Health Impact of the 2004 Andaman Nicobar Earthquake and Tsunami in Indonesia

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Abbreviations:
ARI = acute respiratory infection
CRED = Centre for Research on the Epidemiology of Disasters
ICRC = International Committee of the Red Cross
MOH = Ministry of Health
WHO = World Health Organization

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Abstract

Background: The human impact of the tsunami that occurred on 26 December 2004 was enormous, with Indonesia bearing a huge proportion of the losses. The aftermath brought predictions of communicable disease outbreaks and widespread fear of epidemics. However, evidence from previous disasters due to natural hazards does not support all of these predictions. The objectives of this study were to: (1) describe the relative importance of infectious diseases and injuries as a consequence of a disaster due to natural hazards; and (2) identify key recommendations for the improvement of control and surveillance of these diseases during and after disasters.

Methods: A team from the Center for Research on the Epidemiology of Disasters visited Jakarta and Banda Aceh from 11–23 January 2005, and collected data from the Central and Provincial Ministries of Health (MOH), the World Health Organization (WHO), and a field hospital from the International Committee of the Red Cross in Banda Aceh. The epidemiological profiles of diseases before and after the tsunami were compared. Cholera, tetanus, wounds and wound infections, acute respiratory infections, malaria, and dengue were included in this analysis.

Results: Certain diseases (e.g., cholera, malaria, dengue) are not always an immediate priority post-disaster. Rates of disaster-related health conditions requiring emergency response fell by half, and became negligible around four weeks after the precipitating events. Some conditions, such as aspiration pneumonia and tetanus, which normally are rare, require special preparedness for emergency personnel. In addition, resistant and rare pathogens are associated with disasters due to natural hazards in the tropics and require specialized knowledge for the rapid and successful treatment of related infections.

Conclusions: Within the first four weeks of a disaster, international humanitarian agencies in the health sector should start working with the MOH. The WHO surveillance system established immediately after the tsunami offers lessons for developing a prototype for future emergencies. Guidelines for tetanus and aspiration pneumonia should be included in disaster medicine handbooks, and humanitarian aid groups should be prepared to provide emergency obstetrics and post-natal services. Relief funding after naturally occurring disasters should consider funding sustainability. Donors should know when to stop providing emergency relief funds and transition to recovery/development strategies.

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Introduction

On 26 December 2004, an earthquake with a moment magnitude of 9.3 occurred along Northern Sumatra and the Nicobar and Andaman Islands, triggering a catastrophic tsunami that affected 12 countries. A second earthquake occurred on 28 March 2005, close to the Island Nias with a moment magnitude of 8.6.[1,2] The human impact of the tsunami was enormous: >175,000 people died and nearly two million were affected. Four countries—Indonesia, Sri Lanka, India, and Thailand—were the worst hit. Aceh Province bore the greatest burden, with nearly three-quarters of its population dead and more than half left homeless (Table 1).[3]

Country	Killed	Missing	Affected*
Indonesia	128,645	37,063	532,898
Sri Lanka	31,299	4,100	516,130
India	10,749	5,640	647,599
Thailand	5,413	2,932	58,550
Somalia	298		104,800
Maldives	81	21	25,000
Malaysia	68	12	4,296
Myanmar	61	10	15,700
Tanzania	10		
Seychelles	3		4,830
Bangladesh	2		
Kenya	1		
Total	176,630	49,778	1,906,803

Table 1—Human impact of the tsunami[3]
*Including homeless

Communicable disease outbreaks, which have a devastating potential in emergency situations, were foreseen in the aftermath of the disaster.[4–6] The large number of dead bodies gave rise to widespread fear of diseases, and epidemics of malaria, cholera, and dengue were anticipated. However, evidence from previous disasters due to natural hazards has shown that disease outbreaks are rare and that dead bodies do not pose a health threat. Recovering the dead is more important to families for psychological reasons than for any consideration of sanitation.[7]

In the aftermath, there was a generous global financial response that included US $6.7 billion pledged in total, of which US $892 million was intended for emergency flash appeals.[8] For this kind of funding to be spent most efficiently, it is important to analyze the impacts of disaster-producing events.

The objective of this study was to perform a broad epidemiological investigation of the communicable disease and health impacts of the 2004 Indian Ocean tsunami. The specific aims of this study were to: (1) describe the relative importance of infectious diseases and injuries as a consequence of disasters due to natural hazards; and (2) identify key recommendations for improvement of disease control and surveillance after disasters.

