Tsunami in South Asia: What is the Risk of Post-disaster Infectious Disease Outbreaks?

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Abstract

The World Health Organization has warned that in the aftermath of the recent tsunami, infectious disease outbreaks will add to the heavy toll of the disaster itself, possibly even doubling the number of casualties. However, many experts believe the risks of infectious disease outbreaks following natural disasters have been overemphasised and have led to unnecessary and potentially harmful public health activities. This paper discusses the risk and prevention strategies of potential infectious diseases in the aftermath of the tsunami based on a literature review of previous similar disasters and current evidence. Infectious disease outbreaks, if any, will most likely be the consequence of post-tsunami camp situations involving large displaced populations rather than the tidal wave itself. Lessons have been learned from previous large-scale humanitarian crises about the provision of aid and the mitigation of epidemics. This paper examines the risk and preventive strategies of vector- and food/water-borne diseases, measles, acute respiratory infections and meningitis. Alert thresholds at which to trigger outbreak investigations, and standardised guidelines with regard to their control are outlined, based on the Sphere Project.

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Introduction

The tsunami that struck 11 countries in South Asia on 26 December 2004 represents the greatest natural disaster of our times, prompting the biggest peacetime aid operation in history. Five million people have been severely affected by the tsunami. The World Health Organization (WHO) has highlighted that in the aftermath of the tsunami, infectious disease outbreaks will add to the heavy toll of the disaster itself, possibly even doubling the number of casualties.[1] Consequently, the WHO has strengthened the surveillance for infectious diseases and released several warnings.[2] Although the tsunami catastrophe was unusually vast, it was a classic natural disaster. Many experts believe that the risks of infectious disease outbreaks following natural disasters have been overemphasised and have led to unnecessary and potentially harmful public health activities.[3] This paper discusses the risk and prevention strategies of potential infectious disease outbreaks in the aftermath of the recent tsunami based on a literature review of previous similar disasters and current evidence.

Search Strategy and Selection Criteria

Literature searches were done on the WHO website and on MEDLINE, limited to those with English language, using the search terms of 'tsunami'. All articles between 26 December 2004 and 2 March 2005 (date of manuscript submission) were reviewed. In addition, a search for articles on MEDLINE was performed using the search terms 'natural disasters', 'flooding', 'complex emergencies', 'communicable diseases in complex emergencies' and 'displaced populations'. All abstracts were reviewed for content consistent with the objectives of the paper; only review articles fitting the content criteria were selected. In addition, 2 books were used for further reference.[3,4]

Risk of Infectious Disease Outbreaks in Relation to Past Natural Disasters

The tsunami was a rapid onset, rapidly abated type of natural disaster, comparable to that of flooding and earthquakes. As such, the risk of infectious disease outbreaks following flooding and earthquakes will be examined.

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Flooding is the most common type of natural disaster worldwide, accounting for an estimated 40% of all natural disasters.[3] There are multiple environmental consequences of flooding that can directly affect public health. For example, water sources can become contaminated with faecal materials or toxic chemicals. Water or sewer lines may be disrupted affecting access to a safe and adequate water supply and nutrition.[3] Nevertheless, in the past 3 decades, epidemics of water-borne diseases, such as cholera and shigella dysentery, have been uncommon after floods.[3,5]

In the summer of 1993, 75% of counties in Missouri, USA were flooded.[6] Surveillance documented a significant increase in upper respiratory tract infections and sporadic outbreaks of diseases such as leptospirosis, but these were easily controlled and not widespread.[6] Flooding is often followed by a proliferation of mosquitoes.[3] Surveillance data from the 1993 floods in Iowa, USA showed that vector population increased and an increased prevalence of arboviral diseases was noted (St. Louis encephalitis and western equine encephalitis).[7] However, there was no consequent epidemic of arboviral or protozoal disease, and this was most likely due to the rapid and costly spraying programme.[7]

