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Risk Factors for Death and Injuries in Earthquake: Cross-sectional Study from Afyon, Turkey

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Aim To assess the risk factors for deaths and injuries caused by earthquakes in a high-risk earthquake zone.

Methods A cross-sectional study was carried out in Eber town, Çay County, following the earthquake of February 3, 2002 in Afyon, Turkey. This area was particularly affected by the earthquake, with high number of casualties, including many fatalities. The study included 812 persons living in Eber at the time of the earthquake. The study population was interviewed at their homes to obtain information on the deaths and non-fatal injuries, along with potential risk factors for death and injuries. These included the type and degree of the damage to the building, precise location and the initial actions of victims at the moment of the earthquake, and socio-demographic data.

Results Earthquake-related mortality rate was 16 per 1,000 people, injury rate was 22 per 1,000 people, and death/injury ratio was 1:1.4. During the earthquake, 60% of the buildings collapsed or were heavily damaged. Risk factors for death and injury were higher among those who lived in collapsed or heavily damaged buildings, wooden type buildings, or those who were near the outer walls during the earthquake.

Conclusion The most important risk factor for earthquake-induced mortality and morbidity was the degree of damage to the building. Another important risk factor was the location of the individual inside the room at the time of the quake.

Earthquake-induced injuries range from mild cuts and bruises to more serious conditions, such as severe fractures, internal organ damage, crush syndrome, and burns (1). In the case of earthquakes, the prevention through escape exposure is naturally not likely, therefore reducing the consequences of the earthquake is very important. It is important to know the factors that determine the risk of death or severity of injuries, and to be prepared and take measures of precaution (2).

Turkey is located on active earthquake zone. In the last 58 years, earthquakes claimed 58,202 lives, 122,096 injuries, and 411,465 collapsed buildings (3). The last of these destructive earthquakes occurred in Afyon city on February 3, 2002 at 9:11 a.m. local time, and measured 6.1 in Richter scale. The epicenter of the earthquake was in Eber. Overall, 42 deaths and 325 injuries, 9% of them requiring hospital admission, were reported in and around Afyon city. The most severely affected town was Eber, with 14 deaths, leaving 60% of all buildings in the town heavily damaged (4-5).

The objective of the study was to determine the characteristics and the risk factors for earthquake-induced deaths and injuries.

Methods

The study was carried out in Eber, where the epicenter was and most of the damage and

deaths occurred (Fig. 1). Deaths and injuries were rare in other affected areas. Two hundred and fifty-three families, who were living in Eber at the time of the earthquake, were included in the study, but 229 families were available (response rate = 90.5%). Twelve families moved out of the region immediately after the disaster and did not leave any contact address. In addition, 12 families could not be found at home because they left the region temporarily due to reasons such as unhealthy living conditions and fear of repeated earthquake. Since it was obtained from their neighbors or relatives, the information about the size of these 24 families was not precise. Therefore, overall 812 persons from 229 families were reached. There was no information about one death.

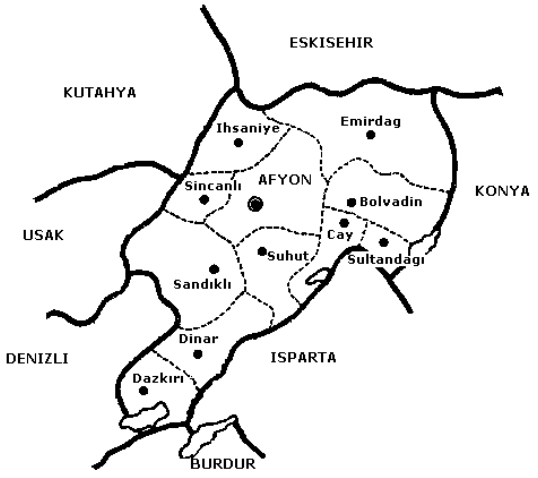

Figure 1. Afyon city map.

This descriptive, cross-sectional study was carried out three months after the disaster. Therefore, it was difficult to obtain information. The study population was interviewed at home, tents, or trailers; the interviews were based on a questionnaire. Information on the dead was obtained from the family members and on the children from their mothers. Interviews were completed in a week by three health workers, who were working at local health center, after being trained to use the questionnaire.

