td>2.0 (1–3)</td>
</tr>
<tr>
<td>Permanent</td>
<td>19 (11/8)</td>
<td>39.5 (26–52)</td>
<td>11.9 (0.4–27)</td>
<td>7.9 (0–19)</td>
<td>4.5 (0.3–19)</td>
</tr>
<tr>
<td>Facility contract</td>
<td>1 (0/1)</td>
<td>26</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>NHM – ayurvedic and homeopathic</td>
<td>4 (2/2)</td>
<td>31 (29–33)</td>
<td>4.9 (3–7)</td>
<td>2.6 (0–7)</td>
<td>4.6 (3–6)</td>
</tr>
<tr>
<td><strong>Nurses</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NHM contract</td>
<td>8 (0/8)</td>
<td>32 (23–47)</td>
<td>5 (1–10)</td>
<td>2 (0–9)</td>
<td>3.9 (1–7)</td>
</tr>
<tr>
<td>Permanent</td>
<td>17 (1/16)</td>
<td>34 (24–55)</td>
<td>11 (0.1–33)</td>
<td>3.6 (0–18)</td>
<td>5.2 (1–30)</td>
</tr>
<tr>
<td><strong>Auxiliary nurse midwives</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NHM contract</td>
<td>1 (0/1)</td>
<td>24</td>
<td>4</td>
<td>3.5</td>
<td>0.8</td>
</tr>
<tr>
<td>Permanent</td>
<td>2 (0/2)</td>
<td>41 (24–52)</td>
<td>17 (4–30)</td>
<td>15 (0–30)</td>
<td>17 (4–30)</td>
</tr>
<tr>
<td><strong>In-service specialists</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NHM contract</td>
<td>1 (0/1)</td>
<td>48</td>
<td>15</td>
<td>1.5</td>
<td>1.0</td>
</tr>
<tr>
<td>Permanent</td>
<td>10 (8/2)</td>
<td>43 (29–58)</td>
<td>16.6 (1.5–26)</td>
<td>3 (0–10)</td>
<td>6.2 (1–19)</td>
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<tr>
<td><strong>Key informants</strong></td>
<td>11 (6/5)</td>
<td>50 (36–58)</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>82 (35/47)</td>
<td>34.1</td>
<td>7.6</td>
<td>4.3</td>
<td>4.3</td>
</tr>
</tbody>
</table>

NHM: National Health Mission.
**Table 2. Motivations of and challenges faced by health workers across cadres and types of contract in rural areas**

<table>
<thead>
<tr>
<th>Factor</th>
<th>Theme</th>
<th>Contractual</th>
<th>Permanent</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Motivations</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Personal</td>
<td>Rural origin</td>
<td>××</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Spiritual motivations</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kinship</td>
<td>Service to own area/</td>
<td>××</td>
<td></td>
</tr>
<tr>
<td></td>
<td>community</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Family support/being close to family</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Financial</td>
<td>Hardship allowance</td>
<td>×</td>
<td>×</td>
</tr>
<tr>
<td>Career</td>
<td>Few employment options</td>
<td>× (M)</td>
<td>× (N)</td>
</tr>
<tr>
<td><strong>Challenges</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Living conditions</td>
<td>Lack of facilities (water, electricity)</td>
<td>××</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Poor road connectivity and transport</td>
<td>××</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Lack, poor condition, inadequacy of staff quarters</td>
<td>××</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Safety</td>
<td>×</td>
<td></td>
</tr>
<tr>
<td>Working conditions</td>
<td>Lack or inadequate supply of drugs, medicines, and equipment</td>
<td>××</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Shortages of health workers – high workload</td>
<td>××</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Unwanted administrative load</td>
<td>××</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Lack of staffing norms</td>
<td>××</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Insurgency – safety issues</td>
<td>××</td>
<td></td>
</tr>
<tr>
<td>Financial factors</td>
<td>Lack of pay parity</td>
<td>××</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Low salary</td>
<td>××</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Irregular compensation</td>
<td>×</td>
<td>×</td>
</tr>
<tr>
<td></td>
<td>Lack of or inadequate hardship allowance</td>
<td>×</td>
<td>×</td>
</tr>
<tr>
<td>Professional factors</td>
<td>Lack of career trajectory, and professional isolation</td>
<td>××</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Poor job security (short contracts)</td>
<td>××</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Slow career growth</td>
<td>××</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Professional isolation</td>
<td>××</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Political influence over/irrational logic of promotions, postings and transfers</td>
<td>××</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Inappropriate norms for service</td>
<td>×</td>
<td></td>
</tr>
<tr>
<td>Family and community</td>
<td>Lack of educational opportunities for children</td>
<td>×</td>
<td>×</td>
</tr>
<tr>
<td></td>
<td>Fitting in with community</td>
<td>×</td>
<td>×</td>
</tr>
</tbody>
</table>

ANM: auxiliary nurse midwife; AYUSH: ayurveda, yoga and naturopathy, unani, siddha and homeopathy.

*Note: ×× refers to themes suggested first and/or without probing by most or all participants and agreed upon by two or more coders as being highly salient; × refers to themes suggested upon probing by two or more participants. All findings are applicable across both states except where the suffixes (M) or (N) are added; (M) refers to a finding applicable to Meghalaya only; (N) applies only to Nagaland.*
working in rural areas. Some doctors and nurses serving in rural primary health centres mentioned that their parents were very encouraging of this career path. Some of the nurses serving in rural areas mentioned that, in addition to taking care of patients, their job enables them to take better care of their family’s health.

My parents did call me, “Why we sent you to become a doctor, because we have very few doctors in X [location withheld to protect participant’s anonymity]. If you don’t give service to the people of your community, then who will give the service? So you come back here”. (permanent doctor, male)

In Nagaland, contractual doctors and permanent nurses spoke of religious/spiritual motivations for service in rural/remote areas. Being a nurse or a doctor was considered to be a form of service to the church. One of the doctors posted in the remotest health facility mentioned “I think like we Christians, we think doctors are just like missionaries. Going to places and reaching people”.

Distinct motivations
It was noted that for permanent doctors in Nagaland, and contractual nurses in Meghalaya across cadres, there were few employment options beyond working in rural areas and this was the reason they were working in rural areas. In the case of contractual health workers, especially nurses, greater financial incentives (i.e. hardship pay) were a motivation.

Challenges to rural service
Table 2 summarizes the challenges of both permanent and contractual doctors and nurses in rural areas.

Shared challenges
Contractual doctors and nurses faced similar challenges as their counterparts in permanent service, in terms of poor working and living conditions.

Living conditions: The inadequacy of services for daily living or social determinants of health – housing, water, electricity, roads and transportation facilities – in rural and remote areas were among the biggest issues across cadres and types of contract. In Nagaland in particular, the lack and/or pitiable condition of quarters was seen as a barrier to rural service. Although quarters were being constructed by the NHM in both states, many participants reported that these quarters were not commensurate with staff numbers. Difficulty in finding rented accommodation was reported by many, and it was common in both states to find three to five nurses sharing a quarter. Owing to inadequacy of quarters provided to them by the state, doctors resided in their homes, which were often far away from the health facility, and travelled to attend the outpatient department. To ensure doctor availability at night in Meghalaya, internal arrangements were made to ensure that at least one doctor stayed at night in the health facility, in a shared or rotated quarter. The need for adequate and well-furnished quarters for all staff was highlighted by all cadres across contract type, particularly doctors. Key informants noted that a drawback of not having quarters at the premises was that doctors could often be absent from work on the pretext of attending district meetings, and there was no record to track their attendance.

Regardless of contract type, safety was a concern among doctors and nurses working in remote areas affected by insurgency. A female doctor working in an insurgency-affected area in Meghalaya mentioned that insurgency groups had demanded money and threatened her colleagues. In Nagaland, while participants did not directly mention insurgency in interviews, interviewers learnt that every 6 months or so, around 20% of their salaries was allocated and diverted for insurgent groups.

Working conditions: The absence of adequate clinical infrastructure, drugs, equipment, diagnostics, ambulances and staff was widely reported as a challenge. Numerous doctors and nurses – regardless of their contract type – mentioned irregularity and inadequacy in the supply of drugs and equipment. A nurse contracted under the NHM in Nagaland reported having to handle bleeding patients with bare hands, in the absence of hand gloves. Among ayurvedic and homeopathic doctors, the lack of medicines and the absence of pharmacists limited their ability to practise their systems of medicine. Another concern raised by doctors was the burden of administrative work, which rested on their shoulders, regardless of the fact that they were not trained for administrative tasks and, further, had to juggle these tasks with providing clinical care in the health facility. Lack of supportive staff further exacerbated this problem.

Professional isolation: Young doctors reported feelings of professional isolation in comparison to their urban counterparts. Some participants expressed the need for mentoring and supportive supervision, in order to improve their performance and productivity.

Distinct challenges faced by contractual health workers
Distinct challenges were seen for contractual workers in the financial and professional domains.

Financial factors: Lack of pay parity between contractual and permanent health workers was reported by participants across cadres. Contractual nurses reported relatively lower compensation in comparison to permanent nurses. At the time of this study, ayurvedic and homeopathic doctors in Nagaland reported salaries (unrevised since 2011) that were lower than those of the nursing cadres.

