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Analyses and anticipating the future trend of accidents in an electricity distribution company of Iran: A time series analysis

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Abstract.
BACKGROUND: Many work-related fatalities happen every year in electricity distribution companies. This study was conducted to model accidents using the time series analysis and survey descriptive factors of injuries in an electricity distribution company in Tehran, Iran.
METHODS: Data related to 2010 to 2017 were collected from the database of the safety department. Time Series and trend analysis were used for data analyzing and anticipating the accidents up to 2022.
RESULT: Most of the accidents occurred in summer. Workers' negligence was the reason for 75% of deaths. Employment type and type of injuries had a significant relationship ($p < 0.05$).
CONCLUSION: The anticipating model indicated occupational injuries are going to have an increase in the future. A high rate of accidents in summer maybe because of the warm weather or insufficient skills in temporary workers. Temporary workers have no chance to work in a year like permanent workers, therefore acquisition experiences may be less in them. Based on the estimating model, Management should pay attention to those sectors of the company where most of the risky activities take place. Also, training programs and using personal protective equipment can help to protect workers in hazardous conditions.

Keywords: Time series analysis, anticipating, electrical injuries

1. Introduction

Collecting and analyzing the correct and precise data related to accidents is necessary to improve workplace safety, despite the fact that is only one of the numerous possible diagnostic sources [1]. In spite of the importance of accident analysis, many companies

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still have accident reporting systems with incomplete recordings and do not necessarily provide a complete picture of the conditions under which accidents take place [2]. Industries with high rates of electrocution included power line contractors, steel erection, construction, painting, and electricians.

Anywhere that there are power tools and electrical circuits, it can be seen a risk of electrical hazards. People may be exposed to these hazards at home and work; obviously workers are exposed to more hazards. There are four main types of electrical injuries: electrocution (death due to electrical shock), electrical shock, burns, and falls caused as a result of contact with electrical energy [2, 3].

Electrocutions are among the most common injuries in industries. Based on epidemiological studies, approximately 67% of all electrocutions are work related. National Traumatic Occupational Fatality Database of NIOSH indicates that approximately 7% of the nearly 6,500 work related traumatic fatalities that occur annually are electrocutions [4]. Many workers are exposed to electrical energy daily during the performance of their tasks. It is necessary to recognize the potential risk factors for electrical injuries especially fatal ones and to provide useful recommendations for developing effective safety programs to reduce the risk of electrocution [3]. In electric power generation, transmission, and distribution industries, electrical current exposes workers to serious occupational hazards; actually all members of the workforce are exposed to electrical energy during their work, and accidents occur to workers in the various jobs. Many workers are unaware of the potential electrical hazards in the workplace, which makes them more vulnerable to dangerous conditions. Whereas offering proper solutions to prevent all electrocutions is not easy, knowing the magnitude of the danger and its components is an important step. Although lots of technical preventive aspects are well known, electric accidents continue to occur [4].

Accident investigation techniques which are based on more robust human factors and accident causation models allow safety managers to make a broader interpretation of their accident statistics. They can determine causes and contributing factors of accidents and reduce the probability of future accidents [5]. Regard for human factors in the investigation of accidents help increase awareness and understanding of accidents main causes.

Considering, the time-series nature of accident data it would be useful to fit a model in accident investigations. Time-series analyses are utilized in order to anticipate future accident data based on past trends [6].

The aim of this study was the description of occupational accidents from 2010 to 2017 to find the responsible parameters of injuries and determine an estimation model for accidents among workers of electricity distribution companies, in years 2017 to 2022 in Tehran a province of Iran. Obviously, determining the distribution of accidents and anticipating them can be applied to plan accident prevention programs and prevent future accidents.

2. Material and methods

This study was performed in Tehran, a city of Iran in 2018. An occupational injury surveillance study was conducted for workers of regions covered by Electricity Distribution Company in Tehran and events recorded in the central buildings and central warehouses in 2010 to 2017 were evaluated. Variables in this study that collected was accident time, age of injured worker, type of employment (permanent, temporary), work experience level of education, marital status (single, married) and type of job (electrical work, others).

