Earthquakes: Casualty Studies

Eric J Noji

An earthquake of great magnitude is one of the most destructive events in nature During the past 20 years, earthquakes have caused more than a million deaths and injuries worldwide (1). In the United States, approximately 1600 deaths attributed to earthquakes have been recorded since colonial times, of which more than 1000 have occurred in California (2). Hospitals and other care facilities are particularly vulnerable to the damaging effects of an earthquake. Because of loss of power and water supply, equipment such as x-ray machines, kidney dialysis machines, ventilators and blood analyzers, and hospital operations such as intensive care units and surgical theaters cannot function normally when they are most needed (3,4,5)

In reviewing historical accounts of earthquakes, disaster medical planners should note injury type or diagnostic classification among survivors, which determines the medical care needed after the event. The primary cause of death and injury due to earthquakes is the collapse of buildings that were not adequately designed for earthquake resistance, were built with inadequate materials, or were poorly constructed (6,7). Studies have shown that factors determining the number of people killed when a building collapses include the following: how badly they were trapped, how severely they were injured, how long they must wait for rescue, and how long they can survive without medical attention (8-10)

Deaths resulting from major earthquakes can be instantaneous, rapid or delayed Instantaneous death can be due to severe crushing injuries to the head or chest, external or internal haemorrhage, or drowning from earthquake-induced tidal waves (tsunamis) Rapid death occurs within minutes or hours and can be due to asphyxia from dust inhalation or chest compression, hypovolemic shock or exposure (e g., hypothermia). Delayed death occurs within days and can be due to dehydration, hypothermia, hyperthermia, crush syndrome or post-operative sepsis (11)

As with most natural disasters, the majority of those requiring medical assistance have minor injuries such as superficial lacerations, sprains and bruises (12). The next most frequent reason for seeking medical attention is simple fractures not requiring operative intervention (13) For example, after the 1968 earthquake south of Khorasan, Iran, only 368 (3 3%) of 11,254 persons injured required inpatient care Hospitalized patients included those with serious multiple fractures or internal injuries, hypothermia, sepsis from wound infections, or multiple organ failure requiring surgery or other intensive care services (14)

More detailed inpatient information is available from data collected on 4832 patients admitted to hospitals following the 1988 earthquake in Armenia (10) Consistent with findings from other major earthquakes, combination injuries constituted 39.7% of the cases. Superficial trauma such as lacerations and contusions were the most frequently observed (24.9%), following by head injuries (22%), lower extremity injuries (19%), crush syndrome (11%), and upper extremity trauma (10%)

Infected wounds and gangrene were major problems following the Armenian earthquake (15). Persons who have been trapped by rubble for several hours or days may also develop compartment syndrome requiring fasciotomy or amputation. These persons may also have significant rhabdomyolysis and must be watched closely for signs and symptoms of crush syndrome such as hypovolmic shock, hyperkalemia, renal failure or fatal cardiac arrhythmias (16,17,18). Following the 1988 earthquake in Armenia, more than 1000 victims trapped in collapsed buildings developed crush syndrome as a result of limb compression; 323 developed secondary acute renal failure requiring renal dialysis (18).

Heavy dust is produced by crumbling buildings immediately following earthquakes. For trapped victims, this dust is a life-threatening hazard that may cause asphyxiation or upper airway obstruction (19). Fulminant pulmonary oedema from dust inhalation may also be a delayed cause of death (11) Asbestos and other particulate matter in the dust are both subacute and chronic respiratory hazards for trapped victims as well as for rescue and clean-up personnel. The degree of hazard depends on the characteristics and toxicity of the dust (2).

