

The Impact of heat change Intensity on the prevalence of work-related accidents in Isfahan Steel industry; a Time -Series Approach

Running Title: Impact of the heat change on accidents among workers

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Abstract

In the steel industries, workers are exposed to heat and ambient thermal stresses on a daily basis, leading to discomfort and limited performance. In this study, the main purpose is to investigate the effect of climate heat stress on the rate of accidents in the workplace for workers for 5 consecutive years.

The data of this study were received without any sampling through the HSE Center for Steel Industry and meteorological data from 2015 to 2019 from Isfahan Meteorological station. The daily number of casualties among workers in the steel industry during 2015-2019 by adjusting seasonal patterns, months, effects of the day of the week and other meteorological factors on the average daily temperature using the studied model has a decreasing effect. EvIEWS software (version 8) was used to model and investigate the relationship between events and meteorological variables.

The mean temperature was at least 40.2-2 and at most 70.34 ° C, respectively. In the time-series study for the main model, the number of accidents shows a direct relationship with the average temperature and wind speed. Climatic indices of humidity and rainfall have the least impact on accidents compared to temperature and wind speed.

A strong correlation was shown between the increase in average ambient temperature and the rate of accidents over the past 5 years. Given the fundamental differences in studies of environmental exposure and wind speed over heat stress, further analysis in workers should be considered.

Keywords: Climate Change, Occupational Accidents, Weather Circumstances, Heat Stress, Precipitation, Accident Mortality, time-series Analyses

Nomenclature		
Symbols	T_{max}	Average maximum temperature (°C)
	\bar{T}	Average temperature (°C)
	RH mean	Average relative humidity (°C)
	V_{mean}	Average air speed (m/s)
	R_{mean}	Average rainfall
Acronyms	S.D.	Standard Deviation
	DC	Determination coefficient
	ACD	Adjusted coefficient of determination
	ESCO.	Esfahan Steel Company
	AT	Apparent Temperature
	TSE	Total square error
	MODV	mean of the dependent variable
	PL	Proof logarithm

1. Introduction

Over the past few centuries, the main features of the global climate have changed significantly. During the years 1880-2012, the average temperature increased by 0.85 °C every year [1]. The Meteorological Agency has published temperature statistics for 2011-2015 and has shown that the Earth's temperature rises by an average of 1 °C each year. The increase in heat and the resulting waves usually occur in the rate low latitudes and in the summer [2]. Mortality from climate change has increased in recent years, with some 258,000 deaths reported in East Africa due to heat and drought between 2010 and 2012. Heat waves in 2015 killed more than 4,100 people in the Indian subcontinent. Excessive heat hurts on the body of living organisms and leads to an increase in the number of work accidents and deaths of workers [3].

One of the occupational hazards for workers in the workplace is rising temperatures and changing climate change [4]. According to the World Meteorological Organization, small changes in the average of climate variables may lead to massive changes in ambient climate, and drastic changes in climatic conditions can lead to floods, droughts, heat waves, or extreme cold [5]. In 2010, more than 370,000 people died due to severe weather conditions. Among the parameters considered by climate, experts include the analysis of climatic characteristics and long-term changes of extreme events, including their severity, frequency, and duration. For this purpose, specialists are looking to develop moderating strategies for communities [6]. Climate change for people includes threats to health, diarrhea, malaria, dengue fever, multiple accidents, and deaths. Severe weather conditions such as floods and heat-related deaths due to cardiovascular disease can negatively affect population health [7-9]. In many areas, systematic research is slowly expanding into the types of accidents and how to prevent them [10]. The effects of climate variables and their changes have been proven as a global factor on the occurrence of dependent variables such as rain, snow, fog, extreme temperatures, and other weather-related events [11, 12].

Dengue fever is one of the pathogens associated with the constant increase in global warming. Based on experimental studies showed per person per year in 2000-2017 compared to the 1986-2005 average each year, about 1.4 times more heat waves are received [13]. One of the effective factors in determining workplace safety and the rate of work-related accidents is climate change. Climate change is used as an organizational factor and a predictor variable in the workplace. Safety climate is a concept used to describe workers' perceptions of the value and role of safety in the organization. It includes issues such as changes in the organization's policies, procedures, and practices to climatic conditions and the environment [14]. Heat waves can hurt on people's health, and when people are exposed to heat, the impact of heat waves on their health occur. Side effects of heat waves are more common in the elderly or

with cardiovascular disease, diabetes, and chronic respiratory disease [15]. Many infectious diseases spread in the face of severe heat conditions, and the percentage of the population vulnerable to heat waves is increasing rapidly around the world [7]. One of the most dangerous and vital complications for workers in the workplace is heat exhaustion and fainting due to heat waves, which leads to an increase in accidents. Even at temperatures above 32.2 ° C, there is a significant decline in mental function. It is observed in a hot and humid environment or hot and dry [16]. Other factors influencing heat waves in the workplace include changes in response speed, decreased reasoning ability, and decision-making, decreased visual acuity, learning, and mental alertness. Each of these cases is considered as one of the causes of accidents leading to death in the workplace [17].