Methods

A team from the Centre for Research on the Epidemiology of Disasters (CRED) visited Jakarta and Banda Aceh from 11–23 April 2005 in the context of the Emergency Southeast Asia Network Project, which aims for the improvement of sustainable development of regions affected by naturally occurring disasters through the development of a network of research institutes in several countries in Southeast Asia. A strategy of this network is to standardize and disseminate evidence collected on naturally occurring disasters to improve the national and international response.

In Indonesia, the Central and Provincial Ministries of Health and the World Health Organization (WHO) provided surveillance data for the epidemiological analysis of important diseases before and after the disaster. In addition, a collaboration was established with the International Committee of the Red Cross (ICRC) field hospital that was operational in Banda Aceh city soon after the events. All patient consultations in this hospital from 11–31 January 2005 were recorded anonymously in the study database. Available diagnoses were standardized and grouped according to the ICD-10 classification.

Five disease groups were included in this analysis according to their importance in disaster responses and the availability of comparable pre- and post-tsunami surveillance data: (1) cholera; (2) tetanus; (3) trauma and wounds; (4) respiratory infections; and (5) malaria/dengue.

Results

Cholera

Cholera, a highly contagious diarrheal disease caused by *Vibrio cholerae*, is transmitted by water and food, and has the potential to cause epidemics if contaminated sources are shared by large populations.[9] The distribution of cholera in Indonesia is summarized in Figure 1. Cholera was reported in 1998 and 1999 in Sumatra and South Sulawesi, respectively, and was caused by the O1 Ogawa serotype.[10] Serotype O139 was reported in Indonesia in 1993, but not later.[11] Cholera was last reported in Sulawesi in 2003 (308 cases),[12] and the last cases of cholera in Aceh occurred in March 1996 (O1 Ogawa serotype). Generally, cholera occurs in Indonesia between the months March and September.[10] In the four months after the tsunami, no confirmed cholera cases were reported to either the WHO or Ministry of Health surveillance systems, and none were found among consultations in the ICRC field hospital in Banda Aceh from 11–31 January.

Malaria and Dengue

Malaria and dengue are the most important vector-borne diseases in Indonesia. Before the tsunami (2000–2004), both were endemic in most provinces and several epidemics occurred. However, the incidence of malaria in Aceh Province, remained relatively low (Figure 2A), with, on average, 27 cases per 100,000 in 2000–2004, which is nine times less then the national average of 269/100,000 during this period. Although dengue has caused increasing concern in Indonesia during the past decade, Aceh is among the provinces with the lowest reported incidence (2.4/100,000) between 2000 and 2004 (Figure 2B).

In the four months after the tsunami, 987 confirmed malaria cases in Aceh Province were reported to the WHO, primarily in the west coastal areas, including Banda Aceh. This corresponds with the number of cases reported in previous years, and less than half of the number of cases reported in 2001 (Table 2). Only a few cases of dengue (29) were reported to the MOH from the two northern districts of Aceh Barat and Aceh Utara. Among consultations in the ICRC field hospital for Banda Aceh, 15 malaria cases were found, but no dengue cases.

Tetanus

Tetanus is caused by the toxin of Clostridium tetani, transmitted through wounds contaminated by soil, street dust, or feces.[13] Vaccination rates for tetanus in Aceh are among the lowest in the country, as indicated by data on pregnant women provided

