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The Trend of Injuries in Building Fire in Tehran from 2002 to 2012

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***Abstract*—**Analysis of fire data is a way for the implementation of any plan to improve the level of safety in cities. Such an analysis is able to reveal signs of changes in a given period and can be used as a measure of safety. The information of about 66,341 fires (from 2002 to 2012) released by Tehran Safety Services and Fire-Fighting Organization and data on the population and the number of households provided by Tehran Municipality and the Statistical Yearbook of Iran were extracted. Using the data, the fire changes, the rate of injuries, and mortality rate were determined and analyzed. The rate of injuries and mortality rate of fires per one million population of Tehran were 59.58% and 86.12%, respectively. During the study period, the number of fires and fire stations increased by 104.38% and 102.63%, respectively. Most fires (9.21%) happened in the 4th District of Tehran. The results showed that the recorded fire data have not been systematically planned for fire prevention since one of the ways to reduce injuries caused by fires is to develop a systematic plan for necessary actions in emergency situations. To determine a reliable source for fire prevention, the stages, definitions of working processes and the cause and effect chains should be considered. Therefore, a comprehensive statistical system should be developed for reported and recorded fire data.

***Keywords*—**Fire statistics, fire analysis, accident prevention, Tehran.

I. Introduction

TEHRAN is the largest city and capital of Iran with a population of 8,429,807 in 22 districts and 123 regions with an area of 730 km^2 located at 51° 2' to 51° 36' east longitude and 35° 34' to 35° 50' north latitude. Tehran is the 18th most populous city in the world. The population density in Tehran is estimated 10,700 up to more than 11,000 people per square kilometer. Accordingly, Tehran is the 16th densely populated city in the world [1]. The growing trend of urbanization and industrial facilities, services and educational and cultural facilities as well as mass construction of houses have led to increased fire figures and events as well as financial losses [2].

Fire data should be analyzed for three reasons: (1) to create a positive attitude in relation to the fire problems, (2) to promote resources related to fire prevention and (3) to identify training needs. Probably, the most important feature of fire data analysis is to provide a deep insight about the problems of fire which in turn can affect executive operations [3].

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Survey of fire statistics is a key for the implementation of any plan in order to improve safety level in cities. At the same time, such analyses are useful to identify factors affecting the occurrence of fires. The results of fire data analysis can be used for determining measures to improve safety level through fire prevention. The US National Fire Incident Reporting System (NFIRS) began its activities 25 years ago with the aim of collecting and analyzing fire data from different parts of the United States. Currently, more than 14,000 fire departments in 50 US states report fires or injuries associated with it to the NFIRS. This has turned NFIRS into the largest organization collecting data on the prevalence of fires in the world. NFIRS collects data on more than 900,000 fires each year in the national fire data collection [4].

According to the National Fire Protection Association (NFPA), most injuries and damages caused by fires occur in residential buildings (according to NFPA standards, residential buildings include houses, apartments, hotels, inns, hostels, transit homes and medical-psychological and addiction treatment centers). In 2010, 1,331,500 fires happened in the United States (1% less than in 2009) and caused 3,210 deaths and the injury of 17,720 citizens as well as the deaths of 72 firefighters. The financial damage of these fires amounted about US$11.6 billion. Of this, 482,000 (less than 1% increase compared to 2009) (36% of total fires) occurred in residential areas and caused 2,755 deaths (88.3%) and injury of 15,420 citizens (87.03%) with total losses of $ 9.7 billion (83.62%). 215,500 fires (16%) occurred in vehicles (1% less than in 2009) and caused 310 deaths and injury of 1,590 citizens with total losses of $ 1.4 billion. In addition, 634,000 fires (48%) occurred in outdoor areas (2% less than in 2009) which caused 55 deaths and injury of 710 citizens with total losses of 501 million dollars [5]. In England (2006), 491 people lost their lives in fires; this value is the same as in 2005. In general, about 78% of total deaths were caused by fires in residential areas [6].

All the aforementioned figures, although brief, show the importance of fires, which raises the need for implementation of fire prevention programs. Note that about 80% of fires that cause death and injury to people and property can be prevented. This is why organizations like NFPA in America and similar organizations in different countries have been established to mainly prevent fires [7].

Since the analysis of fire data is a key to identify and select actions and measures for fire prevention and due to the lack of such a complete and comprehensive analysis in Iran, the aim of this study is to analyze the information and data from more than 66,341 fires in Tehran during a period of 11 years (2002

to 2012). The objectives of this analysis can be stated as follows:

1) To identify the overall changes of fires during 11 years of study period;
2) To identify risk factors of these fires such as the time of fire, geographical area of residence, etc.

