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SPECIAL ARTICLE

Epidemiology and infection in famine and disasters

Despite advances in health care in the tropics, and the inputs of international and voluntary organisations, famine and disaster continue to cause major devastation in many developing countries. In the aftermath of acute disasters such as earthquakes or cyclones and in chronic post-famine relief camps, mortality rates may be 20–30 times greater than those in 'normal' years [1]. The interaction of malnutrition, crowding, poor environmental sanitation, and changes in host parasite relationships due to migration or environmental change, result in communicable diseases playing a major role in excess morbidity and mortality.

The World Health Organisation has designated the 1990s as the Decade of Disaster Mitigation. At the beginning of the decade, mortality rates in current famines remain unacceptably high [2]. In this article, published data on the impact of communicable diseases in disasters over the past two decades is reviewed and strategies for reducing infection related morbidity and mortality are proposed.

The epidemiological background

Throughout history famine and disaster have been associated with excess mortality resulting from starvation and epidemic diseases. In a detailed review of Indian famines, Passmore [3] has described the complex interaction of destitution, malnutrition and 'famine diseases'.

Lechat, at the Centre for Research into the Epidemiology of Disasters (C.R.E.D.), Louvaine, has laid the modern foundation for the application of epidemiology to the assessment and management of disasters [4]. The first requirement has been a classification system for disaster types. While a cyclone in Bangladesh, an earthquake in Guatemala, and a famine in Ethiopia may all be termed disasters, they are very different phenomena and will result in different patterns of morbidity and mortality. Lechat has classified disasters into those that arise from natural events and those that are due to human/political factors, and has subdivided these groups according to the speed of onset (Fig. 1) [5].

This classification system enables a preliminary prediction of the health consequences of disasters. In rapid onset disasters most mortality is due to the disaster event and occurs within hours or days of the disaster. Malnutrition and long term morbidity are often not associated with disasters of this type [6]. In slow onset disasters, there is often no definable disaster 'event', and mortality rates may not peak for many months after a failed harvest or a political upheaval. Famine related morbidity and mortality follow a series of complex, but predictable, events [7]. Food scarcity, whether due to drought or to devastation following war, leads to malnutrition, mass migration, and an indeterminate period in relief or refugee camps. Arrival at relief camps often presents an environment

Disaster type	Onset	Example	Early mortality	Malnutrition	Late Morbidity mortality
Natural	Rapid	Earthquake	High	Low	Low
	Slow	Drought	Low	High	High
Man-made/ political	Rapid	War (e.g. Lebanon, 1982)	High	Low	Variable
	Slow	Forced displacement (e.g. Southern Sudan, 1988)	Low	High	High

Fig. 1. Health and nutrition in different disaster types.

in which communicable disease transmission is very high. Such camps have been described as 'one of the most pathogenic environments imaginable' [8].

Causes of mortality and morbidity in disasters

Excess mortality is the principal measure of the impact of disaster on a community. Surveillance studies have shown that the patterns and causes of mortality vary in different disaster types [9]. In acute disasters, highest mortality rates occur in the immediate post disaster period. Somner and colleagues [10] investigated the time pattern of mortality following an extensive cyclone in the coastal region of Bangladesh. Among an affected population of 1·5 million, a mortality rate of 160/1000, representing 225000 deaths, was recorded in the first few days following the cyclone. A second survey 2 months later showed that death rates had returned to normal. Spencer and colleagues [11] show a similar pattern following the 1976 Guatemala earthquake. Most deaths were reported within 5 days of the disaster. By day 18, referrals to hospitals and clinics had returned to normal levels. In a flood disaster in Puerto Rico, Dietz and colleagues [12] monitored mortality rates over a 5-week period. All deaths resulted directly from the floods, and follow-up over a 5-week period showed a rapid return to pre-disaster mortality rates.

Mortality patterns following famines and among long-term displaced populations are more complex and have recently been reviewed by Toole and Waldman [1, 2]. 'Average' crude mortality rates (CMRs) in developing countries in 'normal' years are in the range of 0·5–3·0 deaths/1000/month [13]. CMRs from selected famines and refugee displacements are given in Table 1. Rates of 20–30 times average are not uncommon. Recent data from southern Sudan [14] have shown mortality rates of 90/1000/month. Such CMRs conceal even higher rates among specific groups. In camps in eastern Sudan in 1985 with a CMR of 27/1000/month, the mortality among children under 5 years of age was 66/1000/month, and among severely malnourished children, as high a 300/1000/month.

