HEALTH POLICY AND PLANNING 1986; 1(2): 118–126

Reducing the impact of natural disasters: why aren't we better prepared?

DEBARATI GUHA SAPIR AND MICHEL F LECHAT
Centre for Research on Disaster Epidemiology, University of Louvain, Brussels, Belgium

Natural disasters can be classified into four main types: floods, earthquakes, cyclones and droughts. This paper compares these types of natural disaster in terms of four characteristics: predictability, scope, onset delay and lethality. Special attention is paid to the last of these characteristics. It is found that the mortality and morbidity associated with natural disasters has changed over time and varies between regions. The variation between regions correlates with differences in socio-economic conditions, the impact of a disaster in a poor area being much greater than the impact of a disaster of similar physical characteristics in a richer area; it appears that the impact of a disaster is as much a function of the local conditions as it is of the nature of the disaster itself. The paper then goes on to consider the nature of the emergency aid that is offered following emergencies. It concludes that it is often wasteful and inappropriate, coming too late into a situation in which conditions have already dictated that mortality and morbidity will be high. Suggestions are made of ways in which funds allocated to disaster relief could be better focused so as to reduce population vulnerability in the face of natural disasters.

Introduction

Natural disasters which occur relatively frequently and have a significant impact may be classified into four main categories: floods, earthquakes, cyclones and droughts. Other catastrophic events, such as landslides, avalanches, snow and fires occur less often and threaten smaller proportions of the populated world. The destructive agents in four main classes mentioned above are wind, water (a lack or excess thereof) and tectonic forces. While all these generally cause structural damage, their mortality and morbidity effects are variable.

The disaster cycle can be differentiated into five main phases, extending from one disaster to the next. The phases are:

- the warning phase indicating the possible occurrence of a catastrophe and the threat period during which the disaster is impending.
- the impact phase when the disaster strikes.
- the emergency phase when rescue, treatment and salvage activities commence.
- the rehabilitation phase when essential services are provided on a temporary basis.
- the reconstruction phase when a permanent return to normalcy is achieved.

The disaster-induced mortality and morbidity differ between these phases and are also a function of the prevailing health and socio-economic conditions of the affected community. As a result of this, global statistics on disasters seem to indicate a significantly higher frequency of natural disasters in the Third World than the industrialized countries.

Assuming nature not to be conscious of economic differences, a disaster may be defined by the vulnerability of the population to a natural event and not by the mere fact of its occurrence (de Ville de Goyet and Lechat 1976).

Special characteristics of natural disasters

It is useful to start by locating the four main disaster types on relative scales of lethality, predictability, onset time and impact scope. This ranking provides some guidance towards understanding the variation in mortality impact noted among disaster events across time and space. Figure 1 displays the four scales with the relative positions of the disaster types.

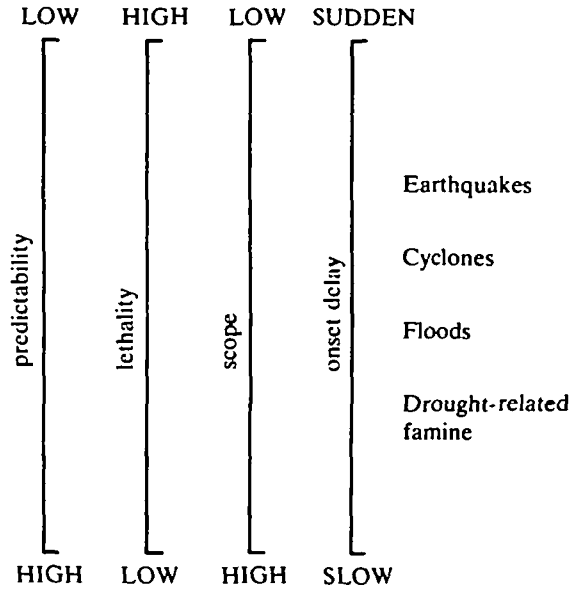

Figure 1. Ranking of principal natural disasters on relative scales of predictability, lethality, scope and onset delay

Although drought-related famine is a very special class of disaster, it nevertheless falls within the general paradigm which characterizes natural disasters. Famines are disasters of high predictability. With the exception of the Great Bengal Famine of 1941–43, almost all important famines since then, and certainly the ones of Sahelian Africa and Ethiopia, were more or less foreseen. Famines, in fact, provide an excellent illustration of the fact that the knowledge of impending disaster does not imply that a community can or will take responsive action.