Allopaths are getting around 45 [thousand rupees] because they are divided under three sector, groups A, B and C [accessible, difficult and most difficult area respectively], whereas ayurvedic and homeopathic [doctors] and dentists, we don’t have any divisions and we are getting less salary than the nurses. General nurse midwives are getting ₹25,000 and we are getting only ₹20,000, whereas the workload here is comparing to allopathy and all, we are equivalent”. (contractual homeopathic doctor, male)

A similar situation was noted for contractual nurses in Meghalaya, where their salary was far below that of their permanent counterparts. Concern about the large disparity in pay for nursing colleagues was raised by a permanent doctor (male), who noted an “almost 50% difference is there for doing the same kind of work”.

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This situation was aggravated by irregular and delayed remuneration and appraisals. At the time of interviews in Nagaland, for instance, these health workers had been waiting 2 months to receive their salaries. Interviewers were informed that sometimes the waiting period is as long as 4 months.

**Professional factors:** The lack of career trajectories was seen by contractual doctors and nurses as a major challenge, and a deterrent factor for continuity in the public sector. Many felt that they held a lower status despite working as much as permanent health workers.

Contractual workers also reported that they had fewer chances of transfers to their choice of location, and limited leave of absence, resulting in prolonged stays in rural and remote areas. This forced married doctors or nurses to live far away from their families, which they also lamented.

In addition, they were frustrated by the short duration of their contracts (between 4 and 6 months). In fact, this was something even permanent doctors and senior nursing staff in Nagaland raised as a challenge, in solidarity with their contracted peers and juniors.

In Meghalaya, doctors expressed their concern over bonding and mandatory rural service. State-sponsored doctors, once educated, were mandated to return to the state and serve 5 years in rural service. Upon their return, because permanent sanctioned posts were not vacant, doctors had no option but to take state contracts. In this arrangement, state-sponsored doctors are recruited as contractual staff in public health facilities and their contract is renewed every 3 months. Under this contract, the state expects doctors to continue working as contractual doctors until the Meghalaya Public Service Commission (MPSC) conducts interviews to transfer them to permanent contracts. At the time of this study, interviewers were informed that the most recent recruitment of doctors by the MPSC had been almost 4 years previously. The irony is that their service as a contractual doctor (even if they had worked for 10 years) would not be counted by the MPSC as years of service for career progression (as would be the case for doctors with permanent contracts). This was deeply demotivating for contractual doctors working in rural service, as their prospects for career progression were actually harmed by taking state contracts. Interviewers found that contractual doctors were keen to complete their mandatory rural service and then leave the public sector, as they felt the odds were, in any case, stacked against them.

Similarly in Nagaland, if contractual doctors were to apply for permanent posts through the Nagaland Public Service Commission, their years of service (including rural service) with the state or NHM would not count as work experience. Regardless of how long they served in a state or NHM contract, they would still begin as an entry-level permanent employee. This situation was grave in Nagaland, given the severe shortages of sanctioned posts in the state. Interviewers learnt that staffing patterns for health facilities were laid down in the late 1960s and 1970s, following which there has been no upgradation of norms or increase in the number of sanctioned posts for any category of health worker. Interviewers were informed by a key informant that, because of cessation of post creation, the state was unable to absorb all state-sponsored doctors and nurses in permanent posts, even after they expressed a willingness to work in the public sector. There is a lack of connection between the processes of upgrading health facilities and deployment of health workers.

**Distinct challenges faced by permanent health workers**

Distinct challenges were seen for permanent workers in the family and community, financial and professional domains.

**Family and community factors:** The lack of educational opportunities for children in rural areas was explicitly expressed as a challenge to rural service, especially as this cadre was, on average, older than the contractual cadre. Many were staying alone in rural areas and their family was based in a town or state capital for their children’s education. A senior nurse in Nagaland noted that she had three households to maintain—one at her place of posting, another for a daughter in college, and another for the rest of her family. A desire was expressed by participants across cadres for sequencing rural posting earlier in careers.

Many cases were noted where doctors and nurses from the community were given high regard and respect. Participants reported getting along with patients and communities and being supported in campaigns, even honoured during festivals throughout the year. However, if a doctor or nurse was not from the same tribe as the community in the area they were serving, they sometimes faced belligerence by members of the community for reasons including their diagnosis, patients’ recovery, lack of drugs and other factors. A doctor in Meghalaya mentioned that sometimes the community pressurized staff and even destroyed health-facility property.

**Financial factors:** In Meghalaya, permanent doctors were concerned about a sudden and unexplained reduction in the hardship allowances provided by the NHM. On the other hand, permanent doctors in Nagaland lamented the lack of hardship allowance for those practising in rural and remote areas, a provision that did exist for contractual doctors under the NHM.

There is another financial incentive for permanent workers in Nagaland, known as non-practising allowance (NPA), for doctors to not practise in private clinics. A doctor is only eligible for NPA after 2 years in rural service but the implementation and adherence to this policy was inconsistent. A male key informant noted that “those doctors serving in Dimapur and Kohima [urban areas], nearly 80% don’t follow the rule, so those who are practising [there] they benefit more”.

On the other hand, Meghalaya does not provide NPA, but permits doctors in the public sector to engage in private practice. Interviewers found a range of views related to private practice. Doctors in rural areas felt that private practice benefits doctors and specialists residing in urban areas, as urban patients are financially better off. However, some felt that it is morally problematic to draw salary as a public-sector doctor and undertake private practice at the same time. A participant reported that this policy has had negative impacts, as some doctors are referring patients to their own private practice instead of treating them at the health facilities. There was also a group of doctors that reported satisfaction with the current arrangement.

**Professional factors:** Some permanent doctors and key informants questioned the rationale of promotions. They felt that the logic of promotions, postings and transfers was a huge
deterrent factor among permanent specialists and doctors, as it was seen to be either irrational or politically motivated.

The politicians they don’t understand: if the state has a specialist doctor, they should know what you mean by specialist doctor. You cannot expect, you know, our specialist doctor to be posted in a primary health centre because “this is my area, my constituency, my political background so I have to get that”. We have seen in our state that some radiotherapist, who has got nothing to do in primary health centres and community health centres [is] posted in the outpost. (permanent specialist, male)

In both states, specialists were concerned about not having staffing norms for rational deployment of health workers. Some specialists reported working in a primary/community health centre and providing basic health services, owing to non-availability of physical infrastructure, equipment, drugs and supplies.

Discussion

Improving the recruitment and retention of health workers in rural areas is a complex policy challenge. This health-systems issue of retaining health workers in rural areas has been studied extensively across countries.10,23–26 The findings in the present study bring out a spectrum of known factors, as well as a few new ones that are critical for recruitment and retention of health workers in rural and remote settings.

The study suggests that serving and representing their community was a specific motivation that brought health workers to rural service. This motivation was high among health workers from rural backgrounds. This confirms findings from other international studies that health workers from a rural background have a high probability of working in rural areas.4,23,27 and underlines WHO’s global policy recommendations for targeted admissions of students from rural backgrounds to medical and nursing schools.22

This said, what the present study has revealed is that, once in service, there are challenges that are shared across cadres and contract types, and distinct challenges across contract types that are a function of contractual work itself (i.e. its financial and labour-related structure), as much of it is seen – and indeed experienced – as a temporary or stop-gap measure to bring human resources to rural areas.

It is unfortunate that there are no incentives for contractual health workers to continue in the public sector, although health systems like those in Meghalaya and Nagaland are counting on these workers to deliver health services in rural and remote areas. Understanding the dearth of health workers in rural India, it would be beneficial for the health sector to lay down transparent procedures for pay parity and a clear career path for contractual health workers. On the other hand, a rationalized posting and transfer policy is essential for health workers in permanent service, to improve morale and service delivery.

This is, of course, part of a global trend of contractualization of labour in India; over the period that the NHM has existed, the proportion of contract workers across all industries in the country has grown from 24.8% in 2002/3 to 2004/5 to 33.8% in 2009/10 to 2011/12.28 On average, this means one in three workers is contractual, allowing “use of contract labour without according them workers’ rights”.29 The interviewers saw this clearly in the treatment of AYUSH doctors contracted under the NHM, who are paid less than nurses and expected to perform tasks for which they are not trained; in states where these systems of medicine are not even well understood.29

The study findings make a strong case that multiple factors influence health workers’ decision to relocate to and stay in rural and remote areas, as well as their job performance, and therefore health systems must consider packaging or bundling strategies for cadres across contracts. Mindful of the challenge, many Indian states (including Meghalaya and Nagaland) have initiated several strategies.5,8–10 This study found that Meghalaya has introduced 5 years of mandatory rural service for state-sponsored medical students after completion of studies. In both Meghalaya and Nagaland, difficult-area or hardship allowances are provided to health workers working in rural and remote areas. However, in Meghalaya, contractual staff are not entitled to these financial incentives. In contrast, Nagaland provides a hardship allowance to some NHM-contracted cadres of health workers, namely allopathic doctors and nurses. It seems that these efforts are fragmented, stop-gap, and often tardy, such that they do not cohere under a strategy or bundle of complementary approaches that are fair across contracts and cadres.

