Sigma J Eng & Nat Sci 38 (4), 2020, 1869-1878

Sigma Journal of Engineering and Natural Sciences
Sigma Mühendislik ve Fen Bilimleri Dergisi

Research Article

STATISTICAL ANALYSIS OF TRAFFIC ACCIDENTS IN THE KÜÇÜKÇEKMECE DISTRICT OF ISTANBUL

Emir Berk KORKMAZ*[1], Mustafa GÜRSOY[2]

[1]*Department of Civil Engineering, Yıldız Technical University, İSTANBUL;* ORCID: 0000-0001-8650-5955
[2]*Department of Civil Engineering, Yıldız Technical University, İSTANBUL;* ORCID: 0000-0002-3782-5941

Received: 20.04.2020 Revised: 13.06.2020 Accepted: 03.09.2020

ABSTRACT

In the globe, accidents cause ten thousand people's death and even more injuries every year. This study has been done by collecting and analyzing the data which consists three years (2015, 2016 and 2017) provided by Istanbul Police Department. Along with the examination of the data based on these three years (2015, 2016 and 2017), computer and satellite aided observations and field investigations were also made. Thus, it has been tried to determine the density distribution of the accidents in the regions, to determine the causes of the accidents and to offer solutions for these reasons.
Keywords: Traffic safety, traffic accidents, statistical analysis, data analysis.

1. INTRODUCTION

According to the Turkish Statistical Institute, in 2018 more than three thousand accidents occurred in Turkey each day (see Table 1 for yearly data) [1]. Also, in the same year, more than eight thousand people died because of traffic accidents and even more were left with injuries. According to the World Health Organization, traffic accidents:

- Cause the death of more than one million people,
- Cause injury to more than twenty million people and
- Cost 3% of countries' GDP [2].

The numbers show that traffic ac cidents cost humankind dearly. There are a lot of factors that may lead to traffic accidents. So, this paper is a study about different factors' effects on traffic accidents. The aim is to identify the pattern between distinct accidents and different accident factors. Various statistical analyses have been conducted to interpret this pattern. There are two types of statistics in this study: one includes all the accidents which happened in Küçükçekmece district (in 2015-2017) and the second one consists of some accidents which happened in various intersections in Küçükçekmece district. (These intersections were selected by the authors and are considered to be "dangerous intersections". The criterion behind their selection was the increased concentration of accidents in these intersections).

* Corresponding Author: e-mail: emirberkkorkmaz@outlook.com, tel: (532) 706 65 31

Table 1. Traffic accidents per year [1]

Year	Total Number of Accidents
2009	1053346
2010	1106201
2011	1228928
2012	1296634
2013	1207354
2014	1199010
2015	1313359
2016	1182491
2017	1102716
2018	1229364

Although traffic accidents may have many reasons, those reasons can be divided into three main categories [3]:

- Driver based traffic safety problems:
  - Using cell phones while driving,
  - Insufficient sleep,
  - Not obeying traffic rules,
  - Alcohol usage,
  - Improper lane changes
- Traffic safety problems caused by weather:
  - Rain
  - Iciness
  - Snow etc.
- Operator (local or central government)based traffic safety problems:
  - Improper geometrical design,
  - Inadequate education,
  - Improper or insufficient signalization etc.

Figure 1 shows the distribution of accidents on the map of the Küçükçekmece district. Red dots represent the accidents in 2017, blue ones represent the accidents in 2016, and the green ones represent accidents in 2015. The arrows and the numbers they are linked to show the intersections which were selected by the authors for examination.

1.1. Literature Review

There are many studies about statistical analysis of traffic accidents. One of them was released in 1989 by Al-Assar and Khasnabis named *"Analysis of Heavy Truck Accident Data—Exposure Based Approach"*. In this article, the ratio of accidents involved by trucks to all traffic accidents was calculated. The ratio was determined and classified according to the distance traveled by trucks and the number of accidents (death, injury or loss of property) [4]. Al-Assar and Khasnabis' article leads to seek how to do an analysis of traffic accidents.

