The 1988 Earthquake in Soviet Armenia: Implications for Earthquake Preparedness

An earthquake registering 6.9 on the Richter scale hit the northern part of the Armenian Republic of the Soviet Union on 7 December 1988, resulting in thousands of deaths and injuries. The majority of these resulted from the collapse of inadequately designed and constructed buildings. Analysis of the effects of the Armenian earthquake on the population, as well as of the rescue and medical response, has strong implications for earthquake preparedness and response in other seismically vulnerable parts of the world. Specifically, this paper will recommend a number of important endeavours deemed necessary to improve medical planning, preparedness and response to earthquakes. Strengthening the self-reliance of the community in disaster preparedness is suggested as the best way to improve the effectiveness of relief operations. In earthquake-prone areas, training and education in basic first aid and methods of rescue should be an integral part of any community preparedness programme.

INTRODUCTION

Sudden impact disasters such as earthquakes present a serious challenge to both developed and less developed countries of the world. A review of the disaster medical literature reveals a general consensus among researchers and disaster planners alike, on the inadequacy of preparedness programmes in communities at risk from disasters such as earthquakes (Guha-Sapir and Lechat, 1986a). This inadequacy, stemming from a lack of appropriate information and research, may result in ineffective and wasteful relief action and marginally-developed preparedness programmes (Noji, 1987). For this reason, we must rely on lessons learned from past earthquakes, particularly regarding the exact nature of immediate medical needs (de Bruycker *et al.*, 1985; de Ville de Goyet and Jeannee, 1976). Better epidemiologic knowledge of the causes of death and type of injuries and illnesses caused by earthquakes is clearly essential to determine the appropriate relief supplies, equipment and personnel needed to respond effectively to such situations (Alexander, 1985; Guha-Sapir and Lechat, 1986b). Thus, the study of international events such as the recent catastrophe in Soviet Armenia can make a significant contribution towards cohesive earthquake preparedness plans for communities at risk from events such as earthquakes.

While in many large cities of the world, relatively sophisticated codes govern the design and construction of new structures, there remains a large number of older, unreinforced masonry and under-reinforced concrete buildings, often inhabited by large numbers of people. Indeed, should a major earthquake occur, it is expected that the majority of the deaths and injuries will be

the result of inadequate performance of these older structures. Unfortunately, the low perceived risk of such an event has led to some complacency, and indeed many countries require little or no earthquake resistance in their adopted codes.

The aim of this paper is to address this problem, i.e., given that earthquakes and building collapses will occur, how can the number of deaths and injuries be minimized? Specifically, what needs to be done to improve medical planning, preparedness and response to earthquakes? The paper will outline a number of important endeavours that are deemed necessary to achieve this important goal.

THE 1988 EARTHQUAKE

The Caucasus region, including the Soviet Republics of Armenia, Georgia and Azerbaijan, is one of the most seismically active regions of the Soviet Union. An earthquake registering 6.9 on the Richter scale hit the northern part of the Armenian Republic of the Soviet Union at 11.41 a.m. on 7 December 1988. Caused by movement along a geological fault near the town of Spitak in the northwestern part of the country, the quake affected 40% of the national territory. 500,000 to 700,000 persons were made homeless, with an official estimate of over 24,000 dead. Virtually all health care facilities (hospitals and clinics) were destroyed in the affected region and many health care workers (e.g. physicians and nurses) were killed or injured. Bridges, lifelines (e.g. water, power, gas, sewage systems), and industrial facilities were also damaged.

IMPLICATIONS FOR EARTHQUAKE PREPAREDNESS AND RESPONSE

Seismic vulnerability

There are large areas throughout the world that share a similar degree of seismic risk with Soviet Armenia. In the United States these would include such areas as the Puget Sound, Salt Lake City in Utah, the New Madrid region and Charleston, South Carolina. There are many buildings in these potentially seismic areas which may not perform significantly better than those in northern Armenia. Given the regional similarities in earthquake potential, building types, and the absence of earthquake preparedness programmes, the possibility of an earthquake of comparable proportions and catastrophic consequences in these areas is real. Unfortunately, while such disasters are feared by the earthquake engineering community, much of the population of dangerously seismic areas in the Western Hemisphere have not exhibited consistent concern about the risk.

Potential collapse of large modern engineered structures

In Armenia, the most dramatic building failures occurred in seismically underdesigned precast frame-panel buildings. These are typically large, high-occupancy buildings, constructed in the late 1970s and early 1980s for commercial, residential and industrial purposes. These buildings were, in theory, designed to withstand earthquake loading, but 54% collapsed and 41% are so heavily damaged that they will require demolition. The fatality rate in these buildings was very high (Noji, 1989b). Very few live recoveries were made from these buildings because their characteristic failure pattern made search and rescue difficult.