II. Materials and Methods

Data from 66,341 fires happened in Tehran over 11 years (2002 to 2012) released annually by Tehran Safety Services and Fire-Fighting Organization was considered as the main information [8]. Information on the population, number of households and so forth was obtained from Tehran Municipality and the Statistical Yearbook of Iran [1], [9]. From these data, figures such as the rate of fires and deaths per one million people in different areas of Tehran during the study period were calculated.

III. Results

Fig. 1 shows the injury and mortality rates of fires per one million population in Tehran during the study period. As can be seen, both graphs indicate an upward trend so that the rate of fire injuries and mortality rate are 59.58% and 86.12% (showing an upsurge in 2011), respectively.

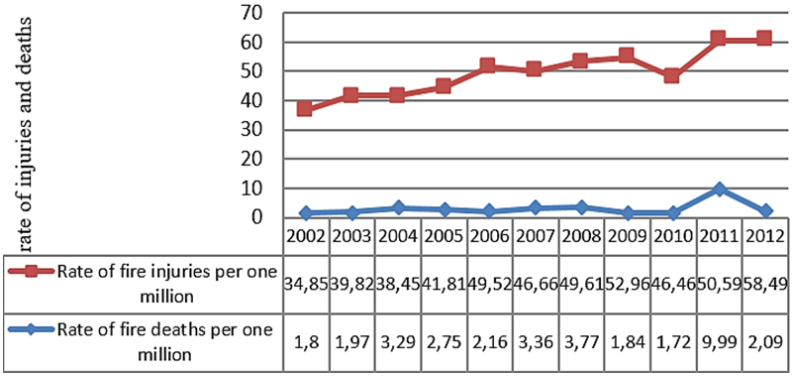


Fig. 1 The rate of injuries and deaths caused by fire in Tehran 2002-2012

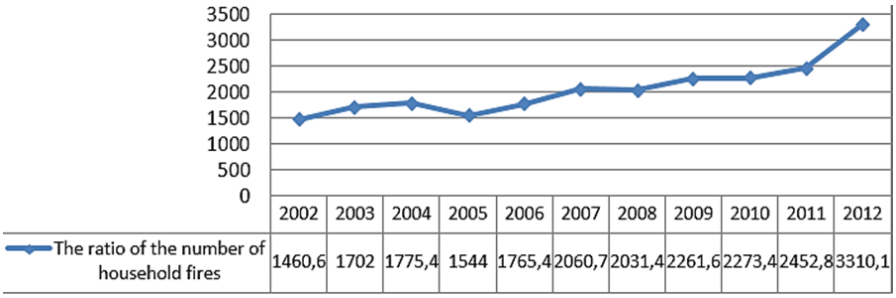


Fig. 2 Fire proportion to the number of households in the study

TABLE I
THE NUMBER OF FIRES AND FIRE STATIONS IN TEHRAN 2002-2012

Year	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Number of fires	4477	3733	4571	5000	4550	5433	6611	6787	7846	8184	**9150**
Fires percent increase over the previous year	-	62.-16	45.22	38.9	-9	41.19	68.21	66.2	6.15	3.4	**8.11**
Fire percent increase over the year 2002	1	62.-16	1.2	68.11	6.1	35.21	66.47	6.51	25.75	8.82	**38.104**
Number of fire stations	38	38	49	53	55	55	55	55	67	74	**77**
Stations percent increase over the previous year	-	0	95.28	16.8	41.2	0	0	0	22	45.10	**05.4**
Stations percent increase over the year 2002	1	0	95.28	47.39	74.44	74.44	74.44	74.44	31.76	74.94	**63.102**

As seen in Fig. 2, the ratio of fires to number of households shows an upward trend so that it increased about 55.79% from 2002 to 2012.

Fig. 3 shows the distribution of fires in different seasons. As shown, the number of fires is increasing from spring to summer. It shows a declining trend in autumn and then increases again in winter.

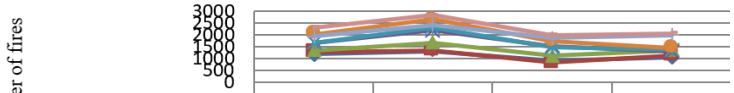
Fig. 4 shows the distribution of fire at different hours of the day. As shown, the number of fires increases from 08:00 hrs to 20:00 hrs and then decreases.

Table I shows the number of fires and fire stations in the study period and its percentage increase compared with the previous year and 2002 (the first year of study). As can be seen, the number of fires and fire stations respectively increased by 104.38 and 102.63% during the study period.