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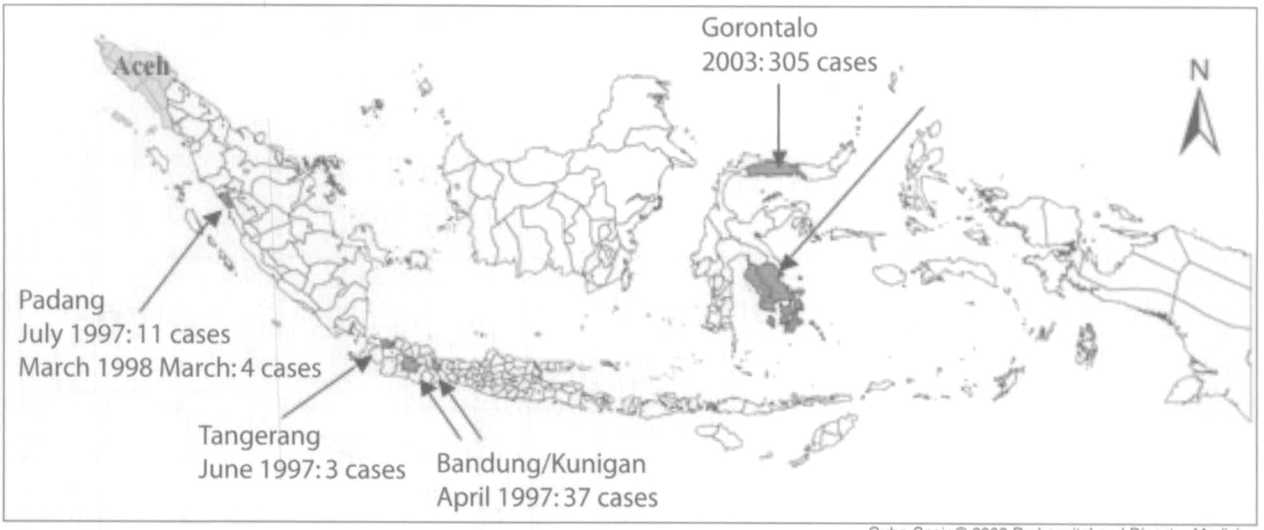

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Figure 1—History and distribution of cholera cases in Indonesia: 1994–2004

