The microbiology of the tsunami

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The earthquake that occurred on 26 December 2004 off the west coast of Sumatra triggered a series of tsunami waves 7-15 metres in height which devastated several countries bordering the Indian Ocean [1]. The estimated death toll exceeded 227,000, thousands more were left destitute and the infrastructure of affected communities was destroyed.

This devastating disaster presented the local health authorities and the international agencies that assisted them in the tsunami relief effort with two different microbiological challenges. Firstly, in the days and weeks after the tsunami, there was the influx of survivors with infected traumatic wounds or pneumonia after near-drowning. Secondly, there was the persisting threat for weeks and months after the tsunami of infectious disease epidemics among the internally displaced persons (IDPs) congregating in temporary shelters with limited sanitation, food and clean water [2].

This article will discuss these two microbiological aspects of the tsunami. The results from the first 3 weeks of the deployment of the Australian microbiology laboratory will also be presented and the published literature on infectious diseases associated with the tsunami will be reviewed.

Figure 1. **Chest radiograph of tsunami survivor in Fakinah Hospital, Banda Aceh, with pneumonia after near-drowning.**

Infections in survivors of the tsunami

The establishment of an Australian microbiology laboratory in Banda Aceh, Indonesia, is described elsewhere in this journal [3]. The laboratory supported the Australian medical teams in Banda Aceh and performed microbiology investigations for public health authorities.

Though 30 years of civil unrest had left Aceh Province relatively isolated from the outside world, isolates of methicillin-resistant *Staphylococcus aureus* (MRSA) and multi-resistant (MR) *Pseudomonas aeruginosa* were obtained from two Acehnese patients with extensive traumatic wounds sustained during the tsunami. The presence of these MR organisms in Indonesia was perhaps not surprising remembering the high rate of such pathogens among the Bali bomb victims evacuated to Australia. Other groups have also reported the isolation of MR organisms (e.g. MRSA, MR Acinetobacter and *Escherichia coli* producing an extended-spectrum β-lactamase) from patients with tsunami-related wounds from Thailand and Sri Lanka [4-6].

Pneumonia after near-drowning was another common clinical presentation among the tsunami survivors (Figure 1). In an excellent review of post-immersion pneumonia, Ender & Dolan describe the epidemiology, pathophysiology, microbiology and treatment of near-drowning [7].

The majority of drowning and near-drowning incidents involve previously healthy young individuals, which was also true among the tsunami survivors. The severity of the ensuing pneumonia depends on several factors – the volume of fluid aspirated, the chemical composition of the aspirated water, any concomitant aspiration of gastric contents, and secondary complications such as nosocomial pneumonia. Aspiration of contaminated water is another factor of particular relevance among tsunami patients. Seventy percent of drowning victims aspirate mud, sand and other debris (cited in reference 7). The tsunami survivors with pneumonia after near-drowning had aspirated a muddy sludge of salt water and dirt, which was reflected in the spectrum of microbiological pathogens isolated.

Ten patients with severe post-immersion pneumonia were treated between 3-28 January 2005 by the Australian civilian medical team working at Fakinah Hospital in Banda Aceh [8]. The following organisms were isolated from the eight patients who were investigated – *P. aeruginosa* (5), *Burkholderia pseudomallei* (4) and *Nocardia* sp. (1) (multiple isolates were obtained from two patients).

Water-borne aerobic Gram-negative bacteria (e.g. Aeromonas species, *P. aeruginosa*, coliforms) are recognised as the most common causes of near-drowning pneumonia [7]. Aerobic Gram-positive bacteria (e.g. *Streptococcus pneumoniae, S. aureus*) are rarely cultured from fresh or saltwater, and would therefore be unexpected causes of near-drowning pneumonia. However, a few cases have been reported and probably represent translocation of resident oropharyngeal flora during the aspiration event.

Aspergillus species and *Pseudallescheria boydii* (including the asexual form, *Scedosporium apiospermum*) are found in soil, seawater, freshwater and contaminated water, and are also recognised pathogens in near-drowning pneumonia.

Prophylactic antibiotics are not recommended after near-drownings. Treatment should rather be instituted when patients exhibit the clinical features of pneumonia (e.g. fever, leucocytosis, chest radiograph abnormalities). However, uninfected near-drowning patients can have the same findings, making the diagnosis of near-drowning pneumonia difficult.

The diagnosis of post-drowning pneumonia was, of course, even more challenging in Banda Aceh after the tsunami due to the limited resources. Extended-spectrum penicillin/ β-lactamase inhibitor combinations (e.g. ticarcillin-clavulanate) with or without an aminoglycoside are suitable agents for treating near-drowning pneumonia. Patients at Fakinah Hospital were treated with penicillin/β-lactamase inhibitor combinations, grading up to a carbapenem if there was no clinical response [8]. Specific therapy was instituted if clinical investigations could be performed and a definite pathogen isolated.