Burns and smoke inhalation from fires used to be major hazards after an earthquake For example, following the 1923 earthquake in Tokyo, more than 140,000 people perished, principally because of fires that broke out in a city where most buildings were constructed from high flammable paper (shoji) and wood material. Since 1950, however, the incidence of burns has decreased considerably (9)

To maximize trapped victims' chances of survival, search-and-rescue teams must respond rapidly after a building collapses (20) Studies of the 1980 Campania-Irpinia, Italy, earthquake (21,22) and the 1976 Tangshan, China, earthquake (23) show that the proportion of trapped people found alive declined as delay in extrication increased. In the Italian study, a survey of 3619 survivors showed, firstly, that 93% of those who were trapped and survived were extricated within the first 24 hours, and, secondly, that 95% of the deaths recorded occurred while the victims were still trapped in rubble (21) Estimates of the survivability of victims buried under collapsed earthen buildings in Turkey and China indicate that, within two to six hours, less than 50% of these buried are still alive (21,22).

Although we cannot determine whether a trapped person dies immediately or survives for some time under the debris, we can safely assume that more people would be saved if they were extricated sooner. Safar, studying the 1980 earthquake in Italy (24), concluded that 25%-50% of victims who were injured and died slowly could have been saved if life-saving first aid had been rendered immediately As suggested by these data, if any significant reduction in earthquake mortality is to be achieved, we must provide appropriate search and rescue action within the first two days after the impact

Parallelling the speed required for effective search and extrication is the speed with which emergency medical services must be provided The greatest demand occurs within the first 24 hours (25). In fact, injured people usually seek medical attention at emergency departments only during the first three to five days, after which time hospital case-mix patterns return almost to normal. A good example of the crucial importance of early demand for emergency care is seen in the number of admissions to a field hospital after the 1976 earthquake in Guatemala (26,27). From day six on, admissions fell dramatically despite intensive efforts to find injured people in remote rural areas of the impact zone, indicating that specialized field hospitals that arrived one week or more after an earthquake are generally too late to help during the emergency phase. After the Armenian earthquake only 22 (2.4%) of the 902 patients requiring hospitalization at a large hospital were admitted seven or more days after the impact (10).

With most earthquakes, trauma caused by the collapse of buildings is the cause of most deaths and injuries However, a surprisingly large number of patients require acute care for non-surgical problems such as acute myocardial infarction, exacerbation of chronic diseases such as diabetes or hypertension, anxiety and other mental health problems, respiratory disease from exposure to dust and asbestos fibers from rubble, and near drowning due to flooding from broken dams. An example of the adverse effects of an earthquake on medical conditions was observed after a magnitude 6.7 earthquake in Athens, Greece. A 50% increase in deaths due to myocardial infarction was documented during the first three days after the earthquake, peaking on the third day (28,29) Finally, an earthquake may precipitate a major technological disaster by damaging or destroying nuclear power stations, hospitals with dangerous biochemical products, hydrocarbon storage areas, and hazardous chemical plants

As with most natural disasters, the risk of secondary epidemics is minimal and mass vaccination campaigns not based on results of epidemiological surveillance are inappropriate following earthquakes (30).

In conclusion, analysis of the health and medical effects of earthquakes, as well as of the rescue and medical response, has strong implications for earthquake preparedness and response in seismically vulnerable parts of the world. I have recommended a number of important endeavours that are necessary to enhance medical planning, preparedness, and response to earthquakes. Strengthening the self-reliance of the community in disaster preparedness is the most fruitful way to improve the effectiveness of relief operations. In earthquake-prone areas, training and education in basic first aid and rescue methods should be an integral part of any community preparedness program.

REFERENCES

1. United States Office of Foreign Disaster Assistance: Disaster history: significant data on major disasters worldwide, 1990-present Washington, D C.: Agency for International Development, 1992

2. Stratton JW: Earthquakes. In. The public health consequences of disasters. Gregg MB, ed. Atlanta: Centers for Disease Control, 1989

3. Arnold C, Durkin M: Hospitals and the San Fernando earthquake of 1971 The Operational Experience San Mateo:Building Systems Development, Inc., 1983.