The questionnaire consisted of questions regarding household characteristics, building type, degree of damage to the buildings, socio-demographic characteristics of the affected people, location and initial actions of affected people at the time of the earthquake, along with the number and characteristics of the dead and injured people.

Statistical Analysis

Categorical data were compared by using χ^2-test, and odds ratios with 95% confidence intervals (CI) were computed. In order to adjust the risk factors, a multivariate logistic regression analysis was used. This analytic process was performed by using SPSS, version 10.0 (SPSS Inc., Chicago, IL, USA).

Results

After assessing the information obtained from 812 persons from 229 families, it was found that the median family size was 4, with a range from 1-10 family members. Approximately, two-thirds of the families had less than 4 members. Twenty three percent of the study population were aged 0-14, 14% were elderly (aged 65 and over), and 50% were men. Sixty-three percent of bread-earners in the families were farmers, followed by pensioners, self-employed, civil servants, and others (Table 1).

As seen in Table 2, 23% of the buildings had one story, 75% of them had two stories, and only 4 buildings had three stories. About half were wooden construction (57.6 %) and the rest were made out of reinforced concrete and masonry. Eighteen percent of the buildings totally collapsed and only 24% were not damaged at all. The degree of damage was affected by the construction type of the buildings. Eighty-three percent of the wooden buildings totally collapsed or were severely damaged; for the masonry and reinforced

Table 1. Distribution of households by age groups, gender, family size, and occupation of family head

Households characteristics	No. (%)
Age groups (n=812):	
0-14	184 (23)
15-64	513 (63)
65 and over	115 (14)
Gender (n=812):	
men	409 (50)
women	403 (50)
Family size (n=229):	
1-2	68 (30)
3-4	91 (40)
5+	70 (30)
Occupation of family head (n=229):	
farmer	145 (63)
pensioner	24 (11)
self-employed	21 (9)
civil servant	14 (6)
others	25 (11)

Table 2. Distribution of buildings (n=229) by building height, type, and degree of damage

Characteristics	No. (%)
Building height:	
1 story	53 (23)
2 stories	172 (75)
3 stories	4 (2)
Building type:	
wooden	132 (58)
reinforced concrete	72 (31)
masonry	25 (11)
Degree of damage:	
undamaged	55 (24)
slightly/moderately damaged	46 (20)
severely damaged	86 (38)
collapsed	42 (18)

Table 4. Distribution of injuries by causes, site, and type of the injury

Characteristics	No. (%)
Causes of injury (n=18):	
wall destruction	15 (83)
jumping out of the window	2 (11)
fire	1 (6)
Site of injury (n=18):	
extremities	10 (56)
trunk	5 (28)
head	3 (17)
Type of injury (n=18*):	
bruises	13 (72)
cuts	5 (28)
fractures	4 (22)
burns	1 (6)

*Some persons had multiple injuries (totally 23 injuries).

concrete buildings, the corresponding proportions were 40% and 11%, respectively.

There were 13 fatalities and 18 non-fatal injuries, which occurred in 18 of the 229 houses (8%). The death/injury ratio was 1:1.4. The mortality rate was 16 per 1,000 people and the injury rate 22 per 1,000 people. There were 7.5 deaths per 100 damaged buildings and 26.2 per 100 collapsed buildings.

Some characteristics of the deaths and injuries are given in Table 3. The median age of the dead was 51 years, and of the injured people 34 years. Thirty-nine percent of the dead and 50% of the injured were men. Of 13 deaths, 12 occurred at the time of the earthquake and one occurred 30 days later. Information about the details of the injuries was obtained directly from the injured persons and from the mothers of the two injured children (3 and 4 years old).

As shown in Table 4, 83% of the injuries occurred due to the destruction of the walls, 11% were caused by jumping out of the window, and 6% were caused by fire. Most of the injuries occurred to the extremities, followed by the trunk and the head. Some persons had multiple injuries, therefore, 18 injured persons had 23 injuries. Most of the injuries were minor such as bruises, whereas other types of injuries were cuts of different size, fractures, and burns of different degree. Nearly half of the injured people sought hospital treatment for their injuries.

