INJURY DISTRIBUTIONS PRODUCED BY NATURAL DISASTERS*

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Abstract: Earthquakes differ from other natural disasters in that they produce large numbers of victims in a relatively short time. The human costs are especially high when the epicenter lies near a major city or other area with a high population density. Medical institutions bear the largest burden in rescue efforts after a disaster. One way to lighten this burden is to know in advance what sort of medical emergencies to expect.

The tsunamis, fires, and landslides following earthquakes greatly magnify the human losses. Over 80% of the victims have external limb injuries. Between 10% and 20% are serious enough to require hospitalization or emergency operations. Such causes as falling objects, flying glass, and toppling objects account for approximately half of all external injuries.

In developing countries, the collapse of dwellings with no earthquake resistance produces much higher death and injury rates than in Japan. Since natural disasters strain a hospital's emergency medical treatment capabilities to the limit, advance planning is essential.

Key words: Urban earthquake disaster; Disaster epidemiology; Emergency medical treatment planning

Introduction

When it comes to earthquakes, volcanic eruptions, storms, floods, and other natural disasters, Japan is a world leader. It is perhaps the leader in terms of earthquakes with some 15% of the world's earthquakes arising in or around Japan at a rate close to 1,000 a year for those detectable without instruments alone.

The death and injury totals for earthquakes greatly outnumber those for volcanic eruptions, storms, and floods. The world's most disastrous earthquake, the 1976 one in Tangshan China, for example, claimed 240,000 lives; the 1923 Kanto Earthquake, 140,000. More recently, earthquakes have produced major losses in developing countries: 10,000 in Mexico in 1985, 50,000 in Armenia in 1988, and 40,000 in Iran in 1990.

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Japan has a long history of storm and flood damage with numerous disasters resulting in major losses of life. The 1959 Ise Bay Typhoon, for example, killed 4,700 and injured some 40,000. The human costs of such disasters have plunged rapidly since then, however, because advances in meteorology now provide better warning of typhoons and localized torrential downpours, rivers incorporate better flood control measures, and residents can be evacuated much earlier. The human costs of volcanic eruptions have also been reduced.

Earthquakes, however, strike more suddenly and are much more difficult to predict. When a major one strikes, the result is unforeseen damage. Quakes with epicenters near major urban centers have particularly great human costs in such sensitive areas as high-density residential neighborhoods and busy traffic arteries. Equally sensitive is the city's intricate web supplying gas, water, sewerage, communications, transportation, and other services. Breaks in these lifelines not only affect the daily lives of residents, but also represent major impediments to emergency medical response.

After a disaster, the first task at hand is treating the injured, and medical institutions bear the largest burden in such efforts. One way to lighten this burden is to know in advance what sort of medical emergencies to expect from each type of disaster and plan the emergency medical response system accordingly.

This paper examines the human costs of earthquakes, looking for patterns to the medical emergencies arising from quakes both in Japan and abroad. The immediate dangers to human lives come from four major sources: I. building collapse and falling objects, II. tsunamis, III. fires, and IV. landslides and avalanches.

Building Collapse and Falling Objects

A building may collapse because of a structural fault within the building itself or inadequate support or other problems within the ground underneath it. Although the building itself may survive, the furniture, windows, signs, fences, and other fixtures in and around it can collapse or fall, risking human lives For major earthquakes striking developing countries, the collapse of buildings made of sun-dried brick, a building material offering little earthquake resistance, results in enormous losses of life.

1. Miyagi Offshore Earthquake

(June 12, 1978; Magnitude 7.4; 27 dead; 10,962 injured)

One characteristic of this earthquake is that the human costs were centered in cities and newly developed areas. The bulk of the fatalities — 19 out of a total of 27 — were children and the elderly struck down by collapsing fences of concrete block or stone. The damage was the result of fences that failed to meet construction standards.

Analysis of the cause and extent of injuries reveals that the most frequent causes of injury were broken glass followed by falling or toppling objects. (See Table 1.) As the Table shows, over 20% of the injuries were due to falling

Table 1 Analysis of Cause and Extent of Injuries in Sendai Conurbation (data courtesy of Sendai City Medical Association)

Category / Medical institutions	Cause of injury						
	Broken glass	Falling objects	Toppling objects	Collisions	Burns	Others	Total
Government- and publicity operated hospitals	54	160	51	21	15	110	411
Privately operated medical institutions	644	505	487	123	78	883	2,720
Total	698	665	538	144	93	993	3,131

Category / Medical institutions	Extent of injury			
	Minor	Moderate	Major	Death
Government- and publicity operated hospitals	100	151	78	1
Privately operated medical institutions	1,157	1,280	157	9
Total	1,257	1,431	235	10

objects — reaffirmation of a particular characteristic of urban earthquakes, that the danger is overhead.[1)]

The most frequent types of injuries were cuts (49.8%) and bruises (28.3%), followed by fractures (10.9%) and burns (3.8%). For these categories, the number of major injuries was under 10%. Most were light to moderate injuries suffered indoors while the building was still shaking. The fact that such a major portion of injuries were from toppled furniture and falling ornaments reflects the cramped nature of Japanese living spaces.

