

# Association of Temperature and Humidity with Trauma Deaths

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## Abstract

**Background:** Few studies worldwide have shown that climate factors such as temperature and humidity may contribute to injuries and sudden death. However, to the best of our knowledge no studies have been conducted on climate and traumatic deaths in Iran.

**Objectives:** The aim of this study was to investigate the relationship between temperature and humidity and trauma deaths in Kerman, Iran.

**Materials and Materials:** In this study, data of all trauma deaths from March 2006 to February 2011 were collected from the Kerman Health Ministry and categorized by causes. Trauma deaths were extracted and matched with data regarding temperature and humidity obtained from the Kerman Meteorology Office during the same time period. Negative binomial regression and Spearman correlation analysis were used to analyze the data using STATA10 and MiniTab16.

**Results:** The findings of this study showed that the overall mortality caused by trauma is higher in the warm season. The highest correlation between mortality and temperature was seen in ages over 60 years ( $r = 0.301$ ,  $P = 0.020$ ) in trauma deaths and was statistically significant. An inverse significant correlation was observed between the incidence of trauma deaths and humidity and was highest in the over 60-year age group ( $r = -0.336$ ,  $P = 0.009$ ). The regression results also revealed an inverse significant relationship between humidity and trauma deaths in the over 60-year age group.

**Conclusions:** High temperatures and low humidity increased the risk of trauma deaths in our study. However, more studies are needed to document this.

**Keywords:** Injury, Death, Temperature, Humidity

## 1. Background

Trauma is a major health problem in most developing countries (1). Trauma causes more deaths than any other cause in people younger than 34 years (2, 3). Medically, trauma refers to any injury or damage that occurs due to external factors including road accidents, falls, sports and other factors (4).

According to the reports published by the World Health Organization (WHO) Regional Office for the Eastern Mediterranean, accidents and trauma are currently one of the three main causes of death in populations (5). The mortality rate due to trauma worldwide is approximately 16% and from traumatic deaths 90% occur in developing countries (6, 7). According to the WHO estimation, road traffic accidents will be the second leading cause of lost years of life worldwide by 2020 (8). A high mortality rate of due to trauma is seen in Iran and unlike most countries, the mortality rate of is more than 20% (9); while other cases such as falling from heights, firearms, disasters, burns, drowning and explosion of landmines are also added (10). Trauma has always been a social and economic problem that not only accounts for mortality, but also requires long-term and costly medical care (11). Trauma

affects all human populations regardless of age, gender, social class or geographic region. In the USA about 500 thousand people per year lose their lives due to trauma from traffic accidents making this kind of trauma the third leading cause of death in that country (12). Approximately, 1.24 million deaths due to road traffic accidents (RTA) occurred worldwide in 2010 (13).

In 2001, 1.5 million out of 4 million annual hospitalizations in Iran were trauma-related. Thirty-two people per day lose their lives due to RTA in Iran (12). Trauma mortality rates per hundred thousand people in the world and in Iran are 99 and 58, respectively (14).

According to a study conducted on injured persons transported to Birmingham Trauma Center, the highest frequency of all-terrain vehicle trauma was observed in warmer seasons and on weekends (15). Results of a study in Taiwan showed that more elderly patients were transported to the hospitals through emergency aero-medical transport services during the cold seasons (fall, winter), and more young patients were transported through this system during the warm seasons (spring, summer) (16).

Through better understanding of trauma and its relat-

ed factors, appropriate programs and strategies can be arranged to prevent such problems (17, 18).

## 2. Objectives

We sought to assess the possible association between temperature and humidity with trauma deaths in Iran.

## 3. Materials and Methods

All causes of mortality from 2006 to 2010 were obtained from the Health Ministry in Kerman and all data on trauma deaths were extracted. These causes were categorized into two main groups namely unintentional and intentional. Unintentional causes included, sports, falls, drowning and RTA. Intentional causes included homicide or suicide.

The average daily temperature and humidity data of Kerman City were obtained from the Kerman Meteorology Office for the period of study. First, data on temperature and humidity were matched with the traumatic deaths in terms of time. Then, the monthly average number of total deaths and trauma deaths were calculated. The relationship between mortality rate, temperature and humidity were examined. Data were analyzed via Spearman's correlation coefficients and negative binomial regression analysis.