In the research *"Introducing Alignment based Risk Indices into the Highway Traffic Accident Analysis"* which was published in 2007, Kang and Lee aimed to classify traffic accidents occurring in four-laned roads in South Korea. They sought to define the effects of geometrical design parameters by starting with the accident ratio on those roads and the Traffic Accident Risk Index (TARI). This article provided us with a good guide for map usage and placement of accidents on a map. Data were based on the distribution of values between 1996 and 2000 with

Multi-linear regression. Ultimately, their map symbolizes risk distribution by colour on the determined highways by alignments and curves [5].

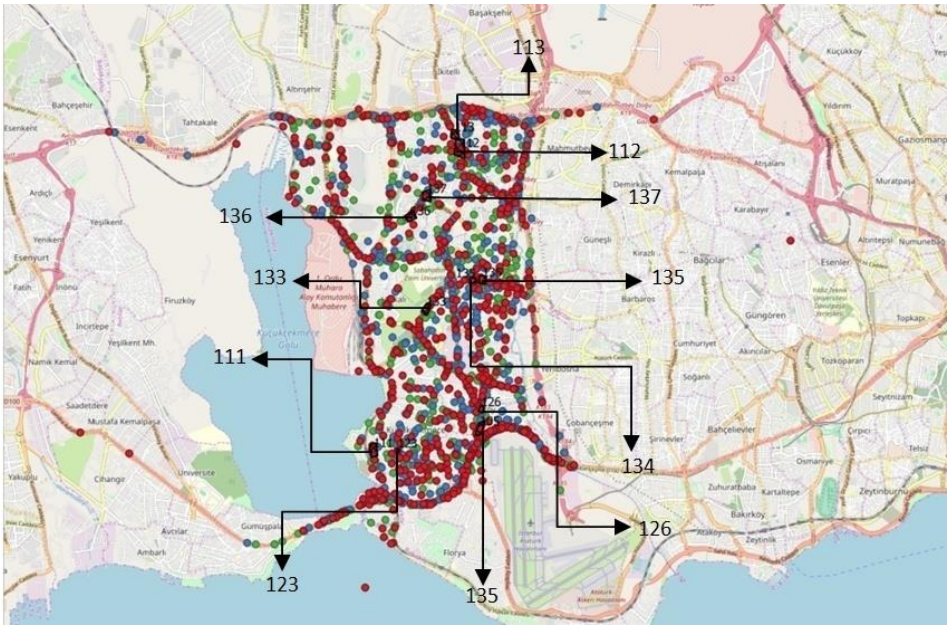

Figure 1. Distribution map of accidents in Küçükçekmece district

"A Security Analysis and Accident Prevention Measure", written by Liu et al. (2010), aimed to define the parameters which can prevent traffic accidents and the possible solutions to causes of traffic accidents [6]. *"A Security Analysis and Accident Prevention Measure"* assisted us in making statements about our raw data.

In the article titled "*Numerical Examinations of Traffic Accident Characteristics Using Analytical Statistical Methods"*, published by Zhang et al. in 2012, answers were sought to questions of the frequency of injury and the risk of accident occurrence at the time of day using regression analysis. The study, which covers the Washington region, contains information from the state's police stations, such as the occurrence of accidents and the types of accidents [7].

Another study was published in 2016 named *"Achieving Safe Road Traffic – the Experience in Japan"*. Oguchi, the author, investigates and tries to explain the differences in accident numbers in different years in Japan. The study also observes the fatalities and injuries in these accidents. Finally, the author makes comparisons on these numbers with European counterparts [8].

Mohan et al.'s *"Urban traffic safety assessment: A case study of six Indian cities"*, published in 2016, is based on accidents that occurred in six cities of India. The fatality rate of these accidents is classified by different types of vehicles. The fatality rates are also examined by the driver's age, time of day, alcohol usage etc. Based on this information, the authors sought to estimate the average number of accidents per 100,000 kilometers by different types of vehicles [9].