Melioidosis, which is caused by *B. pseudomallei*, has only been reported on one previous occasion from Indonesia but its presence in the archipelago is probably under-reported [8]. The disease is well recognised in southeast Asia and northern Australia, and generally presents in patients with predisposing conditions (e.g. diabetes, alcoholism, steroid use, renal failure) as an overwhelming septicaemic or pneumonic illness. None of the four melioidosis patients at Fakinah Hospital had a predisposing condition, and their development of the disease probably represents a massive inoculum in the muddy water aspirated during the tsunami. Interestingly, post-tsunami melioidosis cases have also been reported from Thailand [9].

Nocardia are not listed as common pathogens after near-drowning [7], but the isolation of a *Nocardia* sp. from a patient at Fakinah Hospital is understandable considering that these tsunami survivors aspirated muddy water. Nocardia are one of the 'aerobic actinomycetes', and are ubiquitous organisms present in soil, water and organic matter. Immunosuppressive conditions, including AIDS, are recognised risk factors for nocardiosis, which can present as a superficial cutaneous infection, a pulmonary process, or a systemic disease (often with cerebral involvement). Garzoni *et al.* have also reported a tsunami survivor with a thigh abscess due to *N. africanum* [4]. Other unusual tsunami-related infections due to environmental organisms include a patient with a paravertebral collection due to *Scedosporium apiospermum* [4], and a case of multifocal cutaneous mucormycosis [6].

The threat of communicable disease epidemics

Communicable disease outbreaks are a persistent threat after natural disasters and every effort must be made to avoid epidemics as these can lead to significant and unnecessary morbidity and mortality among disaster survivors [1, 2]. Some of the epidemic-prone diseases that might be expected after a flood or tsunami are listed in Table 1.

The appropriate public health response has been described in detail elsewhere [1,2]. Briefly, public health authorities must obtain baseline data, including information on the infectious diseases normally prevalent in the affected population, the immunisation coverage in the population, and the health resources left intact after the disaster. Rapid assessments must then be undertaken to determine the immediate impact of the disaster, the number and location of survivors, and their urgent needs (including food, clean water, sanitation and shelter).

Surveillance systems to provide an early warning of communicable disease outbreaks must also be established. These surveillance systems need to obtain information in 'real time' from clinical personnel and from laboratories. Specific measures that might need to be instituted include water chlorination, vaccination programs, vector control with insecticides and health education.

The Indonesian Ministry of Health, in partnership with international aid agencies, including the World Health Organization (WHO), instituted all of these measures in Banda Aceh after the

Table 1. **Potential epidemic diseases following floods (adapted [1, 2]).**

Water-borne	Vector-borne
Cholera	Malaria
Dysentery	Dengue fever
Typhoid fever	West Nile virus
Hepatitis	Japanese B encephalitis
Leptospirosis	
Person-to-person	**Wound-related**
Measles	Tetanus
Pneumonia	
Meningococcal meningitis	

tsunami [10]. A surveillance/early warning and response network (EWARN) system was established targeting residents and IDPs. Health facilities were surveyed for clinical syndromes (e.g. acute watery diarrhoea, bloody diarrhoea, fevers, jaundice, suspected measles, acute respiratory infections, meningitis and tetanus).

Public health laboratories were contacted daily for lists of positive results. The Australian microbiology laboratory contributed to this EWARN system and detected four shigella cases (all susceptible only to ciprofloxacin), one non-typhoid Salmonella isolate, two cases of *Plasmodium falciparum*, and one case of *P. vivax*. The public health authorities in Banda Aceh used this information to improve water supplies, sanitation and vector control at the temporary shelters of the affected patients.

Nearly 185,000 clinical consultations were reported to the EWARN system in Aceh Province by 27 March 2005 (i.e. week 12 post tsunami) [10]. Acute respiratory infections (62%), acute watery diarrhoea (23%) and fever of unknown origin (11%) were the most common presenting conditions.

A cluster of 106 tetanus cases was recognised in the month following the tsunami; the experience with 10 tetanus cases at Fakinah Hospital is described elsewhere in this journal [11]. Vaccination of patients with tetanus-prone wounds was instituted and the 'epidemic' abated.

Similarly, 35 cases of measles were reported between 8 January – 19 February 2005, and an emergency vaccination campaign was instituted targeting children aged 6 months – 15 years [10]. The occurrence of these two vaccine-preventable diseases in Aceh Province after the tsunami reflects the province's low vaccine coverage resulting from years of civil unrest.

No significant water- or vector-borne disease outbreaks occurred in Aceh Province after the tsunami, despite the presence of >500,000 IDPs in temporary shelters with initially limited supplies of clean water or adequate sanitation (Figure 2) [10]. Surprisingly, the actual risk of water-borne epidemics is low after floods unless there is significant population displacement and/or water sources are compromised [1]. Even these risks can be minimised if public health authorities recognise water contamination events and priority is given to the provision of clean water, as occurred in Aceh after the tsunami.

Furthermore, the Aceh population was generally healthy and familiar with the need for hand-washing and boiling drinking water prior to consumption [10]. The absence of heavy monsoonal rains after the tsunami also provided public health authorities with an unexpected respite from water- and vector-borne diseases.

Figure 2. Family in temporary shelters in Banda Aceh after the tsunami.

Finally, the absence of communicable disease epidemics in Aceh was a credit to the good cooperation between the Indonesian Ministry of Health, WHO, other international organisations, and the various medical teams that took part in the tsunami relief effort.

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