Toole and Waldman [2] have investigated trends in mortality rates with time for refugees in Somalia, Sudan, Ethiopia and Thailand. Among Kampuchean

Table 1. *Crude mortality rates from selected disasters*

(after Toole and Waldman [2])

Country region	Origin of refugees	Population	Reporting period	CMR: deaths/1000/month	
				Refugees	Host country
Refugees					
Bangladesh	Burma	200000	June–Dec 1978	6·3	1·7
Thailand, Sakaeo	Cambodia	32000	October 1979	31·9	0·7
Somalia, Ali Matan	Ethiopia	60000	August 1980	30·4	1·8
Sudan, Eastern camps	Ethiopia	220000	Jan–March 1985	16·2	1·7
Western camps	Chad	25000	September 1985	24·0	1·7
Malawi, Mankhokwe camp	Mozambique	30000	Jan–June 1987	1·0	1·7
Ethiopia, Hartisheik A	Somalia	170000	Feb–April 1989	6·6	1·9
Internally displaced persons					
Mozambique, Gaza/Inhambane	—	2100000	Nov 1982–Oct 1983	8·0	1·4
Ethiopia, Korem camps	—	100000	Oct–Dec 1984	60–90	2·0
Shoa (famine victims in villages)	—	380000	Feb–Oct 1985	8·2	2·0
Sudan, El Meiram	—	6000	July 1988	90	1·7

Table 2. *Causes of morbidity, E. Sudan 1985 [15]*

Diagnosis	Age (years) < 5	5–14	> 14
Malaria	112*	70	84
Measles	97	47	2
Diarrhoea	130	78	108
Acute respiratory infections	63	47	45

* Cases/1000/month, February 1985.

refugees in Thailand, mortality rates declined rapidly after arrival of refugees in camps. In Sudan and Somalia, mortality rates remained high until 4–6 months after arrival. In the Ethiopia data, mortality rates increased after refugees had been in camps for 6 months. Continuing high death rates may be due to outbreaks of communicable diseases in crowded camps, or to decline in nutritional status because of interrupted food supplies.

Disease specific mortality and morbidity

The impact of communicable diseases on disaster associated mortality and morbidity has been shown to vary in different disaster types. In the studies from acute disasters cited above [10–12], no outbreaks of communicable disease were reported. Western [16] has noted that, contrary to common expectation, epidemics are rare in acute disasters. However, some studies have reported communicable disease outbreaks following cyclones and floods. Siddique and colleagues [17] described a diarrhoea outbreak following a cyclone and flooding in coastal Bangladesh. In a 3-week period following the cyclone, over 12000 cases of diarrhoea were reported. In the limited number of specimens submitted for laboratory investigation, *Vibrio cholerae* 01, biotype El Tor, was the predominant pathogen. Other studies have described an outbreak of leptospirosis following floods in Brazil [18], and malaria following floods in Ecuador [19].

Among famine and refugee populations communicable diseases are a major cause of morbidity and mortality. In descriptive reports of health care in relief camps in Biafra [20], Bangladesh [21], the Sahel [22] and Somalia [23] diarrhoeal diseases, acute respiratory infections, measles and malaria have consistently featured as the principal causes of morbidity and mortality.

Some studies provide quantitative data on the impact of these diseases. In Somalia [24], measles, diarrhoeal diseases and acute respiratory infections were together responsible for 60–90% of all deaths. In Thailand [25] malaria was responsible for 50% of admission to the camp hospital, and was the major cause of mortality. Causes of morbidity in eastern Sudan refugee camps are given in Table 2 [15]. In this study, measles was the principal cause of mortality, with a case fatality rate of 3 to 1 among children aged less than 5 years.

Each of these studies has shown that most morbidity and mortality is due to an increased prevalence of diseases already common among poor communities, and that 'classical' epidemics, of diseases such as cholera, typhoid or typhus are relatively uncommon. Examples of such epidemics have occurred, including cholera in Sudan [26], typhus in Ethiopia [27] and meningitis in Thailand [25].

