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Statistical Modeling of the Beginning and End of Relief Time by Red Crescent in Earthquakes between "1395-1396": a Survival Study

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ABSTRACT

Earthquakes are considered a high catastrophic and unpredictable natural catastrophe and reports on structural collapses reveal a persistent vulnerability and emphasize the importance of better integration of collective response to such disasters. To alleviate the collapses and victims, there is a need to standardize all phases of USAR operations (deployment, search, locate, extrication, on-site medical support) and increase the speed of rescue efforts. Investigating the effective factors on the duration between the start to the end of the relief effort, will be useful to improve crisis management for reducing wasting time and optimizing the management of future events. In this paper, it has been tried to estimate the duration between the beginning and the end of the earthquake relief by some explanatory variables. It is used Survival modeling like Cox regression or Kaplan–Meier to assessment and comparison of the effect of the explanatory variables such as: earthquake magnitude power, the amount of services provided by the Red Crescent society, level of health care and etc. For this research, the relief and rescue organization database has been used. The median of time between start to end of relief operation is 4.6 hours. Cox model applying showed that level of use of air and logistics services and the number of rescuer teams leads to shorter time significantly ($p<0.05$). Log Rank test didn't distinguish difference between time median in two years 1396 and 1395 ($p=0.423$).

Keywords:

Relief Time, Survival Analysis, Earthquake, Red Crescent Society

1. Introduction

An earthquake is a sudden, rapid shaking of the ground caused by the breaking and shifting of rock beneath the Earth's surface. This shaking can cause buildings and bridges to collapse; disrupt gas, electric, and phone service; and sometimes trigger landslides, avalanches, flash floods, fires, and huge, destructive ocean waves (tsunamis). Buildings with foundations resting on unconsolidated landfill, old waterways, or other unstable soil are most at risk. Buildings or trailers and manufactured homes not tied to a reinforced foundation anchored to the ground are also at risk since they can be shaken off their mountings during an earthquake. Earthquakes can occur at any time of the year [1]. Preparedness Planning the reduction of earthquake consequences depends on the community is prepared for a fast and organized response to the urgent needs of its citizens. Regardless of how well organized is the community for a fast response and however prepared they are for undertaking emergency measures for saving of victims, the world experience has shown that the most important aid in the initial time following an earthquake comes from the inhabitants of the affected area themselves [2]. It is obvious that the number of survivors during the rescue period decreases rapidly in the second, third, and subsequent days. It is possible that if the number of the survivors in the first post-earthquake day was larger, the number of the dead would decrease. The relationship between the rate of the rescue and the causes for death has been investigated by Coburn and Spence [3]. Emergency measures are not limited to the activities related to search and rescue. A wide range of activities in case of a natural disaster should be started as soon as possible [4-6]. To alleviate the collapses and victims, there is a need to standardize all phases of USAR operations (deployment, search, locate, extrication, on-site medical support) and increase the speed of rescue efforts. Searching under the ruins of collapsed buildings is actually a fight against time, as time is strongly associated with the chances of survival of the entrapped victims. Survival under the building rubbles is strongly time-dependent and decreasing of the time between occurrence of a disaster (especially earthquake) and appearance rescue team will be helpful for low damages [7-8]. Since the beginning of 1395 to the end of 1396, a total of 85,550 incidents occurred in Iran, 314 of them were earthquakes which distributes differently in the provinces (Figure1). According to the available information in this two-year period, 34% of earthquakes occurred in 1395 and 66% in 1396. An issue that is important at the time of the incident and especially about earthquake is the speed of operation and the optimal use of time in order to minimize casualties and save people life. Investigating the effective factors on the duration between the start to the end of the relief effort, will be useful to improve crisis management for reducing wasting time and optimizing the management of future events. In this paper, it has been tried to estimate the duration between the beginning and the end of the earthquake relief by some explanatory variables. It is used Survival modeling like Cox regression or Kaplan–Meier to assessment and comparison of the effect of the explanatory variables such as: earthquake magnitude power, the amount of services provided by the Red Crescent society, level of health care and etc. For this research, the relief and rescue organization database has been used. A quantitative and qualitative comparison is made between two years 1395 and 1396.