In reducing the effects of heat waves on the health of workers, health professionals have a critical role. They can monitor and record climate change in various centers and to improve the situation of workers, managerial and educational measures, including public education, effective measures to Vulnerable and sick populations. [18]. Climate change is one of the global problems and requires control action at the International level, due to different geographical locations and socio-economic factors in a region; other climates have appeared and led to a decrease in global heat control over different areas. Local public health agencies and the healthcare workforce are responsible for preventing and treating health problems caused by climate change [19]. The challenge of heat change is not limited to health professionals in Iran, and internationally, the development and assessment of health professionals in terms of heat wave control have been relatively weak [20].

One of the reasons for the importance of occupational health professionals in managing workforce health is to focus on objective human resource (HR) outcomes such as reducing absenteeism and life insurance costs and reducing care and outpatient costs [21].

Workplace health professionals can describe the extent of work-related accidents to employers when monitoring the exchange of safety and climate change by providing health and engineering solutions [22]. The purpose of this study is to investigate climate change and climate change on the prevalence of accidents in the industry. This study is one of the first studies of its kind in Iran to examine the situation of climatic conditions on accident changes. Having a health professional reduce the damage caused by heat waves in the workplace is one of the necessities to prepare workers to face harsh temperature conditions.

2. Methodology

2.1. Location and Meteorological Stations

In this study, the minimum and maximum air temperature, flow velocity, and wind direction and the amount of rainfall from 2015 to 2019 have been prepared from Isfahan Meteorological Center, Figure 1. To ensure the quality of private data in this study, more years were used. To evaluate the results of meteorological stations, only the numbers of those stations with missing values less than 5% were accepted.

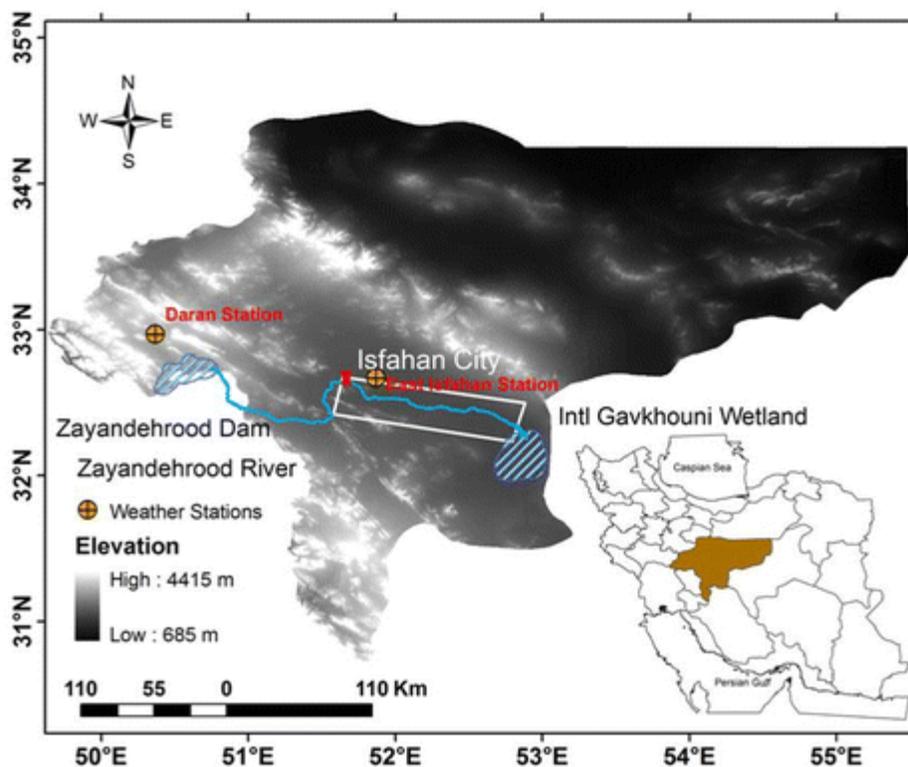


Fig 1. Display of meteorological stations in Esfahan province [23].

Meteorological measuring stations were not scattered at unit distances, and more stations were located in the central, eastern, and southern regions of Esfahan. The loss of data lost can be used to simulate these numbers out of nearby houses [24].

The limited research modeling, spatiotemporal gap between consecutive accidents used a linear regression model. It determined that the accident, incident duration, incident detection by law enforcement agencies, and bad weather conditions increased the distance gap. Therefore, a better model is required. Additionally, the time gap and distance of the second accident should be investigated simultaneously as they are likely to be correlated. This paper aims to address these gaps to better understand the possible time and location of secondary accidents.

2.2. Meteorological data

Meteorological data were received daily from Isfahan Meteorological Base and include minimum and maximum temperature, relative humidity (%), wind speed (km/h), and precipitation (mm/day). To calculate the apparent temperature index (AT), the mean and maximum daily temperatures were used for modeling [25].

$$AT = T + 0.33VP - 0.7V - 4 \quad \text{Equation (1)}$$

Measurement of accident data

It should be noted that in this study, no sampling and sizing has been used, and the accident data in Isfahan Steel Company (ESCO), according to the HSE information system from all parts of the company from January 1, 2015, to December 30, 2019, are collected. The date and causes of accidents were recorded daily in the Steel Company's accident system.

The causes of accidents are defined electric shocks, types of fractures, tendon rupture, eye damage, hair loss and, rupture, rupture of skin on the skin of the body and face, concussion, internal bleeding, death). The code was considered for each of the incidents and the cause of the outbreak and the number of accidents and its final result were recorded in the accident registration system.