At the other end of the scale, earthquakes tend to be the least predictable disasters, striking with little warning. Japan is one of the few high risk countries that have an effective warning and evacuation system, as well as excellent community education programmes (Nakano et al 1974). The earthquake of Niigata (16th June 1964) registered 7.7 on the Richter scale. Although 20 000 houses were destroyed, only 13 people were killed and 315 injured. Due to the quality of its preparedness programmes, Japan suffers very limited mortality despite the high number of seismic shocks it registers (Akimoto 1972).

In terms of lethality, earthquakes present the greatest risk of death to those affected (Table 1). Onset delay is also the shortest in earthquakes, which is related, to a certain extent, to its low predictability. Famine, on the other hand, has a slow build up period before it reaches acute emergency proportions. Floods can be somewhat ambiguous in their onset characteristics. They can be slow-developing and fairly predictable such as the annual floods in the plains of the Ganges in India or in the Itajai River basin in Brazil, but nevertheless regularly cause a number of deaths and a certain amount of damage (Civil Defense of Santa Catarina, personal communication, 1983). Acute and catastrophic floods are usually generated by cyclones or tidal waves; examples are the ones in

Table 1. Crude disaster mortality and population affected between disaster types and over time

Disaster type	Deaths		Affected (millions)		Ratio (one death per number affected)	
	1960–69	1970–79	1960–69	1970–79	1960–69	1970–79
Drought	10 100	231 100	18.5	24.4	1:1832	1:106
Flood	28 700	46 800	5.2	15.4	1:181	1:329
Cyclone	107 500	343 600	2.5	2.8	1:23	1:8
Earthquake	52 500	389 700	0.2	1.2	1:4	1:3
Total	193 800	1 011 200	26.4	43.8	1:136	1:43

Source: OFDA. 1960–80.

Philippines (1984) and Bangladesh (1985). Floods cause somewhat lower mortality than other disasters, but the scope of damage is generally wider and more pervasive.

Mortality from natural disaster: trends and differentials

On a global level, the mortality generated by natural disasters shows some interesting tendencies, creating the beginnings of an analytical framework within which specific impacts may be systematically analysed for robust indicators, efficient needs assessment or preparedness and rehabilitation planning. The mortality from disasters is a function of risk, development and coping or adjustment capacity (preparedness). Table 2 displays comparative data on these from a number of countries.

Table 2. Comparative score of risk, development and adjustment capacity *vis-à-vis* natural disasters

Country	Degree of risk	Development stage	Adjustment capacity
Japan	4.0	4.5	4.5
USA	3.5	5.0	4.0
Chile	4.5	3.0	3.0
Bangladesh	4.5	2.5	2.0
Indonesia	4.5	3.0	3.5
The Netherlands	4.0	4.5	4.5
United Kingdom	2.5	4.0	4.0
Malaysia	4.0	3.5	3.5

Adapted from: Sewell and Foster (1976).

The official disaster data reveal two important variations in disaster mortality: a temporal increase and a geographical correlation.

Time trends in disaster mortality

Mortality per event

Between the two ten-year periods, 1960–69 and 1970–79, a significant increase in *average mortality per event* is noted in all categories except perhaps in floods where direct mortality is generally low (Table 3).

The greatest increase is noted in earthquakes, which takes a quantum leap from one period to the next. The mortality in 1960–69 was 750 deaths per earthquake whereas in the following ten-year period the death toll per event went up to 4871 deaths per earthquake. (It is interesting to note here that the total number of earthquakes requiring international assistance did not increase significantly from one period to the next.) The huge increase in earthquake mortality is partially explained by the Tangshan strike of 1976 in China which contributed more than half of the entire ten-year period death toll. The official estimate of 224 000 dead accounts for exactly 47 per cent of the total number dead due to earthquakes during this time.