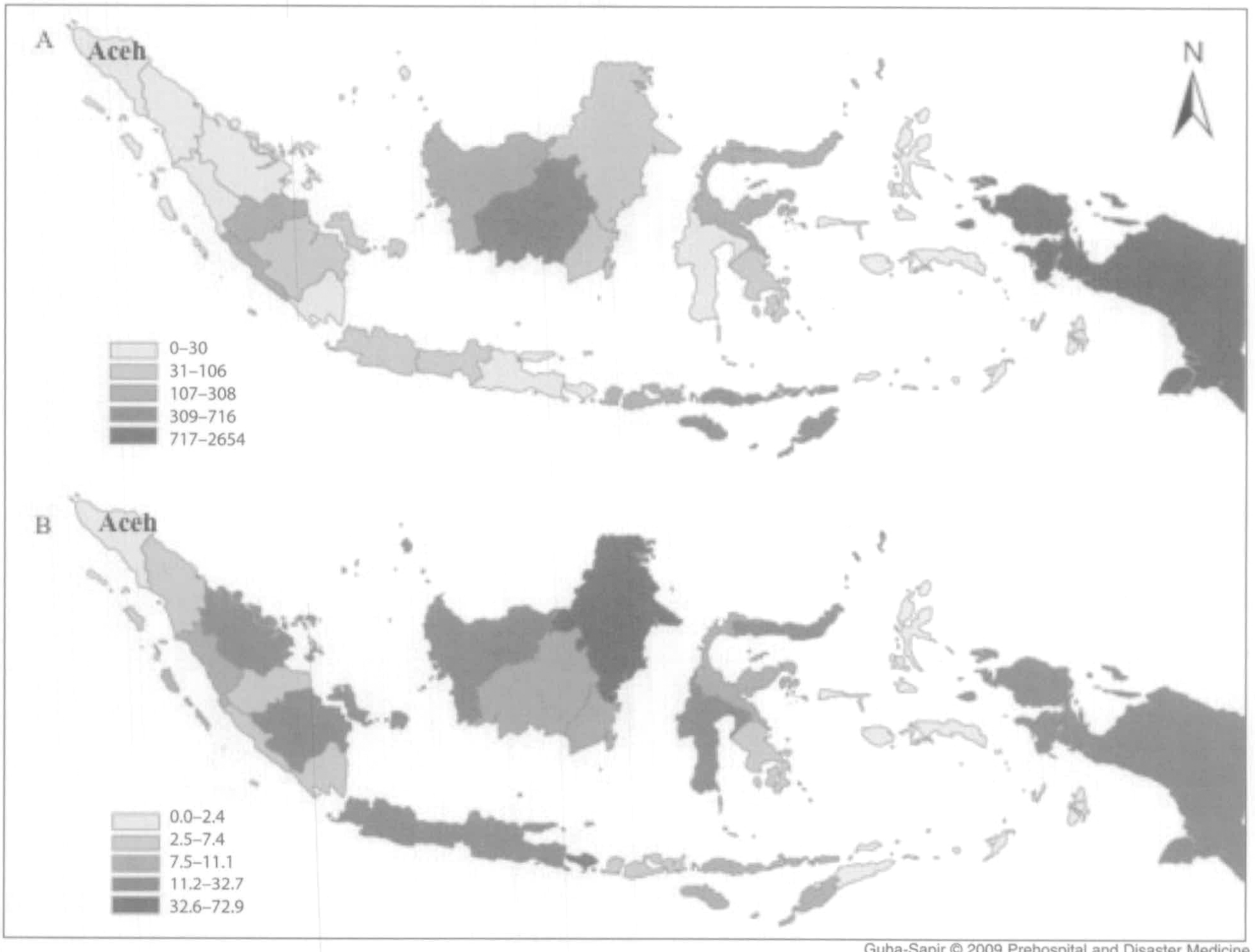

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Figure 2—Average incidence (/100,000) of malaria (A) and dengue (B) in Indonesia 2000–2004

in Figure 3. Of all pregnant women in 2004, 60% were vaccinated with a booster dose of tetanus toxoid in Aceh Province, ranging between 23.6% in the district of Aceh Tenggara to 100% in Sabang (North Aceh). In 2004, there were 279 reported cases of tetanus in Indonesia; Aceh Province reported between 30–35 cases annually for the four years preceding the tsunami (Table 2). In the first month after the tsunami, up to 96 cases were reported in Aceh with an epidemic peak between 8 and 17 January 2005 (Figure 4). Cases included patients from the entire affected area. Fifteen tetanus cases admitted at the ICRC hospital in the month following the tsunami were examined. Most were adults, and the majority were male. More than

Variable	2000	2001	2002	2003	2004	2005*
Population	4,352,214	4,560,956	4,310,612	4,636,684	4,636,684	NA
Population <5 years of age	496,849	550,902	522,919	442,474	NA	NA
Dengue cases	35	39	92	128	252	29
Dengue incidence	0.8	0.9	2.1	2.8	5.4	
Malaria cases	420	2259	325	1,843	993	-987
Malaria incidence	9.7	49.5	7.5	39.7	21.4	
Pneumonia <5 years cases	5,686	16,235	20,133	10,029		37,492**
Pneumonia <5 years incidence	1,144.4	2,947.0	3,850.1	2,266.6		
Tetanus cases		33	30	35	0	96

Table 2—Cases and incidence (per 100,000 population) of diseases before and after the tsunami
*Reported to World Health Organization/Ministry of Health between January and May
**All acute respiratory infections, not only pneumonia