The classification of accidents is measured according to the severity of the injury to the person. The category of accidents based on the number of days lost at work in the workplace is in the "mild" or "major" range. According to data provided by HSE System, a total of 3140 accidents occurred.

2.3. Statistical analysis

Knowledge of time-series allows us to predict data behavior in the future by examining and analyzing data behavior in the past and by modeling it. This time-series study was performed using Eviews (version 8) software. The response variable (events) was arithmetic or non-negative integers, and the effects of meteorological parameters on events were investigated using by integer count data model.

3. Result:

3.1. Descriptive Statistics

In the table below (Table 3.1) for the variables of temperature, humidity, wind speed, and average, average, deviation from the standard, minimum, and maximum are shown from the table below. These two years, there is a significant temperature difference with the other three years. For the variables of humidity, wind speed and, accidents, due to the only winter for 2019, there is a big difference between the indicators mentioned in 2019 and other years. The variables of temperature, humidity, wind speed, and average, average, deviation from the standard, minimum, and maximum are shown from the table below. These two years, there is a big temperature difference with the other three years. For the variables of humidity, wind speed, and accidents, due to the only winter for 2019, there is a significant difference between the indicators mentioned in 2019 and other years.

Table 3.1.Descriptive statistics of research variables during the research period by year

	Year	max	min	S.D	Mean
Temperature	2015	33.50	-0.60	8.64	20.85
	2016	33.70	-2/40	9.17	18.46
	2017	33.50	-0.30	9.23	18.20
	2018	34.70	-1.20	9.84	18.02
	2019	11.70	-1.80	3.06	3.83
Humidity	2015	95.40	7.80	15.70	32.59
	2016	75.60	11.00	13.82	31.49
	2017	75.80	10.80	12.72	32.81
	2018	86.00	14.00	17.27	36.99
	2019	91.63	45.13	10.77	61.35
Wind	2015	7.20	0.00	1.22	1.99
	2016	8.20	0.00	1.37	2.17
	2017	8.00	0.00	1.31	2.37
	2018	6.00	0.00	1.17	1.80
	2019	2.44	0.00	0.64	0.74
Accidents	2015	6.00	0.00	1.12	1.22
	2016	8.00	0.00	1.40	1.11
	2017	10.00	0.00	2.15	1.51
	2018	10.00	0.00	1.29	0.89
	2019	1.00	0.00	0.44	0.24

The following are the average graphs for the variables of temperature, humidity, wind speed and accidents for the years 2015 to 2019. As mentioned before, the beginning of the period, which does not include the winter of 2015 and from 2019 only includes the winter, so a series of differences in the averages of these two years with the other three years can be seen in the charts. For example, in the temperature chart, the average temperature in 2015 is more than three years 2016, 2017 and 2018, but for 2019 the average temperature is less than three years 2016, 2017 and 2018. From the humidity chart, it can be seen that the average humidity in 2018 is more than the three years of 2015, 2016 and 2017, and until the first season of 2019, this upward trend has continued. This downward trend has continued until the first season of 2019. Also, in 2017, the highest average wind speed is observed.

For accidents in 2018, the average is less than three years in 2015, 2016 and 2017, and this downward trend has continued until the first quarter of 2019. Also, in 2017, the highest average of accidents is observed.

