

Risk factors for injuries due to the 1990 earthquake in Luzon, Philippines*

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On 16 July 1990, an earthquake measuring 7.7 on the Richter scale struck the island of Luzon, Philippines. A case-control study was carried out to identify the risk factors for earthquake-related injuries and at the same time observations were made on the rescue efforts.

Being hit by falling objects was the leading cause of injury (34%). Those injured during the tremor were more likely to have been inside buildings constructed of concrete or mixed materials (odds ratio, 2.6; 95% confidence interval (CI), 1.7-4.1) and to have been on the middle floors of multistorey buildings (odds ratio, 3.4; 95% CI, 2.2-5.5). Leaving a building during the earthquake was a protective behaviour (odds ratio, 0.3; 95% CI, 0.2-0.8). Of the 235 survivors who were trapped and rescued alive from the rubble, 99% were rescued within 48 hours of the impact of the tremor.

These findings should prove useful in developing seismic safety codes. People should be taught proper evasive actions to take during earthquakes, and training in basic first aid and methods of rescue should be an integral part of community preparedness programmes.

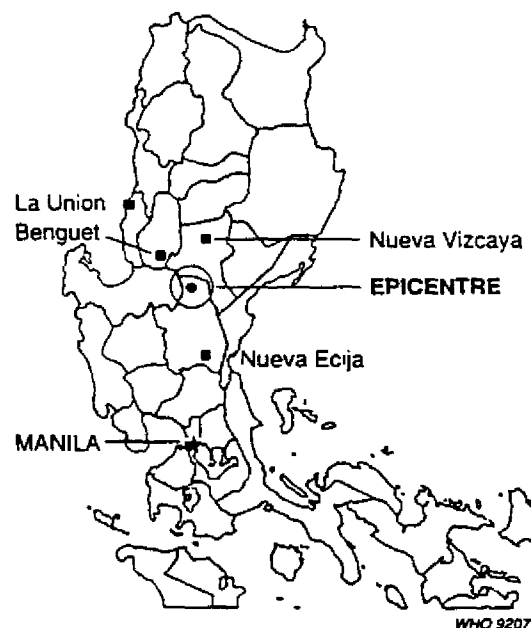
Introduction

On 16 July 1990, at 16h30, an earthquake of magnitude 7.7 on the Richter scale struck northern and central Luzon Island in the Philippines, resulting in substantial morbidity and mortality as well as widespread damage. Officially, 1283 deaths and 2786 injured survivors were reported. Many more injuries and deaths were probably not recorded, especially in remote mountainous areas where landslides occurred. Among the areas severely affected were the mountain city of Baguio, in Benguet, the coastal areas in La Union, and the provinces of Nueva Ecija and Nueva Vizcaya (Fig. 1).

Teams from the Field Epidemiology Training Program (FETP), Philippines Department of Health, in the course of relief efforts, carried out a study to determine the risk factors for injuries and deaths. Observations were made also on the rescue and

medical efforts. Knowledge about the factors associated with death and injuries in earthquakes should prove useful in formulating appropriate public health responses to similar disasters.

Fig. 1 Map of Luzon Island, Philippines.



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Subjects and methods

An unmatched case-control study was performed in Baguio, La Union, Nueva Ecija, and Nueva Vizcaya 1-2 weeks after the earthquake. Cases were persons (dead or alive) who sustained physical injuries during the earthquake of 16 July or its aftershocks; controls were uninjured persons who were in the same neighbourhood as cases during the earthquake or its aftershocks. The cases were identified from hospital records or the Department of Social Welfare and Development lists, while the controls were uninjured family members of cases or persons in refugee centres.

Interviews were conducted using a questionnaire that covered sociodemographic information such as age and gender; location during the earthquake; behaviour during the earthquake; causes and types of injuries; rescue experiences; and medical interventions received. All living subjects, except young children, were interviewed personally by the FETP team. Information about the young children was obtained from the adults who were with them during the earthquake. Fatalities were included in the study only when first-hand eyewitness accounts could be obtained from survivors or rescuers.

The results were analysed using the Epi Info version 5 computer program (Centers for Disease Control, Atlanta, GA, USA); χ^2 tests were calculated and Cornfield 95% confidence limits were determined for the odds ratios.

Results

There were a total of 1104 respondents. Of these, 363 (33%) were cases, 68 (19%) of whom died; the remaining 741 (67%) were uninjured controls.