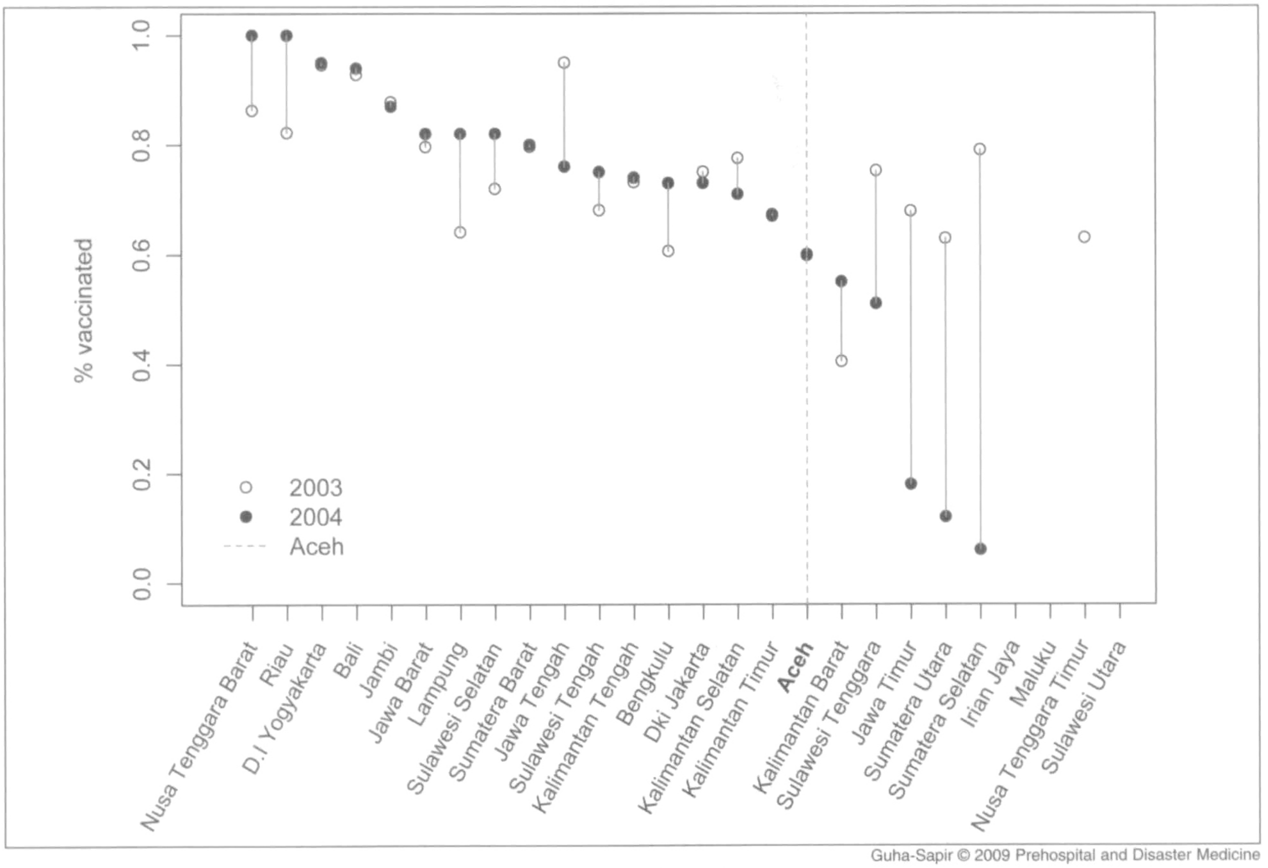

Figure 3—Percent pregnant women that received a booster dose of tetanus toxoid in 2003 and 2004

half needed intensive care treatment with cardiovascular monitoring, and in some cases, required ventilatory support. All of the tetanus cases in this hospital survived.

Trauma and Wounds

After the tsunami, until May 2005, a total of 1,458 injured victims in Aceh were reported to the WHO. Injuries as a percent of total consultations reported to the WHO remained relatively high the eighth week after the tsunami, and the number was reduced to only a few by week 16 (Figure 5). A specific survey conducted by the International Rescue Committee in Calang (Aceh Jaya district) demonstrated the importance of wound infections, which accounted for 16.9% of all diagnoses in a clinic of the Indonesian army. The current analysis of consultations at the ICRC field hospital in Banda Aceh indicated that

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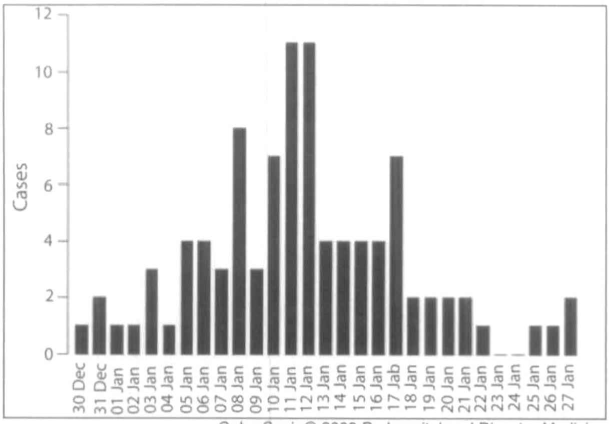

Figure 4—Tetanus cases per day reported in Aceh December 2004–January 2005

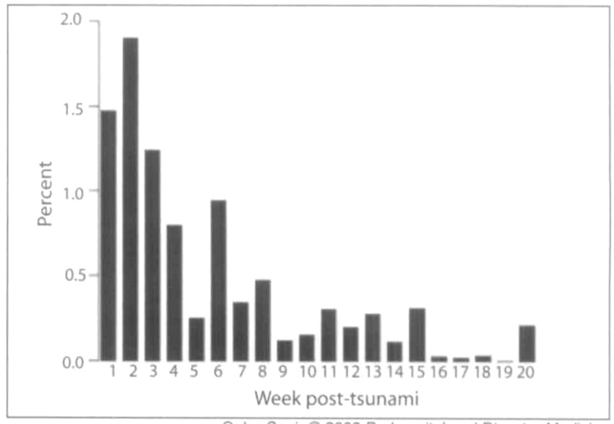

Figure 5—Injuries as percent of total consultations reported to WHO in Aceh by week between January and May 2005