Table II lists the ratio of the number of fires in each district

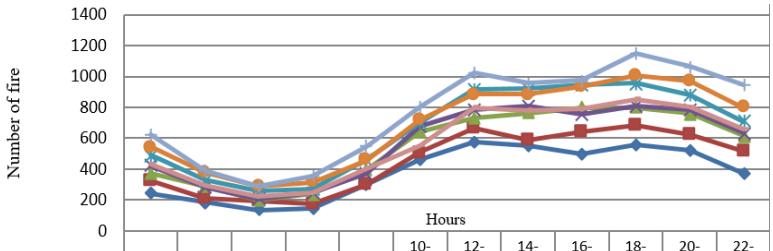
of Tehran to the total number of fires from 2006 to 2012. As can be seen, most fires happened in the 4th District of Tehran which includes 9.21% of all fires.

Table III summarizes the number of fires in terms of the type of occupation and damages per fire. As is clear, passages and crossings, residential areas and vehicles show the highest average in the study period. Furthermore, industrial sector ranks first in terms of damages.



	Spring	Summer	Autumn	Winter
Average 2002 to 2005	1176	1313	908	1030
2006	1273	1335	816	1126
2007	1323	1648	1117	1345
2008	1638	2184	1505	1284
2009	1651	2305	1466	1365
2010	2021	2639	1727	1450
2011	1930	2415	1870	1969
2012	2289	2842	1969	2050

Fig. 3 The distribution of fires in different seasons in Tehran 2002-2012



	0-1:59	2-3:59	4-5:59	6-7:59	8-9:59	10-11:59	12-13:59	14-15:59	16-17:59	18-19:59	20-21:59	22-23:59
2006	244	185	136	145	300	465	574	552	497	559	520	373
2007	323	209	194	178	300	508	666	586	639	686	626	517
2008	373	289	199	239	396	644	730	763	799	800	761	617
2009	422	286	206	245	370	677	788	810	753	808	787	635
2010	491	329	259	274	462	699	917	920	949	956	880	710
2011	545	376	290	315	459	719	886	886	935	1005	970	798
2012	623	389	292	355	549	802	1024	957	975	1152	1063	949
Average	432	295	225	250	405	555	798	782	793	852	801	657

Fig. 4 Distribution of fires at different hours of the day

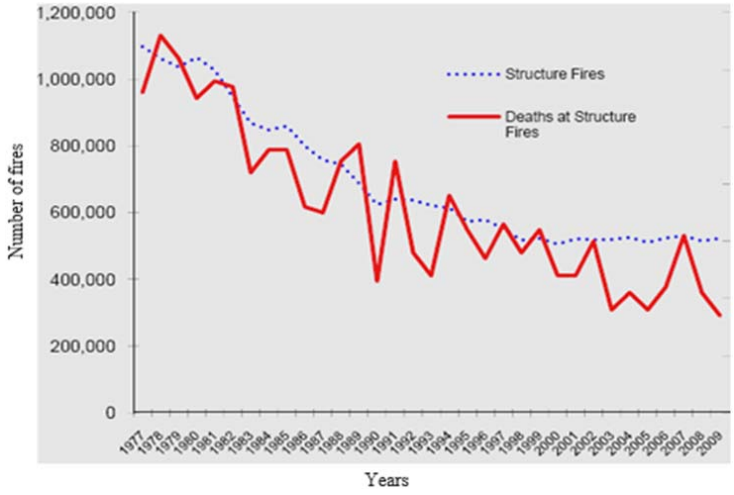


Fig. 5 The changes in the number of fires in the US (1977-2009) [10]