The experience in the USA needs to be seen in contrast to the aftermath of flooding in the developing world. For example, in Ecuador in 1983, large-scale flooding was the primary cause of a documented sevenfold increase in the incidence of malaria.[8] In 1988, floods in Khartoum, Sudan led to significant increases in the rate of hepatitis A and gastrointestinal infections.[9] In 1988, Bangladesh witnessed their worst flood on record, followed by an outbreak of diarrhoeal diseases.[10]

The cause of immediate death in earthquakes continues to be primarily by traumatic injuries, while consequences arising from infectious diseases are minimal.[3,11] This has been explained by most authors by the fact that earthquakes are largely rapid-onset, rapidly abated types of natural disasters and that the relief and restoration efforts are often equally as rapid in comparison. There are, however, a few reports in the literature which documented significant increases in the incidence of certain infectious diseases following earthquakes and volcanoes. The 1983 Columbia earthquake was responsible for a significant increase in the incidence of infectious hepatitis, which was most likely caused by poor hygiene and overcrowding during the post-disaster period.[11] After the earthquake that struck Luzon, Philippines in 1990, the resultant loss of potable water and effective sanitation controls led to widespread increases in gastrointestinal illnesses.[12] Mathematical modelling and analysis of historical data demonstrated a positive correlation between earthquakes, influenza, and the 3 major epidemics of kala-azar in Assam, India between 1875 and 1950.[13]

In summary, the literature on disasters indicate that epidemics of communicable diseases do not always occur after large-scale floods or other natural disasters.[5] If they occur, they are not of the magnitude of complex emergencies.[14] It is usually not the natural disaster itself but the artificial, crowded communities often created in their aftermath that serve as a substrate of the spread of communicable diseases.[4]

Risk of Infectious Disease Outbreaks in Displaced Populations

Displaced populations in camp settings are at high risk of infectious diseases due to a large array of risk factors which act synergistically: inadequate shelter, overcrowding, lack of food, inadequate quantity and/or quality of water, poor sanitation, insufficient soap, poor personal hygiene, poor health care services, low national immunisation coverage rates, interruption of vector control measures, and movement of people from areas of low endemicity to hyperendemic areas.[14-16] Death rates of over 60 times the baseline have been recorded in refugees and displaced people, with over three-quarters of these deaths caused by communicable diseases.[17] Epidemic prone diseases in refugee settings are diarrhoeal diseases, respiratory infections, measles, meningitis and, depending on the country, malaria. HIV/AIDS and tuberculosis are also becoming increasingly important.[17] Children are at particular risk. The most common diseases related to disaster camp settings are vector- and food-borne diseases, measles, acute respiratory infections and meningitis,[17] and the focus of this paper is therefore on these diseases.

Vector-and food-borne diseases: Drinking water storage around temporary dwellings can become a breeding place for vectors, in particular for *Aedes* mosquitoes, compounded by the interruption of effective vector control programmes. Overcrowded conditions and temporary shelters, which increase bite frequency, also promote the transmission cycle. Inadequate access to health care services delays treatment which then protracts the time parasites remain in the blood and thus propagate the cycle.[17] Diarrhoeal diseases are a major cause of morbidity and mortality in disasters. In camp situations, diarrhoeal diseases have accounted for more than 40% of these deaths in the acute phase of an emergency, with over 80% of these deaths occurring in children aged under 2 years.[17] Outbreak investigations have shown that common sources of infections include polluted water sources (by faecal contamination of surface water entering incompletely sealed wells), contamination of water during transport and storage (through contact with hands soiled by faeces), shared water containers and cooking pots, scarcity of soap, and contaminated foods.[17] The largest outbreak of diarrhoeal disease ever reported occurred amongst Rwandan refugees in Goma, Congo in 1994: 85% of the 50,000 deaths recorded in the first month were caused by diarrhoeal diseases, of which 60% were a result of cholera and 40% were caused by shigella dysentery.[18] The most important cause of the epidemic in Goma was a scarcity of water.