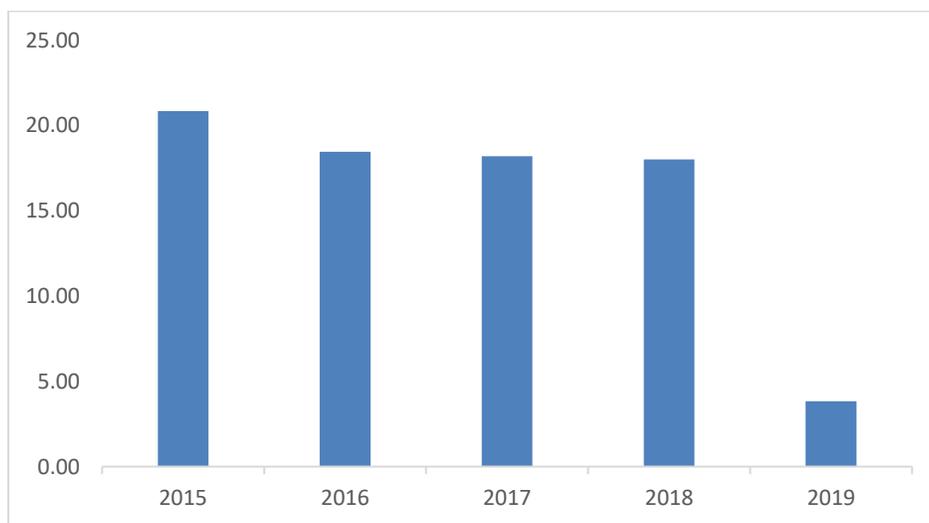


Fig 3.1. Graph of average temperature in different years

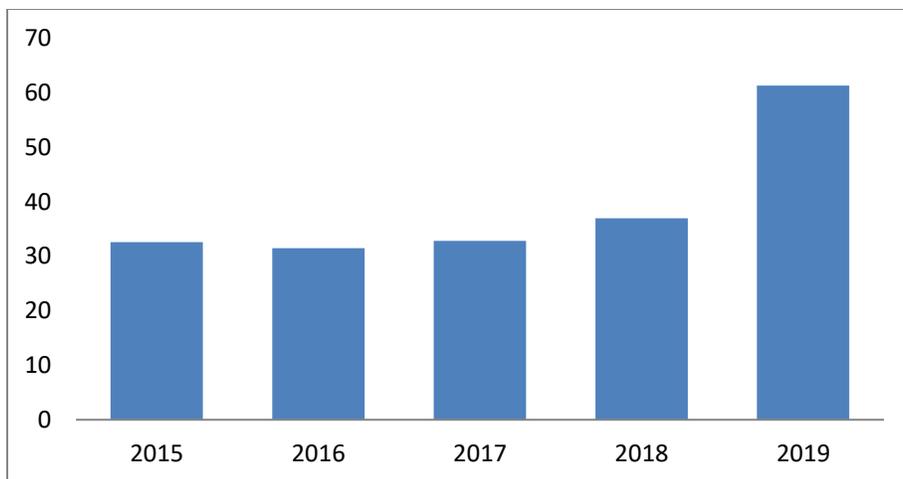


Fig 3.2. Graph of average humidity in different years

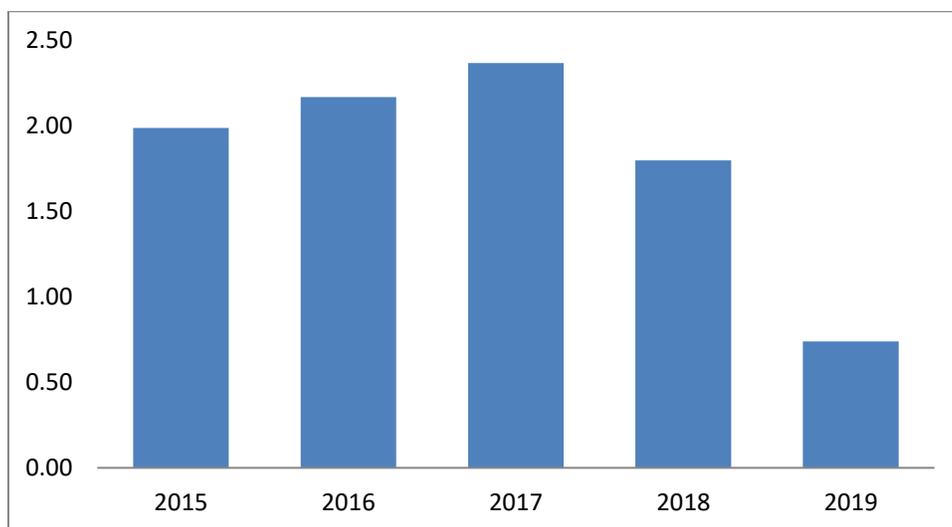


Fig 3.3. Graph of average wind speed in different years

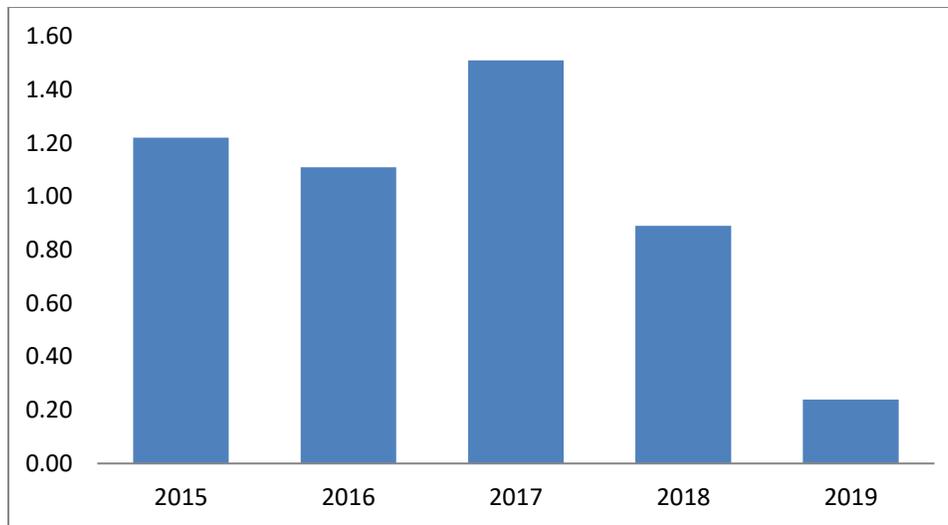


Fig 3.3. Graph of average events in different years

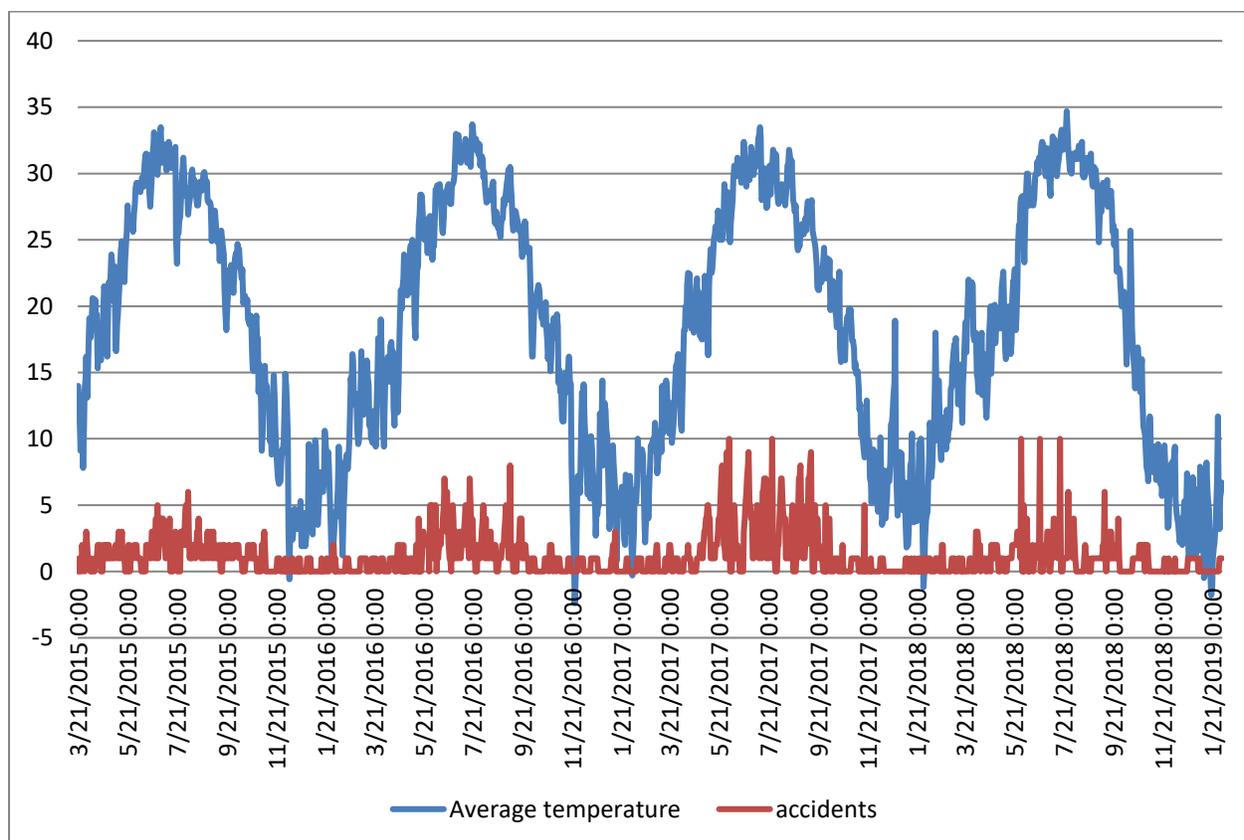


Fig3.4. Time-series of events and air temperature during the years 2015 to 2019

As can be seen from the diagram above, the time-series of temperature has a sinusoidal (or cyclic) trend, and consequently the event diagram also has a sinusoidal trend, but the trend in the temperature

diagram is longer and the distance between the upper and lower limits is greater. It can be said that in accidents, the trend is more vague and milder than the temperature .

3.2. Stability (reliability) of research variables during the research period

Based on single root tests of ADF and pp, because the P-value was less than 5%, all dependent and independent variables of the research during the research period were at a stable level, which means that the mean and variance of variables over time and covariance of variables between It has been constant for different years. The results of the static test of variables during the research period are presented in Table 3.2.

Table 3.2.Results of unit root test for companies

Variable name	ADF		pp	
	Significant	Test statistics	Significant	Test statistics
Temperature	0.00	-5.42	0.05	-2.86
Humidity	0.00	-5.34	0.00	-13.16
Wind	0.00	-4.65	0.00	-34.02
Accidents	0.00	-6.84	0.00	-23.27