The effect of temperature and humidity on trauma mortality was studied first by Poisson regression for dependent count data. However, due to over-dispersion

and lack of fitness with Poisson regression (according to statistical tests), negative binomial regression was used instead. In this regression the dependent variable was the number of intentional or unintentional deaths. The independent variables were temperature and humidity. The software used was STATA10 and Minitab16. The level of significance was set at 0.05.

## 4. Results

The total number of traumatic deaths was 3117, of which 2946 cases occurred due to unintentional accidents and 171 cases happened due to intentional causes (Table 1).

The statistics related to the month the deaths occurred are shown in Table 2. The results showed that the overall mortality caused by trauma was higher in warm months. The findings also revealed that the mortality rate in men was higher than that in women.

Table 3 shows the correlation coefficients of traumatic deaths and the average monthly humidity and temperature. The highest correlation value ( $r = 0.301$ ) for temperature was observed among unintentional deaths in cases over 60-years-old and this correlation was statistically significant.

Inverse significant correlations between the incidence of deaths caused by unintentional accidents and humidity were observed, and the highest was in the over 60-year age group.

**Table 1.** The Number of Deaths in Different Categories From 2006 to 2011

Kind of Death	Men	Women	10 - 30, y	30 ± 60 y	60 <sup>+</sup> y	Total
Intentional deaths	158	13	105	59	9	171
Unintentional deaths	2206	739	1449	1074	424	2946
<b>Total</b>	<b>2364</b>	<b>752</b>	<b>1554</b>	<b>1133</b>	<b>433</b>	<b>3117</b>

**Table 2.** The Number of Deaths Caused by Trauma in Kerman From 2006 to 2011

Months	Men	Women	Unintentional Injuries	Intentional Injuries	Total
April	234	96	303	27	330
May	247	78	303	22	325
June	259	39	298	19	317
July	250	94	334	10	344
August	259	58	317	15	332
September	235	69	294	10	304
October	135	23	158	6	164
November	152	44	181	15	196
December	122	52	167	7	174
January	70	162	221	11	232
February	151	47	177	21	198
March	182	11	193	8	201

The results of regression analysis are shown in Table 4. These results indicate a direct relationship between temperature and unintentional trauma deaths; however, this

was not significant. An inverse relationship between the humidity and unintentional mortality was also observed, but was only significant in the above 60-year age group.

**Table 3.** Spearman's Correlation Values Between Temperature and Humidity, and Trauma Deaths in Kerman

Factors	Overall Mortality		Men		Women		10 - 30 y		31 - 60 y		Over 60 y	
	r	P	r	P	r	P	r	P	r	P	r	P
<b>Unintentional Deaths</b>												
Temperature	0.236	0.069	0.209	0.109	0.277	0.032	0.179	0.170	0.267	0.039	0.301	0.020
Humidity	-0.259	0.046	-0.253	0.051	-0.271	0.036	-0.236	0.069	-0.255	0.049	-0.336	0.009
<b>Intentional deaths</b>												
Temperature	-0.178	0.175	-0.193	0.140	-0.026	0.841	-0.134	0.308	-0.182	0.163	0.117	0.375
Humidity	0.070	0.596	0.083	0.530	-0.061	0.642	0.031	0.815	0.082	0.534	-0.044	0.738

**Table 4.** Negative Binomial Regression Analysis Showing the Effect of per one Unit Increase in Temperature (°C) and Humidity on Trauma Deaths <sup>a</sup>