Sociodemographic profile

Age and gender distributions of cases and controls were similar. The age of cases ranged from 3 months to 92 years (mean, 26 years), while that of controls was 2 months to 81 years (mean, 26 years). The proportion of females was 55% for both cases and controls. Cases were more likely than controls to be single or widowed persons (odds ratio, 1.4) and were also three times more likely to have been transients (tourists or students) in the area when the earthquake struck. Compared with controls, cases were also almost twice as likely to be students (Table 1).

Location when the earthquake struck

Table 2 shows where the study subjects were located when the earthquake struck; most were at home or in school, but many were in the streets. Cases were

Table 1 Sociodemographic profile of cases and controls, July 1990 earthquake, Luzon, Philippines

	No. of cases	No. of controls	Odds ratio	95% CI
Status				
Single/widowed	229 (63) ^a	402 (54)	1.4	1.1, 1.9
Married	134 (37)	339 (46)		
Resident type				
Transient	36 (10)	24 (3)	3.4	2.6
Permanent	316 (90)	717 (97)		
Occupation				
Student	134 (38)	186 (26)	1.9	1.4, 2.6
Others	152 (43)	407 (56)	1.0	— ^b
None	70 (19)	134 (18)		

^a Figures in parentheses are percentages.

^b Reference level.

Table 2. Location of persons when the earthquake struck Luzon, Philippines, July 1990

Place	No. of cases	No. of controls
Home	159 (44) ^a	402 (54)
School	89 (24)	99 (13)
Street	43 (12)	60 (8)
Field	24 (7)	56 (8)
Factory	11 (3)	13 (2)
Others	37 (10)	111 (15)
Total	363 (100)	741 (100)

^a Figures in parentheses are percentages.

twice as likely as controls to be in school (odds ratio, 2.1, 95% confidence interval (CI), 1.5-2.9).

At the start of the tremor, 743 persons (252 cases and 491 controls) were inside the buildings. Cases were three times as likely to be inside buildings constructed of concrete or mixed materials rather than wood, and were three times more likely than controls to be on a middle rather than the ground floor. Also, cases were twice as likely as controls to be on the top rather than the ground floor (Table 3).

Behaviour during the earthquake

The tremor lasted for about 1.5 minutes. The behaviour of individuals during this period was an important predictor of their survival. Escaping from a building during the earthquake was a protective behaviour. At the start of the earthquake, 166 persons were on the ground floor of a building; cases were nearly three times as likely to have stayed inside (odds ratio, 3; 95% CI, 1.3-6.6). Of the 361

Table 3: Risk factors for persons who were located inside a building when the earthquake struck, Luzon, Philippines, July 1990

Risk factor	No. of cases	No. of controls	Odds ratio	95% CI
<i>Building material^a</i>				
Concrete/mixed	198 (86) ^b	324 (70)	2.6	1.7, 4.1
Wood	32 (14)	137 (30)		
<i>Floor level^c</i>				
Top	54 (23)	78 (17)	1.9	1.3, 2.9
Middle	55 (24)	44 (10)	3.4	2.2, 5.5
Ground	122 (53)	336 (73)	1.0	— ^d

^a Data were missing for 22 cases and 30 controls.

^b Figures in parentheses are percentages

^c Data were missing for 21 cases and 33 controls

^d Reference level.

persons who were outdoors at the start of the earthquake, those who remained there were less likely to have been injured than those who went inside (odds ratio, 0.3; 95% CI, 0.11–0.99).

Only 18 (7%) of the 269 persons who remained inside a building during the tremor hid under a table or desk, a recommended evasive behaviour to take during an earthquake. Of these 18 individuals, 12 were uninjured, while six sustained injuries such as contusions or minor abrasions. In schools, stampedes were caused by panic among the students and some teachers, and considerable numbers were injured as a result.

Injury pattern

All the cases were injured during the primary shock on 16 July, except for two who were injured during aftershocks on 17 and 22 July.

The most common types of injuries were contusion (30%), abrasion (16%), fracture (16%), and laceration (12%), most commonly the extremities were injured (56%), especially the lower extremities. A total of 39 persons sustained blunt injuries with no external signs. Many persons sustained multiple injuries, but the median number of injuries per person was one (range, 1–7).

The leading causes of earthquake-related injuries were: being hit by falling objects (34%), being crushed or pinned down by heavy materials (30%), and falling down during the tremor (16%). In mountainous areas, landslides (10%) were also an important cause of injury.

Entrapment (from being crushed or pinned down and requiring help to be freed) lessened the chances of survival. Among the injured, survivors were 30 times more likely not to have been trapped (odds ratio, 29.74; 95% CI, 12.35–74.96).

Rescue and medical intervention

The majority (79%) of cases were rescued, 61% by neighbours. In Baguio, the cadets from a military school together with local miners played a crucial role in the rescue efforts.