But even allowing for the Tangshan quake, the death mortality per strike remains as high as 1780 per earthquake compared to 750 in the previous decade. Population density (Lechat 1984), structural quality (Glass et al 1977), time of strike (de Bruycker et al 1983) and intensity of seismic activity (Alexander 1985) seem to be the main risk factors, but they fail to explain adequately the high mortality in earthquakes. Local conditions, evidently, play a bigger role than expected in determining disaster mortality.

Table 3. Changes in disaster mortality between the periods 1960–69 and 1970–79

Disaster type	Deaths per event		Mortality (per 1000 exposed)		Importance of of increase
	1960–69	1970–79	1960–69	1970–79	
Drought-related famine	202	2 311	0.5	9.5	+ + + +
Flood	158	213	4.5	3.0	–
Cyclone	88	2 291	43.0	122.7	+ +
Earthquake	750	4 871	262.5	324.7	+

Adapted from: OFDA (1960–1980)

Mortality per 1000 exposed

The mortality rates per 1000 exposed to disasters increase significantly over the two decades for all types of disaster except floods, although the increase is relatively slight in earthquakes. This stability in the mortality rates of earthquakes is mainly due to its being a high risk disaster with comparatively localized effects. The greatest increase is observed in drought-related famines where the population get progressively weaker from previous famines and succumb in each successive crisis in greater numbers. Floods show a slight improvement, as it were. However, the mortality impact of floods may be hypothesized as being typically spread over the period following the flood rather than being a direct and immediate effect of the event.

This increase in the mortality rate possibly reflects the inability of current disaster management policies to reduce the vulnerability of a community. Despite significant disaster assistance, and aid of nearly one billion dollars in the 1970–78 period, the increase in mortality, controlling for the number of events, indicates a steady decline in the resistance of the populations to disasters (Stephens et al 1982).

Regional differentials in disaster mortality

Geographically, the mortality generated by disasters is consistently and positively correlated to the level of the economy. Table 4 presents some figures of mortality classified into three national income categories.

Table 4. Disaster mortality by level of economy

Mortality	Economy		
	Low income	Middle income	High income
Per event	3 300	500	125
Per 1000 population	69	28	19
Per 1000 km²	48	8	1

Adapted from: Swedish Red Cross, 1985.

Mortality rates, controlling for the number of disaster events, are substantially higher in poor countries than in the richer ones. The classification is, of course, gross and the data demand closer analyses for better definition of risk factors and vulnerability patterns amongst the severely affected populations. Such analyses can have direct impact on programme planning and policy-orientation. Table 4, however, does serve to indicate the important influence of the prevailing socio-economic conditions on the eventual disaster impact (Cuny 1983, Shah 1985). For predictive and needs assessment purposes then, the prevalent socio-economic and health conditions prevalent in the affected community could be a better determinant of the epidemiological impact than the physical characteristics of the event.

As seen in Table 4, disaster-generated mortality increases dramatically as economies descend the income scale. Barring a deliberate selectivity of nature in her allocation of high intensity disasters to low income countries, a less 'natural' explanation is the differential power of communities to resist and recuperate from shock.

Table 5 presents some data on the 1971–72 earthquakes of Managua (Nicaragua) and San Fernando Valley (USA) (Seaman 1984).

Table 5. Comparison of characteristics of earthquakes in Managua (1972) and California (1971)

Disaster characteristics	Managua	California
Richter scale reading	5.6	6.6
Extent of destruction (Mercalli Intensity Range VI–VII)	100 km²	1 500 km²
Population in affected area	420 000	7 000 000
Dead	5 000	60
Injured	20 000	2 540

The comparison reveals some interesting points. Speaking 'naturally' of the two earthquakes, the seismic activity level of the California earthquake was significantly higher, registering 6.6 on the Richter scale compared to 5.6 in Managua. (One unit increase is an important proportion due to the logarithmic scale of Richter readings.) On the Mercalli scale (measuring the extent of physical damage over surface area) the California quake caused major damage (IX–XI level damage) over 100 km^2, whereas Managua registered a lower level of damage to a smaller area of land. The population directly affected by the earthquake in California was 13 times that of the earthquake in Managua. Despite all physical conditions indicating to the contrary, the mortality in Managua was somewhere around 5000 deaths compared to 60 deaths in California.