Many seismic areas of the world have large buildings with similar design deficiencies which would be subject to catastrophic collapse in a similar earthquake.

Importance of first responder training (e.g. layperson first aid)

Survivable time for victims of building collapse is measured in minutes and hours,

but response time for outside medical aid may be measured in hours, if not days (de Bruycker *et al.*, 1983). With the exception of personnel from countries in close geographical proximity, external medical assistance will arrive after local health services in the affected country have already provided emergency medical assistance (de Ville de Goyet and Jeannee, 1976). Foreign health experts with specialized expertise in areas such as on-site resuscitation and medical first aid usually arrive too late. As in Armenia, the "first responders" after an earthquake will be relatively uninjured survivors – volunteers, friends, neighbours and relatives of the victims (de Bruycker *et al.*, 1985). Unfortunately, in many highly seismic parts of the world (e.g. California), the public has come to be virtually completely dependent on professional health personnel such as physicians, nurses and paramedics to provide emergency medical care. For that, and a variety of other reasons, the general knowledge of life-saving first aid procedures and personal survival techniques is generally low.

A general apathy among the lay population in countries at high risk from earthquakes, as well as among health care organizations and governments, has left the survivors of disasters such as earthquakes vulnerable if an event compromises the formal medical system. This was dramatically illustrated in Armenia, where large numbers of health care personnel were killed or injured and all hospitals were destroyed or rendered non-functional in the parts of the country devastated by the earthquake.

Therefore, when a major earthquake strikes, untrained local people, supplemented by surviving fire, rescue and emergency medical personnel, and still-functioning hospitals will do their best to cope with the initial onslaught of large numbers of seriously injured patients, while awaiting outside aid. Countries vulnerable to earthquakes should establish continuous programmes for public motivation, and regarding what to do when an earthquake occurs, first aid, and organized volunteer work.

Quality of heavy urban search and rescue

When a building collapses, whether due to an earthquake, a terrorist bombing, or structural failure, a variety of challenges confront rescue/medical personnel. Before patients can be treated, they have to be located and extricated; before patients can be extricated, rescuers have to ensure their own safety.

A number of significant recent events, such as the 1985 Mexico City quake, the El Salvador earthquake in 1986 and, most recently, the 1988 earthquake in Soviet Armenia, demonstrate that the collapse of reinforced-concrete buildings is a significant and continuing problem (Zeballos, 1986; Noji, 1989a). There are large numbers of such extremely precarious buildings in seismic areas throughout the less developed countries, as well as in the industrialized, highly technological countries.

Unfortunately, most search and rescue teams in the world have no experience in collapsed building rescue (Noji, 1989a). For example, the rescue activities in most fire departments are primarily geared towards extrication of victims from trucks and automobiles. Those personnel who have experience with building rescue only have experience with buildings that are on fire, not in working with collapsed reinforced-concrete buildings. This lack of building collapse experience results in a tremendous safety problem for both rescuers and victims in buildings that are unstable as a result of a collapse.

Most of the existing heavy urban rescue technology is also adapted from other uses. Hurst tools were developed for cars; the cutting equipment for concrete and ream bars is taken from other applications. Agencies responsible for rescue operations

in earthquakes need to look at the development of technologies specifically for the penetration and reconnaissance of small spaces in these sorts of buildings, and then for rapid cutting.

The primary lesson learned in Mexico City and Soviet Armenia for earthquake planners is that urban heavy rescue is a critical issue on which to focus their response planning. Prior to these two catastrophes, attention had not been focused on the specific problems of location and extrication of victims in modern, engineered collapsed buildings (Zeballos, 1986). It may be the coincidence of the Armenian earthquake and other events, such as recent international terrorist bombings, as well as other sorts of building collapses, that has finally brought attention to this problem.

Quality of medical care delivered at sites of building collapse

In Armenia, as in other recent earthquakes mentioned above, very little in the way of basic medical care was administered to persons actively being extricated from the debris (Noji, 1989b). These were patients who were successfully located and reached by the rescue personnel, however, not quite yet extricated. Very few of these patients were observed to have received intravenous fluids, stabilization of the neck with cervical collars or maintenance of patent airways. The institution of these very basic procedures, particularly intravenous fluids, may well go a long way towards reducing the morbidity and mortality related to building collapse, particularly in preventing the development of crush syndrome with its attendant kidney failure and cardiac arrhythmias.

Despite these observations, most rescue personnel are not trained in intravenous techniques. Even when trapped persons are discovered, it may take several hours for them to be successfully extricated – plenty of time to develop severe muscle damage and secondary kidney failure.