Table 3. Age, gender, time of death, and building damage in death and injury cases

Characteristics	Death cases (n=13)	Injury cases (n=18)
Median age (range)	51 (4-74)	34 (3-78)
Gender:		
men	5	9
women	8	9
Time of death:		
at the moment of earthquake	12	18
after earthquake	1	0
Building damage:		
collapsed	11	12
severely damaged	2	4
slightly/moderately damaged	0	2

The risk of earthquake-induced death/injury was higher among women, elderly, and children, but this was not statistically significant (Table 5). Location of the victim inside the building, particularly in the living room or on second floor, was not identified as a risk factor. In contrast, the location in the room at the time of the earthquake, type of the building, and degree of damage to the building were significant risk factors. Persons in wooden-type buildings had a 3.6-fold higher death/injury risk, compared with other types of buildings. Those who were near the outer wall at the time of the quake had a 6.0-fold higher death/injury risk, compared with other locations. Location inside collapsed or severely damaged buildings increased the risk of death/injury 22.8 times (Table 5). Following adjustment for all factors by logistic regression analysis, the type of the building was not important predictor of deaths and injuries (Table 6).

Discussion

Our study, which determined the risk factors for earthquake-induced deaths and injuries, was carried out in Eber town where most of the damage occurred in 2002 Afyon earthquake. Although Eber was heavily damaged, the size of the affected population and the number of the dead and injured was small. The small size of the population was one of the limitations of this study.

Table 5. Risk of earthquake-induced death/injury by gender, age groups, building characteristics, and location during earthquake

Risk factors	No. (%)	χ^2-test	*P*	OR (CI)*
Gender:				
men (n=409)	14 (4)			
women (n=403)	17 (4)	0.35	0.554	0.8 (0.3-1.7)
Age groups:				
0-14 (n=184)	9 (5)			
15-64(n=513)	15 (3)			
65 and over (n=15)	7 (6)	3.31	0.191	
Location:				
inside a building (n=658)	28 (4)			
outside a building (n=154)	3 (2)	1.78	0.182	2.2 (0.6-7.0)
Location inside the house:†				
living room (n=396)	18 (5)			
other rooms (n=244)	10 (4)	0.72	0.788	1.1 (05-2.4)
Location inside the room:‡				
near to outer wall (n=12)	15 (13)			
others (near to inner wall, middle of the room) (n=520)	13 (6)	25.82	<0.001	6.0 (2.7-13.0)
Damage to the building:				
collapsed/heavily damaged (n=334)	29 (9)			
slightly-moderately damaged/ undamaged (n=478)	2 (0)	36.57	<0.001	22.8 (5.2-138.9)
Height of the building:				
two/three stories (n=623)	25 (4)			
one story (n=189)	6 (3)	0.28	0.596	1.2 (0.5-3.1)
Location inside the building:				
second floor (n=218)	9 (4)			
first floor (n=594)	22 (4)	0.09	0.780	1.1 (0.5-2.5)
Building type:				
wooden (n=446)	25 (6)			
reinforced concrete/ masonry (n=366)	6 (2)	8.61	0.003	3.6 (1.4-9.9)

*OR – odds ratio, CI – confidence interval.
†Unknown, n=18.
‡Unknown, n=26.

Table 6. Odds ratios and confidence intervals of earthquake-induced deaths and injuries in a logistic regression analysis

Variables in the model	Odds ratio (95% confidence interval)
Age women (vs men):	1.7 (0.7-4.1)
0-14 (vs 15-64)	1.6 (0.6-4.3)
65+ (vs 15-64)	1.9 (0.6-5.7)
Living room (vs other rooms)	0.8 (0.3-1.9)
Being near to outer wall (vs others)	8.8 (3.3-23.3)
Collapsed/heavily damaged buildings (vs others)	70.7 (8.2-608.4)
Two-three stories (vs one story)	0.3 (0.1-1.2)
Second floor (vs first floor)	1.8 (0.6-5.3)
Wooden type building (vs others)	0.6 (0.2-2.0)

However, as there is a paucity of data in this field, this study provided some key information which could help in preparing for future earthquakes. One of the factors giving rise to effect for people after earthquake is crowded settlements (1).