Oguchi's and Mohan's studies were examined to see the differences between accident fatality and injury rates in our paper and those of other countries. They were also influential in terms of the different accident factors in traffic accidents.

A much more recent study, *"What are the factors that contribute to road accidents? An assessment of law enforcement views, ordinary drivers' opinions, and road accident records*" was written by Rolison et al. in 2018. In this study, data were collected through questionnaires, and the factors affecting accidents were sought [10]. The study revealed the factors of an accident. Also, it helped us to make statements about the statistical analysis.

In the article titled *"A geographically weighted regression to estimate the comprehensive cost of traffic crashes at a zonal level"* published in 2019, accident costs were calculated according to zones in the USA Tennessee region. The scope of the study ranges from the total accident cost to the average accident cost. Making use of map markings, this study preferred the infrastructure of Google and Bing [11]. The use of map markings and geographical databases in this article helped us with a method to locate accidents on a zonal map.

2. DATA

In this study, causes of accidents are clarified in line with the data received from the Istanbul Police Department, which are classified according to the following items:

• Accident year • Accident hour • Accident coordinates (X, Y) • Accident time • Accident district • Accident area (Residential or rural area) • Road type (Dual carriageway, one-way road etc.) • Pavement of road • Class of highway (State highway etc.) • Number of lanes • Lane width • Horizontal geometry (alignments and horizontal curves) • Vertical geometry (On-level or not) • Intersection geometry (Intersection type) • Time of day (Day, night etc.)	• Weather condition • Road surface (Dry or wet) • Type of accident (Rear end collision etc.) • Number of cars involved in the accident • Place of the accident (On the road, on the shoulder etc.) • Road faults affecting accident • Road maintenance status • Road width • Highway guardrail status • Pedestrian way status • Safety lane status • Traffic line status • Road sign status • Signalization status • Lighting of the road • Obstructed object status • Number of deaths • Number of injuries

In addition to this data, we have also added these factors:

- Which day of the week the accident occurred and
- At which intersections the accident occurred.

Descriptive information about the data set can be found in Tables 2 and 3 below:

Table 2. Average number of monthly and daily accidents

Years	Average of Monthly Accidents	Average of Daily Accidents
2015	58.58	1.92
2016	58.75	1.93
2017	62.25	2.05
Total	59.86	1.97

Table 3. Descriptive statistics for three years

	Range	Minimum	Maximum	Mean	Std. Deviation	Variance
Number of Injured People	43	1	44	1.43	1.389	1.928
Horizontal Geometry	2	1	3	1.07	0.269	0.072
Vertical Geometry	3	1	4	1.29	0.480	0.230
Intersection Geometry	7	1	8	6.18	2.589	6.704
Walkway Geometry	4	1	5	4.84	0.466	0.217
Day Condition	2	1	3	1.44	0.551	0.304
Weather Condition	4	1	5	1.25	0.690	0.476
Type of Accident	13	1	14	5.38	3.403	11.581

Number of accidents for three years is 2155.

In Table 3, the range indicates the difference between the minimum and maximum values. For example, the range for the number of injured people shows the difference between the accident which had the most injuries and the accident which had the least injuries. This example has a numerical value. An example of a categorical value is for the horizontal geometry, where the range is 2, while the minimum and maximum numbers are 1 and 3, respectively. In this instance, a value of 1 indicates alignment, a value of 2 indicates a curve and a value of 3 indicates a dangerous curve.

3. METHODOLOGY

To determine the cause of accidents and for determining the dangerous intersections, several approaches have been implemented in this paper. Firstly, the data were corrected and then several field observations were conducted for better results. Finally, statistical analyses (which are explained below) were done to conclude the research.