Trauma Mortality	IRR	Confidence Interval 95%	Significance
<b>Unintentional deaths</b>			
Temperature			
Men	1.003	0.987 - 1.020	0.701
Women	1.007	0.993 - 1.021	0.332
10 - 30 y	1.003	0.988 - 1.019	0.664
> 30 - 60y	1.005	0.991 - 1.020	0.487
> 60 y	1.013	0.999 - 1.030	0.057
Total	1.004	0.988 - 1.020	0.592
Humidity			
Men	0.993	0.982 - 1.003	0.185
Women	0.995	0.985 - 1.005	0.329
10 - 30 y	0.994	0.983 - 1.004	0.231
> 30 - 60y	0.993	0.984 - 1.003	0.184
> 60 y	0.988	0.978 - 0.998	0.024*
Total	0.993	0.983 - 1.004	0.222
<b>Intentional deaths</b>			
Temperature			
Men	0.988	0.962 - 1.013	0.348
Women	0.987	0.937 - 1.040	0.631
10 - 30 y	0.993	0.968 - 1.019	0.598
> 30 - 60y	0.975	0.945 - 1.006	0.109
> 60 y	1.014	0.961 - 1.070	0.616
Total	0.987	0.961 - 1.014	0.346
Humidity			
Men	1.005	0.985 - 1.026	0.595
Women	0.991	0.954 - 1.030	0.663
10 - 30 y	1.001	0.981 - 1.022	0.887
> 30 - 60y	1.010	0.989 - 1.031	0.318
> 60 y	0.986	0.941 - 1.033	0.569
Total	1.004	0.983 - 1.026	0.671

<sup>a</sup> Abbreviation: IRR: Incidence Rate Ratio.

## 5. Discussion

This study is the first investigation in Iran done to examine the relationship between trauma deaths and environmental factors such as temperature and humidity. The effect of climate, particularly temperature, on mortality has attracted the attention of many researchers. Some researchers have shown a significant association between temperature and mortality in some cities of the world. In this context, the results of one study in Los Angeles showed that an increase in temperature dealt greatly to the mortality rate (19). The more the temperature goes beyond the human comfort zone, the more the stress and mortality (20-24).

The most important finding in this study was the association between unintentional trauma deaths and temperature change. Unintentional trauma deaths rose in warm seasons and low humidity.

These results may be attributed to the increase in activity or travelling in warm seasons and therefore an increased risk of unintentional injuries such as traffic accidents, falls, drowning and heat exhaustion. A research conducted on children showed that the trauma mortality is associated with warm seasons; this finding is likely due to the fact that children are more likely to play outdoors in warm seasons and consequently more likely to get injured (25). In our study the maximum correlation of coefficients for unintentional deaths belonged to the over 60 years age group. This finding is probably because older people are less able to tolerate hot environments (26).

Elevated environment temperature in warm seasons can affect body temperature, number of white blood cells and blood sugar. In addition, this impact is directly related to age and gender. Accordingly, this effect may play a role in trauma mortality. It has been shown that white blood cell count is an indicator for predicting the outcome in trauma patients (27). Increased temperature and increased white blood cell count accompanied by increased heart rate and blood pressure are signs of systemic inflammatory responses. Increase in white blood cells is considered to be a sign of acuteness and occurs in conditions such as infection, and trauma (28). Since the investigations in this area is very limited, it is recommended to evaluate the effect of climatic on unexpected deaths in different cities with different weather conditions.

Also, in our study traumatic deaths (both intentional and unintentional) were higher among men than women. This can be attributed to the fact that men are more exposed to outdoors and work environments.

In this study, no significant relation was found between intentional deaths (suicide and homicide) and temperature. Although some studies have shown a peak in suicide rates during the spring season, and attributed it to increased temperatures; Dixon et al. showed no correlation between suicide and temperature in five US counties

(29). In a study by Woo et al. no relation between pollen counts and suicide rates after adjusting for median income, number of psychiatrists and urban versus rural location. Pollen is the most important seasonal aeroallergen that may act as an environmental trigger for suicide (30). These authors have suggested that the previously reported seasonal changes in suicide rates may have been driven by socioeconomic confounders (30).

Some researchers believe that suicide is a complex, psychopathological phenomenon driven by not only biological variables but also certain interactions between individuals and their environments; weather variables may only exacerbate the risk (29). However, more investigations are needed in this area.

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## Footnotes

**Authors' Contribution:** Study concept and design: Narges Khanjani. Acquisition of data: Laleh Ranandeh Kalankesh. Analysis and interpretation of data: Laleh Ranandeh Kalankesh and Narges Khanjani. Drafting of the manuscript: Narges Khanjani, and Laleh Ranandeh Kalankesh. Critical revision of the manuscript for important intellectual content: Narges Khanjani, and Laleh Ranandeh Kalankesh. Statistical analysis: Laleh Ranandeh Kalankesh and Narges Khanjani. Administrative, technical, and material support: Fatemeh Mansouri. Study supervision: Narges Khanjani.

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