Time factor

It is clear from our experience in Armenia as well as in other recent earthquakes that emergency medical needs, requiring the rapid mobilization of resources in order to prevent death and minimize suffering, are best handled by local authorities. Results from Armenia suggest that the emergency phase for medical care of the severely injured was limited to the three to four days after impact. In fact, highly sophisticated medical resources that were six or more hours distant from the earthquake-affected region were of little assistance to victims who needed immediate resuscitation and stabilization. It is clear that only local medical resources can initiate a timely disaster response to severely injured victims of building collapse (Noji, 1987). This was dramatically illustrated in Armenia, where in certain towns and villages, 85–95% of the persons extricated alive from the debris were rescued in the first 48 hours, usually by untrained laypersons. In any major earthquake, the bulk of the rescue effort must be planned for the first 48 hour period.

Equipment

In Armenia, there was a great demand by the authorities for appropriate search and rescue supplies and equipment. These included heavy lifting cranes and tools for rapid cutting of concrete. Unfortunately, cranes are not enough. The hasty use of heavy equipment can be a serious hazard to entrapped victims by causing further settling of debris. Research must be carried out on the proper use of such heavy equipment in rescue operations. Search equipment also must be developed for specific application in collapsed reinforced-concrete

buildings. Much of the specialized rescue equipment from abroad was designed for other purposes, such as vehicle extrication. It did not prove to be very effective for reinforced concrete.

Manpower requirements

The number of trapped persons requiring rescue greatly exceeded available manpower resources. It is clear that a far larger number of properly trained and equipped personnel than had previously been thought, need to be involved in building collapse rescue from the beginning – preferably within the first 48 hours.

In Armenia, on the average, it required over 50 man-hours to extricate successfully a single trapped individual. Extrapolating further, if there are 25,000 severely trapped victims, the manpower requirements would be 1,250,000 man-hours. This means that if rescuers worked 12 hour shifts, over 50,000 rescuers would be needed in the first critical 48 hour period. In Armenia, there were about 30,000 Soviet relief workers (not all involved in search and rescue), supplemented by perhaps a thousand foreign rescue personnel. Earthquake planners must be aware that prior forecasts of search and rescue manpower requirements in earthquakes have been greatly underestimated, and that for maximal life-saving potential, these resources must be applied in the first 48 hours.

RESEARCH PRIORITIES

Despite the major advances made in the field of earthquake engineering over the past several decades, there remain significant risks to human life in major events due to collapse of older structures. Unfortunately, the knowledge base of the precise causes of deaths and injuries in such collapses is not well developed, resulting in often misdirected provision of relief services as well as inadequate community medical or health planning for earthquakes (Kates *et al.*, 1973; Saidi, 1963; Whittaker *et al.*, 1974).

In most past earthquakes, very few data have been collected concerning the actual victims themselves (e.g. location in the structure, type and severity of injuries, post-rescue behaviour, etc.) (Lechat, 1974; Glass *et al.*, 1977). It is therefore difficult to plan search and rescue activities and proper medical care adequately, and to request appropriate outside aid effectively.

The following sections identify the research areas of greatest priority.

Epidemiologic analysis of risk factors for deaths and injuries

In Armenia, thousands of people were killed as a result of the earthquake. The specific mechanisms of death and injury in building collapse clearly need much more extensive study (Noji and Sivertson, 1987; Alexander, 1985). In particular, very little is known as to what distinguishes those who survive from those who do not (de Bruycker *et al.*, 1985). The morbidity (injuries) and mortality (deaths) resulting from the recent earthquake in Soviet Armenia were clearly related to structural factors, search and rescue activities, evacuation procedures, and medical relief action in the immediate post-disaster phase. For example, the possibility of escape was crucial for survival and depended on the type of building and occupant behaviour (i.e. running out of the building decreased casualty rates in certain situations).

Early work by epidemiologists has produced an indication that research on risk factors for building collapse-related fatality and injury might benefit from more disciplined study (de Ville de Goyet and Jeannee, 1976; Glass *et al.*, 1977). Such research will have direct implications on the rescue-relief

activities and the medical supplies that will be required.

Earthquake injury epidemiology

Basic knowledge of the type of injuries and illnesses caused by earthquakes, as well as the severity of such injuries, is also essential to determine the appropriate relief supplies, equipment and personnel needed in similar situations (Alexander, 1985; Ortiz *et al.*, 1986). Unfortunately, existing data from past earthquake events have not been systematically collected with the intention of improving our understanding of injury and illness patterns and improving survival rates (Binder and Sanderson, 1987).