1. Accident data were obtained from the Istanbul Police Department and then made suitable for analysis. This process can be summarized by:
   a. Inappropriate data (such as wrong coordinated accidents or fatal accidents) were extracted.
   b. Some of the parameters which were not stated in the original data set (such as week day of the accident) were assigned.
2. Descriptive statistics of the accident data were determined.
3. Accident data were processed on the map by the aid of Geographical Information System (GIS) software. For the GIS software, QGIS was chosen for this study.
   a. Google's *"Open Street Maps"* was used as the base layer.
4. Upon processing the data on the map, the intersections with the majority of accidents were determined based on the average rate of accidents on those intersections.
5. Site observations were done on the selected intersections and findings were noted.
6. Accident situation tables of selected intersections were drawn.IBM SPSS software was used for the classification and tabulation of accidents at dangerous intersections which can be classified as those intersections with high accident rates.
7. Data analyses of accidents were done according to both general data and selected intersections.
8. Various figures and tables for accident data were prepared.
9. Solution suggestions based on the findings from the accident data analysis are presented.

3.1. Assumptions

Before starting the study, one of the assumptions we made was that fatal accidents could give false results. As can be seen in Table 4, the proportion of fatal accidents corresponds to less than 1.5% of all data. For this reason, fatal accidents are not included in the study as they may negatively affect the distribution of the data.

Table 4. Distribution of fatal and injurious accidents by year

Years	Accidents Causing Injury	Fatal Accidents	Total Accidents
2015	704	11	715
2016	705	12	717
2017	747	4	751
Total	2156	27	2183

Table 5. Accident numbers at selected intersections

Intersection No.	Accident Year	N
105	2015	2
	2016	3
	2017	7
	Total	12
111	2015	3
	2016	3
	2017	0
	Total	6
112	2015	7
	2016	5
	2017	10
	Total	22
113	2015	3
	2016	3
	2017	4
	Total	10
126	2015	3
	2016	2
	2017	2
	Total	7
133	2015	3
	2016	3
	2017	2
	Total	8
134	2015	4
	2016	2
	2017	2
	Total	8
135	2015	2
	2016	2
	2017	3
	Total	7
136	2015	1
	2016	2
	2017	5
	Total	8
137	2015	3
	2016	4
	2017	3
	Total	10
Total	2015	31
	2016	29
	2017	38
	Total	98

Based on the occurrence rate of accidents, ten intersections were selected. Ninety-eight accidents occurred in these ten intersections. Assumptions will be made according to these intersections. The distribution of accidents at these intersections by year is given in Table 5.

4. FINDINGS AND RESULTS

The main purpose of this article was to find the causes and effects of accidents. These are the findings:

- The vast majority of accidents at selected intersections occurred in the form of pedestrian crashes. Apart from that, rear bumps and collisions with obstacles/objects are also at a considerable level. Figure 3 can be examined for detailed information.
- Almost all of the accidents that occurred at night on pedestrian crossings occurred in the form of pedestrian crashes (see Figure 2). It is striking that drivers do not pay attention to pedestrian crossings at night.
- Rainy and snowy days in the city of Istanbul are very rare [12]. Thus, making deductions for rainy and snowy days will be inaccurate with this amount of data.
- The major difference between daytime and night time accidents is whether or not the accidents occurred by collision with an object on the road. In the night time, this rate is rather high. Accidents that take place at night by driving off line are a little higher than the number of accidents of the same type during the day.
- It is observed that the rate of head-to-head collisions and rear crashes at night are lower than at daytime. The effect of vehicle headlights on safety can thus be seen. On the other hand, side-on collisions at night are considerably higher than the same type of accidents during the day.
- The ratio of the number of accidents on rainy, snowy and sleety days to the total number of accidents at night is more than twice the number of accidents in the same weather during the day.
- At the intersection 105 (see Figure 1), the number of pedestrian crashes increased significantly in 2017 and, moreover, the number of pedestrian crashes increased at all of the selected intersections. Although similar statistics can be seen in the data in Küçükçekmece, the rate mentioned at intersection 105 is relatively higher.
- Although the amount of rain in 2017 is close to the other years [13], the number of accidents in 2017 on rainy days is much higher than the other years.
- It is difficult to make any deductions from the numbers of injured people in accidents at the marked intersections. There were no fatal accidents.
- The number of accidents on level roads is 1549, while the number of accidents on level roads is 594. The total number of injured people in these accidents is 2134 on non-level roads and 933 on level roads. When the total number of injured people is compared to the number of accidents, this rate is 1.57 on level roads and 1.38 on non-level roads.