Measles: Epidemics of measles have been a major cause of mortality in camp settings, especially in children. The case fatality of measles in complex emergency settings is reported to be as high as 33%, whilst in stable populations the case fatality rate is generally around 1%.[16] Overcrowding is associated with the transmission of a higher infectious dose of measles virus, resulting in more severe clinical disease.[19,20] Populations with poor national measles vaccination coverage are obviously at highest risk of measles outbreaks. In a refugee camp in Sudan in 1985, measles accounted for 53% of deaths, with the highest proportion in children. Since international agencies are now rapidly implementing measles vaccine campaigns in emergency settings and camps, measles outbreaks have been less frequently reported since the 1990s.[17]

Acute respiratory infections and meningitis: Acute respiratory infections are facilitated by overcrowding and poor shelters and account for a large proportion of the morbidity and mortality in refugee settings, particularly in children. Acute respiratory infections caused 63% of the morbidity in Nicaraguan refugees in Costa Rica in 1989.[21] Most data on acute respiratory infections in emergencies are limited to mortality; few studies have been done on morbidity rates and even fewer on the specific pathogens causing these infections.[17] Acute respiratory infections amplify the transmission risk for meningococcal disease through droplet transmission of respiratory secretions during coughing and sneezing.[22] Outbreaks of meningococcal meningitis have mainly been described in complex emergencies in Africa.[17]

The Risk of Infectious Disease Outbreak Related to the Tsunami

Although the tsunami catastrophe was unusually vast, it was a classic natural disaster in several ways.[5] The clinical and epidemiological profile of this disaster is similar to that of a cyclone or hurricane with resultant flooding.[5] The causes of death were drowning and blunt trauma and the injuries among the survivors arise from complications of near drowning and trauma. The short-term public health needs of the surviving population are also similar: water, sanitation, food, shelter, and appropriate medical care administered to persons remaining in place and the thousands living in self-settled displaced communities.[5] The huge numbers of dead bodies marked out this disaster beyond all others. The vast numbers of dead and the small numbers of major injuries in survivors are an indication that severely injured people did not survive the 20-minute battering by the tsunami waves. Wound infections and, in unvaccinated populations, tetanus presented a major problem in this disaster, and are discussed in detail by Lim[23] in an earlier issue. The myth that dead bodies cause a major risk of disease, which is reiterated in all large natural disasters from the earthquake in Nicaragua to Hurricane Mitch, the Turkish earthquake, or the floods in Mozambique is just that — a myth.[24,25] The bodies of victims from earthquakes or other natural disasters do not present a public health risk of cholera, typhoid fever, or other plagues.[24,25] However, the tsunami has left hundreds of thousands of survivors displaced in refugee camps, with similarities to complex emergencies, with the potential for epidemics related to the 5 main communicable diseases as described above.

Public health surveillance was conducted in affected provinces in Thailand, and cases of diarrheal disease increased after the tidal wave, but quickly stabilised.[26] The post-tsunami rate of diarrheal disease in Thailand (2950 cases per 100,000 population) was far lower than that reported in disaster settings in other countries.[26] At the time of writing, no cholera outbreak has been reported in any of the tsunami-affected areas. The overall low incidence of diarrheal disease, as compared to previous humanitarian emergencies, is most likely due to the prompt international aid efforts to provide large quantities of clean water. At the time of writing, no published data were available on the incidence of respiratory infections in tsunami-affected areas, but based on personal communication with various front-line relief workers, acute respiratory infections appeared to be the most common complaint at makeshift outpatient clinics. Large outbreaks of meningococcal meningitis have previously been reported in complex emergency settings, but these all occurred in Africa within and outside its meningitis belt[17] and are unlikely to occur on the same magnitude in Asia.

To date, no measles outbreak occurred in tsunami-affected areas, and this is most likely due to the fact that measles vaccination campaigns were implemented immediately in most tsunami camps where baseline national measles vaccination coverage was deemed to be low, particularly in Banda Aceh.

