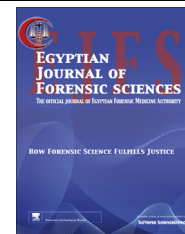


Contents lists available at [SciVerse ScienceDirect](http://SciVerse.Sciencedirect.com)**Egyptian Journal of Forensic Sciences**journal homepage: www.ejfs.org**ORIGINAL ARTICLE****Evaluation of the deaths secondary to entrapment under the debris in the Van earthquake[☆]****Yavuz Hekimoglu^{a,1}, Ipek Esen Melez^{b,2}, Gurol Canturk^{c,3}, Zerrin Erkol^{d,4}, Nergis Canturk^{e,*}, Mustafa Gokhan Dizdar^{a,5}, Deniz Oguzhan Melez^{b,2}, Osman Nuri Guler^{f,6}**^a Van Branch Office, The Council of Forensic Medicine, The Ministry of Justice, Van, Turkey^b The Council of Forensic Medicine, The Ministry of Justice, Istanbul, Turkey^c Department of Forensic Medicine, Medical Faculty, Ankara University, Ankara, Turkey^d Department of Forensic Medicine, Medical Faculty, Abant İzzet Baysal University, Bolu, Turkey^e Department of Criminalistics, Institute of Forensic Sciences, Ankara University, Ankara, Turkey^f Van Attorney Generalship, Ministry of Justice, Van, Turkey

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KEYWORDSEarthquake;
Entrapment under the debris;**Abstract** *Introduction:* An earthquake occurred on October 23, 2011 at 13:41 in the Van city of Turkey. According to the Kandilli Observatory and Earthquake Research Institute, the magnitude of this earthquake was measured as 7.2 on the Richter scale. The earthquake caused deaths and injuries due to entrapment under the debris. This study has been planned in order to evaluate

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Crush syndrome;
Death;
Autopsy

the features of these deaths and to discuss the obtained data comparatively with the literature.

Materials and methods: External examination of the corpses and autopsy reports drawn up for Van Attorney Generalship in the city center were evaluated retrospectively.

Results: Totally 51 deaths secondary to the entrapment under the debris were analyzed. Twenty-seven cases (52.9%) were females and 24 cases (47.1%) were males. All the deaths occurred in houses or workplaces. The causes of deaths were as follows: head trauma together with visceral organ laceration in 30 cases (58.8%), mechanic asphyxia in 14 cases (27.5%) and the crush syndrome in seven cases (13.7%). Deaths due to the crush syndrome occurred after victims' were rescued alive after having been under the debris.

Conclusion: Traumatic findings are usually generalized and extensive in deaths related with earthquakes. Multiple fractures of cranial bones, ribs, extremities and injuries of visceral organs and major vessels are determined in the external examination. On the other hand, forensic pathologists should not disregard the diagnosis of the crush syndrome in traumatic deaths, especially if the trauma is secondary to the entrapment under the debris following an earthquake.

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1. Introduction

Turkey is a country located on a seismic belt. Earthquake is the most important fatal natural disaster.¹ An earthquake occurred on October 23, 2011 at 13:41 in the Van city of Turkey. The epicenter of the earthquake was Tabanlı, which is 17 km away from the Van city center and according to the Kandilli Observatory and Earthquake Research Institute the magnitude of this earthquake was measured as 7.2 on the Richter scale. The human losses comprised 239 dead and 1100 injured people; and a great number of houses and workplaces were destroyed.²

Earthquake is associated with numerous deaths in crowded city regions and in buildings with weak structural quality. The injuries resulting in death are usually penetration wounds and involve multi-systems. The mortality rate increases due to the crush syndrome and related complications.³ Chest trauma is an important risk factor for death in the earthquakes.⁴⁻⁸ The crush injury of the chest, which is a life threatening injury, can lead to pulmonary parenchymal damage and multiple fractures.^{9,10}

The aim of this study has been to evaluate the deaths secondary to the entrapment under the debris following the earthquake which was one of the largest on the scale in the country's history.

2. Materials and methods

External examination of the corpses and autopsy reports drawn up for Van Attorney Generalship in the city center were evaluated retrospectively. Deaths secondary to entrapment under the debris in the earthquake were analyzed. Van city of Turkey is nowadays a critical region of terrorism having counties located far from each other and the city center. Thus, this study has been planned to cover the data of only deaths that occurred in the city center. Deaths which had occurred in the counties or villages and the deaths for which death certificates had been drawn up in the district hospitals could not be included in the study. The number of deaths evaluated and presented in this study as a forensic medicine view of point is 51 (21.33%). These 51 deaths were the ones for which postmortem external examinations had been performed among totally 239 deaths resulting from the earthquake. Due to the following

conditions after the earthquake: disorganization, technical problems, disallowance to step into the court house after its moderate destruction, obligation of the forensic experts serving in a tent for 4 months, movement of the central court house to a prison building out of the city center and still providing service in the prison building, only one autopsy was able to be performed after the medico-legal postmortem (external) examinations of the corpses in all 51 deaths. Therefore, postmortem external examinations were performed in 50 cases and complete autopsy was performed only in one case. The causes of death for these 50 cases were determined through considering the findings from the scenes of incidence, external examination and hospital records. All the cases have been analyzed according to the parameters of sex, age, death place, and zone - characteristics of the traumatic lesion and cause of death. The statistical analysis was performed by using SPSS 16.0 Packet Program.