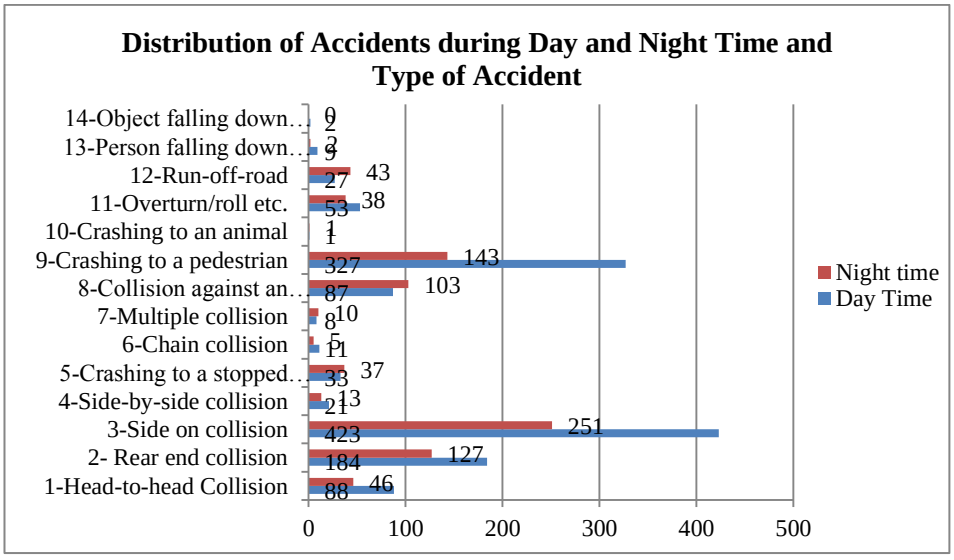

Figure 2. Distribution of accidents

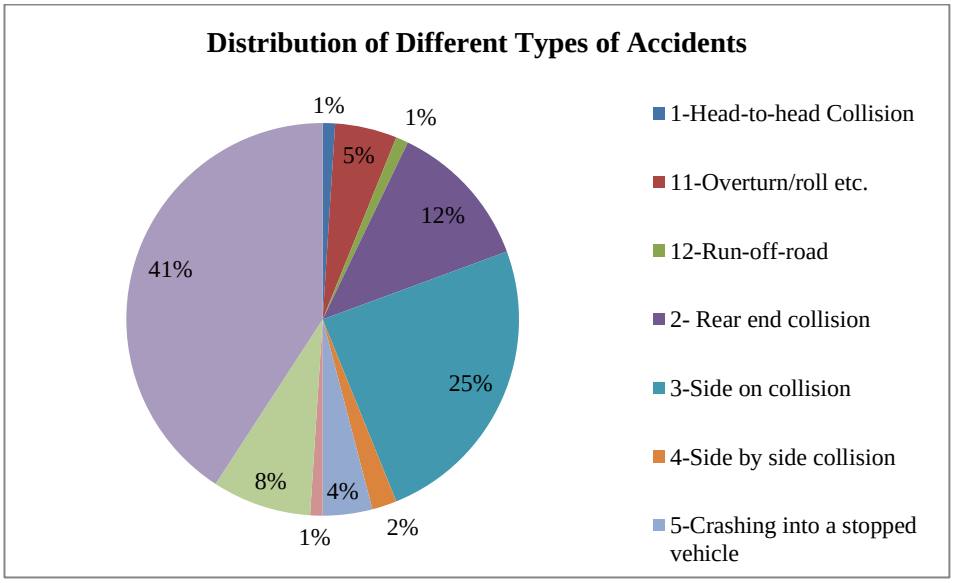

Figure 3. Distribution of accidents at selected intersections for three years

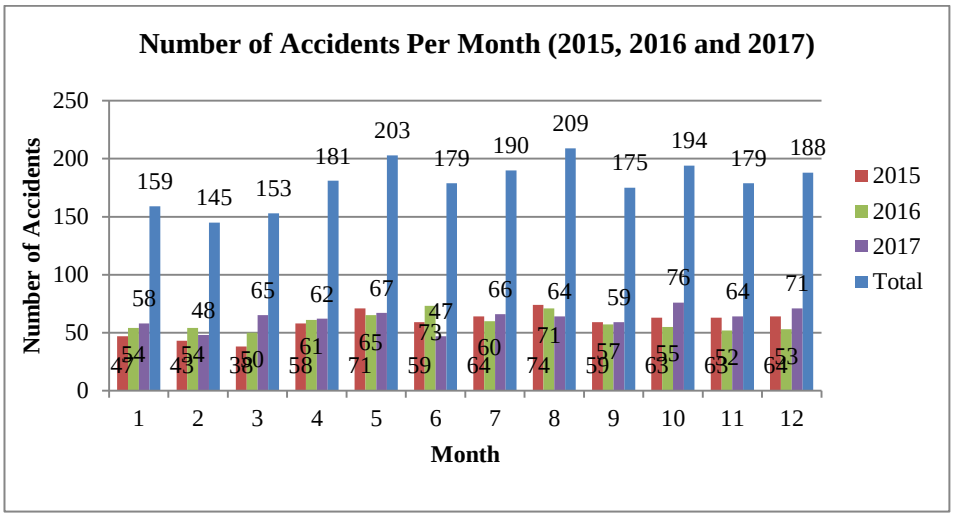

Figure 4. Number of accidents per month for 2015, 2016 and 2017, combined

5. DISCUSSION AND CONCLUSION

The first problem encountered in this study is that Annual Average Daily Traffic (AADT) values are not specified for the city. If a study on AADT values is made on urban roads, it will be possible to further study the reasons of accidents on urban roads and get more realistic results.

Accident statistics for three years were used for the research, but it is important that the study is based on more years for more accurate results. In order to make more determinations, data from other years can be added as well.

The study suggests that drivers driving at night should pay attention to pedestrians and objects that may be on the road. The use of vehicle lighting is one of the main factors for traffic safety at night.

The data from this study reveals that the risk of injury in accidents on level roads is 14% higher than on level roads. The risk of injury during night time accidents was 3.8% higher than during daytime.

The data from this study show that the accident type with the highest risk of injury is side-by-side collisions with an average of 1.89 injuries per accident, followed by pile-up accidents with 1.82, and head-to-head collisions with 1.72. It is worth noting that the type of accident where this ratio is the least is a pedestrian crash, which is 1.14.

When the findings of the study were examined, it was revealed that drivers should be more careful to avoid pedestrian crashes and possible objects while driving at night time (see Figure 2).

Even though crashing-into-pedestrian types of accidents are high at night time, the ratio to total accidents of the same type (day and night accidents by crashing into pedestrians) is lower than the ratio of crashing intoobjects in day time to total number of accidents on the same type (day and night accidents by crashing into objects.) (See Eq. 1) The reason for this might be that the night time pedestrian circulation numbers in this district are lower than other districts of the city. Also, some of the streets which were examined for this purpose have higher average speeds as some of them are a type of main arterial road which is distant from high density settlements. Another reason for this outcome is that, thanks to new settlement in these zones, traffic signs and traffic safety equipment hadbeen recently installed and properly applied according to standards.