When thinking about interventions and bundling them, the present study suggests that a paradox has to be resolved in these states. At present, the paradox is that while expectations of health workers are the same across cadres (reflected in the nature of their shared challenges), the treatment of these workers is not commensurably the same (reflected in the distinct challenges – especially pecuniary and professional ones). If the health system can resolve the paradox by saying equal expectations means equal treatment, the focus may perhaps initially be placed on distinct challenges, i.e. improving the financial and professional conditions across cadres in response to the limitations this study has raised. Longer term however, the key strategy should be creating permanent contracts and clear trajectories.

Much of this is in the control of the health department, notwithstanding the limitations it faces in terms of budgets, processes and political will. If the health system in each state does not seek to resolve this paradox, and continues to have equal expectations with unequal treatment by cadre, it may choose to prioritize shared challenges so that at least health workers can deliver on what they are expected to do. Long term, however, the split between expectations and treatment may result in further weakening and destabilization of rural retention and job performance.

Finally, in Nagaland and Meghalaya, there is clearly a need for steady improvement in the living and working conditions in rural areas. Social determinants of health, such as road connectivity, telecommunications, housing, water, electricity, access to schooling, and physical safety, affect both the professional and personal lives of health workers, as well as the ability of communities to seek care. Since these improvements cannot be undertaken by the health sector alone, they require central and state government together to engage key stakeholders within and outside the health sector, for broader political, institutional and financial commitment on these determinants.
The study has some limitations. As a qualitative study, it was designed to understand recruitment and retention in rural and remote areas. It was not possible in this study to look at the experiences of allied staff such as pharmacists and laboratory technicians working in rural and remote areas. These practitioners play important roles in the delivery of health service in rural areas, and their needs and experiences are yet to be understood. Another limitation was not being able to look at human resources from the perspective of the patient. Is the receipt of service variable based on cadre or contract? What would patients prefer? Patient perspectives would help triangulate findings and indicate where strategic silences may exist in the interviews of health workers. This may be all the more relevant when considering issues like absenteeism of doctors; this is something to which doctors themselves will never admit and nurses will never report their supervisor’s absenteeism.

Conclusion
This study of motivations and barriers to rural service found that, while the former tend to be uniform across types of health-worker contract, shared and distinct challenges have emerged. Health reform would do well to be guided by these variations and, ideally, to resolve the paradox they present. Concerted attention and long-term political commitment to overcome system-level barriers and governance may yield great gains in rural recruitment and retention, in service of the nation’s path to universal health coverage.

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Conflict of interest: None declared.

Authorship: PR participated in the study design, data collection and analysis, and conceptualized and drafted the manuscript. DN led the study design, data collection and analysis, and drafted the manuscript. NC participated in data collection in Nagaland and reviewed the manuscript. KR conceived the study, participated in the study design, data collection in Meghalaya, and reviewed the manuscript. All authors read and approved the final manuscript.


References


Implementation of G6PD testing and primaquine for P. vivax radical cure: operational perspectives from Thailand and Cambodia

Suravadee Kitchakarn1, Dysoley Lek2,3, Sea Thol4, Chantheasy Hok2, Aungkana Saejeng5, Rekol Huy2, Nipon Chinanonwait1, Krongthong Thimasarn6, Chansuda Wongsrichanalai6

1Bureau of Vector Borne Diseases, Ministry of Public Health, Nonthaburi, Thailand, 2National Centre for Parasitology, Entomology and Malaria Control, Phnom Penh, Cambodia, 3School of Public Health, National Institute of Public Health, Phnom Penh, Cambodia, 4Cambodian Pharmacovigilance Centre, Department of Drugs and Food, Ministry of Health, Phnom Penh, Cambodia, 5Office of Disease Prevention and Control No. 10, Chiang Mai, Thailand, 6Independent consultant, Bangkok, Thailand

Correspondence to: Dr Chansuda Wongsrichanalai (dr.chansuda@gmail.com)

Abstract
Following progressive success in reducing the burden of malaria over the past two decades, countries of the Asia Pacific are now aiming for elimination of malaria by 2030. Plasmodium falciparum and Plasmodium vivax are the two main malaria species that are endemic in the region. P. vivax is generally perceived to be less severe but will be harder to eliminate, owing partly to its dormant liver stage (known as a hypnozoite) that can cause multiple relapses following an initial clinical episode caused by a mosquito-borne infection. Primaquine is the only anti-hypnozoite drug against P. vivax relapse currently available, with tafenoquine in the pipeline. However, both drugs may cause severe haemolysis in individuals with deficiency of the enzyme glucose-6-phosphate dehydrogenase (G6PD), a hereditary defect. The overall incidence of malaria has significantly declined in both Thailand and Cambodia over the last 15 years. However, P. vivax has replaced P. falciparum as the dominant species in large parts of both countries. This paper presents the experience of the national malaria control programmes of the two countries, in their efforts to implement safe primaquine therapy for the radical cure, i.e. relapse prevention, of P. vivax malaria by introducing a rapid, point-of-care test to screen for G6PD deficiency.

Keywords: glucose-6-phosphate dehydrogenase, Greater Mekong subregion, malaria, Plasmodium falciparum, Plasmodium vivax, primaquine

Background
Towards the elimination of P. vivax malaria
Plasmodium vivax malaria remains an important public health problem in many parts of the world. The World Health Organization (WHO) estimates that P. vivax was responsible for 8.5 million cases of malaria globally in 2015. Outside of the African continent, P. vivax accounted for approximately 41% of malaria cases. Most cases of P. vivax malaria occur in the WHO South-East Asia Region (58%), followed by the WHO Eastern Mediterranean Region (16%) and the WHO African Region (12%).

Two sets of guidance – the Global technical strategy for malaria 2016–2030 and Control and elimination of P. vivax malaria: a technical brief – were published by WHO in 2015. They marked not only an important step in the transition from malaria control to an elimination strategy but also a recognition of radical cure for P. vivax infection as a key determinant for successful elimination of all malaria. At the 9th East Asia Summit in November 2014, 18 heads of government declared support for malaria elimination in Asia Pacific by 2030. In the WHO South-East Asia Region, malaria-endemic countries have already set some elimination targets, either nationwide or subnationally. Countries are making efforts to fulfil the regional commitment to malaria elimination.

Radical cure for P. vivax malaria
Prioritization of radical cure for P. vivax malaria has become better recognized recently, along with malaria elimination. Treatment with a 14-day course of primaquine is the only currently available therapy known to be effective against P. vivax liver-stage hypnozoites, thus preventing relapses and providing radical cure. Tafenoquine is an investigational medicine under development as a single-dose radical cure for P. vivax malaria; however, primaquine and tafenoquine are known to cause haemolysis in individuals with inherited deficiency of glucose-6-phosphate dehydrogenase (G6PD) enzyme. More emphasis has recently been placed on safe primaquine therapy guided by testing for G6PD status before prescription and the most recent WHO treatment guidelines indicated that it is good practice to use a patient’s G6PD status to guide primaquine administration. The availability of rapid, point-of-care (PoC) G6PD test kits is encouraging but also increases the complexity of factors facing national malaria control programs.
control programmes (NMCPs), in terms of product choices, current technical limitations and appropriate approaches for test introduction and programme implementation.

**G6PD testing**

The introduction of PoC G6PD testing in the rapid-test format in 2013 has increased opportunity for access to routine screening prior to primaquine prescription. Cost has been cited as a concern for some countries with a high malaria burden; thus, economic modelling has been advocated to synthesize the evidence on the epidemiology of *P. vivax* malaria and the prevalence of G6PD-deficiency variants, to provide the most cost-effective option for different settings. Some countries, including Thailand and Cambodia, have experienced a significant reduction in the burden of malaria. Given the smaller case-loads remaining, cost has been less of a concern, as these countries have been keen to focus on *P. vivax*, in order to accelerate elimination.

The prevalence and distribution of G6PD mutants vary geographically and among ethnicities. While extreme concern surrounding prescription of primaquine persists in some countries (e.g., Cambodia), owing to fears about fatal haemolysis, primaquine has been used for decades elsewhere without G6PD testing and with no severe adverse events recorded, including in South America, the Democratic People’s Republic of Korea and the Republic of Korea. However, it should be noted that the absence of recorded incidents does not necessarily equate to an absence of severe adverse events.

In some situations, such as in Viet Nam, continuation of prescribing primaquine without G6PD testing seems to be preferred because of the local confidence in its safety, based on decades of use and the generally low prevalence of severe G6PD-deficiency variants. Primaquine treatment without G6PD testing is viewed as a contributory factor to the successful progress towards malaria elimination in northern Viet Nam. Therefore, introduction of G6PD testing is not being considered, on the grounds that it would unnecessarily increase not only the cost of malaria case-management but also the administrative and logistic complexities of a programme that is already functioning.