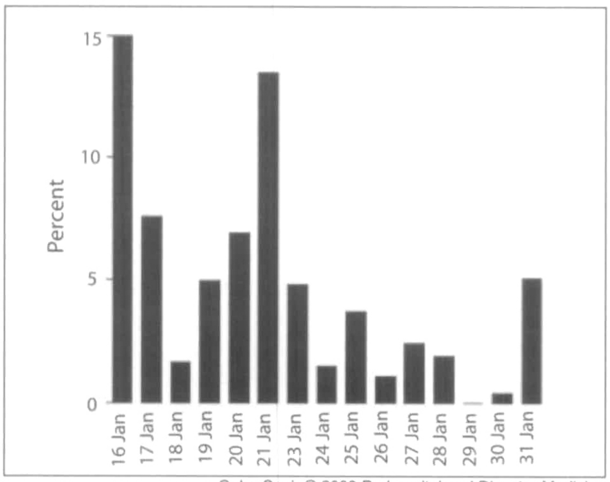

Figure 6—Injuries as percent of all consultations per day at the International Committee of the Red Cross hospital in Aceh January 2005

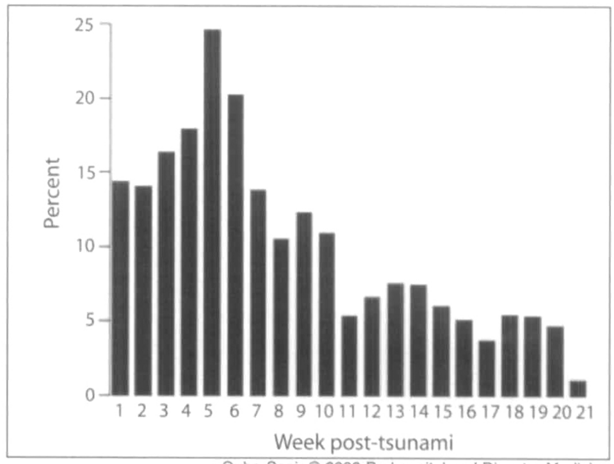

Figure 7—Acute respiratory diseases as percent of total consultations reported to WHO in Aceh by week between January and May 2005

wounds, fractures, and general trauma accounted for 15% of consultations by 16 January, and gradually decreased afterward (Figure 6). The hospital medical and nursing staff confirmed the involvement of highly resistant and unusual pathogens in wound infections after the tsunami.

Respiratory Infections

During the first five months following the tsunami, 37,492 cases of acute respiratory infections (ARIs) in Aceh were reported to the WHO. This compares to 10,000 pneumonia cases reported among children <5 years of age in 2004. As indicated in Figure 7, ARI, as a proportion of all reported consultations, decreased significantly after the first six weeks, suggesting that the largest caseload occurred within two months after the tsunami. A large proportion of cases occurred in adults, with less than one-third in children <5 years of age. The ARIs treated at the ICRC hospital in the three weeks following the tsunami are in Figure 8. The number of lower respiratory tract infections declined sharply in the second week. From week 4 onward, the proportion of upper respiratory tract infections increased again, suggesting a transition to a normal disease pattern. Hospital staff confirmed that high antibiotic resistance and unusual pathogens complicated the treatment of pneumonia, often necessitating advanced antibiotic regimens as first-line treatment.