TABLE II
THE NUMBER OF FIRES IN EACH REGION TO THE TOTAL NUMBER OF FIRES IN THE STUDY PERIOD

Region	2006	2007	2008	2009	2010	2011	2012	Mean
1	05.5	23.5	3.5	32.5	34.4	22.5	83.6	**57.4**
2	7.6	03.7	61.8	06.8	63.8	58.7	72.8	**9.7**
3	55.4	93.4	81.5	61.4	26.5	61.5	44.4	**03.5**
4	31.8	9	16.12	9	11.10	41.8	45.7	**21.9**
5	7.6	61.5	87.6	78.6	28.6	6	15.6	**34.6**
6	16.5	04.5	13.4	07.4	63.4	85.2	4	**27.4**
7	22.4	07.3	9.2	77.2	9.2	85.2	03.3	**11.3**
8	7.2	45.2	74.2	12.2	68.2	87.2	22.3	**68.2**
9	37.2	76.2	31.2	71.3	52.2	6.1	42.1	**38.2**
10	06.2	41.2	48.2	94.1	06.2	43.2	05.3	**35.2**
11	42.4	1.4	63.3	23.3	36.3	03.4	8.3	**8.3**
12	94.8	07.9	89.6	16.7	8.6	1.7	07.7	**58.7**
13	47.3	66.3	62.2	95.2	8.2	64.2	46.2	**94.2**
14	25.3	83.2	42.2	53.2	9.2	3	95.2	**84.2**
15	92.6	48.6	85.5	76.6	6	82.6	27.7	**59.6**
16	03.3	32.2	31.2	71.2	78.2	7.2	14.3	**71.2**
17	69.1	2	56.1	12.2	77.1	08.2	14.2	**9.1**
18	69.5	94.5	02.6	1.8	62.7	85.6	68.5	**56.6**
19	4	1.5	6.4	4.4	45.3	16.3	9.3	**1.4**
20	06.6	5	93.4	17.6	51.6	46.7	37.6	**07.6**
21	08.1	6.0	88.0	15.0	04.1	04.2	96.1	**11.1**
22	65.1	45.2	16.2	68.2	36.2	65.1	88.1	**12.2**
*****	**53.2**	**94.2**	**8.2**	**68.2**	**22.3**	**51.3**	**07.3**	**3**

*out of area

IV. DISCUSSION

The analysis of locations and causes of fires, age distribution and the number of victims of the fires, the time of occurrence of fire and the financial damages caused by the fires can be used to provide a strategy to prevent fires and to reduce the likelihood and severity of fires in most countries and cities. According to the results, the number of fires increased by 104.38% in the 11-year study period; this indicates this important point that the number of fires has increased in Iran over the years. In the other words, control and preventive measures provided by the Fire-Fighting Organization and other relevant organizations have failed in the face of population growth and the number of households and buildings. This increase in the number of fire relative to the number of households can be seen in Fig. 2. However, according to Fig. 5, in the 32-year period from 1977 (3,264,000 fires) to 2009 (1,348,500 fires), the number of reported fires has decreased 59% in the United States. The rate of reported fires per 1,000 inhabitants decreased by 70% from 14.9 in 1977 to 4.4 in 2009 [10].

The number of fires and fire stations, respectively, increased by 104.38 and 102.63% over the study period (Table I). The rate of average increase in the number of fires and fire stations for each year compared with the previous year is about 8.2 and 7%, respectively. On the other hand, the rate of population growth in Tehran is 4.1% in the past decade [11]. Comparing the rate of population growth and the increased rate of fires indicates that population growth is not the cause of increased fires, since the rate of population growth is exactly half the increase in the rate of fires. Combining data in Table I with those in Figs. 1 and 2, it can be concluded that burnout urban fabric, failure to observe safety precautions when constructing residential and administrative buildings and the lack of planning and management in fire control have led to an increase in the number of fires and thereby damages and deaths caused by fires.

The average mortality rate in the study period is 3.16 persons per one million population (Fig. 1). However, this very low mortality rate is not seen in most countries and is not believable. For example, the average mortality rate in the US was 19.5 people between 1991 and 1993. The average mortality rate in China is about two persons per one million people. The difference between the average mortality rates in Iran and China with that of America can be related to different policies of these countries. In some countries, only big fires with significant consequences are reported and small fires are neglected. Another reason for this difference is different reporting systems used in various countries. However, the rates of injury per one million people in Iran and China are significantly different. The injury rate in China and Iran is 46.29 and 3.9, respectively. In the other words, the injury rate in China is 11.87 times that in Iran. This difference can only be attributed to differences in the reporting systems in both countries [12].

As is clear from Table III, the 4th District of Tehran with an average of 9.21% of total fires is in the first place. According to the topography of Tehran, the 4th District is in the first place in most indicators such as the ratio of the total number of households to the number of households in all districts of Tehran (10.06%), population (10.2%) and the number of residential units (10.17%). Therefore, this rank can be related to the household density, the population, and housing units, as all three parameters in the 4th District are higher than those in other districts [1]. Among the seasons, most fires occurred in summer (Fig. 3). High electricity consumption in this season followed by the increased current flow through wires and overheating could be a reason for the high number of fires in summer. This reason can be also deduced from Fig. 4, since most fires occurred at peak hours of power consumption.

According to Fig. 4, most fires often occur during daytime hours (08:00-20:00 hrs). The ratio of the number of fires in day to that in night (20:00 to 08:00 hrs) is approximately 1.18:1 (this ratio in China is 1.4:1). The above graph also shows that the average number of fires during 10:00-24:00 hrs is higher than the average of all fires (482.56) (this range in China is between 08:00 to 22:00 hrs). The difference in the time of occurrence of fires can be due to the increased use of electric equipment as peak hours of consumption of electrical equipment (18:00 to 20:00 hrs) almost match the peak hours of fires (from 18:00 to 20:00 hrs in Fig. 4). As shown in Table III, most fires occur in residential areas [12].