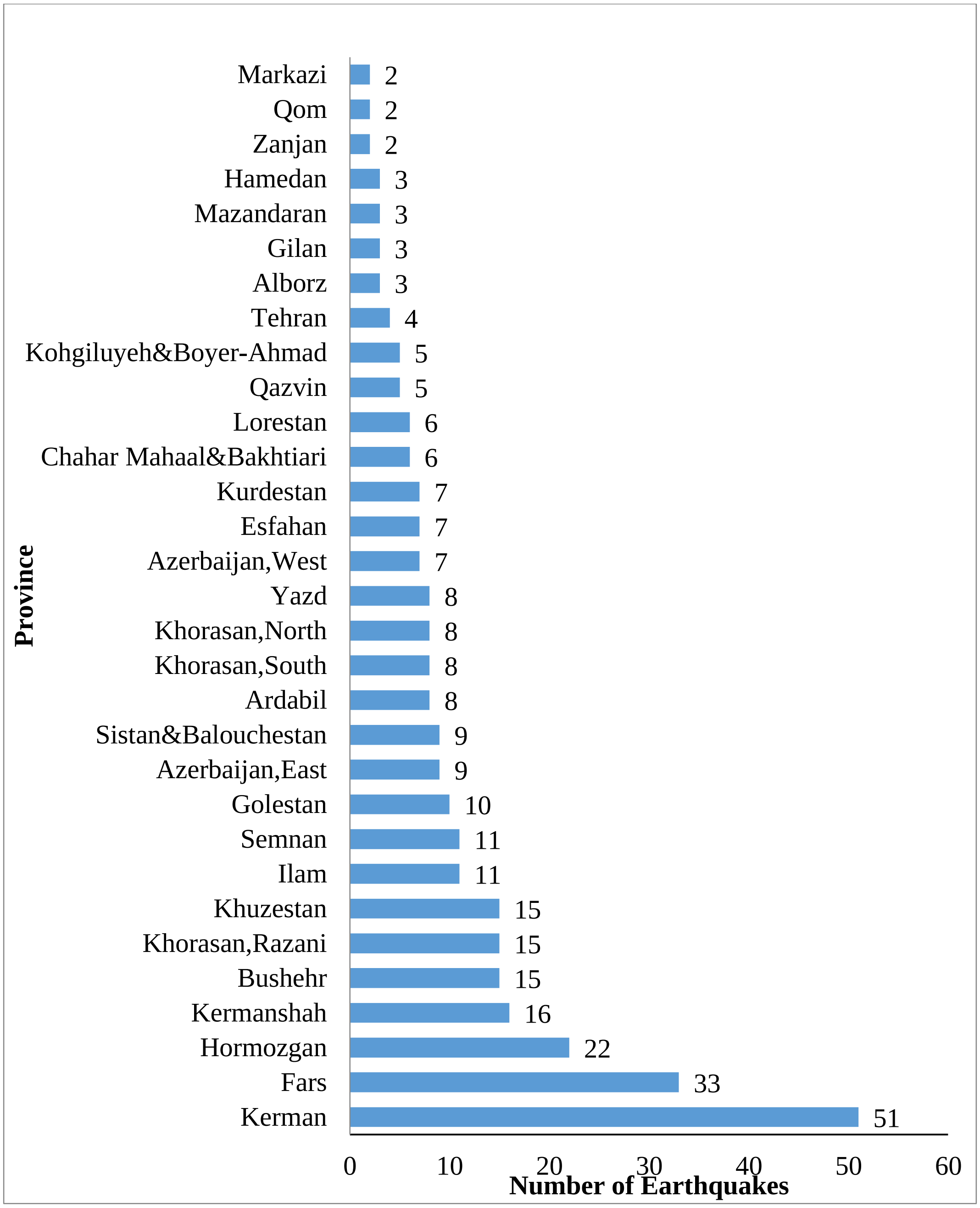

Figure1. Distribution of Earthquake Number by Province 1395-1396.