The G6PD gene is located on the X chromosome; thus, females can be homozygous or heterozygous, but males can only be hemizygous. The PoC qualitative G6PD tests that are currently available can reliably distinguish individuals with true normal enzyme level from hemizygous males (characterized by very low enzyme levels). However, they can be problematic in individuals with intermediate enzyme levels, usually heterozygous females, because the subpopulation of healthy erythrocytes may show normal G6PD activity. Incorrect classification of G6PD status in those women (from G6PD deficient to normal) may result in them being mismanaged and at risk of haemolysis, despite having been tested. Currently available PoC qualitative G6PD tests are also limited because they provide no control line and no control solution to monitor test validity, and the results are sometimes ambiguous. Owing to the imperfect products available, there is an ongoing debate as to whether NMCPs should proceed with the introduction of currently available PoC qualitative G6PD tests, or should delay until a quantitative PoC assay becomes available.

This paper describes the malaria situation in Thailand and Cambodia and the countries’ efforts to introduce routine G6PD testing along with radical cure for *P. vivax* malaria. The two countries differ in their general malaria situations; malaria control and elimination strategies; regulatory requirements for pharmaceutical products and diagnostics; public health organization and infrastructure; and availability of health-care resources. Enabling factors and limitations are identified in this study and potential solutions are discussed as to how safe radical cure for *P. vivax* can be made widely available to the malaria-endemic communities.

**Current malaria status in Thailand and Cambodia**

The overall burden of malaria has significantly declined in both Thailand and Cambodia over the last 15 years. *P. falciparum* used to be the most common species. However, *P. vivax* has replaced *P. falciparum* as the dominant species in large parts of both countries. A summary of the malaria situations and factors related to radical cure for *P. vivax* by country is presented in Table 1.

Both countries have adopted malaria elimination in their national strategic plans. Thailand and Cambodia aim to achieve zero indigenous case status (i.e. no local transmission) by 2024 and 2025, respectively. Both plan to introduce or revise guidelines for safe, effective radical cure for *P. vivax* malaria with routine G6PD testing.

Thailand is gradually reorienting its malaria programme towards elimination, and increasing the integration of malaria services with the general public health system. The remaining vertical part of the malaria control operations is budgeted for, and being implemented in, districts that remain endemic for malaria (248 out of the total 878 districts). There are 161 vector-borne diseases control units and 286 malaria clinics in these districts, under the technical support and coordination of the Bureau of Vector Borne Diseases at the central level and 12 offices of disease prevention and control at the peripheral level. Surveillance is being strengthened in districts that are already free of malaria, where specific malaria interventions are being transferred to the general health services, under the responsibilities of provincial public health offices and district health offices for continuing operation. This includes implementation of the elimination campaign and accountability for its progress.

According to the *National strategic plan for elimination of malaria in Cambodia (2011–2025)*, the Government of Cambodia aims aggressively to reduce malaria morbidity and mortality and to extend case-management to patients in high-risk areas, with emphasis on adherence and follow-up to ensure complete cure. Cambodia’s National Centre for Parasitology, Entomology and Malaria Control (CNM) is a unit in the Ministry of Health responsible for malaria control activities at the national level. The programme is decentralized, with the provincial health departments and operational districts involved in planning and implementation activities. Village malaria workers, village health volunteers, migrant malaria workers and local health authorities form part of the network to expand the availability of malaria services and improve their accessibility to those at risk.
Table 1. Summary of malaria status and factors related to the introduction of radical cure for P. vivax malaria by country

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<th>Factors related to malaria</th>
<th>Thailand</th>
<th>Cambodia</th>
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| Malaria cases in 2016     | Fiscal year: October 2015 to September 2016:¹
  • Total: 18 136 cases:
    – P. falciparum = 3422 (18.9%)
    – P. vivax = 13 006 (71.7%)
    – Mixed infections = 123 (0.7%)
    – Others = 1583 (8.7%) | January to December 2016:²
  • Total 23 367 cases:
    – P. falciparum = 12 144 (52.0%)
    – P. vivax = 9623 (42.0%)
    – Mixed infections = 1400 (6.0%) |
| Implementation of radical cure for P. vivax | PQ for radical cure has been used for more than three decades with no reports of serious adverse events. Counselling on compliance and on the adverse effects of PQ by health-facility staff is encouraged. Follow-up with blood smear on days 14, 28, 60 and 90 is recommended.²³ | As of July 2017, PQ radical cure is not yet implemented in the country. |
| Malaria situation | Characterized by border malaria. High-risk groups are refugees in camps and workers in rubber plantations and fruit orchards, most of whom are migrants from neighbouring countries. Non-Thais account for about half of reported cases. Cases on the western border with Myanmar have declined by 50% in the last 5 years but epidemics on the other borders led to case increment in those areas. The increase on the eastern border with Lao People’s Democratic Republic and Cambodia is associated with illegal logging and forest-related activities, while the increase along the southern border is due to poor access to malaria control services as a result of insurgency.³⁵–³⁷ | An overall decline of over 50% in the incidence of malaria has been observed in the past 5 years. The burden of malaria is prominent in ethnic minority groups and mobile, migrant and cross-border populations. The incidence is highest in the north-eastern parts of the country and lowest in the western provinces. Artemisinin resistance and migrant populations are key challenges to successful control and elimination.²⁴,²⁵ |
| Elimination efforts | A consolidated malaria elimination strategy and an operational manual for malaria elimination, encompassing all essential activities required at each decision/implementation level, has been published.²⁶ Reorientation of the national control programme towards malaria elimination is ongoing, aiming at the integration of malaria services with the general public health system, thus reducing specialized field malaria services. | The Cambodia Malaria Elimination Action Framework 2016–2020 has been launched.²⁷–²⁹ Pilot elimination is being conducted in selected endemic areas in the north and north west. |
| Relapse | There is a relapse rate of 50%, with a mean interval of 3 weeks to the first relapse if rapidly eliminated antimalarial drugs are given. Second-relapse recurrences of parasitaemia occur ~6 weeks after chloroquine treatment.³⁹ | There is a lack of data on studies aiming specifically at the characteristics of P. vivax relapses in Cambodia. However, relapse is probably “rapid and frequent”, as is typical in the tropics. The majority of P. vivax infections arising after treatment of P. falciparum malaria probably originate from relapsing liver-stage parasites.³⁰ |
| G6PD test | National treatment guidelines: “[patients] should be screened to determine G6PD status (where possible),” but G6PD testing is not mandatory.²¹ The Thailand NMCP is piloting PoC G6PD testing at selected malaria clinics (results pending). | National treatment guidelines indicate that a patient is to receive PQ radical cure only if they have been determined to be G6PD non-deficient.¹³ G6PD testing is not available at most peripheral health facilities in endemic areas. Following the CNM Diagnosis and Treatment Working Group meeting in November 2016, recommended pilot-testing with CareStart™ rapid diagnostic tests in male P. vivax malaria patients before radical treatment with primaquine (0.25 mg/kg daily for 14 days) is conducted. Female patients will not be included, owing to the known limitation of the current PoC test in detecting G6PD deficiency in heterozygous females. |
| Characteristics of G6PD deficiency | Prevalence ranges are 10–17% in men and 6–15% in women, depending on factors such as geographical region.³³–³⁴ Reports, most with limited sample sizes and ethnic components, roughly show Mahidol, some Chinese and Viangchan variants to be most common. In general, the Mahidol variant is dominant, especially in the west and the north west near the Myanmar border, while the Viangchan variant has been reported from the north east near the borders with Lao People’s Democratic Republic and Cambodia. The common presence of Mahidol, which is a less severe variant, in a large part of Thailand, may partly explain the more favourable experience with PQ use in the country.³²–³⁴ | Prevalence ranges are about 8–15% in men and 3–8% in women.³⁵ Predominantly the Viangchan variant (known to be associated with severe haemolysis). Severe deficiency is more prevalent in western Cambodia, where P. vivax has recently become the dominant species. It is not known whether this could explain the historical observation of cases with dark urine that resulted in the negative attitude in the country towards PQ use. |

CNM: National Centre for Parasitology, Entomology and Malaria Control; G6PD: glucose-6-phosphate dehydrogenase; NMCP: national malaria control programme; PoC: point-of-care; PQ: primaquine.
¹Bureau of Vector Borne Diseases, Department of Disease Control, Ministry of Public Health Thailand.
²National Centre for Malaria, Parasitology, Entomology and Malaria Control, Ministry of Health, Cambodia.
The international borders of the Greater Mekong subregion are well known for their significance as risk areas for malaria. In Thailand, specific malaria outreach activities aimed at remote endemic communities and migrant populations, especially along the Thailand–Myanmar border, are currently implemented through nongovernmental organizations and the government’s 25 border malaria posts and 327 malaria posts. These activities have been supported by the Global Fund to Fight Aids, Tuberculosis and Malaria (GFATM). However, current GFATM support will end in 2017, and a different funding channel will be needed to sustain these services. On the eastern side of the Thai borders and the border of Thailand–Lao People’s Democratic Republic–Cambodia, occasional malaria outbreaks occur, often due to increased forest-related activities among migrants. The situation is complicated by weak capacity for rapid surveillance and effective responses.