Most of those rescued (80%) were saved by persons using no equipment, 18% through the use of hand tools such as picks and shovels, while only 2% were rescued through the use of heavy equipment. The chance of survival decreased as the time of rescue increased (Table 4): 84% of the survivors were rescued within the first hour and 99% within 48 hours. Medical treatment was received by 73% of cases, as follows: first aid (63%), plaster casts (17%), suturing (11%), and major surgery (9%). Of those who were medically treated, 70% (171) received their treatment in hospital, 13% (32) at the rescue site, 10% (24) at home, while 7% (19) were seen by volunteer medical groups who visited the various refugee centres.

Discussion

In the first week after the earthquake, the FETP team concentrated on assisting in the rescue and medical treatment of victims, monitoring the needs of refugees, and ensuring the delivery of basic health services. In the second week, when the case-control study began, it was impossible to interview all the individuals who had been in the affected areas at the time of the earthquake or take a random sample of the exposed and unexposed populations. Records were not made of all the consultations at hospitals after the earthquake, especially during the first 48 hours, since the priority was to treat the injured and airlift to tertiary hospitals in Manila patients who needed more complex medical care. Also tourists and other transients in the affected areas had already returned home. We therefore carried out a case-control rather than a cohort study.

As in previous studies of earthquake-related injuries (1, 6), we encountered difficulties in selec-

Table 4 Time from the impact until survivors were rescued after the earthquake, Luzon, Philippines, July 1990

Time before rescue (hours)	No. of survivors	Cumulative %
<1	197	84
1–12	26	95
12–24	7	98
24–48	3	99
>48	2	100
Total	235	—

ting the controls. Earthquakes disrupt the normal patterns of life in a community, people are relocated, and often no complete lists are available of persons who were in a particular area during the earthquake. In the confusion following the disaster, it was difficult to find persons willing to spend time answering questions about the tragedy. Because our controls were family members of the cases or uninjured persons in refugee centres, they may have been over-matched with the cases. For example, many persons were in refugee centres because their houses had been destroyed by the earthquake, which may have biased our study by reducing the differences between the cases and controls.

Most of the injuries sustained during the earthquake were caused by the collapse of man-made structures. In accord with the findings of previous studies of earthquakes (2-5), reinforced concrete was the most dangerous building type. The collapse of modern high-rise concrete buildings, such as the Hyatt Terraces Hotel in Baguio, from the failure of their supports, typifies the damage to such buildings. Concrete is doubly hazardous because of its weight and potential for causing injury when it falls, compared with lighter materials such as wood.

Another important cause of injury was falling objects such as bookshelves, glassware, and other items that could hit and injure people. During a tremor, persons should try to move out of the path of falling objects; better still, such objects should be properly secured to prevent them from striking people in the event of an earthquake.

Since earthquakes recur in affected areas, a practical way to control the hazards that they cause is to develop and enforce effective seismic building safety codes and to retrofit or phase out older structures that do not meet them.

Buildings can be designed to various levels of seismic safety (7). At the very least, structures should be designed so that the occupants can survive, even if the building is irreparably damaged. The presence of holes or crevices ("void spaces") within the collapsed structure can provide possible survival areas for persons who are caught inside; it is also easier to rescue persons from such places than those who are entrapped or totally pinned down. Information about the likely locations of void spaces is important to help rescuers locate and free trapped persons quickly (6).

At the next level of seismic safety design, the building remains functional, even though damaged. This is an important criterion for hospitals, schools and other public buildings that must be usable after an earthquake. During the 16 July earthquake, 12 hospitals were totally damaged and two medical centres suffered serious partial damage. The staff of

these hospitals had to improvise temporary facilities using tents, salvaged materials, and donated shelters. Apart from the structural damage to the infrastructure, medical equipment was also destroyed, including oxygen gauges, anaesthetic equipment, microscopes, and other instruments. Many young persons were killed when school buildings collapsed.

When new hospitals and schools are rebuilt or constructed, it is important to make certain that they are "earthquake-proof", i.e., they must be able to withstand tremors of at least a similar magnitude to the July 1990 earthquake.

The most important findings of the study were the differences between the location of cases and controls at the time of the earthquake and in their behaviour during the earthquake.

Deaths and injuries caused by panic in schools underline the need for earthquake drills. Although earthquakes occur suddenly, there are often a few seconds in which to react before the tremor reaches maximum intensity, making it possible to take evasive action to escape injury. People should therefore be encouraged to practise actions such as running quickly outdoors or hiding in a safe place, e.g., under a table. Earthquake preparedness programmes and educational materials ranging from regular reminders or "earthquake tips" disseminated through the media to earthquake drills for occupants of specific institutions, such as hospitals and schools, should prove useful. People should resort to recommended actions during an earthquake instead of panicking.