3.3. Model test

Since that the answer variable is of arithmetic number or non-negative integers, as a result of data analysis, it is of integer count data type, and the data range is from 2015/03/21 to 2019/02/02. The following is the model with the Poisson distribution. The coefficient of determination of this model is equivalent to 0.22, and the criteria of Akaike and Schwartz are equivalent to 2.73 and 2.74, respectively. In this model, due to the significant level for the variables of humidity and wind speed, which is less than 0.05, ie, the assumption of zero equality of these coefficients with zero is rejected. It is accepted that these variables have a significant effect on events (Table 3.3).

Table 3.3. Results of Poisson model estimation for data

Variable name	Significant	T statistic	S.D	Coefficient
Constant	0.00	-10.32	0.20	-2.14
Temperature	0.19	1.30	0.02	0.02
Humidity	0.00	3.12	0.00	0.01
wind speed	0.00	17.36	0.00	0.08
DC	1.16	Average dependent variable	0.22	
ACD	1.56	S.D of dependent variable	0.22	
S.D	2.72	Akaike index	1.38	
TSE	2.74	Schwartz Index	2692.43	
PL	0.00	Significant level	-1926.80	

The model with negative binomial distribution is given in the table below. The coefficient of determination of this model is equal to 0.22 and the criteria of Akaike and Schwartz are equivalent to 2.66 and 2.67, respectively. In this model, due to the significant level for the variables of humidity, and wind speed, which is less than 0.05, ie, the assumption of zero equality of these coefficients with zero is rejected. It is accepted that these variables have a significant effect on events (Table 3.4).