The study quoted above found that, although the risk of injury at home is high, the resulting injuries tend to be minor. At school and work, however, the risk is low, but injury severity tends to be higher. It also noted that, since the earthquake knocked out traffic lights in Sendai, the resulting traffic jams slowed down the ambulances transporting the injured.[2)]

2. Mexico City Earthquake

(September 19, 1985; Magnitude 8.1; 10,000 dead; 40,000 injured)

Although the epicenter was 400 km away near the Pacific Coast, Mexico City suffered the most extensive damage as the soft ground underlying the city center amplified the shock waves, releasing enormous amounts of energy that toppled large numbers of buildings. One particular characteristic of this earthquake was damage concentrated on hotels, hospitals, and other sites crammed with people, targets that significantly boosted the number of victims. Since there was no system of construction standards in place, the fact that many buildings were not earthquake resistant was a major contributor to the high human costs.

Fig. 1 Foares Hospital, Mexico City—site of 700 deaths

(See Figure 1.)

Although many injuries were in such categories as bruises, cuts, abrasions, and fractures, one distinctive feature of this earthquake was the number of persons who developed respiratory ailments or suffocated after extended trembling caused the low-grade concrete and other building materials to disintegrate, filling the air with fine dust.[3] Such major medical centers as the Red Cross Hospital soon fell into disorder under the onslaught of a large number of injured persons brought in a very short time.

Moriya *et al.* conclude that the type of building most urgently requiring earthquake-resistant construction is the hospital because of its importance to rescue efforts.[4] The Mexico earthquake therefore contains a valuable lesson for us in Japan, where a similar urban quake could strike a major city at any time.

3. Italian Earthquake

(November 23, 1980; Magnitude 6.9; 2,755 dead; 8,918 injured)

This earthquake in southern Italy produced a large number of victims. The single most frequent type of injury involved those to the limbs. Approximately 20% of the injuries were recorded as major. Table 2 gives a more detailed breakdown.[5]

The 1968 Tokachi offshore earthquake that struck Hokkaido had a similarly high percentage (18%) of major injuries.[6]

Table 2 Major Injury Classifications (%) for Italian Earthquake

Head injuries	4.0	Multiple external wounds	3.4
Chest injuries	3.0		
Bruises	20.0	Trauma	47.1
Limb fractures	12.3	Shock	5.0
		Burns	4.7

Tsunamis

An earthquake under shallow ocean waters sometimes lifts the sea surface to produce a tsunami, a swelling that then travels to the shore to wreak considerable damage. In 1960, a tsunami triggered by an earthquake in Chile traveled all the way across the Pacific and killed over 100 Japanese. More recent examples include one produced by the 1983 Japan Sea coast earthquake and the one that extensively damaged Flores Island in Indonesia in 1992.

1. Japan Sea Coast Earthquake

(May 26, 1983; Magnitude 7.7; 104 dead; 316 injured)

A fifth-degree tremor on the seismic scale produced a tsunami over 5 m high that struck the Japan Sea coasts of Aomori and Akita Prefectures, claiming 104 lives, including 13 primary school pupils on a school outing. Particularly hard hit was Noshiro City, where major hospitals all had their lifelines cut, rendering them unable to function properly in face of the incoming stream of victims from the earthquake and tsunami.[7]

Most fatalities from this earthquake were from the tsunami. Although the magnitude was 7.7, there were surprisingly few injuries from falling or toppling objects. One possible explanation is that a population density lower than that of Sendai and the greater number of parks and other open spaces in which residents

Table 3 Nature and Extent of Injuries after Japan Sea Coast Earthquake (data from the Journal of the Akita Medical Association)

Injury	Number of injuries
Contusion	60
Cut	21
Fracture	25
Ruptured muscle or tendon	3
Bruise	78
Dislocation	1
Sprain	15
Puncture	1
Burn	9
Internal injury	49
Others	56

Extent of patient injury	Number of patients
Major	31
Moderate	92
Minor	193
Total	316