While epidemics cause considerable public anxiety and have implications for the host governments, epidemic related mortality has usually been much less than that due to the increased prevalence of diseases such as measles.

In an outbreak of cholera in a refugee camp of 30000 people in Sudan in 1985 [26], 1175 cases and 60 deaths occurred over a 6-week period. This figure gives a mortality rate due to cholera of 3/1000 population/month compared to a mortality rate of 15/1000/month for measles in adjoining camps.

Most studies of mortality and morbidity have been undertaken in the early stages of refugee crises. If refugees stay in relief camps for extended time periods, the pattern of diseases changes. In Somalia, mortality due to measles declined considerably after immunization programmes had been implemented. However, tuberculosis, which had been relatively uncommon in the early stages of the camps [24] became the major public health problem by 1982 [28]. Problems of defaulting from treatment, particularly in a potentially mobile refugee population, exacerbate the difficulty of tuberculosis management. Mastro and Coninx [29] have described the difficulties of maintaining tuberculosis treatment programmes in Khmer camps on the Thailand border. All eight camps in which T.B. programmes were started were attacked at different stages, leading to dispersion of patients on treatment, though many were relocated and continued treatment. Other studies from long term refugee camps [30] have shown acute respiratory infections, diarrhoeal diseases and malaria to be continuing problems.

Risk factors associated with communicable disease morbidity and mortality

Foege [31] has described the health risk factors among famine affected populations (Fig. 2). Famine conditions result in increased individual susceptibility to infectious disease through malnutrition, and increased transmission through crowding, poor sanitation and population movement.

Malnutrition

Many papers have been published describing the clinical association of malnutrition and infection [32, 33]. Among refugee populations, severely malnourished children experience the highest mortality rates [15]. Despite these apparent associations, the role of malnutrition *per se* as a cause of mortality in refugee or famine affected populations is open to question, and has been reviewed by de Waal [34]. De Waal proposed two opposing models, the 'food crisis model' which states that starvation is the major cause of mortality, and the 'health crisis model', which suggests that increased transmission of communicable diseases, independent of nutrition status, leads to most mortality. De Waal supports the 'health crisis model', based on studies of mortality in famine affected areas of western Sudan, where mortality rates among children were shown to be independent of various measures of 'destitution', though nutrition status itself was not measured. Other data from Sudan give further support to this model.

In the camps in eastern Sudan [15], while mortality rates were exceptionally high among severely malnourished children, only a small proportion of the camp population came into this category, and the vast majority of deaths occurred in children who were not severely malnourished. While other studies have shown higher mortality rates in camps with higher proportions of moderately

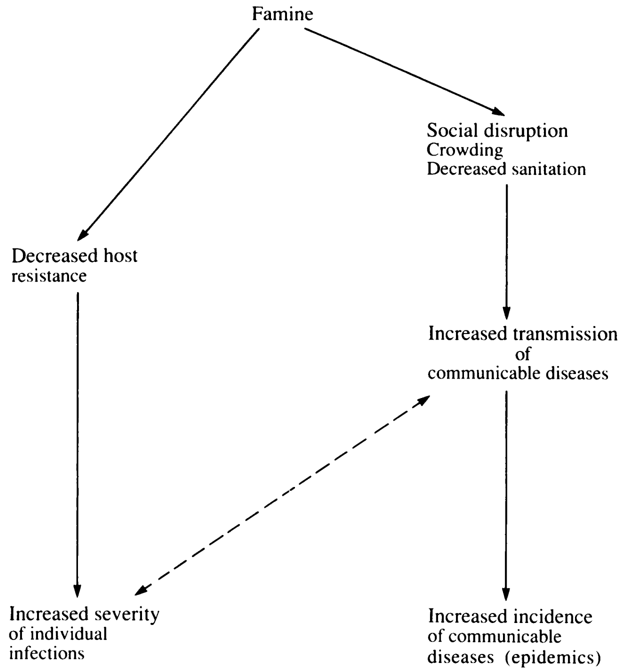

Fig. 2. Risk factors causing increased disease transmission and morbidity.

malnourished children [35] these studies have not excluded other variables such as crowding, underlying immune status, quality of health care etc. which may also have been responsible for higher mortality rates in these camps. The distinction between the health crisis model and the food crisis model is important in relation to relief inputs. Continuing emphasis on the food crisis model, while providing necessary food inputs may reduce the urgency for disease control interventions.