Table 3.4.The results of negative binomial distribution model for data

Variable name	Significant	T statistic	S.D	Coefficient
Constant	0.00	-9.19	0.23	-2.15
Temperature	0.34	0.94	0.02	0.02
Humidity	0.00	2.69	0.00	0.01
wind speed	0.00	15.34	0.01	0.09
DC	1.16	MODV	0.22	
ACD	1.56	S.D of dependent variable	0.21	
S.D	2.65	Akaike index	1.38	
TSE	2.68	Schwartz Index	2695.58	
PL	0.00	Significant level	-1874.44	

The model with exponential distribution is given in the table below. The coefficient of determination of this model is equal to 0.22, and the criteria of Akaike and Schwartz are equivalent to 1.79 and 1.80, respectively. In this model, due to the significant level for the wind speed variable, which is less than 0.05, ie, the assumption of zero equals this coefficient with zero is rejected. It is accepted that this variable has a significant effect on events (Table 3.5).

Table 3.5.Results of exponential model estimation for data

Variable name	Significant	T statistic	S.D	Coefficient
Constant	0.00	-7.94	0.24	-1.94
Temperature	0.98	0.03	0.03	0.00
Humidity	0.07	1.77	0.00	0.01
wind speed	0.00	14.05	0.05	0.09

DC	1.16	MODV	0.22
ACD	1.56	S.D of dependent variable	0.22
S.D	1.79	Akaike index	1.38
TSE	1.80	Schwartz Index	2701.32
PL	0.00	Significant level	-1261.36

The model with normal distribution is given in the table below. The coefficient of determination of this model is equal to 0.22 and the criteria of Akaike and Schwartz are equal to 3.74 and 3.76, respectively. In this model, due to the significant level for the variables of humidity and wind speed, which is less than 0.05, ie, the assumption of zero equality of these coefficients with zero is rejected. It is accepted that these variables have a significant effect on events (Table 3.6).

Table 3.6. Results of estimating the normal model for the data

Variable name	Significant	T statistic	S.D	Coefficient
Constant	0.00	-6.25	0.32	-1.99
Temperature	0.14	1.45	0.03	0.04
Humidity	0.04	2.14	0.00	0.01
wind speed	0.00	11.19	0.01	0.08
DC	1.16	MODV	0.22	
ACD	1.56	S.D of dependent variable	0.22	
S.D	3.74	Akaike index	1.38	
TSE	3.75	Schwartz Index	2686.57	
PL	0.00	Significant level	-2643.58	

Considering the four models mentioned above, considering that the lowest value of the Akaike and Schwartz index belongs to the exponential, so we consider the exponential distribution as the final model. Its mathematical model is as follows. The final model is as follows, and according to the exponential model, wind speed is significant and has a significant effect on events (Table 3.7).

$$\text{Equation (2) } accidents_{it} =$$

$$e^{-1.94238349819 + 0.000899937141035 \times \text{average WIND}_{it} + 0.00652579667533 \times \text{average HUMIDITY}_{it} + 0.0873507412866 \times \text{average temperture}_{it}}$$

Table 3.7. Results of exponential model estimation for data

Variable name	Significant	T statistic	S.D	Coefficient
Constant	0.00	-7.94	0.24	-1.94
Temperature	0.97	0.03	0.02	0.00
Humidity	0.07	1.77	0.00	0.00
wind speed	0.00	14.05	0.00	0.08

To investigate the relationship between accidents and air temperature without other independent variables, we fit the following models. The model with Poisson distribution is shown in the table below. The coefficient of determination of this model is equal to 0.22 and the criteria of Akaike and Schwartz are equivalent to 2.73 and 2.74, respectively. In this model, due to the significant level for the temperature variable, which is less than 0.05, ie, the assumption of zero equality of this coefficient with zero is rejected. It is accepted that this variable has a significant effect on events (Table 3.8).

Table 3.8. Results of Poisson model estimation for data

Variable name	Significant	T statistic	S.D	Coefficient
Constant	0.00	-18/54477	0.08	-1.52

Temperature	0.00	24/07453	0.00	0.08
DC	1.16	MODV	0.22	
ACD	1.56	S.D of dependent variable	0.22	
S.D	2.73	Akaike index	1.38	
TSE	2.74	Schwartz Index	2706.20	
PL	0.00	Significant level	-1932.26	

The model with negative binomial distribution is given in the table below. The coefficient of determination of this model is equivalent to 0.22 and the criteria of Akaike and Schwartz are equal to 2.66 and 2.67, respectively. In this model, due to the significant level for the temperature variable, which is less than 0.05, ie, the assumption of zero equality of this coefficient with zero is rejected. It is accepted that this variable has a significant effect on events (Table 3.9).

Table 3.9.Results of estimating the negative binomial distribution model for the data

Variable name	Significant	T statistic	S.D	Coefficient
Constant	0.00	-16.97	0.092	-1.55
Temperature	0.00	21.09	0.00	0.07
DC	1.16	MODV	0.22	
ACD	1.56	S.D of dependent variable	0.21	
S.D	2.66	Akaike index	1.38	
TSE	2.67	Schwartz Index	2708.81	
PL	0.00	Significant level	-1878.38	

The model with exponential distribution is given in the table below. The coefficient of determination of this model is equivalent to 0.22 and the criteria of Akaike and Schwartz are equal to 1.79 and 1.80, respectively. In this model, due to the significant level for the temperature variable, which is less than 0.05, ie, the assumption of zero equality of this coefficient with zero is rejected. It is accepted that this variable has a significant effect on events (Table 3.10).