3. Results

Totally 51 deaths secondary to entrapment under the debris were evaluated. Twenty-seven cases (52.9%) were females and 24 cases (47.1%) were males. The age range was between 1 and 72 years. The mean age was calculated as 27.39 (sd = 17.92) whereas the median was 27.00. Age could not be identified in 2 (3.9%) cases. Eighteen of the cases were in the childhood period (between 1 month and 17 years). The sex distribution of the cases based on the age groups has been

Table 1 Age groups - sex distribution of the cases that died in the earthquake and were evaluated in this study.

Age groups	Sex		
	Female	Male	Total
0-10	4 (7.85%)	3 (5.88%)	7 (13.72%)
11-20	7 (13.72%)	4 (7.85%)	11 (21.57%)
21-30	5 (9.80%)	6 (11.76%)	11 (21.57%)
31-40	4 (7.85%)	5 (9.80%)	9 (17.64%)
41-50	2 (3.92%)	2 (3.92%)	4 (7.85%)
51 and above	5 (9.80%)	2 (3.92%)	7 (13.72%)
Unknown age	0 (0.0%)	2 (3.92%)	2 (3.92%)
Total	27 (52.94%)	24 (47.05%)	51 (100.00%)

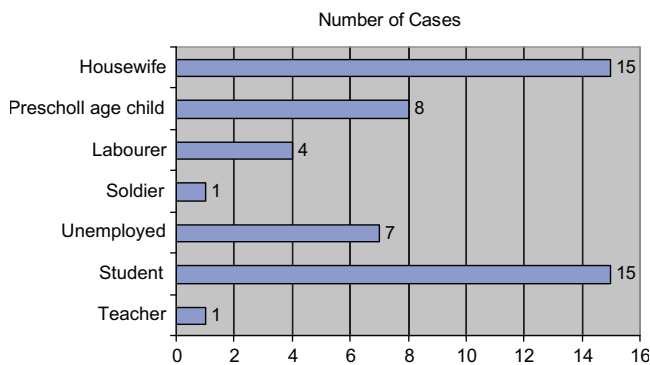


Figure 1 Occupational distribution of the cases that died in the earthquake and were evaluated in this study.

shown in Table 1. There was no statistically significant difference between the groups ($p > 0.05$).

The causes of deaths were head trauma together with visceral organ laceration in 30 cases (58.8%) and mechanical asphyxia in 14 cases (27.5%). Seven cases (13.7%) were found to have died due to crush syndrome and related complications. Extremity injuries were found in 23 (45.1%) of the cases. Chest trauma was found in 25 (49.02%) of the cases. The deaths of 39 cases (76.5%) occurred at the scene on the same day and 12 deaths (23.5%) occurred in the hospital. Of these hospital deaths, 11 (91.66%) out of 12 deaths occurred between 1 and 7 days while 1 (8.34%) death was on the 30th day of the earthquake. The cause of death was found to have been identified as the crush syndrome in seven out of 12 cases. These seven cases (58.33%) had undergone surgeries during the hospital stay. Two of those surgical interventions (16.66%) were detected to be fasciotomy operations.

The occupational distribution of the cases has been demonstrated in Fig. 1. When the cases in the childhood period and two cases whose ages could not be determined were omitted, it was seen that among 16 females one had been a teacher and 15 had been housewives. Among males three (20%) had been students, one (6.66%) had been a soldier, four (26.67%) had been laborers and seven (46.67%) had been unemployed. The scene of the incident was found to be the house in 42 (82.4%) and the workplace in nine (17.6%) cases. The regions of birth registration among the cases were as follows: 30 (58.8%) from the Eastern Anatolia Region, six (11.8%) from the Southeastern

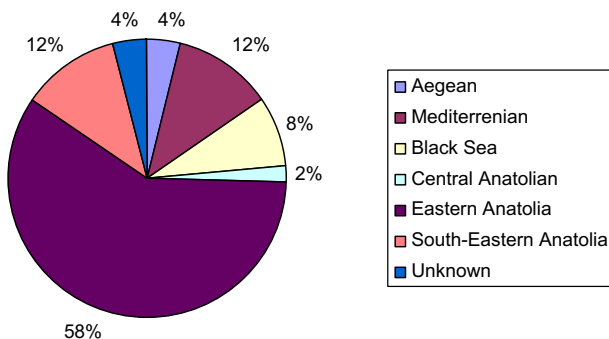


Figure 2 Regional identity register data of the cases that died in the earthquake and were evaluated in this study.