Water supply and sanitation

Diarrhoeal diseases are clearly responsible for much morbidity and mortality in disasters. In most studies this appears to be due to an increased prevalence of 'endemic' gastroenteritis rather than due to epidemics of cholera or dysentery. There have been few investigations however to determine either the aetiological agents responsible or the routes of transmission. In one study in relief shelters in Ethiopia [36], known bacterial pathogens were identified in only 5% of cases of diarrhoea, virus pathogens were not investigated. Attempts to define sources of infection and hence possible strategies for intervention, have rarely been successful. In the outbreak of cholera in refugee camps in Sudan [26], no common source of infection was determined. In a study of cholera outbreaks in famine affected villages in Mali [37], both polluted wells and contaminated foods were shown to be responsible for disease transmission.

Improvements in water supply, and to a lesser extent, excreta disposal, are important components of many disaster relief programmes, but no data has been published to measure the impact of these interventions. In non-refugee programmes in Bangladesh, improvements in water quality have not always resulted in reductions in diarrhoea prevalence in the absence of other environmental improvements [38, 39].

Crowding and increased disease transmission

The relative roles of increased *exposure* and increased *susceptibility* in explaining the high prevalence rates of diseases such as measles in poor communities is complex [40], and have not been investigated in refugee communities. Outbreaks of typhus have occurred in refugee 'shelters' in Ethiopia [27] related to crowding and high rates of vector mediated disease transmission. Apart from the relief 'shelters' used in Ethiopia, and some feeding centres in which large numbers of children congregate, most refugee camps in Africa are relatively uncrowded, with family units living in separate huts or tents. This may explain the relatively infrequent occurrence of outbreaks of diseases such as meningitis, associated with crowded conditions.

Effects of environmental change and migration on disease transmission

The effects of floods on increased transmission of diarrhoeal and vector related diseases has been cited above [18, 19]. Population movement may lead to the introduction of new diseases or to changes in the epidemiology of disease transmission in the host community. A resurgence of smallpox occurred in Bangladesh in 1972 following the return of large numbers of refugees from camps in west Bengal in which smallpox outbreaks had occurred [41]. In outbreaks of meningitis in crowded camps of displaced communities in Khartoum, Sudan, in 1988, chromosomal restriction enzyme typing suggested infection had been introduced by pilgrims returning from Mecca [42]. Movement of susceptible populations into different ecological zones may lead to increased disease prevalence and morbidity. The movement of refugees from highland areas of Ethiopia to lowland, malaria endemic areas adjoining Sudan has been associated with high rates of malaria transmission [15]. A detailed review of internally displaced communities in Ethiopia has described the health aspects of movement to different ecological zones [43]. During 1984–5, 600000 drought victims from the highland regions of northern and central Ethiopia were re-settled in a lowland, semi-tropical area. Malaria, trypanosomiasis, yellow fever and onchocerciasis were identified as new health hazards, to which the population had not previously been exposed.

In war affected areas of southern Sudan, and in camps of displaced southern Sudanese around Khartoum, outbreaks of leishmaniasis have recently been reported [44], which may be due to movement of a non-immune population and changes in vector ecology.

Surveillance strategies for communicable diseases in disasters

Although effective surveillance systems have only occasionally been implemented as part of disaster relief, the recognition of their importance is not new. In his review of Indian famines published in 1951, Passmore stated 'clearly a basic requisite of any famine organisation is an intelligent study of up-to-date returns on mortality' [3]. The lack of surveillance or epidemiological input into most disaster relief has led Lechat to describe disaster response as 'the crisis dominated convergence of mobile hospitals, specialized surgeons, time expired drugs, and vaccines for diseases with zero incidence' [4].

In many disaster affected areas, data collection is difficult, and different strategies have been implemented for disease and mortality surveillance. Where most of the affected population can reach clinics or hospitals, passive surveillance based on outpatient or admission data can be effective, and has been used following an earthquake in Guatemala [11] and floods in Puerto Rico [12]. However, in less acute disasters, passive reporting can lead to an over representation of minor conditions, particularly among traditional societies where some diseases such as measles may not be brought to medical attention. In refugee camps in Sudan, while most mortality occurred among children under 5 years of age, over 50% of all clinic attendances were by adults [15]. Clinic based studies in Somalia have shown a high reporting of non acute conditions [45].