Table 3.10.Results of exponential model estimation for data

Variable name	Significant	T statistic	S.D	Coefficient
Constant	0.00	-16.67	0.09	-1.56
Temperature	0.00	19.74	0.00	0.079
DC	1.16	MODV	0.22	
ACD	1.56	S.D of dependent variable	0.22	
S.D	1.79	Akaike index	1.38	
TSE	1.79	Schwartz Index	2709.94	
PL	0.00	Significant level	-1264.53	

The model with normal distribution is given in the table below. The coefficient of determination of this model is equivalent to 0.22 and the criteria of Akaike and Schwartz are equal to 3.75 and 3.76, respectively. In this model, due to the significant level for the temperature variable, which is less than 0.05, ie, the assumption of zero equality of this coefficient with zero is rejected. It is accepted that this variable has a significant effect on events (Table 3.11).

Table 3.11.Results of estimating the normal model for the data

Variable name	Significant	T statistic	S.D	Coefficient
Constant	0.00	-15.40	0.08	-1.33
Temperature	0.00	19.56	0.00	0.07
DC	1.16	MODV	0.21	

ACD	1.56	S.D of dependent variable	0.21
S.D	3.74	Akaike index	1.38
TSE	3.75	Schwartz Index	2700.99
PL	0.00	Significant level	-2650.79

Considering the four models mentioned above, considering that the lowest value of the Akaike and Schwartz index belongs to the exponential, so we consider the exponential distribution as the final model. Its mathematical model is as follows. According to the exponential model, the temperature is significant and has a significant effect on events (Table 3.12).

$$\text{Equation (3) } accidents_{it} = e^{-1.568283 + 0.079368 \times \text{average temperature}_{it}}$$

Table 3.12. Results of exponential model estimation for data

Variable name	Significant	T statistic	S.D	Coefficient
Constant	0.00	-16.67	0.09	-1.56
Temperature	0.00	19.74	0.00	0.08

4. Discussion

This study aimed at investigating the effect of heat climate change Intensity on the prevalence of work-related accidents among workers in the Iranian steel industry during various exposure times. Findings show the statistically significant difference of heat changes in low and high temperature in the different months and years. According to a study by Mihye Lee et al, in 2014, a time-series analysis to examine the relationship between temperature and mortality from 1973 to 2006 analyzed 38,005,616 deaths in 148 cities in the United States and showed that the maximum effects of heat on mortality in spring and early summer, the maximum effects of cold in late autumn and according to meteorological data and accident rates of the current study could be said that the results of this study are consistent with the present study [26], And according to study by Andersson in 2011, winter weather could affect the rate of road accidents. Climate change scenarios were used to examine the relationship between temperature and severe road accidents in the UK. The results of this study showed that hot weather meters could increase the trend of road accidents and in this regard, is consistent with the present study [27].

The results of this study showed a lot of accident occurs in hot months of year and there is Direct communication between these parameters and showed in A 2018 survey by Robb conducted the accident

rate and its effects in the summer using data from 12.6 million accidents in New Zealand during the years 2005-2016, and showed that work accidents have a limited impact on the trend of DST changes in winter. During the week (Friday 13% less than Monday) shows a considerable decrease, while road accidents have a significant increase (Friday 19% higher than Monday) and in the present study, accidents in winter compared to the season the heat is more limited [28], another study was designed by Malin in 2019 to investigate the relative risk of accidents in different road weather conditions and the combination of conditions. This study included the total report of accidents of one or more police vehicles (N = 10,646) on 43 main roads in Finland during the years 2014-2016. This article covers the speed of traffic and, therefore, the article examines the risk of accidents with the time spent on the road in certain conditions. Weather and road conditions data were obtained every hour from nearby road meteorological stations and showed that the risk of relative accidents for lousy road conditions increased. In bad weather conditions, the risks associated with relative accidents to In general, compared to multi-vehicle crashes, there were more crashes with one vehicle thus, it was shown that there is a significant relationship between climate change and crashes and confirms the present study [29].