Similarly, in 1974, Hurricane Fifi left an estimated 8000 dead in Honduras, crashing through at a windspeed of about 250 km/h and causing 80 per cent disruption of impact area. In the same year, Cyclone Tracy killed 49 in Darwin, Australia, with a similar windspeed and proportion of impact zone disruption. The selectivity of impact can also be observed on a more localized scale. The Guatemala earthquake in 1976 killed about 1200 people and left 90 000 without homes in the city alone, but almost exclusively from the slum populations.

Shanty towns and slum areas in the burgeoning metropolises of several high risk Third World countries are especially fragile in all kinds of disasters. The unprecedented increase in these slum populations has contributed to the inflation of the disaster victims in the recent years. The Jakarta shanty towns, for example, where floods frequently cause the canals-cum-latrines to overflow into the living quarters of the slum-dwellers, have created epidemics of typhoid and skin and gastro-intestinal diseases and raised infant and child mortality. Flooding in low-lying areas of Bangladesh has exacerbated endemic cholera and other diarrhoeal diseases.

Morbidity after natural disasters

The data on morbidity (namely injuries and disease) after a disaster are remarkable by their absence or incomparability. The definition of injury, when registered, is largely unstated and reporting of diseases largely incomplete. This has resulted in a series of observations, some anecdotal, some systematic, but nearly all fragmentary. There is clearly an urgent need for standardized reporting of injuries and cause of death (preferably using a standard format such as the International Classification of Disease). Without such standardization, disaster planning and management remains an *ad hoc* activity and analyses of the kind attempted here can only be undertaken somewhat superficially.

Injury profiles of natural disasters

There are some recorded figures available on injuries sustained in earthquakes where authorities registered and published morbidity data. It is uncertain what qualified as injury and, more importantly, the bias introduced by those who were not treated in hospital. There are even fewer data on non-traumatic morbidity. Classification bias and general incomparability pose important problems for those making analyses for programme or policy purposes.

In the case of earthquakes, the disaster type most prone to causing traumatic injury, fractures constitute the major portion of the impact. Fractures of the extremities are significantly more frequent than any other sort. In the Tashkent (1966) and Ashkabad (1948) earthquakes, two of the few instances where injuries were classified according to type, about 69 per cent were fractures of the limbs (Beinin 1981). Fractures of the extremities as a proportion of injuries sustained in Managua (1971) and Iran were 77 per cent and 58 per cent respectively (Whittaker 1974, Saidi 1963). In the recent volcanic eruption of Colombia, gaseous gangrene was the second most serious morbid condition next to suffocation. The Mexico earthquake seemed to have relatively few injuries compared to deaths, although the official figures are not yet available. Most injuries, be they lacerations in cyclones or fractures in earthquakes, tend to occur during the catastrophe itself or in the very immediate post-impact phase.

Clearly, in both earthquakes and cyclones, structural quality of housing is a major determining factor of the extent and type of injury, which is, in effect, a proxy variable for the socio-economic level of the community or the household (Haas et al 1977). The relationship between injury and death and other variables not directly related to the catastrophe is discussed later in the paper.

Disease profiles of natural disasters

Despite popular belief, major epidemics are fairly rare events after natural disasters (de Ville de Goyet and Lechat 1976, Seaman 1984), especially in industrialized countries. Some risk exists in developing countries where sanitation is poor and endemicity of many communicable diseases is normally high. A severe malaria epidemic occurred after Hurricane Flora in Haiti in 1964, ostensibly caused by the multiplication of breeding places for mosquitoes in the damaged area. However, the interrelationships between the disaster and the hurricane are more complex and epidemiologically interesting than this explanation indicates. (Lechat, personal communication, 1985).

Overcrowding and breakdown of fragile sanitation systems could, conceivably, provoke epidemics in developing countries. An epidemic of leptospirosis was reported in Recife, Brazil, after floods in 1975 (Correa et al 1972). These are, generally, fairly unimportant in scope. Of a more serious nature are those brought on by famine conditions, such as the cholera epidemic in Somalia in 1985 and meningitis in Ethiopia earlier. Camp conditions, reduced resistance and breakdown of the social systems are possibly the provoking factors for these epidemics, but to what extent and how these factors are associated with the diseases cannot be conclusively established without specific study. Usually, however, disasters do not generate 'new' diseases unless they are brought in by migrating populations, as has been observed in the recent African famines. Floods tend to exacerbate endemic communicable diseases in populations, especially if sanitary and sewage systems are primitive or, as is more often the case, non-existent.