Despite efforts to provide access to health services according to basic human rights, migrants remain high-risk populations in such border areas. Their mobility is a challenge to reliable assessment of their treatment outcomes and drug side-effects, especially for the radical cure of P. vivax malaria, which requires a 14-day course of treatment. Some cross-border collaboration activities in the Greater Mekong subregion were initiated in response to artemisinin resistance in recent years. Cross-border coordination was one of the key action plans for the emergency response to artemisinin resistance in this subregion. However, actual on-the-ground activities need to be stepped up for more fruitful outcomes.

**Radical cure for P. vivax malaria in Thailand and Cambodia**

**Use of primaquine**

Primaquine therapy for P. vivax malaria is included in the national treatment guidelines of both countries. However, the actual implementation differs, largely due to the inability to determine a patient’s G6PD status at the point of care in remote settings.

Thailand shares with Cambodia the problem of artemisinin-resistant P. falciparum malaria. However, P. vivax is still highly susceptible to chloroquine, which is the first-line therapy for all confirmed P. vivax cases in Thailand. Uncomplicated P. vivax cases are treated with chloroquine and a 14-day course of primaquine, on an outpatient basis. If a patient is known to be G6PD deficient, he or she is referred for treatment by medical practitioners in hospital, but access to G6PD testing is generally limited in the rural areas. No serious adverse effects have been reported, although compliance has not been ascertained. However, in a clinical research environment, where patients are kept hospitalized, haemolysis due to primaquine has been recorded.

In Cambodia, primaquine was used during the era of malaria eradication from the late 1950s to the early 1960s and thereafter up to 1985. However, in the 1980s, a mass treatment with primaquine (unknown dose regimen) was thought to have caused severe and fatal haemolysis, thus precipitating complete abandonment of the drug in malaria control. Cambodia started replacing chloroquine with an artemisinin-based combination therapy, dihydroartemisinin–piperaquine (DHA-PPQ), for the treatment of P. vivax malaria from 2009, following documented chloroquine resistance. The 2012 version of the national treatment guidelines introduced a standard course of primaquine in addition to DHA-PPQ as the first-line treatment for radical cure of P. vivax malaria. These guidelines recommended the use of G6PD testing, depending upon availability. If G6PD testing was not available, the guidelines recommended directly observed therapy and termination of primaquine if signs of haemolysis developed. In the 2014 revision, the recommendation on primaquine treatment for P. vivax malaria was revised to recommend its use only if the patient was determined to be G6PD non-deficient.

In 2016, an artemunate–mefloquine fixed-dose combination replaced the first-line therapy for both P. falciparum and P. vivax in 11 provinces of Cambodia considered to be the core areas of P. falciparum resistance to artemisinin (as well as PPQ), namely, Battambang, Kampong Thom, Kampong Speu, Kampot, Kratie, Oddar Meanchey, Pailin, Preah Vihear, Pursat, Siem Reap and Stung Treng. Directly observed therapy for antimalarial drugs is documented in the guidelines but in practice this is not done, except in the context of clinical research studies or pilot implementation. In early 2017, artemunate–mefloquine replaced DHA-PPQ countrywide.

**Making medicines and medical devices available**

The Association of Southeast Asian Nations (ASEAN) harmonization scheme adopted in recent years has eased the pharmaceutical regulatory procedures across south-east Asia. Some specific procedures still vary by country but these are unlikely to be an obstacle for the registration of new diagnostic devices/drugs that are important for malaria elimination, including PoC G6PD test kits.

Primaquine has been available in Thailand for a long time. It used to be available as 5 mg and 15 mg tablets manufactured locally by the Government Pharmaceutical Organization. Recently, these have been replaced by imported 7.5 mg tablets. A qualitative PoC G6PD test product (CareStart™ G6PD test, Well Bio Inc., Republic of Korea) has already been registered with the Medical Device Control Division, Food and Drug Administration, Thai Ministry of Public Health, and is available commercially. Unlike Cambodia, registration and import of G6PD test kits in Thailand have been processed for commercial purposes by a local company, independently of the NMCP.

To be in alignment with the government’s goal of malaria elimination, Cambodia added primaquine to its essential drug list in 2015, allowing health centres to request supplies of this drug from the government’s central medical supplies unit as needed. The Cambodian Department of Drugs and Food (DDF) is the responsible agency for registration of drugs, diagnostics and cosmetics. A registration licence is required for import of products. Normally, the dossier format follows that of the ASEAN common technical dossier, and dossier files should contain clinical evaluation results to be assessed and approved by the DDF. It is not necessary for the clinical trials to have been conducted in the country, but inclusion of local data, if available, is encouraged. Drug samples have to be analysed by the National Health Products Quality Control laboratory and the registration approval process takes 8–12 months. Fast track is available, especially for WHO-prequalified products (for public use only); it may take less than 3 months from the time of DDF submission to approval.
Primaquine phosphate tablets, equivalent to 15 mg primaquine base (manufactured by Sanofi Canada Inc., Laval, Québec, Canada), were registered with the DDF in September 2016. This is one of the two sources of primaquine in the List of malaria pharmaceutical products classified according to the Global Fund Quality Assurance Policy. Through the support of the GFATM, the first purchase order of 56,000 tablets arrived in Phnom Penh in January 2017. A pilot study with PoC G6PD screening and 14-day primaquine therapy is being planned. However, since only 15 mg tablets are available in the country, issues of inconvenience and accurate dosing, e.g. for children, need to be resolved.

In the case of tafenoquine, it is envisaged that CNM would hold the licence, if it applies for registration, probably through a fast-track channel. Since CNM is part of the Ministry of Health, the product will not be available to private providers. For both countries, import of tafenoquine in the future could be indirectly facilitated by prior clearance of the product by stringent regulatory agencies such as the United States Food and Drug Administration and the Australia Therapeutic Goods Administration.

In both countries, registration of medical devices is usually faster than for drugs. In Thailand, only the certificate of free sale from the country of origin is required, although risk assessment of diagnostic products will be needed and the process will be more complex in the near future. Dossier submission will be based on the ASEAN harmonization scheme (Common Submission Dossier Template [CSDT] of the ASEAN Medical Device Directive [AMDD]). The quality standard/requirement for registration of the G6PD test has been developed. In Cambodia, product prequalification by WHO would be helpful but is not essential. Application for registration is required the first time a medical device product is imported. Requirements for registration of new medical devices include International Organization for Standardization (ISO) certification (for quality management system in manufacturing) and a free sale certificate from the country of origin. Registration of the PoC G6PD test kits is expected to be initiated by the NMCP for primary use in the malaria programme.

Some considerations for the implementation of routine G6PD testing in P. vivax malaria

Which G6PD test?

There are several ways to determine a person’s G6PD enzyme status. Key methods are based on an estimation of the remaining G6PD enzyme activity, which is a reliable assessment of the G6PD-deficiency phenotype. Their benefits and limitations have been reviewed elsewhere. Two main quantitative testing methods – spectrophotometric assay and cytochemical assay – provide precise measurements of G6PD activity. However, these two diagnostic tests are costly and not suitable for use in field settings, as they require a functioning cold chain, laboratory equipment and skilled workers. Until recently, the fluorescent spot test has been the recommended qualitative screening method for G6PD deficiency, since it is affordable and provides qualitative visual results within minutes. However, it requires skilled staff and specialized equipment; thus, it is unsuitable as a PoC test in the field.

PoC G6PD test products have been reviewed by Ley et al. Future products will probably include a quantitative G6PD test with digital reading. Addition of a haemoglobinometer as a companion test would be an advantage. This has important implications for implementation because anaemia is common in malaria-endemic areas and the relative proportion of younger red cells (which have higher activities of G6PD enzyme) associated with anaemia may give a false-normal test result.

Currently, CareStart™ is the G6PD rapid-test kit in a cassette format available in the market in several endemic countries. The product is not ideal, but has been shown to be a sensitive and specific qualitative test if performed under the required conditions and with caution in the interpretation of test results. However, improvements are needed in its test performance. An improved product with a control line to verify a valid reaction, and with a storage temperature up to 40 °C, is in the pipeline. Recent improvements include the availability of a visual-aid chart for comparison of colour shades in reading results.

The two countries expect the availability of PoC tests with some “ideal” characteristics in the near future, including: (i) the ability to sustain long-term storage at >35 °C; (ii) a valid assay can be performed at ≥35 °C; (iii) affordability (e.g. not more than a few US$ for Thailand); and (iv) a shelf-life of at least 2 years. In the absence of an established quality-assurance/quality-control mechanism, WHO has recently defined “preferred product characteristics” for qualitative PoC G6PD tests. These include (i) test sensitivity of >95% for detecting G6PD activity of <30% of normal (compared to that of spectrophotometry or equivalent quantitative tests for detecting G6PD enzyme activity); (ii) negative predictive value of >95% (i.e. providing at least 95% probability that the patient has >30% normal G6PD activity when the diagnostic test indicates that they are not deficient); (iii) stability at 30–40 °C; and (iv) a visual read-out that clearly distinguishes between “deficient” and “normal” G6PD activity.