The results of simple regression show that average Daily Accidents has a significant effect in hot months According to a study conducted by Otte et al, In 2017, a study aimed at reviewing studies on the effect of air temperature on unintentional injuries in high-income countries showed that the results of the study out of 13 studies found for an increase 1 ° C the air temperature has increased between 4 and 3.5% of the risk. Since this study is a systematic review study, it is sufficient to report only the number of studies performed on air temperature and does not correspond to the present study [30]. and in another study shows that George Yannis et al, 2010 study to determine the relationship between weather conditions and the number of traffic accidents was performed in this study time-series results showed an increase in temperature causes an increase in traffic accidents and the study of the results do not follow of this study .[31] The results of simple regression show that climate change has increased in 6 months of years usually (May – October), According to a 2017 study by Liu et al, there is linking weather events and the risk of motor vehicle accidents in Maryland found that between 2000 and 2012, a total of 1.28 million road accidents occurred. Of these, 46, 1009 accidents resulted in casualties, deaths and injuries. The results also showed that on rainy days, there was a 23% increase in casualties, especially on roads. In this study, the main purpose of the researcher was to investigate severe weather events and analysis was performed on road accidents, so it is not consistent with the present study [32], And in another Study by Won-Kyung Lee et al, In 2014, a time-series study was conducted to determine the effect of cold temperature on road accidents between 2007 and 2011 in Seoul, South Korea. The results of the study showed the effect of temperature on accidental injuries. Roads were minimal in spring and summer, with the highest association between temperature and injuries from accidents in winter. In this study, in exchange for a 1°C decrease in air temperature, a 2.1% increase in injuries caused by road accidents has been reported. This study has examined the injuries caused by accidents and this study is not consistent with the present study regarding of purpose and type of work method [33] On the contrary with the other researches, the results of the study in the Iranian steel industry do not show a significant difference in the scores of hot weather and frequency of accident. According to a 2014 study by Aurelio Tobias et al., A time-series study was conducted to investigate the relationship between temperature and mortality in 50 Spanish cities. It has increased and its results are directly related to the present study in terms of temperature increase and accidents[34]. In 2019, Antão conducted a study to investigate the contribution of human error in cargo ship accidents in different weather conditions and found that fishing boat crews are more exposed to accidents than recreational craft because they are directly They are involved in climatic conditions and are directly related to the present study and the number of workers exposed to the climatic conditions of the workplace[35]. According to a 2015 study by Basagaña et al, A time-series study examined the relationship between high temperatures and the number of car accidents in the Spanish province of Catalonia between 2000 and 2011, which showed that out of 118,482 accidents, the risk was on days Gram has increased significantly by 2.9%. ; however, this study did not include the car's cooling and heating system due to the involvement of the car and caused interference in the results and did not

show the effect of air temperature on accidents. This study is due to the inadequacy of the study environment and many interfering factors. Not consistent with the present study [36]. According to a study conducted by Luis et al, in 2001, they examined the relationship between climate indicators (temperature and relative humidity) and mortality in 12 US cities. The results showed that the temperature of hot days was 4% and cold days 3% has caused increased daily mortality. In this study, the minimum measured temperature was reported to be 13 degrees Celsius. This study is not consistent with the present study in terms of minimum and maximum temperature and atmospheric conditions.[37] According to a 2014 study by Morabito et al, In Italy, a study was conducted to investigate the relationship between temperature and outdoor work-related injuries. There is a risk of 2.3% increase for 1 degree Celsius decrease in air temperature, so this study is not in line with the present study [38]. However, the effect of heat intensity level shows the increased level of disease in the workers, that shows According to Yang et al, In 2015, the study of the relationship between temperature and air quality with daily mortality due to cardiovascular disease in Shanghai, China, the results of the study showed that the relationship between temperature and daily mortality due to cardiovascular disease It is J-shaped and has been reported significantly at both high and low temperatures. Also, the effect of high temperature did not occur immediately in this study and disagrees with the present study [39]. In 2011, Gasparrini et al, conducted a study to investigate the relationship between temperature and specific diseases in the United Kingdom Has increased. In this study, the greatest effect of temperature on the increase of mortality due to respiratory disease was reported to be 4.1% per degree Celsius, and this study does not confirm the results of the present study. [40] According to the results of a study by Zhao et al, In 2017, the relationship between air temperature and emergency admission was done in 12 cities in China. The results showed that the effect of heat on the increase in the number of emergency patients appeared immediately, the number of emergency patients laid. This observational study was conducted in the three years period from 2011 to 2014 and this study shows increased the effect of temperature on the rate of accidents and is consistent with the present study [41].

we found a direct relationship between heat stress and accident during eight years but this issue is not limited to the steel industry and could be related to accidents in other industries and jobs like the study by Zhang in 2016 that expressed, mines is one of the riskiest occupations in the world, and showed that 320 dangerous accidents were caused by the unsafe behaviour of the operator in the coal mine. The rock occurred with a frequency of 1590. The analysis of the results led to three conclusions that the three factors influencing coal mine accidents were (with the frequency of the effect decreasing in order of order). "Lack of training and safety training", "Rules and regulations of safety production responsibility, and "Rules and Supervision and Inspection Regulations" [42]. Another study focused on Climate heat stress risk management in construction was performed by Rowlinson in 2014 and it was shown that climate heat stress leads to accidents at construction sites caused by a wide range of human factors caused by heat-induced disease. Fatigue leads to impairment of physical and mental ability it supports the primary purpose of the present study, which is to investigate the effect of heat on the rate of accidents [43]. Finally, According to a 2008 Picard retrospective study, the association of occupational noise and occupational accident risk was performed on a sample of 52,982 male workers exposed to at least 80 dBA of noise. People's hearing status was assessed once a year between 1983 and 1996. The results showed that in the metal sectors of the industry there is a direct and significant relationship between the risk of accident and hearing sensitivity of the worker and hearing loss and is not consistent with the present study [44].

5. Conclusion:

This presents paper a new time-series analyzes for predicting industrial accidents with changes in climate change such as heat stress. Every year with global warming, the amount of rainfall decreases and the temperature increases, which can also increase the damage caused by heat in the workplace. In this study,

workers with heat sensitivity and low heat tolerance had more accidents. Workers in the steel industry adjacent to hot and furnace areas are severely affected by heat stress and require intensive care and managerial control action in the workplace. Further studies in other countries or similar industries with different populations and age groups are recommended to compare the effect of climate on heat stress and accidents.

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