A regional variation in diseases similiar to that seen between developed and developing countries is noted within a developing country. The incidence rates during a cholera epidemic in Bangladesh were found to be correlated to education and income. The poorer sections of the affected region used canal water for drinking and washing purposes and presented, furthermore, a generally lower resistance to infections. The incidence rate of the disease per 1000 families with no schooling was 16.3 whereas it was 8.2 among families with at least one high school graduate (Levine et al 1976). In famines, the synergy between malnutrition and infectious diseases gives it an altogether different dimension as compared to others. Communicable and nutritional deficiency diseases in famine disaster are, in fact, the principal manifestation of the event.

Long-term impact of natural disasters

The long-term impact of disasters, possibly the most pervasive and destructive phase, expresses itself variously. Disaster-induced death and disability of an earning member of a family implies a lifetime's loss of revenue and possible destitution. A study by Karakos et al (1983) after the earthquake of 1980 in Thessaloniki, found that 50 per cent of all the families with at least one death lost their only working member and thus experienced a direct decrease in income. In developing countries, where the informal sector is an important source of revenue for a large proportion of the population and social security is less developed, such a loss can be fatal to the surviving members of the family.

In flooding disasters, salt-water contamination of subsistence and marginal land indicates not one, but several, harvests lost. For nutritionally and economically fragile populations, this means a rise in mortality as a secondary effect of the disaster. Similiarly, death of breeding stock of herdsmen and loss of capital or tools of trade due to water damage, cyclones or earthquakes effectively destroy the means of livelihood of these families (PAHO Disaster Reports 1981). Finally, the death of a mother has a devastating effect on small children, raising the morbidity rates among them (Patil and Koshy 1984). A great deal of empirical work, clearly, needs to be done in order to evaluate accurately the complete health impact of a disaster. So far, impact evaluation stops at counting the dead.

Conclusions and policy implications for the health sector

The increasing interest shown in the impact of natural disasters by researchers in disciplines other than engineering, geology and meteorology has had a salutary effect of raising questions on current international and national disaster policy and relief action. The growing body of literature emphasizing the importance of discriminating between the geophysical event and its human consequences is provoking organizations and governments to take another look at disaster relief. This is an encouraging turn of events given the large calamities witnessed in the last three years and the worrisome increase in the number of victims, dead or destitute (Wijkman and Timberlake 1984, OFDA 1982). Furthermore, with non-emergency developmental aid and co-operation between the first and third worlds grinding to a slow halt, the substantial resources generated by public appeals for disaster assistance demands an efficient and cost-effective use, oriented towards a long-term resolution of the problem instead of an emergency, stop-gap measure.

It is not difficult, even with the patchy and incomplete data available, to demonstrate that the physical characteristics of a natural event do not satisfactorily explain its impact. This paper has cited several comparative instances illustrating this point. Most natural disasters and the damage associated with them are characteristic rather than accidental features of the afflicted community (Hewitt 1983). Although this is well proven (but not widely accepted) in the case of famines, it is less well documented in the more acute disasters. Two of the largest famines since World War II have been in countries with a normal or more than normal food production during the famine year. Rivers (quoted in Wijkman and Timberlake 1984) observed that Ethiopia was a net exporter of food in 1973, and both Bangladesh and Bengal produced more grain in 1974 and 1941 respectively than in the preceding years (Wijkman and Timberlake 1984, Sen 1983). Drought sometimes serves as a trigger mechanism for a famine, but the disaster remains a largely poverty-related catastrophe with a very weak causal relationship to food supply. Similiarly, the impact of other disasters is a function of the physical and economic resistance of the population.

This distinction between the event and the impact brings into a so far simple situation a host of messy, complex and difficult socio-political and economic considerations. The essence of the vulnerability issue lies in the fact that the communities can 'cope with earthquakes but not with their fellows' (Brecht 1965). Japan, as cited earlier, has minimized earthquake-generated damage despite frequent shocks of high magnitude, where Nicaragua and Guatemala are unable to withstand quakes of much lower intensity.