For studying a five-year period, accident registers and payrolls were examined to gather data on the number of workers involved in activity, nature of employment, nature of the activity, and the number of accidents. Data related to no time loss injury (the affected worker resumes work within 24 hours of injury and there is no leave) as well as time loss injury (the affected worker does not resume work within 24 hours of injury and leave is taken until the worker becomes fit to resume duty) were taken into consideration for the analysis of occupational injury data. While an occupational accident happens, preliminary therapy is done in company's center of occupational health and safety and details of injury are reported to the concerned inspectorate and social security system. Afterward, all related records are documented in the center of occupational health and safety. Ethical approval was granted by the Iran University of Medical Scienses under number IR.IUMS.REC.1399.1184

3. Statistical analysis

Some tests such as descriptive statistics, were performed using SPSS version 18 (SPSS Inc., Chicago,

IL, USA). Tests such as Chi-square and univariate analysis of variance were used for data analysis. The level of significance was taken as $p < 0.05$. Time Series analysis, and Trend analysis were applied for data analyzing using Minitab version 16. Time Series Model was used to anticipate accidents among the workers of this company up to 2022.

4. Results

The information of 131 injured workers due to accidents was collected in an electricity distribution company. According to Tables 1 and 2, the average age of them was 34.79 ± 9.87 years (range,22 and 56 years). Most workers were married (65%). About 29% of workers had a high school degree, 60.3% had a diploma, and only 10.69% were academic educated. Most injured workers had temporary employment (67.94%), 35.11% of them had 1–5 years of work experience, and about 74% had an electrical job. The bar chart in (Fig. 1) indicates that the maximum of accidents occurred in 2016 (18.32%).

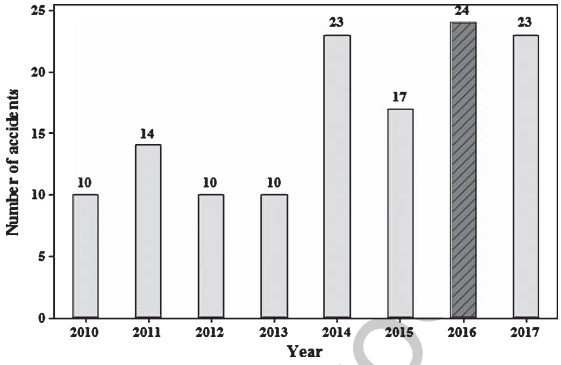

Fig. 1. Frequency distribution of injured workers by year ($n = 131$).

The highest rate of accidents was in the first half of the each year (61.07%). Therefore, the most of accidents occurred in summer season (36.64%).

Testing different models for accidents data proposed the quadratic trend model with Equation (1):

$$Y_t = 9.05 + 0.85t + 0.137t^2 \quad (1)$$

As it can be seen in Fig. 2, the red dotted line indicates the fitted model and continuous line is related to observed data. Indeed, in this graph, there is an anticipating model for accidents in future based on past trend. Based on the model, this estimation can be used to predict the rate of accidents during 2018–2022 (dotted line related to these years). And assuming that the current trend continues, in 2022 there will be more than 43 accidents.

Table 1
Descriptive data for injured workers in Electricity Distribution Company (2010–2017)

Variables	Descriptive statistics
Marital status	**N (%)**
Married	85(64.89)
Single	46(35.11)
Level of Education	
High school	38(29.01)
Diploma	79(60.30)
Academic	14(10.69)
Work experience (year)	
1–5	46(35.11)
6–10	39(29.80)
11–15	17(12.98)
16–20	10(7.63)
21–25	10(7.63)
>25	9(6.87)
Type of job	
Electrical work	97(74.05)
Others	34(25.95)
Type of employment	
Temporary	89(67.94)
Permanent	42(32.06)
Age (year)	
Mean ± SD	34.79 ± 9.87
Minimum	22.00
Maximum	56.00
Total	**131 (100)**

Table 2
Occupational accidents by Year and Season (2010–2017)