What about vector-borne diseases then? The tsunami had led to an environmental disturbance and disruption of routine vector control that may result in increased mosquito breeding. While pools of salt water would not support mosquitoes, the monsoon rains in Indonesia and Sri Lanka will change the flooded areas from brackish to fresh water, and can become ideal breeding places for the malaria vector.[5] Most of the tsunami-affected areas are endemic for malaria, except for the Maldives.[27] It is crucial to know the pre-disaster incidence of malaria to determine an increase in incidence. Maps of the Sri Lankan malaria situation preceding the tsunami were published in a timely manner.[28] The incidence of malaria was 1 case per thousand population in the 10 months leading up to the disaster, in the districts with the highest transmission in Sri Lanka. Similar maps and surveillance reports are urgently needed from Aceh to estimate the risk of a major malaria epidemic. Thailand's province of Phuket has very low malaria endemicity.

Dengue fever is carried by the *Aedes aegypti* mosquito. *Aedes aegypti* is a peridomicillary mosquito and well adapted to urban life as it typically breeds in clean stagnant water in a wide variety of man-made containers such as tires, tin cans, pots and buckets that collect rainwater.[29] The WHO rightly raised concerns about a major dengue epidemic, particularly in Indonesia where there was already an ongoing dengue epidemic before the tsunami.[27]

The implications of Japanese encephalitis (JE), in the aftermath of the tsunami, in combination with monsoon rains, are much more speculative than those for malaria and dengue.[30] The JE virus is transmitted by some mosquitoes of the genus *Culex*. These mosquitoes prefer to breed in vast expanses of freshwater, and are normally associated with flooded rice fields in the early stages of the cropping cycle. JE is endemic in Sri Lanka, South India and other parts of Asia where rice production and pig rearing are combined. Outbreaks normally occur under circumstances of intense transmission, when the virus spills over from pigs into the human population.[26] In receptive disaster zones, pigs are likely to have been wiped out. Culicine mosquito populations may build up which, in the absence of domestic animals, will bite humans instead. Transmission may take place directly from ardeid birds (herons, egrets and similar birds that carry the virus) to humans. Vaccination, particularly of children, is most effective in preventing outbreaks, but it is expensive, requires basic logistics and is onerous because of the need for 2 repeat vaccinations. Larviciding is not an option, because of the extent of the breeding places.[30] Space spraying with hand-held fogging machines can have an important function in keeping mosquito populations down. The health sector should be prepared to deal with JE cases once large stretches of flooded areas have changed from brackish to fresh water and a build-up of the indicated culicine mosquito population is observed.[30]

The Public Health Response to the Threat of Infectious Diseases Related to the Tsunami

Lessons have been learned from previous large-scale humanitarian crises about the provision of aid and the mitigation of epidemics.[5,31,32] A selection of websites on emergency preparedness is presented in Table 1. Several leading non-governmental organisations (e.g., Médecins Sans Frontières and Oxfam) have produced technical field manuals.[33,34] Standardised strategies and interventions for large-scale public health emergencies are provided in the Sphere Project Handbook.[4] The WHO has published a list of suggested alert thresholds to trigger further investigation in the tsunami-affected areas (Table 2).[35]

The WHO now focuses on 5 key objectives to ensure the rapid recovery and rehabilitation of public health service. This encompasses the coordination of health relief, access to essential health care, disease surveillance and response, technical support and strengthening the medical supply chain.[2] Experts have been deployed and early warning and surveillance systems have been established in affected regions. Public health laboratory services are being restored, including provision of rapid diagnostic kits, medical supplies and equipment, and training of local health workers. The prevention and control of communicable diseases, case management, and surveillance are the 3 key components with regard to infectious diseases.

