

Implementing a Weather-Based Early Warning System to Prevent Traffic Accidents Fatalities

¹Jafar Hasanzadeh, ²Mohammadreza Amiresmaili,

³Mahmood Moosazadeh, ⁴Farid Najafi and ⁵Mehdi Moradinazar

¹Department of Epidemiology, Shiraz university of Medical Sciences, Shiraz, Iran

²Health care services department, Kerman University of medical sciences, Kerman, Iran

³MPH and PHD student of epidemiology, Research Center for Modeling in Health, Institute of Futures Studies in Health, Kerman University of Medical Sciences, Kerman, Iran

⁴Department of Epidemiology, School of Medical Sciences Kermanshah, Iran

⁵Department of Epidemiology, Shiraz university of Medical Sciences, Shiraz, Iran

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Abstract: Introduction: The present study aims to design a weather-based early warning system to prevent traffic accidents fatalities. Methodology: In this study, the Early Aberration Reporting System (EARS) was used to determine epidemic threshold. By roc curve, the Sensitivity and Specificity of temperature points were determined and, the point with highest sensitivity and specificity was selected based on Youden's index. They were analyzed by Excel and statistical package of SPSS (version 19) software. Results: The number road traffic accidents deaths in Fars province was reduced during 2004 to 2009. Epidemic threshold for mortality of accidents by EARS method was 179 people per month. By roc curve, Youden's index of the maximum sensitivity and specificity was achieved at 10°C. Sensitivity, Specificity and Predictive Value Positive for road traffic accidents deaths by cut of point were 82%, 81, 83%. Conclusion: This study proposes that based on predictability of mortality of accidents by weather variables and high ratio of Sensitivity, Specificity and Predictive Value Positive of the variables for early diagnosis of mortality of accidents we can have a good planning by coordinating between a defined section, health centers, Road office and traffic police by identifying the times with maximum mortality of accidents.

Key words: Accidents • Traffic • Early warning • Roc curve

INTRODUCTION

Road traffic accidents are among the ten leading causes of death worldwide imposing considerable burden on the health economy of all countries including developing and developed countries [1, 2]. Based on the World Health Organization (WHO) report, every year more than one and a quarter million people die and more than fifty million are seriously injured in road traffic accidents. It is predicted that by the continuance of this trend in the next 10 years, 3 million people will be killed and 60 million people will be wounded in developing countries [2, 3]. In Iran, with the population of about 71 million people, there are about 17 million cars, the highest number of cars among Eastern Mediterranean countries [4, 5]. The current statistics of deaths due to road traffic

accidents in Iran is similar to the situation of 1960s in European countries. Based on the reports of the forensic medicine organization, Iran has a 10% annual increase in deaths due to the road traffic accidents. This mortality rate in Iran was 15 times more than other developing countries [4-7]. Such burden needs to be managed by application of appropriate measurements. Without such strategies, the death caused by road traffic accidents will be increased by 67% by 2020. While the increase in deaths due to road traffic accident for low and middle income countries would be 83% the corresponding value for high income countries would be a reduction of 27% in such deaths [8].

For the diseases or conditions with considerable changes, health care providers are aimed to establish a system in which the fluctuations are detected at minimum

time, or even before the disease are reached to the epidemic level. Such system can avoid epidemic or by identifying the epidemic time, the health requirements are provided in a more efficient way for susceptible people. One of the methods to predict the disease is using early warning system. By the aid of environmental data, we can have a correct and rapid prediction of the problem. Early warning system means on time prediction by existing data to reduce or predict the risks faced to the vulnerable people.

The preventive and Management measures for different types of risks are different. While some of the health problems are very fast spreading such as the spread of a harmful chemical substance or Influenza virus; some others are occurred very rapidly as road traffic accidents. Therefore, establishing early warning system should act in accordance with the type of problem and therefore the speed of the system is adjusted based on the nature of risk. This speed can be determined ranging from minutes to years. In this study we aimed to design an early warning system by using weather data and deaths due to road traffic accidents from 2004 to 2009 from Fars Province.

MATERIALS AND METHODS

Study Population: In this study, all road traffic accidents (excluding data from Fasa and Jahrom) resulting in the death during 2004-2009 was investigated in Fars province. Fars province is the most populated southern province in Iran and based on the census data of 2011, it was 4585300 people. On the other hand, it has about 2229 kilometer main way, of which 569 km is of highway type.