Season		Year								Total
		2010	2011	2012	2013	2014	2015	2016	2017	
Spring	Count	2	4	2	1	6	7	4	6	32
	Percent	1.53	3.05	1.53	0.76	4.58	5.34	3.05	4.58	24.43
Summer	Count	4	4	5	2	8	5	11	9	48
	Percent	3.05	3.05	3.82	1.53	6.11	3.82	8.40	6.87	36.64
Fall	Count	2	2	1	3	6	2	4	4	24
	Percent	1.53	1.53	0.76	2.29	4.58	1.53	3.05	3.05	18.32
Winter	Count	2	4	2	4	3	3	5	4	27
	Percent	1.53	3.05	1.53	3.05	2.29	2.29	3.82	3.05	20.61
Total	Count	10	14	10	10	23	17	24	23	131
	Percent	7.63	10.69	7.63	7.63	17.56	12.98	18.32	17.56	100

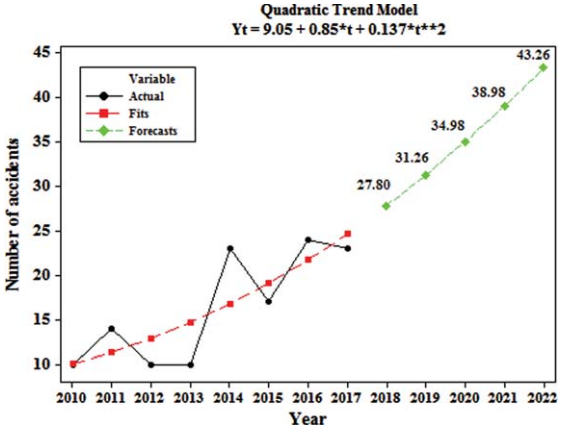

Fig. 2. Trend analysis for accident anticipating during 2018–2022 based on accident trend during 2010–2017.

5. Discussion

The aim of this study was to descript the occupational accidents to find the responsible parameters of injuries and determine an estimator (anticipating) model for accidents in electricity distribution company workers, in years 2017 to 2022 in Tehran province. To investigate accidents with adverse effects on workers, unimportant events or near misses were excluded from the recorded events. A proper database for accidents and injuries can help to determine their causes and adopting suitable actions to prevent accidents in the future. Anticipating the accidents is helpful to know the current status, explain accidents in the future, and adopt appropriate measures early. Estimation model showed the future trend of accidents in studied company. Therefore, the output of model will provide major information to appraise the accidents rate in the future and apply the correct approaches for preventing the occurrence of accidents.

Based on results, there were six of deaths during seven years in this company. Therefore, more electrical safety researches and preventive efforts are suggested in this regard. Also, appropriate strategies are considered according to the number of injuries, rates of fatal and nonfatal electrical injuries, as well as their classification by location and type.

There was a decline in annual rate of occupational fatal injuries (due to different causes) between 1992 and 2002 in the U.S. And the lower rate of electrical injuries was also seen. Statistics indicated 3378 worker fatalities classified as electrical events between 1992 and 2002 [7]. Also, in America,the electricity is expressed as the sixth cause of injuries related to occupational death. The electricity was the cause of 4.7%of all occupational deaths during 1999 to 2002 and 5.2% during 1992 to 1998 [7]. In Sweden, the use of electricity has increased steadily during the last century, while the incidence of fatalities due to electricity has decreased. A study conducted by Lindstrom etal. Indicated 285 electrocuction deaths occurred in Sweden between 1975 to 2000 and 132(49.8%) of them were work related [8]. About 14.6% of all fatal accidents were electrical fatalities andthese accidents was the second cause of occupational fatalities in Taiwan, following falling fatalities (30%) [9]. In Finland, 17000 electrical workers are exposed to electrical risk in their workplace and annually 70 electrically skilled persons suffer from electrical injuries leading to 0 to 2 deaths for them [10].

Improper use or lack of protective equipments and workers negligence (carelessness) were the most important risk factors for occupational damages in the current study. The findings of this study can be generalized because of the appropriate sample size and accessible data source for work-related injury and accidents statistics in the intended companies. A recent study in Kerman, Iran on occupational accident sofcopper companies between 2003 and 2004 has found a similar result in which the most common reason of job accidents over the two successive years was carelessness [11]. According to similar studies in Persian Gulf,carelessnesshasalways been the main cause of accidents at work [12].