Table 1. List of Selected Educational Websites for Emergency Preparedness and Response

http://www.bt.cdc.gov/	Contains information on natural disasters, outbreaks, bioterrorism, chemical and radiation emergencies, and mass trauma
http://www.emprep.com	Provides information on emergency kits and supplies, custom packaged assortments, disaster kits, large inventory of supplies
http://www.sphereproject.org	Describes minimum standards for disaster response
http://www.who.int/infectious-disease-news/IDdocs/whocds200527/whocds200527chapters/index.htm	A manual on communicable diseases control in emergencies
http://www.nlm.nih.gov/medlineplus/disastersandemergencypreparedness.html	Provides overview, research and latest news stories on emergency preparedness
http://www.who.int/hac/techguidance/pht/communicable_diseases/en/CD_EWARN12012005.pdf	Provides technical guidance for communicable diseases following the South Asia tsunami

Table 2. Suggested Alert Threshold to Trigger Further Investigation[35]

Health Event	Alert Threshold	Action Suggested
Acute watery diarrhoea (suspect cholera)	One death for acute watery diarrhoea in patients 5 years of age or older A cluster of 5 cases in 1 week of watery diarrhoea in patients 5 years of age or older	Active case finding and immediate specimen collection for laboratory confirmation
Acute diarrhoea	1.5 times the mean of cases calculated over the last 3 weeks	Active case finding and immediate specimen collection for laboratory confirmation
Acute bloody diarrhoea	A cluster of 3-5 cases of acute bloody diarrhoea in the same settlement in 1 week or the doubling of cases in 2 consecutive weeks	Active case finding and immediate specimen collection for laboratory confirmation
Acute lower respiratory infections	1.5 times the mean of cases calculated over the last 3 weeks	Active case finding and immediate specimen collection for laboratory confirmation. Clinical tests. Confirmation of clinical diagnosis
Suspected measles	One case of suspected measles detected in settlements should be considered the beginning of an outbreak	Immediate active case finding and immediate response in coordination with the national immunisation programme
Acute jaundice syndrome	A cluster of 3-5 cases of acute jaundice syndrome in the same settlement	Active case finding and immediate specimen collection for laboratory confirmation
Suspected meningitis including suspected encephalitis	Two suspected cases of acute jaundice syndrome in the same settlement	An investigation for the active case finding should be triggered and the collection of cerebrospinal fluid should immediately be ensured to confirm the cases
Suspected malaria	1.5 times the mean of cases calculated over the last 3 weeks	Active case finding and specimen collection for laboratory confirmation
Acute flaccid paralysis (suspected poliomyelitis)	One case of acute flaccid paralysis	Active case finding and specimen collection for laboratory diagnosis
Adult tetanus	One case of adult tetanus	Immediate active case finding
Neonatal tetanus	One case of neonatal tetanus	Investigate hygienic practices used for deliveries

Vector control: In principle, aerial spraying, scrub clearance, and outdoor spraying with residual insecticide are inappropriate interventions at any stage of an emergency.[19] Insecticide-treated nets are the most effective intervention.[17] Indoor residual spraying of insecticide is commonly used in chronic emergency situations and is appropriate for populations that live in more permanent housing structures in which the vector rests indoors. New initiatives are insecticide-treated plastic sheeting that may have more relevance where shelter materials are distributed.[14] Plastic sheeting of polyethylene tarpaulins has replaced canvas tents previously used in camp settings.[17] Insecticide-treated top sheets, blankets and, in Islamic countries, cloth wraps (chaddars) could be used as forms of protection in disaster situations.[17] The WHO and United Nation Children's Fund have provided long-lasting insecticidal nets to displaced individuals and families in tsunami-affected areas for malaria prevention, along with other key supplies such as insecticides, fogging machines and spray tanks (as well as the hiring of vehicles for spraying activities).[27] In Banda Aceh alone, some 100,000 insecticide-treated mosquito nets, 20,000 rapid diagnostic tests for malaria and 150,000 treatment courses of artemisinin-based combination therapy have been made available by private donors and UN agencies.[27] The WHO also assists in the clean-up of debris in which water collects, to prevent the formation of dengue breeding sites. In India, a number of anti-vector measures are being implemented, including the strengthening of vector surveillance measures, while family-sized insecticide-impregnated bed-nets have been distributed to families living in displacement camps. In Thailand, in addition to prevention activities, the Ministry of Health has stockpiled anti-malarial treatments in hospitals across the affected areas. In the Maldives, which is not endemic for malaria, the Ministry of Health continues to conduct its routine vector-control activities. Providing support to countries to implement vector control strategies including establishment of a proper drainage system and engineering methods are other key components.