Data Gathering: The death accidents data were obtained from death registering system. Death data in Iran are managed by health center of each province and all the resources including hospitals, cemetery, forensic medicine and health and rural centers are used for this purpose. The causes of death were coded in accordance with international classification of diseases ICD 10 and were recorded by uniform computer software. Weather data including the number of rainy days, snowy days, average monthly humidity and average maximum monthly temperature in the province were obtained from all meteorology stations of the province. The data of gasoline consumption of the province were obtained from the Ministry of Petroleum and Natural Gas of Iran [9].

Data Analysis: Data due to fatalities caused by road traffic accidents, weather and gasoline consumption in the province during 2004 to 2009, were separated monthly and death cases of road traffic accidents were investigated by linear regression. The data were analyzed using the SPSS (version 19) software.

The Calculation of Sensitivity, Specificity and Predictive Value Positive: In this study Early Aberration Reporting System (EARS) method was used to determine the epidemics threshold that is widely applied in public health system of USA [10-14]. By Receiver-Operating Characteristic (ROC) curve. Sensitivity (Σ True Positive / Σ Condition Positive) and Specificity (Σ True Negative / Σ Condition Negative) of temperature points were determined and the point with highest sensitivity and specificity was selected based on Youden's index (Sensitivity + Specificity - 1).

RESULTS

The results of this study showed that the number of deaths of accidents in Fars province are reduced during 2004 to 2009 and this reduction was statistically significant ($p < 0.03$) (Figure 1).

The investigation of the death caused by road traffic accidents in Fars province showed that the traffic accidents deaths follow a periodic trend such that 23% of the mortality caused by road traffic accidents is predictable on a monthly trend and at better condition 31% of the death caused by road traffic accidents is predictable on a seasonal trend. As is shown in Figure 2, the maximum cases of deaths were occurred in summer (September) and the minimum death cases were occurred in winter (December) and the difference observed in the number of death number caused by the road traffic accidents were significant in different months (Figure 2) ($P < 0.001$).

Epidemics threshold for accident deaths in Fars province by EARS method was 179 deaths per month. By Roc curve and Youden's index, the maximum sensitivity and specificity of temperature to determine epidemics of death due to road traffic accident were obtained at 10°C. Sensitivity, Specificity and Predictive Value Positive for the death of road traffic accidents by this cut of point were 82%, 81% and 83% (Table 1). As is shown in Figure 3 (Roc curve), there were significant changes in Sensitivity,