Since in this study age distribution had positive skewness, median and mode were 34 and 23 year, respectively, we conclude that accidents are more common among the younger age groups. This is consistent with previous findings [13–17]. Based on the Fatality Assessment and Control Evaluation (FACE) surveillance data, the mean age was 34 years for victims aged 17 to 70 (243 men and 1 woman) [3]; whilst, the highest occupational death rates overall in the United States happened among those aged 45 and over [18]. The study of accidents happened in Fars showed that the average age of injured people was 33 [19].

The results showed that the highest rate of accidents were among workers (%35.11) with working experience of one to five years. Direct relationship between age and work experience can be a cause for higher rate of accidents. Young people have usually fewer experiences and have passed less training courses. Based on this paper, although the

occupational electrical injuries to skilled persons are relatively rare, risks are high in all electrical works. A similar study in Iran in 2001 indicated that occupational accidents in age group 25–29 were considerably more than the other groups [20] and younger and less experienced workers were exposed to more occupational accidents due to work stress. Also, lack of skills, low experience, less attention to safety matters and youth courage have also been recognized as the most important risk factors for occupational accidents [13, 21]. According to Tappura [10], in Finland over 2003–2006, a total of 258 injuries were reported to the FAII (the Federation of Accident Insurance Institutions), 13% of which had taken place in the energy industries. In this case, the most serious injuries and all accidents leading to death had occurred in the energy sector and among the older worker with higher work experiences. Differences between studies may simply due to the use of different population at risk.

The higher rate of accidents [13] among married people might be attributed to mental and familial problems. This result is consistent with findings of researches in Iran and other countries [19]. But Bakhtiyari investigation indicated that unmarried workers were more vulnerable to occupational accidents (partial or total disabilities) in comparison with married workers [22]. It may be due to less experience and low age of unmarried workers or more cautious behavior of married ones.

The average annual ambient temperature in Tehran is more than 30°C in January, July and August. As the results indicate the maximum work accidents happened in summer. High rate of accidents in summer may be due to the warm weather in Tehran province or insufficient occupational skills and experiences in temporary workers (high school and university students). This is consistent with Halvani study conducted on construction accidents [23]. It is worth to mention the lack of training can be effective in this regard. Also, workers are susceptible to electrocution in the summer, because during hot, humid weather the skin has less resistance to electric current. A possible explanation for drop-in electrocution accidents during the winter months is that there is the use of heavier clothing, gloves and boots.

Results of this study demonstrate that the risk of occupational injuries has been unequally distributed between permanent and temporary employment; temporary workers have higher risk than permanent ones. Therefore, a relationship may be seen between the type of employment and the risk of occupational injuries.Spanish surveys on working conditions illustrated a similar pattern, particularly in relation to ergonomic and psychosocial risk factors [24]. The view of authors is that temporary workers are exposed to more hazardous working conditions because their lower length of employment leads to lower work experience,lack of knowledge of hazards, and sometimes improper work tools. In addition, temporary workers do not usually report the occupational injuries because of fears of being fired. Hence, there is an underestimating of results. The Third European Survey on Working Conditions has shown that workers with nonpermanent contracts are more likely to have undesirable working conditions such as repetitive movements, intense and tiring positions, discrimination and low time control [24, 25]. On the other hand, the results showed a clear inverse trend between length of employment and risk of occupational injuries among both permanent and temporary workers. It means that higher length of employment, lower risk of injuries. This is consistent with findings of Benavides and et al in a study on associations between temporary employment and occupational injuries [24]. Understanding the true risk of temporary employment needs more assessments and studies on effective variables specifically [25–27].

6. Limitations

Lack of access to the data of all accidents and lack of complete registration of accidents in the accident registration system of the electricity distribution company are the limitations of this study.

7. Conclusion

According to anticipating model for accidents, it seems that the increasing trend will continue in the future. Our predictions indicate that by 2022, 35 cases of accidents will occur in the company, regardless the insignificant and negligible accidents. Anticipating models can be used as a tool for managerial decision in reducing accidents and injuries in work environments. Given the importance of man power, improving the safe conditions in the company and raising the standards to decrease the incidence of accidents is recommended. Providing trainings through media and pre-working trainings can be effective to decrease the accident rate in the workplace. Management should pay more attention to those sectors of

company where most of the risky activities take place. Also, the use of personal protective equipment's can help to protect workers in hazardous conditions.

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Conflict of interest

There is no conflict of interest to be declared.

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