Food, water and sanitation: Provision of sufficient clean water (the minimum agreed standard is 20 litres of water per person per day), adequate sanitation for excreta disposal and good management of solid waste can avert diarrhoeal disease, hepatitis A, typhoid fever, vector-borne diseases and scabies.[4] A minimum of 250 g of soap should be available per person per month.[4] The provision of appropriate and sufficient water containers, cooking pots, and fuel early in the relief response ensures that water storage is protected and that food is cooked. Chlorination of water is essential where no other alternative supply of safe water exists. Good case management for diarrhoea can save large numbers of lives. Food needs of the population need to be satisfied through the provision of adequate general rations, and for targeted groups through selective feeding programmes, as malnutrition leads to increased susceptibility to infectious diseases.

Vaccinations: Measles campaigns are one of the most cost-effective interventions in public health.[17] Measles immunisation should be implemented immediately in all disaster refugee situations if vaccine coverage rates are less than 90% and should not await a single case. The target populations are those aged 9 months up to 12 or 14 years. If the incidence of measles in the 6- to 9-month age group is high, campaigns should include children in this group because case-fatality is likely to be high; but these children need to be revaccinated at 12 months of age.[17] Where high vaccination coverage rates can be documented in the affected population, relief workers should carefully assess public health priorities to determine the appropriate time for a mass measles vaccination campaign.[14] Vitamin A supplementation during measles vaccination campaigns also acts as a protective factor for acute respiratory infections independently of measles.[36-38] Other major vaccines used in emergency situations are against meningococcal meningitis, poliomyelitis and yellow fever.[17] Two suspected cases of meningitis in the same week in a settlement should trigger an alert for further investigations and implementation of vaccination campaigns against meningococcal disease. Poliomyelitis is not a disease that kills during complex emergencies, but it is associated with poor water and sanitation.[17] Yellow fever does not exist in Asia.

Table 3. Diseases Targeted by Preventive Measures in Refugee Settings in South Asia

Preventive measure	Impact on spread of
Site planning	Diarrhoeal diseases, acute respiratory infections
Clean water	Diarrhoeal diseases, typhoid fever
Good sanitation	Diarrhoeal diseases, vector-borne diseases, scabies
Adequate nutrition	Tuberculosis, measles, acute respiratory infections
Vaccination	Measles, meningococcal meningitis, Japanese encephalitis, diphtheria, influenza, pertussis
Vector control	Malaria, dengue, Japanese encephalitis
Personal protection	Malaria, dengue
Insecticide-treated nets	Malaria
Personal hygiene	Louse-borne diseases: typhus, relapsing fever, trench fever
Health education	Sexually transmitted infections, HIV/AIDS, diarrhoeal diseases
Case management	Cholera, shigellosis, tuberculosis, acute respiratory infections, malaria, dengue haemorhagic fever, meningitis, typhus, relapsing fever

Conclusion

A summary of the main public health interventions to minimise infectious diseases is presented in Table 3. The public health impact of the tsunami in South Asia can potentially be immense, comprising high rates of communicable diseases, elevated prevalence of acute malnutrition, and high excess mortality rates, but these are most likely a consequence of the refugee camp settings and large displaced populations rather than the tidal wave itself. As with most natural disasters, the threat of post-disaster infectious disease outbreaks should not be overrated but also not underestimated. Exaggerated fear of infectious disease outbreaks should certainly not divert funding from the most pressing needs of the reconstruction of communities and restoration of livelihoods. At the time of writing, no outbreak has occurred, and this is partly due to the prompt international aid response, but it will take months before we can rule out the possibility of a major epidemic. Complacency must not set in as disease surveillance systems still have gaps, not all health actors are reporting through the same systems, conditions in affected areas remain favourable for communicable diseases, and people's capacities are overstretched. The international community will need to sustain the surveillance and outbreak preparedness for a long time.

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