The results of the study also highlighted that most of the crucial and life-saving rescue work was carried out by members of the local community. This supports similar observations in connection with the Mexico City, San Salvador, and Loma Prieta earthquakes (2, 9, 10). The earthquake destroyed transport networks and communication lines, thus isolating Baguio, the most severely damaged area. For the first 24-48 hours after the earthquake struck, residents in this area had to fend for themselves. As in other earthquake-damaged areas, this was also the critical time for saving lives in the Philippines (8). Foreign rescue teams with sophisticated equipment and trained dogs were only able to reach the disaster sites 48 hours after the first tremor, by which time 99% of survivors had already been rescued.

In earthquake-prone areas, strengthening the self-reliance of a community is the best way to improve the effectiveness of relief operations. Training and education in basic first aid and methods of rescue should be an integral part of any community preparedness programme. Such training should involve close coordination between formal response organizations, such as local health and social services, police and fire departments, and local informal

community groups, such as volunteers, who are likely to make first contact with earthquake injury victims. Foreign rescue teams usually arrive during the consolidation phase, when they can help to meet the needs of refugees by providing tents, blankets, food, safe drinking-water, and by assisting in the reconstruction of damaged bridges, roads, communication networks, and power lines. Engineers who could help to assess damage to the infrastructure and begin reconstruction would be more effective than teams for digging out trapped persons. Also, there is a need for psychologists and psychiatrists to help survivors and rescuers deal with feelings of helplessness, depression, and anger.

Conclusions

The greatest risk for persons during the earthquake was from the collapse of man-made structures. The development and enforcement of seismic safety codes remain the best way to prevent earthquake-related casualties. People's behaviour during and immediately after an earthquake is also an important predictor of their survival. Since the critical time for saving lives after an earthquake is the first 24–48 hours after its impact, the disaster preparedness of local communities must be strengthened by conducting drills for evasive actions to be taken during earthquakes and by providing training in rescue and first aid skills to local community members.

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Résumé

Facteurs de risque chez les victimes du tremblement de terre de 1990 à Luzon, Philippines

Le 16 juillet 1990, un tremblement de terre de magnitude 7,7 sur l'échelle de Richter a fait de nombreux morts et blessés à Luzon, aux Philippines. Nous avons entrepris une étude cas-témoins pour déterminer les facteurs de risque

chez les victimes de ce séisme dans quatre des régions les plus touchées — Benguet, La Union, Nueva Ecija et Nueva Vizcaya; cette étude nous a également permis de faire des constatations sur les opérations de sauvetage. Ont été considérées comme "cas" les victimes (blessées ou décédées) du séisme proprement dit ou des secousses qui ont suivi. Les témoins n'étaient pas apparentés, mais ont été choisis parmi les membres indemnes des familles des victimes ou parmi les personnes se trouvant dans les centres de réfugiés. Au total, 1104 sujets ont été interrogés à l'aide d'un questionnaire type et les résultats ont été soumis au test χ^2 . L'âge moyen était de 26 ans, tant chez les cas que chez les témoins, et les deux groupes comptaient 55% de femmes. Sur les 363 cas, 68 (19%) étaient décédés.

La chute d'objets a été la principale cause de blessures (34%). Les types de blessures les plus courants ont été les contusions (30%), les fractures (16%) et les écorchures (16%). Lors des premières secousses, 743 des sujets de l'étude se trouvaient à l'intérieur de bâtiments. Les "cas" étaient plus souvent à l'intérieur de bâtiments construits entièrement ou partiellement en béton (odds ratio 2,3, intervalle de confiance à 95% (CI): 1,5–3,6) et à un étage intermédiaire d'un bâtiment élevé (odds ratio: 3,5; CI 95%: 2,2–5,6). Ceux qui sont sortis pendant le tremblement de terre du bâtiment où ils se trouvaient ont été relativement épargnés (odds ratio: 0,3; CI 95%: 0,2–0,8). Parmi les 235 personnes qui ont été retirées vivantes des décombres, 99% ont été libérées dans les 48 heures suivant le déclenchement du séisme. Les habitants des localités touchées ont joué un rôle dominant dans les opérations de secours.

Ces constatations devraient se révéler utiles pour l'élaboration de codes de sécurité sismique. Des instructions devraient être données à la population sur la conduite à tenir en cas de tremblement de terre et des cours de secourisme devraient faire partie intégrante des programmes de préparation communautaire aux situations d'urgence.

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