$$Night\ time\ ratio\ of\ crashing\ into\ pedestrians = \frac{143}{143+327} = 0.30$$

$$Night\ time\ ratio\ of\ crashing\ into\ objects = \frac{103}{103+87} = 0.54$$

Equation 1. Night time ratios for crashing into objects and pedestrians

REFERENCES

[1] "TÜİK Haber Bülteni." *http://tuik.gov.tr/PreHaberBultenleri.do?id=30640*", TurkishStatisticsInstitute

[2] "Road Traffic Injuries." *World HealthOrganization*, World HealthOrganization, www.who.int/mediacentre/factsheets/fs358/en/.

[3] Lenka, Komackova, andPoliakMilos. "FactorsAffectingthe Road Safety." *Journal of CommunicationandComputer*, 2016, pp. 146-152.

[4] "Journal of TransportationEngineering." *Analysis of Heavy Truck Accident Data-ExposureBasedApproach | Journal of TransportationEngineering | Vol 115, No 3*, Jan. 1989, ascelibrary.org/doi/abs/10.1061/(ASCE)0733-947X(1989)115:3(298).

[5] Ascelibrary.org. (2020). *IntroducingAlignmentBased Risk IndicesintotheHighwayTrafficAccident Analysis | Computing in CivilEngineering (2007)*. [online] Available at: https://ascelibrary.org/doi/10.1061/40937%28261%2956 [Accessed 7 Feb. 2020].

[6] Liu, Shenquan, et al. "A Security Analysis andAccidentPreventionMeasure." *Icctp 2010*, 2010, doi:10.1061/41127(382)73.

[7] Zhang, Guohui et al. "Numerical Examinations of Traffic Accident Characteristics Using Analytical Statistical Methods." *Cictp 2012*, 2012, doi:10.1061/9780784412442.358.

[8] Oguchi, Takashi. "AchievingSafe Road Traffic – theExperience in Japan." *IATSS Research*, Elsevier, 3 Feb. 2016, www.sciencedirect.com/science/article/pii/S0386111216000042.

[9] Mohan, Dinesh, et al. "Urban TrafficSafetyAssessment: A Case Study of SixIndianCities." *IATSS Research*, Elsevier, 11 Feb. 2016,

[10] Rolison, Jonathan J., et al. "WhatAretheFactorsThatContributeto Road Accidents? An Assessment of LawEnforcementViews, Ordinary Drivers' Opinions, and Road AccidentRecords." *Accident Analysis &Prevention*, Pergamon, 9 Mar. 2018, www.sciencedirect.com/science/article/pii/S0001457518300873.

[11] Hezaveh, AminMohamadi, et al. "A GeographicallyWeightedRegressiontoEstimatetheComprehensiveCost of TrafficCrashes at a Zonal Level." *Accident Analysis &Prevention*, Pergamon, 21 June 2019, www.sciencedirect.com/science/article/abs/pii/S0001457518307449.

[12] T.C. Tarım ve Orman Bakanlığı Meteoroloji Genel Müdürlüğü İllere Ait Mevsim Normalleri (1981-2010). (2020, June). Retrieved June 26, 2020, from https://www.mgm.gov.tr/veridegerlendirme/il-ve-ilceler-istatistik.aspx?m=ISTANBUL

[13] "T.C. TARIM VE ORMAN BAKANLIĞI Meteoroloji Genel Müdürlüğü." *Yıllık Toplam Yağış Verileri - Meteoroloji Genel Müdürlüğü*, www.mgm.gov.tr/veridegerlendirme/yillik-toplam-yagis-verileri.aspx.

[14] Peden, Margie, editor. *World report on road traffic injury prevention*. World Health Organization, 2014, pp. 107–143, *World report on road traffic injury prevention*.

[15] "http://www.tuik.gov.tr/PreHaberBultenleri.do?Id=27668." *Türkiye İstatistik Kurumu Trafik Kaza İstatistikleri, 2017*, TÜİK, 27 June 2018.