Most of the families had 1-4 members and were living in buildings with 1-2 stories. Nearly half of the buildings were made of wooden materials, and the half of the rest was reinforced concrete and masonry. Wooden-type buildings were more damaged than one or two storey reinforced concrete buildings. This finding is similar to the report from a previous Turkey earthquake study, carried out after the 1992 Erzincan earthquake (6). Killed persons were slightly older than the injured ones, and the percentage of women among dead persons was higher than men. Most of the deaths and all of the injuries occurred at the time of the earthquake. Nearly all of the buildings in which deaths occurred were completely destroyed. The other findings regarding the injuries showed that most of the injuries occurred because of the destruction of the outer walls and most of them were bruises. This contrasts the findings from the earthquake in Northridge, California, USA in 1994, when over half of the injuries were caused by falling or breaking objects and most of the injuries were cuts and/or bruises (7). Most of the injuries affected the extremities, which is similar to the findings of the Northridge and the Gujarat earthquake studies (7,8).

Earthquake-related mortality and injury rate varies by the magnitude of the earthquake and building type. Crude mortality rates were 0.4 per thousand people in 1991 Costa-Rica earthquake, 25% in Armenia in 1988, 13.4% in Taiwan in 1999, and 38% in 1999 earthquake of Gölcük, Turkey (9-12). Mortality rate was 16 per thousand people in Eber. On the other hand, the injury rate was 22%. The death/injury ratio was 1:1.4, which is slightly less than the ratio reported in Armenia (1:1.8) and in Gölcük, Turkey (1:1.9) (10,12). There is an average of one death for every three injuries in earthquake. In this earthquake, as well as in Gölcük earthquake, mortality was higher. This could be because Eber was the epicenter of the earthquake and the most severely affected area, and also because the earthquake took place early in the morning.

Previous reports have assessed different types of risk factors for earthquake-induced mortality and morbidity, such as building characteristics and individual factors (9-19). In many previous studies, it has been reported that elderly people and women are the most vulnerable groups in earthquake (11,13). In this study, the risk of earthquake-induced death/injury was higher among women, elderly, and children, but this was not statistically significant. This result is similar to the findings of Gölcük, Turkey and 1999 Taiwan earthquake study (12,14). In the earthquake of

Erzincan, Turkey, and Armenia, location inside a building was a significant predictor of death (10,15). Although in our study the risk of earthquake-induced death/injury was higher among persons who were inside a building than those outside a building, the difference was not statistically significant. In general, morbidity and mortality have increased with height of the buildings (10,15). At the same time, location of a person inside the building is of great importance. Higher mortality among people living in the lower floors of the building than among those living in the upper floors was found in previous studies (12,15), except in the study of Armenia earthquake, in which mortality was higher among those on the upper floors (10). In our study, nearly all of the buildings had 1 or 2 stories; therefore no significant association was found between death and the height of the buildings.

Structural type of the buildings is another risk factor for the earthquake-related morbidity and mortality. In this study, living in wooden buildings was a significant risk factor for death/injury during earthquake, same as in the study of Costa-Rica earthquake (9). This study also showed that persons who were near the outer wall at the time of the quake had a 6.0-fold increase in death/injury risk, compared with other locations in the room. Also, those inside collapsed or severely damaged buildings had 22.8 times increased risk of death-injury, compared with those who were in mildly damaged or undamaged buildings. The multivariate analysis of data revealed that type of the building was not very important predictor of deaths and injuries, following adjustment for all factors. At the same time, it was found that being near the outer wall increased the risk of death/injury 8.8 times and being inside collapsed or severely damaged buildings increased the risk 70.7 times. The type of structure and material of construction may play a role in the increased risk of death/injury among persons who were near the outer wall of the house.

In conclusion, the most important risk factor for earthquake-induced mortality and morbidity is the damage degree of the building, followed by location of a person inside the room.

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