Discussion

The epidemiological evaluation of the impact of disasters due to natural hazards on disease requires information from the periods before and after the event. Often, disaster-prone countries have limited resources for disease surveillance, limiting the pre-disaster information. Post-disaster information often is limited due to acute challenges to the health system posed by the disaster, such as mass-migration, damaged infrastructure, etc. The 2004 tsunami had the largest impact on Aceh Province in Indonesia, where disease surveillance and public health services already were limited before the tsunami. In addition, the damage caused by the tsunami also included structures of the MOH leaving most surveillance documentation destroyed. Therefore, analysis depends on scattered information on major diseases in the period before the tsunami from the national MOH and surveillance data collected by the WHO after

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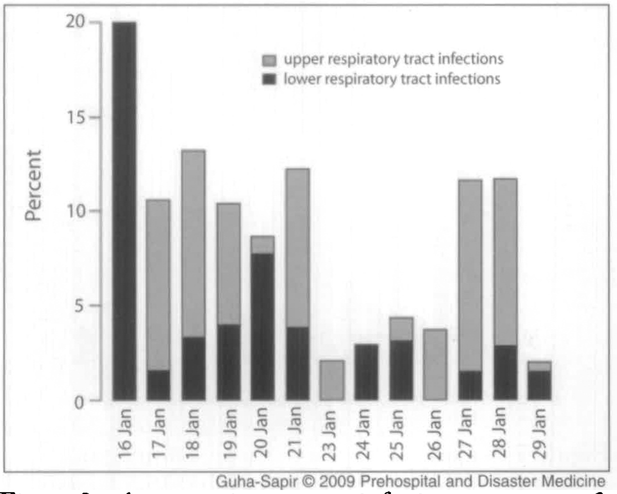

Figure 8—Acute respiratory tract infections as percent of all consultations per day at the International Committee of the Red Cross hospital in Aceh January 2005

the tsunami. Post-tsunami surveillance data lacked denominators because of large-scale population movement in the affected area. This lack of denominators limited the comparison between pre- and post-disaster period, because numbers of cases of certain diseases could not be standardized by population counts (Table 2).

No cases of cholera were reported after the tsunami. This corresponds with the epidemiological profile of this disease in the tsunami-affected areas of Indonesia. Generally, cholera occurs in Indonesia between the months March and September and not in December, when the tsunami occurred.[10] In the winter, the temperature of the coastal waters in the tsunami-affected areas is too low for cholera transmission.[14] After the tsunami, all relief agencies identified drinking and washing water as critical, and the displaced were housed in small, organized camps, rather than in large, crowded camps. These two preventive measures further mitigated the already unlikely potential for a cholera outbreak. Heightened media attention encouraged rumors and triggered investigations, ultimately with negative findings. In spite of this absence, around mid-April 2005, a cholera immunization campaign targeting 150,000 people began using a new oral vaccine (Dukoral®). Each individual >2 years of age received two doses in a 1–2 week interval.[15] No evidence indicates a heightened risk of cholera epidemics following sudden-onset disasters due to natural hazards in general, and this was even less the case in Aceh, given the pre-existing profile of the disease in this province. The media should be discouraged from sensational reporting that leads to ineffective use of funds, and evidence-based risk assessment should be emphasized.

Despite the anticipation of large outbreaks of vector-borne diseases after the tsunami, few cases of dengue and malaria were reported. The risk of vector-borne diseases after a flood requires the presence of several risk factors in addition to the flooding itself, such as presence of the vector, presence of the pathogen, breeding sites, population migration to and from endemic areas, reduced access to health facilities for diagnosis and treatment, and disruption of prevention and control programs.[16] There were few such risk factors for dengue or malaria outbreaks in Aceh. The coastal area of Aceh is a naturally low endemic region with most cases occurring further inland. The main vectors of malaria and dengue are the *Anopheles* and *Aedes* mosquitoes respectively, which breed in freshwater.[17] The saltwater flooding from the tsunami was more likely to decrease such breeding sites.[18] The dengue vector mainly breeds in discarded containers and water storage jars, and such breeding sites may have been increased by debris from the tsunami filled with rainwater.[16,19] Altogether, there was little epidemiological basis for anticipating an increase in vector-borne diseases, much less an epidemic. Similar conclusions were drawn in Sri Lanka and India.[19,20] A large heterogeneity of malaria and dengue incidence among localities requires rapid risk analysis to be undertaken before launching major disease control operations in this region.

The risk of tetanus during disasters due to natural hazards has been observed previously, such as after hurricanes Andrew and Iniki in 1992.[21,22] Low coverage rates of tetanus vaccination in Aceh posed a significant post-tsunami risk of this disease, especially given the number of injuries associated with removing debris from homes and searching for belongings. The lack of preparedness for a tetanus outbreak after the tsunami emphasizes the importance of developing emergency guidelines for tetanus control and appropriate training of medical relief personnel, as demonstrated by the 100% survival rates at the ICRC hospital. Equipment and facilities should be available immediately post-disaster, as the first cases will develop rapidly.