Various degrees of active surveillance have been utilized in different disasters. Woodruff and co-workers [46] used existing and temporary health centres for the reporting of diseases with highest potential for morbidity or epidemics following extensive flooding in Khartoum, Sudan. They used standard reporting forms, with symptom orientated case definitions, for use by basically trained health workers. In Thailand, an active system of surveillance for 12 diseases, each requiring urgent public health intervention, was initiated in Kampuchean refugee camps [30]. Among other benefits, the system provided an early indication of an outbreak of dengue haemorrhagic fever.

Where no health centres or clinics exist, an active system based on field surveys is necessary. Following the 1970 cyclone in east Bengal, in which an area of 2000 square miles with a pre-disaster population of 1700000 was devastated, initial data collection was undertaken at relief centres, the only point of access to the affected population [10]. As movement in the area became possible, a subsequent survey used cluster sampling to ensure uniform coverage of the affected area.

Effective surveillance systems enable the most at risk groups to be identified, and the more effective planning of often limited health and nutrition interventions [47]. Equally important, surveillance systems have enabled health staff to correct media rumours of epidemics. Following the 1976 Guatemala earthquake, 30 reports of outbreaks involving 8 different diseases were shown by the surveillance study to be without foundation [11].

Laboratory support for disease surveillance is usually severely limited in disasters, particularly in famine affected areas of Africa, and most reporting is based on clinical definitions. There is a need to develop appropriate field laboratory systems for disease surveillance and outbreak investigation [48].

The effectiveness of surveillance in influencing decision making will depend on rapid data analysis and early dissemination to field personnel and to national bodies for co-ordination of relief inputs [2]. Use of computer software incorporating disease surveillance and outbreak investigation such as EPI-INFO [49] may both facilitate disease surveillance and increase its acceptance by relief administrators.

Discussion and conclusions

There is little evidence to suggest the occurrence of disasters and famines, particularly in the tropical world, will decrease in the next several decades. However, excess morbidity and mortality, particularly due to communicable diseases, could potentially be reduced. From this review of communicable disease morbidity and mortality in disasters, a number of strategies to mitigate the health effects of disasters are evident.

Different disaster types have been shown to have different health problems, both in the causes and time pattern of morbidity and mortality. The relative lack of epidemics following acute disasters should reduce the unnecessary shipment of medicines and vaccines and allow limited transport supplies to be used for the less emotive but more practical requirements of shelter and reconstruction materials.

In relief camps in famine affected areas of Africa, the need to base health programmes on infectious disease control, in particular the prevention of measles, rather than on general, curative clinics, is evident from most of the published studies. While food inputs for the displaced communities are essential, an emphasis on nutrition programmes at the expense of disease control may lead to unnecessary morbidity and mortality.

There are a number of areas requiring further epidemiological research. The conflicting 'health crisis' and 'starvation crisis' models of de Waal need to be further investigated to determine the relative role of moderate malnutrition to morbidity and mortality. This may be different in refugee camps with high disease transmission rates compared to non-refugee situations in which these relationships have previously been investigated [50]. Studies of the epidemiology of diseases such as meningitis and measles, whose seasonal patterns among the local community may be modified by inward migration of susceptible refugees may improve the predictability of outbreaks in new refugee areas. The role of risk factors such as crowding, water supply and vector populations on morbidity and mortality may be a fruitful area of research by disease modelling [51]. In the immediate future, the principal recommendation must be for a general acceptance of the need for effective disease and mortality surveillance systems. Considerable progress is being made in disaster epidemiology even though its value may not be generally accepted. The work of Lechat at the Centre for Research in the Epidemiology of Disasters (C.R.E.D.), the studies by Toole and Waldman and colleagues at the Centers for Disease Control, Atlanta, and the recent formation of Epicentre by the relief agency Medicins sans Frontières in Paris, provide together a major resource in disaster epidemiology and surveillance [52].

In the coming decade, the application of such techniques may contribute to reducing the excess morbidity and mortality that is still associated with famine and disasters.

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