2. Methodology and Data

For this research, the relief and rescue organization database, was used (9). The duration between the beginning and the end of the earthquake relief by some explanatory variables, were estimated. It is used Survival modeling like Cox regression and Kaplan–Meier to assessment and comparison of the effect of the explanatory variables such as: earthquake magnitude power, the amount of services provided by the Red Crescent society, level of health care and etc. A quantitative and qualitative comparison is made between two years 1395 and 1396. Data was analyzed by IBM 24.0 software and significant level for statistically hypothesis was consider 0.05.

2.1. Survival modelling

Survival modeling and analysis, is one of the oldest fields of statistical science. As the name implies, this branch of statistical science deals with the study of the waiting period until a particular event occurs, such as the duration of a particular disease, time to earthquake, death, disease, relapse, and recovery. This time is shown by the variable T. The survival probability function and risk level are among the most important quantities considered in survival analysis (9). The survival function for the random variable T at the specified time t is:

$$S(t) = P(T > t) \tag{1}$$

In reviewing the texts related to survival analysis, familiar estimates be seen. In 1985, Kaplan and Meyer proposed a well-known non-parametric estimator for the survival function (10), the highest reference in the history of statistics (35,000 times). The Kaplan Mayer estimate of the survival function is as follows:

$$\hat{s}(t) = \begin{cases} 1 & if \quad t < t_1 \\ \prod_{t_1 \le t} [1 - \frac{d_i}{Y_i}], & if \quad t_1 \le t \end{cases} \tag{2}$$

The use of nonparametric methods of estimating the survival probability function, despite its simplicity of application, does not make it possible to investigate the possible effect of some auxiliary variables on survival probability and even compare the probability of survival based on auxiliary variables and various factors. Thus, Cox's paper in 1972 revolutionized the analysis of survival data and, with 25,000 citations, proved its potential role in this field (64). In Cox's proportionate risk model, the risk function for the subject i , Which has a vector of auxiliary variables $\boldsymbol{Z}_i(t) = (z_{i1}(t), \ldots, z_{ip}(t))$, is defined as follows:

$$h(t|\boldsymbol{Z}_i(t)) = h_0(t)\exp[\boldsymbol{\beta}'^{\,\boldsymbol{Z}_i(t)}] \tag{3}$$

The Cox model is derived from the product of the unknown basic risk function $h_0(t)$, and an exponential function of regression coefficients $\boldsymbol{\beta} = (\beta_1, \ldots, \beta_p)$. $\acute{\beta}Z = \sum_j \beta_j Z_{ij}$ is the parametric part of the model in which it is usually assumed to be constant. In addition to β, $h_0(t)$, the unknown parameter of the model is actually the same value $h(t|Z_i(t))$ as the vector of the auxiliary variables is equal to zero.

3. Results

According to the available information in this two-year period, 34% of earthquakes occurred in 1395 and 66% in 1396. According to the results, 70 percent of earthquake happened in 4.0-4.9 power range. The median of time between start to end of relief operation is 4.6 hours. Cox model applying shows that power has significantly effect on the time of duration between start to end of relief operation and also the services like level of use of air and logistics services and the number of rescuer teams leads to shorter time significantly (Figure2) and (Table1) (p=0.028). Log Rank test distinguished difference between time median in two years 1396 and 1395 (Figure3) and (Table2) (p=0.015), the distance between two lines is increasing through the time that may indicate better relief in 1396 year. Advancing all these factors is the key for getting faster decisions and improving reaction times.