Wounds and injuries are among the major causes of morbidity and mortality during sudden-onset disasters[16] due to natural hazards and many were reported in Aceh. Many wounds became infected and were difficult to treat due to unusual pathogens and antibiotic resistance. This implies that the capacity for diagnosis, confirmation, and treatment of unusual and highly resistant pathogens must be built into preparedness frameworks, such as inclusion of antibiotics for expected pathogens in emergency health kits, which currently is not done.[23] Finally, in-depth studies of injury and wound infections following such disasters would contribute substantially to better medical relief.

Even in the absence of a disaster, respiratory infections are among the leading causes of mortality and morbidity in developing countries: they accounted for 50.4% of the infectious disease burden in Southeast Asia in 2002.[24] However, during disasters, the acute infection rate is likely to increase because of the disaster, forming a significant proportion of the immediate health effects requiring medical relief. In addition, chronic infections (especially tuberculosis or asthma in poor communities) already may be significant before the disaster and may require continued care afterward.

In water-related disasters like the tsunami, aspiration pneumonia is important. In near-drowning events in tropical settings, such as the tsunami, some rare pathogens may cause these pneumonias as have been reported from Thailand and Australia.[25–27] Many of these are especially difficult to diagnose and treat. Antibiotic resistance in Indonesia makes treatment of even common microbiological pathogens complicated.[28] Many antibiotics necessary for the treatment of unusual pathogens in near drowning (e.g., imipenem, amphotericin B, ceftazidime, clindamycin, azithromycin, and vancomycin) are drugs that generally are not available in developing countries. Timely and appropriate treatment is essential because near-drowning-associated pneumonias are linked to high fatality rates in young, otherwise healthy persons.[27, 29] Medical relief agencies working during flood disasters should be prepared to diagnose and treat severe and uncommon pneumonias using second-line antibiotic treatment regimens, as well as intensive care equipment such as ventilators and monitors. Emergency medical teams should be aware of the resistance patterns in the target areas before or shortly after arrival in order to respond appropriately to the situation.

Conclusions

There are several conclusions to be drawn from the post-tsunami findings. First, although certain diseases (cholera, malaria, dengue) are commonly feared, they are not always a priority immediately after a disaster-causing event. A quick evaluation of the existing patterns of disease should be a prerequisite before funding and launching massive response operations. In most circumstances, national and state ministries typically can provide the needed data and pertinent advice. Even in emergency situations, decisions should be based on evidence.

Second, because the number of disaster-related health conditions fell to almost negligible around six weeks post-earthquake and tsunami, health and humanitarian agencies should begin immediate coordination with the Ministries of Health for appropriate use of relief funds and integration into existing systems.

Surveillance systems require more research and development, as evidenced by advances made with the WHO system used immediately after the tsunami. An applicable prototype should be developed for upcoming emergencies, whether natural or manmade. Priorities should be estimating denominators and reporting formats, with a design that allows integration into normal systems once the relief phase ends. Key national health officers should be consulted immediately after a disaster-producing event regarding the risk of outbreaks, and population denominators should be established as soon as possible and monitored for changes. If military medical corps are involved, as increasingly is the case, protocols for handing over military medical services should be a part of the international preparedness plans.

Third, guidelines for tetanus and aspiration pneumonia should be included in disaster medicine development strategies and handbooks. Wound management is an important aspect of immediate relief, and also should be included in the medical training for emergency relief. In addition, although there are no findings presented here on maternal and child health services, deliveries occurred with undiminished regularity and in worsened conditions following the tsunami. Humanitarian aid groups should be prepared to provide emergency obstetrics and post-natal services.

Finally, funding for relief during disasters due to natural hazards always should involve consideration of funding sustainability limits. This approach is not contradictory to providing immediate relief, but requires planning and technical capabilities. Relief spending levels can be significant relative to past aid for development of the affected society, but to spend the funds on one-off actions that contribute little to the long-term welfare of the populations is thoughtless and wasteful. Clear strategies must be established for effective transition from emergency relief to development strategies.

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