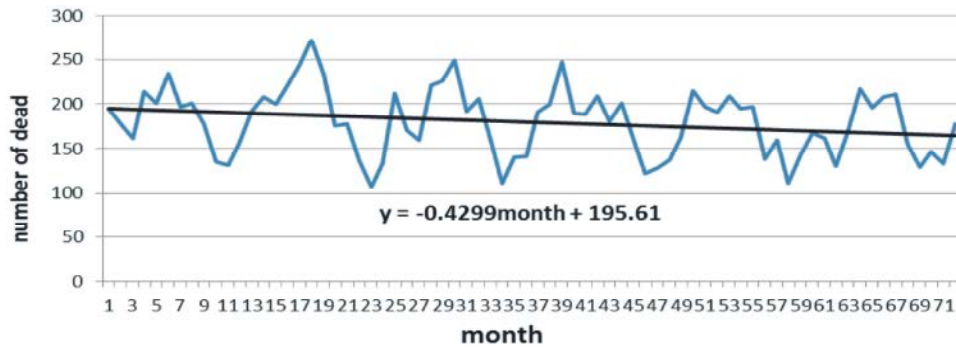


Fig. 1: Trend of traffic accidents based on the month

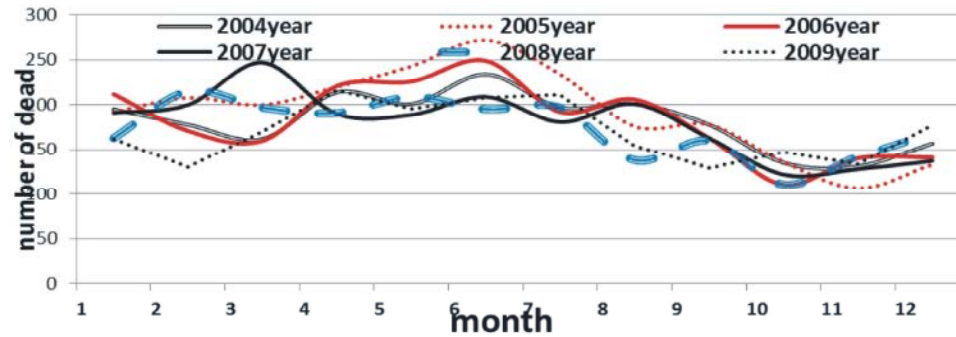


Fig. 2: The number of deaths of accidents in Fars province based on month

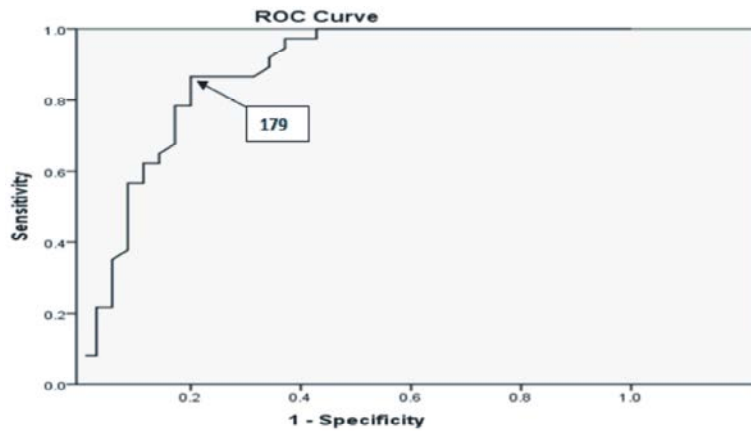


Fig. 3: Determining sensitivity and specificity of temperature by Roc curve to determine epidemics of death accidents

Table 1: The number of months lower and higher than threshold 179 based on the mean temperature

Temperature	NO Epidemic	Epidemic	Total
Higher10	7	28	35
Lower=10	31	6	37
Total	38	34	72

28/34=83%: Sensitivity 31/37=83.7% Predictive value negative
 31/38=81.5%: Specificity 28/35=80% predictive value positive

Specificity when the epidemics threshold is changed. The best point with maximum Sensitivity, Specificity is cut of 179 deaths per month for road traffic accidents.

Table 2: The accuracy of different variables to establish early warning system for accidents death

Variable	Sensitivity	Specificity	Predictive value positive	Predictive value negative
number of rainy days*	72%	84%	63%	89%
freezing days number	80%	83%	77%	80%
humidity	78%	70%	80%	67%
gasoline consumption	44%	50%	92%	8%

*To find suitable cut of pint for the investigated variables, Youden's index was applied.

Other results of the study showed that in case of using other weather variables as the number of rainy days, the average freezing days and average humidity per month as prognostic variables because of the relation of the variables with each other, we can achieve acceptable sensitivities, specificities and predictive values. While using monthly gasoline consumption of the province to establish early warning system for mortality rate of accidents have less sensitivity and specificity (Table 2).

DISCUSSION

The EARS was applied for the first time by Center for Disease Control and prevention (CDC) of USA to increase the ability of public health executers for early diagnosis of any outbreaks in trends of diseases. Applying this system was considerably taken into attention by epidemiologists. The reasons for such attentions are related to different factors: it's easy function and use by most computer software's, high flexibility of the program, rapidity in diagnosis of any abnormal situations and high sensitivity of the method with acceptable error. This method had more error compared to most of epidemic diagnosis methods [11, 15-19].

The results of the study showed that the road traffic accidents deaths can be predicted. And we can define early warning system for this condition by various variables. If we predict the changes of death due to road traffic accidents based only on monthly and seasonal trends, the prediction efficacy of the system is lower because of contribution of non-seasonal components and unknown factors. But if we use weather changes to set up early warning system, because of strong relation with other known and unknown effective factors have high sensitivity, specificity and predictive value to model the deaths related to road traffic accidents. Because of high correlation between weather variables (Table 2), each of the variables can be used and the prediction power will be high. Overall, the average monthly temperature of the province had better performance compared to others. Conversely, there was not strong correlation between the number of deaths due to road traffic accidents and monthly gasoline consumption.

The results of the study showed that during the period of 2004-2009, the number of deaths due to road traffic accidents reduced in Fars province and this reduction trend was significant and in line with the results of similar studies conducted in Iran [4, 5]. One of the important findings of the study was the at the same time performance of the changes in weather variables and the

change in mortality of accidents and caused that the variables had more predictive role compared to some variables as monthly gasoline consumption.

This study proposes that based on the predictability of road traffic accidents deaths, by weather variables and high sensitivity, specificity and predictive value positive of the variables for early diagnosis of death of accidents we can have a good planning to reduce it by coordinating between a defined section, health centers, Road office and traffic police by identifying the times with maximum mortality of accidents.

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