Anatolia Region, six (11.8%) from the Mediterranean Region, four (7.8%) from the Black Sea Region, two (3.9%) from the Aegean Region, and one (2%) from the Central Anatolia Region. The birth registrations of two (3.9%) cases could not be determined (Fig. 2). Through these findings, showing the differences in birth registration regions, it can be concluded that the earthquake in Eastern Anatolia Region resulted in losses and negative impacts not only in that geographical area but also in other regions of the country.

4. Discussion

Even though a formula has been developed in order to predict the death rate after an earthquake using the parameters such as age, thrombocyte count, the use of vasopressor medication, the need of dialysis; children usually constitute the main group affected from the natural disasters.¹¹ In our study, there were 18 cases (35.29%) in the childhood period. It is anticipated that the relative death risk can be decreased by 37% with 'pediatric trauma centers establishment' hypothesis.¹² The death rate has been reported to be higher among the injured children and elderly in the earthquakes.¹⁰ In our study, seven cases (13.72%) were over 50 years of age. Another group, which is affected negatively from the earthquake, is women. Premature membrane rupture has been reported in 7.9% of the pregnant women in the NATO peninsula earthquake.¹³ In our study, 27 of all the cases (52.9%) were females.

Head trauma and asphyxia have been reported to be the most important two earthquake related death causes in the acute phase.¹⁴ Besides, abdominal injury, head trauma and injury of the chest have been determined to be associated with death during and after an earthquake.¹⁵ According to another study, 30% of the death cases were secondary to head trauma.¹⁰ In our study, the deaths occurred due to head trauma and internal organ injuries in 30 cases (58.8%), and mechanical asphyxia in 14 cases (27.5%).

It has been reported that the deaths had occurred due to cardiopulmonary arrest, severe cranio-cerebral injury, hemorrhagic shock, and crush syndrome resulting in multiple organ dysfunction in the Wenchuan earthquake in China. Severe cranio-cerebral injuries were noted in 5% of the cases.¹⁶ It was added that after the elimination of moderate injuries, among the rest of the cases, 8.2% had faced the crush syndrome and several of these developed complications such as infection, sepsis, acute renal failure, hematologic abnormality, ARDS, congestive heart failure, multiple organ dysfunction syndrome, 15.9% had hyperkalemia, and 41.6% had developed acute renal failure.¹⁷ Chest trauma constitutes approximately 15% of all traumas in the earthquakes and when chest trauma is considered separately, the mortality rate of chest trauma is concluded to be up to 35% in the clinical series.^{18,19} In our study, the cause of death was chest trauma and the complications secondary to the crush syndrome in seven cases (13.7%).

The most common injury in chest trauma is rib fracture. Furthermore, the number of fractured ribs is a good parameter in assessing the severity of the injury.⁴ Besides, it is known that the deaths resulting from acute renal failure secondary to crush syndrome are more frequent in the elderly and in children.²⁰

It has been also reported that there were a higher number of fractured ribs in trauma related with the earthquake compared to the traumas caused by the reasons other than the earthquake, besides it was common to have three or more fractured

ribs and flail chest with more frequent bilateral rib fractures, crush syndrome, parenchymal and pleural injuries in this group.^{4,21} In the 1995 Southern Hyogo Prefecture earthquake, 12.9% of 487 injured individuals presenting to the Kobe University Hospital were reported to have chest trauma.⁵ In our study 49.02% of the cases had chest trauma.

Usually, the deaths in an earthquake occur due to the trauma of being entrapped under the debris. For this reason, the earthquake causes deaths usually in enclosed places.²² Similarly, the scene of incidence was the house in 42 cases (82.4%), and the workplace in nine cases (17.6%) in our study.

When the cases in the childhood period and two cases whose ages could not be determined were omitted, it was seen that among 15 males seven (46.67%) had been unemployed and among 16 females 15 (93.75%) had been housewives. Occupational distribution of the cases was parallel to the profile of the eastern cities in our country.

It is well known that the death rate increases closer to the epicenter of an earthquake.¹⁰ Being only 17 km away from the epicenter, Van city center was affected in the first degree from the earthquake. According to the data of 2009 from Turkish Statistical Institute (TSI), the population of Van city center was 360,810. In our study, 30 cases (58.8%) were registered officially in the Eastern Anatolia population of our country, which was the earthquake region; 21 cases (41.2%) were registered in other regions of Turkey except the Marmara Region. This finding reflects the fact that the Van earthquake caused negative impacts not only in the Eastern Anatolia region but also in other regions of Turkey through the traumas and deaths of members of families from other regions who had been in the Van area during the earthquake although it was not their original hometown.

5. Conclusion

Earthquakes cause death usually with generalized traumatic findings. In most of the cases, death occurs as a result of head trauma and/or general body trauma quickly in the scene of the incident. Determining the cause of death is essential to develop protection strategies for the traumatic effects of the earthquake on the bodies of human beings or other living organisms. In addition, with a forensic approach, to be able to eliminate or elicit other possible causes of death which can be concealed within the results of an earthquake is also important.

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