Technical constraints

Despite its availability in a rapid-test format suitable for PoC implementation, use of the G6PD test is not as straightforward as a malaria rapid diagnostic test, because there are multiple steps of treatment algorithm to follow, including patient counselling on the safety of primaquine. Thus, there is a concern that the tool may not yet be ready for peripheral health settings, where the majority of individuals with malaria in the Greater Mekong subregion are primarily seeking treatment for their malaria. Examples of such remote settings for passive case-detection are a malaria post in Thailand and the house of a village malaria worker in Cambodia.

Unlike the Philippines and Malaysia, a national neonatal G6PD screening scheme is available in neither Thailand nor Cambodia. Both countries agree that PoC G6PD test kits should be piloted at selected facilities above the levels of village malaria workers and malaria posts. In Cambodia, initial implementation is planned for a provincial hospital or referral hospital levels. The readiness of the infrastructure will have to be re-examined in both countries.

Thailand has started piloting CareStart™ tests at 61 malaria clinics with refrigerators and air-conditioned laboratory space, to ensure the manufacturer’s required optimum storage (4–30 °C) and conditions for a valid assay (≥32 °C). A new generation of PoC G6PD tests that can sustain a storage and performance environment of 35–40 °C will expand patients’ access to wider endemic areas.
Recently, a study in the Philippines suggested that CareStart™ performed more accurately with venous blood than capillary blood. This has raised further concern, as staff at most peripheral malaria clinics in Thailand and Cambodia are not trained to perform venepuncture. In addition, venepuncture may not be acceptable to uncomplicated malaria patients and is likely to further increase the cost of malaria case-management.

**Training and preparing system readiness**

To prepare for implementation of G6PD testing, the NMCP needs more than selection of what is believed to be a suitable G6PD test based on known evaluation of performance. The programme also needs to ensure testing skills; ability to interpret results reliably; correct recording of results; and staff understanding of the algorithm for primaquine prescription, case-referral and pharmacovigilance. According to WHO, the capability and readiness of the local health services in emergency handling of primaquine-induced haemolytic anaemia should be considered prior to implementation.

Staff must be well trained to ensure adherence to a well-designed case-management plan. Training materials must be carefully prepared and pretested to satisfaction, to avoid any misleading interpretation. Emphasis should be placed on supervised therapy when possible. Local health staff must be trained to explain clearly to patients the importance of compliance with 14-day treatment (to continue taking the medicine to finish the full course, despite feeling well several days before the end of the course) and how to observe early signs of haemolysis, such as dark urine. In addition, a plan should be made to allow an objective evaluation of pilot implementation, in order to guide decisions as to whether improvements or modifications are needed before expansion.

In Thailand, supervisor-level staff of the regional office of disease prevention and control and the central Bureau of Vector Borne Diseases unit for standards of malaria case-management work together to develop a training plan and decide on the materials needed. The regional staff will then train staff at selected malaria clinics. In Cambodia, trainers will be laboratory supervisors of the provincial health department (bachelor degree minimum), who will be initially trained by CNM’s senior technical staff (training of the trainers). The trainers from the provincial health department will then train staff of selected peripheral hospitals where PoC G6PD tests will be deployed.

The possibility of keeping data on G6PD status, a hereditary condition, in a permanent and retrievable database should be considered, so that patients, especially men, will not have to be tested again following another episode of *P. vivax* infection. The national malaria database or national pharmacovigilance database can be modified to accommodate these additional variables, but it is still debatable whether a person’s definitive G6PD status should be based upon a single PoC qualitative G6PD test result.

WHO guidelines include a recommendation for a prolonged treatment regimen (8 weeks) among those with mild or intermediate G6PD deficiency. In practice, this is usually not followed. Based on the available qualitative PoC G6PD rapid test, used in the ongoing pilot implementation in Thailand, malaria clinical staff are advised to refer such patients to a district hospital, or a higher-tier health facility. Further clarification on the guidelines is needed for consistent practice.

Besides the concern that patients are unlikely to complete an 8-week course, Thailand’s decision is also based on the belief that a G6PD-deficient individual should be treated by a medical doctor. The issue will have to be re-discussed, as this is currently not practical because malaria clinics and health facilities that provide malaria treatment in remote areas are not normally staffed by doctors.

**Logistics of procurement and product supply-chain system**

While an optimum procurement strategy and an uninterrupted supply-chain system for G6PD test kits and anti-relapse drugs have yet to be determined, it is likely that each country would prefer to integrate them with existing systems and practices used for antimalarial drugs and rapid diagnostic tests. For now, G6PD tests and primaquine may have to be procured and distributed separately. In the future, once tafenoquine, a single-dose anti-relapse therapy, becomes available, one of the options might be co-packaging of tafenoquine and PoC G6PD tests, to avoid prescription without G6PD testing.

The country’s experience with the current procurement and distribution systems for antimalarial drugs and rapid diagnostic tests should help in designing a system for the procurement of G6PD test kits and new anti-relapse therapies. In both countries, rapid diagnostic tests and quantification of antimalarial drugs is based on calculation of the number of malaria cases in the previous year(s). To avoid too short a shelf-life, Cambodia specifies in the bidding that shipment is to be made twice per year.

Thailand’s procurement and distribution are made through a centralized government agency. Management of warehousing and the stock inventory are adequate for malaria control commodities. This is a beneficial system in terms of costs and quality assurance. In Cambodia, drugs and rapid diagnostic tests are stored at the Central Medical Store in Phnom Penh. However, storage in the periphery of the public health system, including at operational district and health centre levels, is under less stringent conditions. Temperature control is inconsistent or unavailable. Therefore, only a small amount of supplies is usually kept at the facilities below the provincial level, with a monthly inventory to determine refill needs.

For G6PD test kits, the demand scenarios are still unclear. Implementation of radical cure will probably be on a limited scale initially but with potential expansion in a later phase. Quantification will be made accordingly, based on the reported number of cases of *P. vivax* malaria.

**Ensuring the quality of G6PD test kits**

The lack of a product prequalification scheme by WHO for PoC G6PD tests is a factor in why some countries, including Cambodia, are hesitant to adopt routine G6PD screening in a malaria programme.

Significant development has occurred since 2015 for prequalification of PoC G6PD tests. Previously, the G6PD test was not in the WHO programme portfolio for prequalification of in vitro diagnostics. The PoC G6PD test is considered to have high public health impact but has not yet undergone a stringent regulatory assessment. Therefore the Expert Review Panel for Diagnostics mechanism was set up by GFATM and the International Drug Purchasing Facility (UNITAID), coordinated...
by WHO. As a result, in February 2016, a call was made for manufacturers to submit an expression of interest for product evaluation by the Expert Review Panel for Diagnostics. This will help to identify assays meeting a minimal set of requirements, assist NMCPs in procurement decisions and facilitate procurement of G6PD tests using GFATM grant funds. As of June 2017, the WHO prequalification process for G6PD tests is under way and specifications have been set for the assessment of G6PD tests.

Assessment of community uptake
Most countries feel that more evidence is needed to improve confidence in the community, in order to enhance smooth introduction of a radical cure for P. vivax malaria. In Cambodia, acceptance is difficult among medical practitioners, owing to the long-term belief in a haemolytic adverse effect of primaquine causing “black water fever”. It is hoped that, given the government policy, improved PoC G6PD tests and a better case-referral system, these practitioners will be willing to comply. The Cambodian NMCP bears a huge responsibility for proving to the local people the safety of primaquine administration as guided by G6PD testing.

Acceptability to patients is also a factor. Gastric irritation, for example, often discourages patients from completing the 14-day course. Advice to patients to take primaquine with a meal could improve compliance.

According to the current plan, patients will be subjected to finger pricking twice, first for malaria diagnosis and, if found to be positive for P. vivax, then a second prick for G6PD enzyme testing. Not all patients may find this acceptable.

In Thailand, some patients may prefer to take the risk of side-effects from primaquine if advised to go to a higher-level health facility for further G6PD assessment. This has to be considered in a case-management algorithm.

Pharmacovigilance
Thailand has used primaquine in uncomplicated cases of malaria for decades but it is not known whether adverse events related to primaquine are really absent, because there is an inadequate effort to detect and report adverse effects and an inability to ascertain compliance to the 14-day regimen for P. vivax infection. Both Cambodia and Thailand have an established pharmacovigilance system, but improvement is needed to increase emphasis on antimalarial drugs and to enable the system to capture patients at the lower level of public health, where most malaria patients seek treatment.

Nonetheless, current capabilities are encouraging. For example, the Cambodian Pharmacovigilance Centre, a unit under the Essential Drug Bureau in the DDF, has been established since 2008 and has been a full member of the Uppsala Monitoring Centre (Uppsala, Sweden) under the WHO Programme for International Drug Monitoring, since 2012. The Cambodian Ministry of Health has also established a Pharmacovigilance Advisory Committee. Monitoring of antimalarial adverse drug reactions has recently been introduced into the Cambodian Pharmacovigilance Centre system, aiming at coverage of both the public and private sector.

Primaquine, and in the near future tafenoquine, should be placed under close vigilance for any adverse outcomes. WHO recommends that, at a minimum, the pharmacovigilance report should include who the patient is (age, sex, pregnancy status, illnesses and concomitant medicines), the drug dose and duration of treatment, a description of the adverse event (symptoms, severity, times of onset) and the name of the reporter.