Information necessary for immediate needs assessment in earthquakes

Currently, the data on damages collected in earthquake events are usually crude estimates based on superficial observations of limited technical and statistical validity (Guha-Sapir and Lechat, 1986b; Noji, 1987). There are currently no standardized methods or indicators to determine rapidly the health needs of earthquake victims and communities. It is critical to live-saving activities to be able to identify those pieces of information that can realistically be gathered in the field for rapid decision-making after an earthquake.

The development of such methods will be of great value to communities and local officials who will need rapidly available information in order to decide when to request outside assistance and what their greatest needs are (e.g. determining the requirements for food, medicine and clothing, the need for temporary accommodation for the homeless, as well as assessing the need for infectious disease control).

Rescue activities

Research needs to be conducted on rescue of persons trapped under debris (techniques, equipment, composition of rescue teams). Most of the rescue and relief work during the first 48 hours in Armenia was carried out by unprepared local people using their bare hands or, at best, primitive hand tools. Research must answer the question of how trapped persons can be located, reached and extricated in the most efficient manner. How really effective are the highly touted search dogs, infrared detecting devices, remote fibreoptic cameras, sound-sensing instruments, etc.?

Management of casualties

Research needs to be conducted on the medical management of casualties resulting from earthquakes (e.g. perfecting triage techniques, determination of resuscitation potentials, on-site treatment of crush syndrome), as well as logistical questions such as how health care facilities can improve their handling of large numbers of patients, the allocation of limited health resources, the operation of temporary facilities, and improving record keeping (Zhi-Yong, 1987; Whittaker *et al.*, 1974; Saidi, 1963). The average period of time elapsed between discovery of a trapped person, extrication, on-site medical care, evacuation and arrival at hospital is a decisive factor, study of which can deeply influence future relief operations (Noji, 1989b).

Medical supplies

In Armenia, as in several past major disasters, there were major problems in identifying, selecting and distributing large quantities of unsolicited donated medical supplies, food and clothing. Operational research is needed to determine what medical supplies are:

- Actually needed (based on number and nature of injuries and standard acceptable treatments).
- Most commonly requested at local and national levels.

— Provided by the national or international community.

Disease control and sanitation

The question of the actual risk of increased disease transmission following earthquakes requires extensive, current and retrospective field study (Alexander, 1982). The effectiveness of disease control measures and the techniques of epidemiological surveillance are areas of considerable practical interest (Binder and Sanderson, 1987). Although outbreaks of food or waterborne diseases (e.g. cholera, typhoid) have not been a major problem in recent earthquakes (e.g. Mexico City, El Salvador, Ecuador), many people in Armenia were still very concerned about epidemics and were encouraging the implementation of a mass immunization programme against typhoid as well as tetanus (Ortiz *et al.*, 1986; Zeballos, 1986). In Armenia as well as in past earthquakes, the public was also worried regarding the possible transmission of disease from decaying corpses. This has never been documented as a major public health problem in any past natural disaster, unless the bodies were already infected with organisms known to be transmissible through contact with bodily fluids (e.g. hepatitis, tuberculosis).

Expensive and sophisticated emergency measures were taken by Soviet authorities to distribute drinking water in affected areas of the country. However, no systematic attempt has been made by scientists in past earthquakes to estimate the vulnerability of water supply systems to contamination by specific infectious agents and determine the significance of such contamination. The role played by other factors (rodents, insects, etc.) also remains to be documented.

External relief

The effectiveness of and problems associated with the influx of large quantities of relief supplies and relief personnel from outside the affected area need to be studied thoroughly, and the results disseminated. Studies of the role of outside medical volunteers following earthquakes may settle the controversy surrounding their usefulness and provide the public health authorities and medical associations with guidelines and criteria for a constructive approach. For example, the local authorities in Armenia had difficulty handling the tremendous influx of physicians entering Armenia from other parts of the Soviet Union as well as from abroad during the first few days (1,200 of these physicians came from Moscow alone while 450 foreign physicians entered the country during the first 10–14 days following the earthquake). These large numbers of relief workers placed an added burden on local resources for food and lodging. Many of the foreign doctors were unable to speak the local language or lacked specific skills necessary for field management of the injured.

CONCLUSION

The 7 December 1988 earthquake in Soviet Armenia was one of the most lethal in the 20th century in terms of morbidity and mortality. During my recent work in this country, I found that the Armenian government, and its associated medical and health care community, recognized that the establishment of a comprehensive, integrated and well-organized national emergency medical system is necessary if they are to reduce significantly the tragic morbidity and mortality likely to be associated with future disasters. Furthermore, the government of Armenia is beginning to attach significantly more importance to medical preparedness for disasters after reviewing the hard lessons of the recent catastrophe. Certainly, physicians and other members of the medical community in other earthquake-prone regions of the world have taken a special interest in the lessons of their

Armenian colleagues, for it is they who will be called upon first when a major earthquake occurs.

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