Disaster relief has traditionally been based on policy formulated from charitable motives drawing on critical and emergency care approaches. This has made it a primarily medical activity, involving surgical units flown out with specialist teams and field hospitals equipped with sophisticated life-saving apparatus. On the other hand, research and development in natural catastrophes has concentrated almost exclusively on climate monitoring, radar tracking, flood barriers and other middle to high technology devices. Finally, the charitable nature of disaster relief permits policy to be dictated by the principle that any aid is good aid, thereby generating anecdotes in the literature on the superfluous, inappropriate and frequently, absurd relief packages. Lechat (1981) has pointed out that even volunteers, who tend to descend upon the scene, can be a serious liability in a crisis situation, due to their inexperience and redundancy.

As far as policy is concerned, two observations are in order before discussing further the implications. First, although medical care (in so far as surgical and critical care is implied) appears largely unnecessary, health and public health, having played thus far a small but significant role, have a responsibility and potential in this area. Second, the central issue in management and relief in natural disasters has to be recognized as the reduction of vulnerability to disasters of the community and, within it, the population at risk. The progressive diminution of mortality and morbidity impact of a catastrophe should be the main health policy objective of disaster management.

The extraction of disaster relief from its comfortable niche of charity and emergency care would force planners to address structural issues of the availability, equity and appropriateness of health care in the community. This widening of scope permits and, indeed, demands the inclusion of health planning for disasters in the on-going health plans of the region, thus providing an existing working base and infrastructure. A disaster response could be successfully incorporated into the training of the health workers and their activities. The fundamental tenets of primary health care may be applied to disaster preparedness and prevention programmes, in so far as both involve community participation, multi-sectoral objectives, the use of local resources and building human resource capability.

These aspects of primary health care are especially relevant in disaster management for the several reasons. External emergency disaster assistance is rarely, if ever, either on time or particularly appropriate. This is not due to any sluggishness on the part of the distant agencies, but rather the result of inadequacies in communication, assessment of need, accessibility and other difficulties. It has been observed that families, friends and neighbours search, evacuate and extricate their own in the immediate aftermath of a disaster and that by the time external relief teams are functional on site, a very large majority of the total dead have already died (de Bruycker 1983). In other words, those that die do so within the very first hours of the event, and immediate emergency rescue and care are provided by the local inhabitants. Those that survive the first twenty-four hours generally survive without major bodily harm. In addition, the survivors, contrary to expectations, are rarely in a panic and disorganized. In fact, they act with calm and common sense to manage to the best of their abilities their own affairs (Wijkman and Timberlake 1984). External emergency relief, therefore, is largely expensive, wasteful and not particularly effective.

This, however does not imply that disaster relief should be abandoned, because in a catastrophe people need help and the resources exist. It simply indicates that external disaster relief should focus on reducing population vulnerability and invest in structural changes in health care organization and accessibility of the population. It should also provide training and education at the local level for emergency activities such as evacuation, first aid and so forth. This rationalization of policy would provide the communities with the tools and knowledge by which they could defend themselves against future hazards. Disaster assistance resources could be deployed to expand the primary health care structure and train their personnel in emergency shelter management, rapid epidemiological surveillance and control, food distribution and needs assessment and recording and registration. Health workers are trained to do most of these activities in normal circumstances; the operating principles remain fundamentally the same in a crisis situation, requiring only a certain adjustment due to the urgency and peculiarities of crisis situations. Disaster policies along these lines would use existing, local infrastructure, use and create local human resources and reduce dependence on external emergency assistance.

References

Akimoto R. 1972. 'Some aspects of earthquake prediction in Japan.' In *Social and economic aspects of earthquakes*. Proceedings of the Third International Conference, Yugoslavia

Alexander D. 1985. Death and injury in earthquakes. *Disasters* **9** (1): 57–60

Beinin L. 1981. An examination of health data following two major earthquakes in Russia. *Disasters* **5** (2): 142–6

Brecht B. 1965. *The Messingkauf dialogues*. London: Methuen

Correa MAO, Sabura H and Azevedo RD. 1970. Considerations on the new epidemic outbreak of human leptospirosis in Recife, Pernambuco, Brazil, in 1970. *Rev Inst Adolfo Lutz* **32:** 83–7