Capability strengthening
Both countries welcome external technical support to plan for successful implementation of G6PD testing and safe primaquine therapy. Both share the problem of limited human resources dedicated to malaria case-management. Intercountry collaboration to develop templates for standard operating procedure, training materials and other documents for sharing could accelerate successful implementation.

Conclusion
The enabling environment for malaria elimination and for tackling P. vivax hypnozoites has reached a higher level than ever experienced before. This is a good opportunity, given the availability of certain funds.

On the negative side, the addition of routine G6PD testing may not be viewed highly by some countries, where malaria funding has to compete with other health priorities. However, this is not currently an issue for Thailand or Cambodia, owing to their smaller case-loads.

Rapid PoC G6PD tests are available but not ideal. Current PoC G6PD tests have limitations and do not confer 100% primaquine safety. They can be useful for malaria programmes if implementation is well planned and undertaken with caution. Next-generation quantitative tests, paired with a haemoglobinometer, will provide an improved level of primaquine safety. The new-generation qualitative test with a control line and storage temperature of up to 35–40 °C should also be of benefit to malaria programmes.

Policy alone is not sufficient. Programmes can only profit from policy if they have planning and implementation capability. Countries need time and specific guidance to prepare for training and other activities related to G6PD testing. Simple instructions are important, as complex instructions will be ignored. In terms of human resources, inadequacy of staff is an issue, as there is a tendency to shift staff towards more urgent tasks like outbreak responses to other tropical diseases, or to integrate malaria services with general health services, such as in Thailand. Thus, more technical support is needed for a smooth introduction of G6PD testing. Without such support, pilot implementation can turn out to be fruitless and actual integration of G6PD as a part of standard P. vivax case-management can be a lengthy and expensive process. This is complicated by the technical constraints of current test kits, which limit accessibility for those in remote areas, where the majority of malaria cases are passively detected.

Thailand and Cambodia both have a policy for and are making efforts towards the reality of effective radical cure for P. vivax malaria, though their strategic approaches may be different. The path to success may be easier for Thailand, given the more advanced health-system infrastructure and lower fear of haemolytic adverse effects from past experience within the medical community. The two countries would benefit from working together in planning for and sharing experience with the use of G6PD tests. This should be expanded into a
subregional effort to enhance radical cure for *P. vivax* and eventually speed up malaria elimination from the Greater Mekong subregion.

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**References**


Policy and practice

Package of essential noncommunicable disease (PEN) interventions in primary health-care settings in the Democratic People’s Republic of Korea: a feasibility study

Choe Suk Hyon1, Kim Yong Nam1, Han Chae Sun1, Renu Garg2, Suraj Man Shrestha2, Kim Un Ok3, Rajesh Kumar4

1Ministry of Public Health, Pyongyang, Democratic People’s Republic of Korea, 2World Health Organization Regional Office for South-East Asia, New Delhi, India, 3World Health Organization Country Office for the Democratic People’s Republic of Korea, Pyongyang, Democratic People’s Republic of Korea, 4School of Public Health, Postgraduate Institute of Medical Education and Research, Chandigarh, India

Correspondence to: Dr Rajesh Kumar (dr.rajeshkumar@gmail.com)

Abstract

The prevention and control of noncommunicable diseases (NCDs) is a priority for the Democratic People’s Republic of Korea. Mortality due to NCDs in people aged over 30 years was 1239 per 100 000 in 2009 and the 2014–2020 national strategy includes population-level goals for health promotion and disease prevention. This paper reports a pilot study on the feasibility of implementing components of the World Health Organization (WHO) Package of essential noncommunicable disease (PEN) interventions for primary health care in low-resource settings (WHO PEN) to enable early detection and management of cardiovascular disease and diabetes mellitus at the level of primary care. WHO PEN protocols were adapted for local use by household doctors, who provide ambulatory care in polyclinics in the mornings and household visits in the afternoons. The pilot project was implemented in two polyclinics in Pyongyang, covering a population of 32 000. After training, and during routine household visits in June 2014, 70 household doctors screened all adults aged over 35 years (18 340) for cardiovascular disease and diabetes mellitus, and their risk factors. A total of 2319 patients with cardiovascular disease or diabetes, and those with high-risk factors, were referred to the polyclinics for three quarterly visits for testing and management. Final household screening of the population was done in June 2015. This pilot project demonstrated the feasibility of integrating screening and management into the standard primary health-care system in the Democratic People’s Republic of Korea. The household doctors were able to detect and manage risks for cardiovascular disease and diabetes by using the protocols based on WHO PEN. Among 18 340 individuals aged over 35 years, implementation of WHO PEN interventions led to a significant reduction in the number of people with a 10-year risk of cardiovascular disease ≥20% (from 1748 [9.5%] to 543 [3.0%]) over a 1-year period. Involvement of household doctors can increase access to services for prevention and control of cardiovascular disease and diabetes in the Democratic People’s Republic of Korea.

Keywords: cardiovascular disease, Democratic People’s Republic of Korea, diabetes, intervention, primary health care

Background

Noncommunicable diseases (NCDs) pose a significant public health burden globally.1 In most countries, people of low socioeconomic status who live in marginalized communities have a higher risk of death from NCDs than those in more advantaged communities.2 In terms of both morbidity and mortality, the global epidemic of NCDs is not only increasing but also having a disproportionate impact in low- and middle-income countries.3 In the Democratic People’s Republic of Korea, mortality due to NCDs in individuals aged over 30 years was 1239 per 100 000 in 2009.4 Prevention of NCDs has been a priority for some time for the Democratic People’s Republic of Korea, which ratified the World Health Organization (WHO) Framework Convention on Tobacco Control in 2005.5 The 2014–2020 national strategy aims to reduce the prevalence of NCDs, the proportion of premature deaths, loss of working ability, and risk factors for NCDs. It also aims to conduct multisectoral activities to target risk factors and improve the quality of medical services.6

In addition to the policies for health promotion and disease prevention targeted at the population level, approaches to risk detection and risk management at the individual level have also been advocated. Early detection and management of individuals with NCDs or at high risk of NCDs can reduce the complications of NCDs, thereby improving survival and quality of life. In high-income countries, mortality from cardiovascular disease has declined, owing to better access to services for prevention and treatment of NCDs.7 The WHO Package of essential noncommunicable disease (PEN) interventions for primary health care in low-income settings (WHO PEN) was developed to enable early detection and management at...
the primary-care level in low-resource settings.\textsuperscript{9} WHO PEN is a prioritized set of cost-effective interventions that can be delivered to an acceptable quality of care at low cost; it is the minimum standard for NCDs, to strengthen national capacity to integrate and scale up care of heart disease, stroke, cardiovascular risk, diabetes, cancer, asthma and chronic obstructive pulmonary disease in primary health care in low-resource settings.\textsuperscript{8}

This paper describes the processes and outcomes of piloting WHO PEN protocols for cardiovascular disease and diabetes mellitus in the Democratic People’s Republic of Korea in 2014. The specific aim of these pilots was to assess the feasibility of integrating the interventions into the existing primary health-care system.

Local setting

According to WHO data for 2013, the Democratic People’s Republic of Korea had a population of 24,895,000, of whom 61% were living in urban areas, and is a low-income country by World Bank classification.\textsuperscript{9} The health-care system in the country comprises primary-, secondary- and tertiary-care clinics/hospitals. Household doctors deliver primary health care through polyclinics in urban areas or ri (administrative unit) people’s hospitals in rural areas. On average, each household doctor looks after 130 households. These doctors provide ambulatory care in the polyclinics or ri people’s hospitals in the mornings and visit households in the afternoon. Comprehensive primary care, consisting of prevention, diagnosis, treatment and hospitalization, is provided free of cost. The network of polyclinics and ri people’s hospitals is supported by specialist doctors in the secondary- and tertiary-care institutions at county, provincial and national levels. To date, the major focus of the health system has been on prevention and control of communicable diseases and on maternal and child health.

Protocol development and PEN pilot implementation

Preparations for adaptation of the WHO PEN protocols began in 2012 at a country-level consultation workshop. Only the protocols for cardiovascular disease and diabetes were selected for implementation in this pilot. Guidelines for integrated management of cardiovascular disease and diabetes in polyclinics and ri people’s hospitals were finalized in 2013. In June 2014, the pilots were initiated in two polyclinics in Pyongyang, which were staffed by household doctors, specialist doctors, nurses, laboratory technicians and pharmacists.

After conducting the training of trainers (directors and specialist doctors of polyclinics), household doctors were trained in each of the two polyclinics in 2-day workshops in 2013 and 2014. Equipment to measure blood glucose and cholesterol at the polyclinics, WHO/International Society of Hypertension (ISH) 10-year risk prediction charts for cardiovascular disease (with or without diabetes),\textsuperscript{10} and health education materials were provided by WHO. The WHO/ISH charts are country specific and are used to indicate the 10-year risk of a fatal or non-fatal major cardiovascular event (myocardial infarction or stroke), according to age, sex, blood pressure, smoking status, total blood cholesterol and presence or absence of diabetes.\textsuperscript{10} Medicine supplies were also augmented by WHO, to cater for the basic medical needs of patients with cardiovascular disease or diabetes in the two polyclinics.