According to Table III, the number of fires in residential areas approximately includes 21 percent of all fires. In terms of type of places, the residential sector ranks first with 35.16% of all damages caused by fires. Due to the nature of industry and expensive equipment used as well as the large extent of fires occurred in these types of occupations, the industrial

sector is in the first place in terms of damages caused by fires.

According to the results, the recorded data of fires have not been systematically planned for fire prevention, since one of the ways to reduce injuries caused by fires is to develop a systematic program for emergency services and the necessary actions in emergency situations [13]. To determine a more reliable source for fire prevention, the stages, definitions of working processes and the cause and effect chains which can lead to incidents should be considered [14]. Therefore, there should be a close cooperation between the relevant organizations and people. This in turn requires the promotion of education and identification of ways and means of fire prevention [14]. Finally, three programs can be implemented for fire prevention: (1) establishing a program for promoting fire prevention level, (2) the successful implementation of preventive activities in the field of disaster training for fires occurring in residential areas, and (3) the use of emergency rescue decision-making system [13].

It should be noted that since all fires are not reported, statistical analysis of fires cannot be considered as an overall plan for fire prevention. In addition to such analyses, other control measures should be considered, since when using statistics from past years in the prevention of fires, the impact of social development and a variety of risks should be taken into account [14]. For this reason, a comprehensive statistical system should be developed based on the topographic map of the urban risks, local needs and intersectional cooperation [9].

TABLE III
NUMBER OF FIRES IN TERMS OF THE TYPE OF OCCUPATION AND DAMAGES PER FIRE (RATE OF IRANIAN TOMAN)

Type of occupation	2006		2007		2008		2009	
	Number of fire	Average damage per fire	Number of fire	Average damage per fire	Number of fire	Average damage per fire	Number of fire	Average damage per fire
Industrial	200	5804925	200	7990177	157	13907292	193	10467305
Warehouse	116	7317241	170	7317241	156	13593205	198	10845035
Commercial and business	281	4125900	327	3377186	364	4225107	362	4576030
Professional	415	1973995	486	1980034	563	3350591	490	2352245
Military and Police	42	2176785	42	1434095	50	904500	54	1910925
Services Work	57	883772	74	1104621	68	536102	59	1328898
Vehicles	464	878054	583	922276	694	1202291	737	2560185
Private (cumulative)	109	323968	122	673467	127	532641	135	1503777
Governmental, administrative	131	416427	156	670641	155	1608903	189	336931
Risky Activities	84	608750	137	587116	147	657353	131	2294580
Residential	1201	517947	1242	509491	1313	514713	1332	651262
Green areas, agriculture	494	539490	620	502621	1084	158397	1115	407082
Healthcare	35	730857	63	381349	71	650563	46	2783695
Cultural and educational	62	1424677	65	254277	63	1715555	68	706617
Passages and crossings	859	66534	1146	45148	1599	55585	1678	123028
Total	4550	1261036	5433	1277373	6611	1535124	6787	1667347

Type of occupation	2010		2011		2012		Mean	
	Number of fire	Average damage per fire	Number of fire	Average damage per fire	Number of fire	Average damage per fire	Number of fire	Average damage per fire
Industrial	195	18983000	223	18383341	206	40331942	197	16552569
Warehouse	265	16155023	268	11252778	284	10618820	209	11014192
Commercial and business	429	8796527	493	5416681	532	4084172	399	4943086
Professional	529	5632546	491	3424006	506	2489445	498	3028980
Military and Police	52	1029327	36	1454028	49	2383877	47	1613362
Services Work	73	898055	71	1032253	89	1784640	71	1081192
Vehicles	910	1247367	1208	1288806	1384	1163795	855	1323283
Private (cumulative)	164	1101055	191	990953	181	1245525	147	910198
Governmental, administrative	259	1099514	230	722826	279	801713	200	808136
Risky Activities	161	1303571	188	641888	267	1072303	160	948165
Residential	1556	1092411	1725	1137187	1729	911939	1443	762136
Green areas, agriculture	1290	234421	975	137289	1142	187146	960	309492
Healthcare	59	729237	55	3217636	48	1102708	54	1370864
Cultural and educational	86	9839884	76	1316921	70	931857	70	2312827
Passages and crossings	1818	72924	1954	171803	2384	148354	1634	97625
Total	7846	3286964	8184	1995821	9150	207646	6938	47076107

1 USD =32,00.00IRR

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