Cuny FC. 1983. *Disasters and development*. Oxford, UK: Oxford University Press

de Bruycker M et al. 1983. The 1980 earthquake in southern Italy. *Bull WHO* **61:** 1021–5

de Ville de Goyet C and Lechat MF. 1976. Health aspects in natural disasters. *Trop Doct*, October: 168–70

Glass RI and Urrutia JJ. 1977. Earthquake injuries related to housing in a Guatemalan village. *Science* **197**, August: 638–43

Haas JE, Kates RW and Bowden MJ. 1977 *Reconstruction following disasters*. Mass, USA: Massachusetts Institute of Technology

Hewitt K (ed). 1983. *Interpretations of calamity*. Mass, USA: Allen & Unwin

Karakos A et al. 1983. A preliminary investigation of socio-economic problems following the 1978 Thessaloniki (Greece) earthquake. *Disasters* **7** (3): 210–14

Lechat MF. 1981. 'Disaster and health'. In Porter R, Price J and Read R (eds). *Trauma and after*. Proceedings of the Conference on Trauma and after, held at the University of Sheffield, UK

Lechat MF. 1984. *Disasters: a public health problem*. Paper presented at WHO Disaster Preparedness Workshop, Trieste

Levine RJ et al. 1976. Failure of sanitary wells to protect against cholera and other diarrhoeas in Bangladesh. *Lancet* **2:** 86–9

Nakano T, Kadomura H, Mitzutani T, Okuda M and Sekiguchi T. 1974. 'Natural hazards: a report from Japan'. In White GF (ed). *Natural hazards*. New York: Oxford University Press

OFDA. 1960–1982. *Annual Reports*. Washington DC: US Office of Foreign Disaster Assistance

PAHO Disaster Reports. 1981. *The effects of Hurricane David, 1979, on the population of Dominica*. Washington DC: Pan American Health Organization

Patil BR and Koshy S. 1982. An evaluation of the composite programme for women and pre-school children in Kerala – an analysis of CARE data. UNICEF Report. New Delhi: Council for Social Development

Saidi, F. 1963. One 1962 earthquake in Iran – some medical and social aspects. *N Engl J Med* **268:** 929–32

Seaman J. 1984. *Epidemiology of natural disasters*. Basel: Karger

Sen A. 1981. *Poverty and famines: an essay on entitlement and deprivation*. Oxford: Clarendon Press

Sewell WRD and Foster HD. 1976. 'Environmental risk: management strategies in the developing world'. In *Environmental management*. 1 (1): 49–59. New York: Springer-Verlag

Shah BV. 1983. Is the environment becoming more hazardous – a global survey 1947–1980. *Disasters* 7 (3): 202–09

Stephens Lynn H and Green SJ. 1979. *Disaster assistance: appraisal, reform and new approaches*. New York: New York University Press

Swedish Red Cross. 1985. *Prevention better than cure. A report of the Swedish Red Cross*. Stockholm

Whittaker R et al. 1974. Earthquake disaster in Nicaragua. *J Trauma* 14: 37–43

Wijkman A and Timberlake L. 1984. *Natural disasters: act of God or acts of man?* London: International Institute for Environment and Development

Biographies

Debarati Guha-Sapir and Michel F Lechat, Centre for Research on Disaster Epidemiology, Catholic University of Louvain, 30.34 Clos Chapelle aux Champs, 1200 Brussels, Belgium.

Having studied at the University of Calcutta for her undergraduate degree in liberal arts, Debarati Guha-Sapir went to the USA where she trained in demography and population studies at the Johns Hopkins University and in statistics at the University of Wisconsin. She has since done research on population risk factors for cancer, population policies in the Third World, forecast models for physician manpower and impact of physician supply. Currently, she is a research associate at the Centre for Research on Disaster Epidemiology and is working on the epidemiological and developmental aspects of natural disasters including famines.

Michel Lechat studied medicine at the Catholic University of Louvain, followed by postgraduate training in the Institute of Tropical Medicine, Antwerp, and the Johns Hopkins University. He is currently Professor and Head of the Department of Epidemiology at the Catholic University of Louvain, Brussels, and the Director of the Centre for Research on Disaster Epidemiology. He serves as a consultant to various international and national agencies and is a member of several expert groups and commissions on communicable diseases and public health.