In June 2014, using a structured questionnaire, household doctors screened adults aged over 35 years during household visits. These doctors identified known cases of cardiovascular disease and diabetes and assessed their risk factors. In addition, for all household members older than 35 years, they measured height, weight, waist circumference and blood pressure; tested urine for sugar and albumin; and assessed 10-year risk of cardiovascular disease, using the WHO/ISH risk prediction charts.\textsuperscript{10} The household doctors counselled household members for smoking cessation, alcohol harm reduction, healthy diet and physical activity. Patients with any of the following were invited to the polyclinic for further examination and management:

- diagnosed hypertension, heart disease, stroke, diabetes or kidney disease;
- new chest pain or change in the severity of angina or breathlessness;
- suspected diabetes – positive urine glucose test or symptoms of weight loss, polydipsia, polyuria and nocturia;
- cardiac murmurs, lung crackling/rales;
- blood pressure $\geq 160/100$ mmHg or $\geq 140/90$ mmHg ($\geq 130/80$ mmHg in patients with diabetes) while on treatment with two or three drugs;
- a high ($\geq 20\%$) 10-year risk for cardiovascular disease.

The household screening was repeated after 1 year, using the same methods.

At the polyclinic, a clinical record form was used for registration and follow-up of patients, and was kept in a folder alongside the records of chronic disease. In the first clinic visit, fasting and 2-hour post-prandial blood glucose and cholesterol were tested with the glucometer and cholesterol meter, and appropriate counselling was given and treatment prescribed in consultation with the specialist doctor. The same assessment was done at the polyclinic after 3 months and 6 months. Those who did not respond to treatment were referred to hospital.

Medicines prescribed according to a defined protocol, depending on the patient’s condition, were dispensed for 3 days initially and the patient was reassessed; thereafter, medicines were dispensed at weekly intervals for as long as the patient’s condition required. Whenever shortage of medicine occurred, patients with mild disease were prescribed koryo traditional medicines. Supervision was carried out by Ministry of Public Health and WHO officials. Monitoring reports were sent to the Ministry of Public Health every quarter.

Performance assessment

The performance of the pilot project was evaluated in December 2015. Based on the WHO health-system evaluation framework, a pilot project-evaluation framework was prepared in consultation with the programme managers.\textsuperscript{11} WHO health-system building blocks were used to trace the link between inputs, coverage and outcomes.

The WHO planning guide for implementation of WHO PEN to strengthen primary health care was utilized for preparation.
of tools for observation of PEN sites, and interviews with key informants.12 Using the evaluation tools, the two project sites were observed; training material, screening questionnaires, equipment, patient clinic records and monitoring reports were reviewed; and key personnel (2 directors, 8 household doctors, 2 specialist doctors, 2 nurses, 2 laboratory technicians, 2 pharmacists and 8 patients) were interviewed.

Outcomes

As already described in detail, the PEN project was implemented in three selected dongs (neighbourhoods; total population 32 000) of two polyclinics in Pyongyang. Screening of the household population was carried out in the selected dongs, by 70 household doctors affiliated to the selected polyclinics. In all households of the selected dongs, individuals aged over 35 years were screened, and those with high risk were invited to polyclinics for further evaluation. Household screening was also repeated after 1 year.

Household screening

All individuals aged over 35 years were screened at household level, irrespective of their disease status. Of the total number screened \( (n = 18 340) \), the numbers with WHO/ISH 10-year risk of cardiovascular disease <10%, 10% to <20%, 20% to <30%, and ≥30% were found to be 15 047 (82.1%), 1545 (8.4%), 925 (5.0%) and 823 (4.5%), respectively; 2723 (14.8%) had high blood pressure (>140/90 mmHg); 777 (4.2%) had positive urine glucose; 2282 (12.4%) had positive urine albumin; 4497 (24.5%) had high waist circumference (men >90 cm, women >80 cm); and 4494 (24.5%) had high body mass index (>23 kg/m\(^2\)) (see Fig. 1, baseline). All those screened were counselled for risk reduction, and those who met the referral criteria specified in the screening protocol were referred to a polyclinic for further examination and testing for blood glucose and cholesterol. After 1 year, the repeat assessment of risk factors by household screening in the same population revealed a significant decline in risk factors (see Fig. 1, 1 year).

Follow-up of high-risk patients

Of the 18 340 persons screened in the households, 2319 (12.6%) met the criteria listed above and were referred to the two polyclinics. They were registered and followed up. Those consuming alcohol were counselled for alcohol harm reduction and those who were current smokers were advised on smoking cessation. They were also counselled for healthy diet and physical activity. Polyclinic records indicated that PEN reports were submitted regularly to higher authorities, which supervised the project periodically by site visits.

The polyclinic records indicated that several risk factors declined significantly from the first polyclinic visit to the third visit (see Fig. 2). A significant reduction had occurred in the categories of 10-year cardiovascular risk of (i) 20% to <30% and (ii) ≥30% from (i) 587 (25.3%) to 306 (13.2%) and (ii) 395 (17.0%) to 176 (7.6%) respectively between the first and third polyclinic visit. Compared to baseline (data not shown), by the third quarter, the number with a fasting blood glucose level of >7 mmol/L declined from 642 (27.7%) to 232 (10.0%) and the number with a blood cholesterol level of >6.6 mmol/L declined from 247 (10.7%) to 74 (3.2%) among the 2319 high-risk patients.

Medicines were prescribed as per protocol and those who did not respond to treatment were referred to hospital. Indents for medicines were sent regularly but some shortage of medicine was experienced in the last week of the month.

Lessons learnt and challenges

Household doctors were able to use the adapted protocols on cardiovascular disease and diabetes. They were also able to use the WHO/ISH charts for 10-year risk of cardiovascular disease.10 Their capacity has been enhanced and their awareness about major NCD risk factors has increased. Among individuals aged over 35 years who were screened at the household level, a large proportion were found to have high (≥20%) 10-year risk of cardiovascular disease. All high-risk patients were followed up and a significant reduction occurred in the 10-year risk of cardiovascular disease over a 9-month follow-up period. Most of

Fig. 1. Prevalence of risk factors for cardiovascular disease among individuals aged over 35 years in three dongs of Pyongyang, Democratic People’s Republic of Korea, 2014–2015 \( (n = 18 340) \)

<table>
<thead>
<tr>
<th>Risk Factor</th>
<th>Baseline</th>
<th>1 year</th>
</tr>
</thead>
<tbody>
<tr>
<td>10-year CVD risk ≥20%</td>
<td>9.5</td>
<td>3.0</td>
</tr>
<tr>
<td>Blood pressure &gt;140/90 mmHg</td>
<td>14.8</td>
<td>2.0</td>
</tr>
<tr>
<td>Urine sugar</td>
<td>4.2</td>
<td>0.7</td>
</tr>
<tr>
<td>Urine albumin</td>
<td>12.4</td>
<td>5.5</td>
</tr>
<tr>
<td>Waist circumference: M&gt;90 cm, F&gt;80 cm</td>
<td>24.5</td>
<td>18.0</td>
</tr>
<tr>
<td>BMI &gt;23 kg/m(^2)</td>
<td>24.5</td>
<td>22.7</td>
</tr>
</tbody>
</table>

BMI: body mass index; CVD: cardiovascular disease; F: female; M: male.
the patients had received medicine free of cost from the health facility close to their home; thus, regular intakes of medicines may have led to the favourable changes observed in this short period of time. Similar findings were observed in the evaluation of the Bhutan PEN project and a cardiovascular disease risk-management project in north India. Though risk factors showed a declining trend, there is scope for further improvement, as many of the patients referred to the polyclinics (20.8%) still had a high risk (≥20%) of cardiovascular disease at the end of the third follow-up visit. It is important to analyse the level of adherence to medication and lifestyle changes. In the Bhutan PEN pilot, high adherence to medicine was reported. The extent of the availability of laboratory consumables and medicines could not be assessed in the Democratic People’s Republic of Korea, as reporting on these items was not included in the routine monitoring system. Computer software (spreadsheets) could be developed to record patients’ clinical data and facilitate monitoring of outcomes.

Assessment of the population-level impact of the PEN pilot was done by a repeat household screening survey, which revealed significant changes in the risks at the population level. Household doctors can carry out screening at periodic intervals during their routine household visits. An assessment of cost effectiveness, as was done in Bhutan, could help policy-makers to decide whether it is possible in the current economic scenario to extend PEN to the entire country in a phased manner, by supplying medicines and laboratory reagents from the regular health budget.

In conclusion, implementation of WHO PEN protocols related to cardiovascular disease and diabetes has improved risk management in selected polyclinics of the Democratic People’s Republic of Korea, which has a well-defined system of primary care staffed by household doctors. Efforts should be made to extend the pilot project to rural areas and peripheral hospitals in the provinces, before scale-up to the entire country. Protocols for cancer and chronic respiratory diseases should also be developed.

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