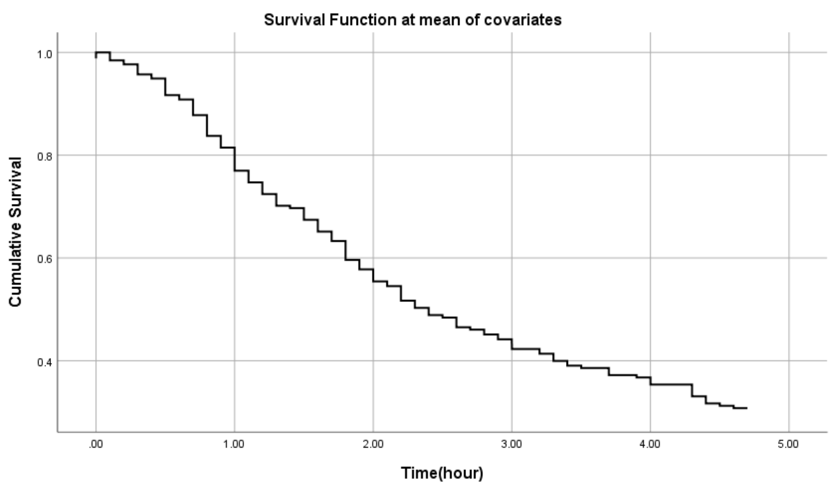

Figure2. Overall Survival function for time between start to end of relief operation.

Table1. Cox proportional model results

Items	B	P-value	Exp (B)
year	0.400	0.015*	1.492
Rescuer	0.053	0.671	1.054
Vital support	2.645	<0.000*	14.081
Food pack	-0.006	0.440	0.994
Physician	0.004	0.439	0.998
Ambulance & other cars	-0.216	0.029*	0.806
*:Significant at level 0.05			

Table2. Log Rank test of equality of survival distributions for the different levels of year.

Test	Chi-Square	df	P-value
Log Rank (Mantel-Cox)	4.804	1	0.028*
*:Significant at level 0.05, df: degree of freedom			

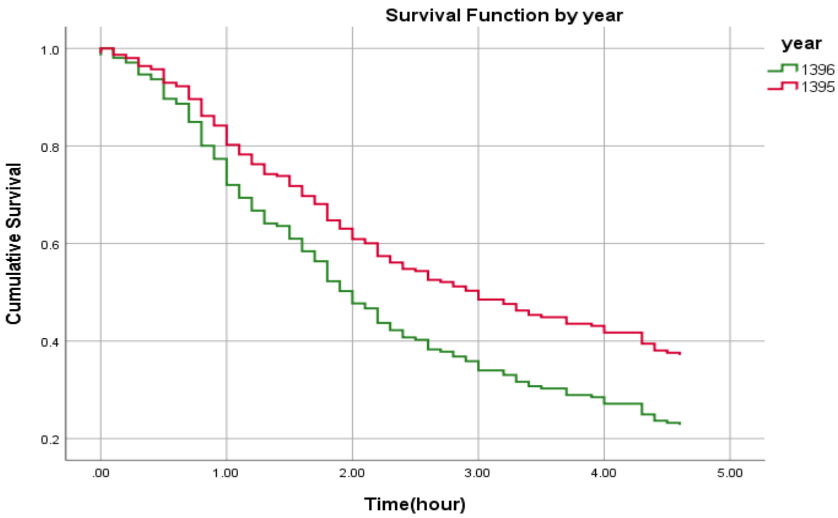

Figure3. Survival functions for time between start to end of relief operation by years.

4. Discussion

In this survival-longitudinal study, it was investigated the effect of some explanatory variables like logistic instruments on the time between beginning to the end of relief by red crescent, during two years 1395-1396, in Iran. In totally since the beginning of 1395 to the end of 1396, a total of 85,550 incidents occurred in Iran, 314 of them were earthquakes. 34% 66%of earthquakes occurred in 1395 and 1396, respectively. The results showed that air and logistics services and the number of rescuer teams leads the less relief time and on the other hand, the survival time in 1396 year is smaller than 1395 which implies to better relief action in 1396 rather than 1395. a similar study to this research has not been conducted before to compare the results, but it has been mentioned to this fact that preparedness is very important in risk management [11]. Preparedness means to have prepared plans for response by national, regional, and local governments, organizations, communities and individuals; the listed activities within corresponding timing should be undertaken. The activities of the health sectors and other services that should be planned accordingly are given below. Following our and the world experience for an appropriate response to a disaster event, the main sectors responsible for plans preparation are the public, health, and engineering sectors. For each of these main sectors, the items on which they should prepare plans of actions, with appropriate responses. Investigating the effective factors on the duration between the start to the end of the relief effort, will be useful to improve crisis management for reducing wasting time and optimizing the management of future events.

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