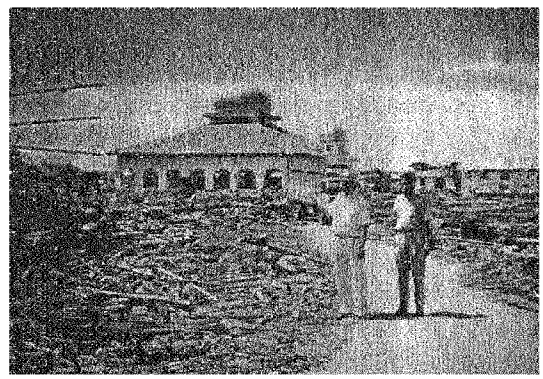

Fig 2 Flores Island, Indonesia after tsunami

could take refuge helped reduce the human costs. The most frequent types of injury were bruises, sprains, and fractures with only about 10% listed as major. Unfortunately, there were also such tragedies as an elderly person suffering cardiac arrest as a result of the shock.

2. Flores Island Earthquake, Indonesia

(December 12, 1992; Magnitude 7.5; 2,080 dead; 2,103 injured)

This earthquake triggered a tsunami that not only caused extensive damage to Flores Island itself, but claimed 750 lives out of a total population of 950 on nearby Babi Island. As with other natural disasters in developing countries, rebuilding took an inordinate length of time. Japan and other aid-giving countries must help by providing integrated ranges of support services covering everything through to rehabilitation.

Fires

Fires triggered by earthquakes greatly magnify the damage. The 1923 Kanto Earthquake, Japan's most notorious example, led to the establishment of the slogan "Earthquake! Put out your fires!"

1. Kanto Earthquake

(September 1, 1923; Magnitude 7.9; 140,000 dead)

This earthquake struck as households were preparing their noon meal. The resulting fires, concentrated in Tokyo and Yokohama, spread for 45 hours. Since most structures were of wood, as the fires spread, they grew in intensity until they produced firestorms that used up most of the oxygen in the immediate vicinity. At least 30% of the fatalities were due to these firestorms with the cause of death being asphyxiation due to the lack of oxygen or respiratory system burns from the hot blasts.

The widespread slaughter of Koreans and Chinese after the earthquake

because of wild rumors [that they had started the fires] can only be called a human tragedy.[8] The Japanese have also long forgotten that such countries as China and the United States sent medical teams to help with the recovery effort.

Landslides and Avalanches

Earthquakes in mountainous areas never fail to trigger landslides and landslips. These produce human losses both directly and, when they dam rivers to produce floods, indirectly.

1. Western Nagano Earthquake

(September 14, 1984; Magnitude 6.8; 29 dead; 11 injured)

The shock wave from the earthquake loosened rock on the southeast slope of Mt. Ontake (3,063 m), producing a rock fall that turned into an avalanche of rocks and mud as it roared down the Gyokuryu River valley. The 29 people who died were pinned beneath buildings collapsing before the force of this onslaught.[9]

Conclusion

(1) The tsunamis, fires, and landslides following earthquakes greatly magnify the human losses.
(2) Urban earthquakes produce vastly greater number of injuries, the bulk of which are external injuries due to flying glass and falling objects.
(3) The most frequent injuries are external ones such as bruises, contusions, and cuts.
(4) Hospitals must plant ahead since having their lifelines cut off throws emergency medical treatment activities into mass confusion.

REFERENCES

1) Miyagi Prefectural Government General Affairs Department: Overview of 1978 Miyagi Offshore Earthquake, 1978, pp. 67–75. (in Japanese)
2) Sendai City Science Study Group: Comprehensive Analysis and Evaluation of Miyagi Offshore Earthquake Damage Surveys, 1979, pp. 99–156. (in Japanese)
3) Kaneda, M.: Medical report from Mexico City earthquake. *Seikei Saigai Geka* 29: 555–558, 1986. (in Japanese)
4) Moriya, K.: Report from September 19, 1985 Mexico City Earthquake, Shigakusha, 1985. (in Japanese)
5) Corrddo, M.: Italian Earthquake. Proceedings of the First International Assembly on Emergency Medical Services. Italy, 1982.
6) Aomori Prefectural Government Planning Division Prefectural Resident Section: Major Aomori Prefecture Earthquake Records, 1969.
7) Damage Report from Central Japan Sea Coast Earthquake, Journal of the Akita Medical Association, 1984, p. 723.
8) Niki, F.: Massacre of Chinese Residents after the Kanto Earthquake, Iwanami Shoten, 1991. (in Japanese)
9) Nagano Prefectural Government: Western Nagano Earthquake Records, 1985.