4 Noji EK, Jones NP: Hospital preparedness for earthquakes In: Emergency preparedness. when disaster strikes Tomasik KM, ed. Oakbrook Terrace Joint Commission on the Accreditation of Health Care Organizations, 1990 13-20

5 Reitherman R How to prepare a hospital for an earthquake, J Emerg Med 1986; 4:119-131

6 Malilay J Medical and healthcare aspects of the 1992 earthquake in Egypt Report of the Earthquake Engineering Research Institute Reconnaissance Team. Oakland: Earthquake Engineering Research Institute, 1992

7 Glass RI et al. Earthquake injuries related to housing in a Guatemalan village, Science 1977; *197*.638-643

8. Coburn AW, Hughes RE. Fatalities, injury and rescue in earthquakes. In: 2nd conference of the Development Studies Association, Manchester, England, 1987. Manchester University of Manchester, 1987.

9. Coburn AW. Murakami HO, Ohta Y Factors affecting fatalities and injury in earthquakes. Engineering Seismology and Earthquake Disaster Prevention Planning Internal Report, Hokkaido, Japan, 1987. Hokkaido. University, 1987.

10 Noji EK et al The 1988 earthquake in Soviet Armenia a case study, Ann Emerg Med 1990; *19*:891-897.

11 Safar P, Pretto EA, Bircher NG: Resuscitation medicine including the management of severe trauma. In: Medicine for Disasters Baskett R and Weller R, eds. London: Wright, 1988.36-86. pp 36-86

12. Pointer JE et al: The 1989 Loma Prieta earthquake Impact on hospital care. Ann Emerg Med. 1992; *21*:1228-1233

13. Seaman J. Epidemiology of natural disasters, Contributions to Epidemiology and Biostatistics 1984, 5 1-177

14 Memarzadeh P The earthquake of August 31, 1968, in the south of Khorasan, Iran. In Proceedings of the joint IHF/IUA/UNDRO/WHO Seminar. Manila World Health Organization, 1978.

15. Noji EK. Medical and healthcare aspects of the 1988 earthquake in Soviet Armenia, Earthquake Spectra Suppl 1989:101-107

16 Better OS, Stein JH Early management of shock and prophylaxis of acute renal failure in traumatic rhabdomyolysis, N Engl J Med, 1990 322 825-829.

17. Noji EK. Prophylaxis of acute renal failure in traumatic rhabdomyolysis [Letter], N Engl J Med 1990, 323.550-551.

18 Noji EK: Acute renal failure in natural disasters, Renal Failure 1992; *14* 245-249

19 Hingston RA, Hingston L Respiratory injuries in earthquakes in Latin America in the 1970s a personal experience in Peru (1970); Nicaragua (1972-3), and Guatemala (1976) Disaster Med 1983, *1* 425-26.

20. Noji EK. Medical consequences of earthquakes: coordinating medical and rescue response, Disaster Management 1991, *4* 32-40

21. de Bruycker M et al The 1980 earthquake in Southern Italy rescue of trapped victims and mortality, Bull World Health Organ 1983, *61* 1021-1025.

22 de Bruycker M, Greco D, Lechat MF: The 1980 earthquake in Southern Italy morbidity and mortality, Int J Epidemiol 1985, *14* 113-117.

23 Yong S Medical support in the Tangshan earthquake. a review of the management of mass casualties and certain major injuries, J Trauma 1987, *27*·1130-1135.

24. Safar P. Resuscitation potentials in mass disasters, Prehosp Disaster Med 1986; *2*:34-47

25. Thiel CC et al: 911 EMS process in the Loma Prieta earthquake. Prehosp and Disaster Med 1992, *7*·348-358.

26. de Ville de Goyet C et al: Earthquake in Guatemala. epidemiologic evaluation of the relief effort, Pan Am Health Organ Bull 1976, *10*:95-109

27 de Ville de Goyet C, Jeannee E: Epidemiological data on morbidity and mortality following the Guatemala earthquake, IRCS Med Sci Soc Med 1976, *4*:212.

28. Katsouyanni K, Kogevinas M, Trichopoulos D· Earthquake-related stress and cardiac mortality, Int J Epidemiol 1986, *15*:326-330.

29 Trichopoulos D, Katsouyanni K, Zavitsanos X: Psychological stress and fatal heart attack. The Athens 1981 earthquake natural experiment, Lancet 1983; 1.441-443

30. Toole MJ Communicable disease epidemiology following disasters, Ann Emerg Med 1992; *21*:418-420