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Identification and Ranking of Accident Black Spots in Jordan

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Abstract In any country, identifying high-intensity accident hotspots is essential in establishing effective techniques to minimize high-intensity accident sites. Because of Jordan's continual population growth in recent years, vehicle ownership has grown, leading to an increase in accident rates. According to many researches, Jordan suffers from damages caused by traffic accidents. As a result, the current study focuses on finding the black spots in selected Jordanian localities as a first step toward identifying the strategies to minimize traffic accidents in Jordan. To achieve this objective, the researcher started their investigation by collecting the accidents that occurred in Jordan during three years in 30 departments in Amman. The study area includes 30 segments in seven intersections in Amman city. Based on the collected data, the case study traffic sites were ranked based on their safety performance using several methods: accident rates, accident frequency, and accident severity index. The study's findings revealed that the high safety segment in the study area is from al-zamakhshre to interchange al-shfaa. In contrast, the high black spots are found from Jordan University to major streets. Results confirmed that identifying the high black spots segments contributes to reducing expected traffic accidents.

Keywords Black Spots, Accident, Traffic

1. Introduction

Traffic accidents are a serious problem and a big challenge for the modern countries all around the world, due to their direct and significant effects on humans and the economy [1]. With an estimated 1.24 million persons killed by the accidents yearly, traffic accidents are the greatest cause of mortality for young people and the eighth highest cause of death worldwide [2]. Furthermore, traffic accidents cost countries about 2% of their gross national outcome [3]. Many studies have shown that developing countries suffer from traffic accidents. According to (Worley, 2006), about 85% of annual deaths have occurred in the developing countries. Unlike developed countries, developing countries still regard road accidents as a matter of fate or an unavoidable cost of growth [4]. As a result, unless significant efforts are made to improve traffic safety in emerging countries, the number of people killed in traffic accidents is predicted to rise by 80% by 2020 [5].

Also, Jordan as a developing country faces traffic accidents. It is considered as one of the riskiest places in terms of traffic accidents, which accounted for nearly 4.5 percent of all fatalities in 2007 and rated as the third leading origin of death in 2010 [6]. The survey results of the Jordanian Traffic Institute (2009 – 2011) indicate that the number of registered traffic accidents was (405,395); causing 2040 deaths and 51,187 injuries, besides the estimated losses of 883.5 million JD. Moreover, it was

found that the costs of accidents were estimated at 146.3 million US dollars in 1996 [7], and increased to 440 million US dollars in 2010 [8]. These indicate the seriousness of traffic accidents in Jordan, which requires finding possible solutions to reduce the incidence of these accidents. Hence, and for investigating the main strategies that control traffic accident ratios in Jordan, to reduce its frequencies, impacts and severities, it's necessary to analyze and identify the traffic locations that are more dangerous than others (black spots).

2. Traffic Accidents in Jordan

Traffic accidents are a complex phenomenon. They are caused by various factors, including roadway and its environment, road users' behavior, and vehicle aspects [4]. Official data show that the human factors (drivers and their behavioral mistakes) reached up to 90% of the accident's responsibility. Accident's data were analyzed from 20 countries in Europe. The results revealed that 39.7% of fatal accidents occurred in urban areas, 35.5% of fatal accidents occurred in rural areas, and 44.6% of fatal accidents occurred on highways [9]. Further, statistics showed that more than 85% of the drivers' mistakes were speeding, and about 77% of the crash caused by speeding. However, the percentage of vehicles, road geometry, and environmental factors of accidents didn't exceed 10%.

Traffic accidents in Jordan are a major health problem [4]. Road accidents increased significantly during the years 2015-2018 due to the increase in the number of people using vehicles daily. All this makes road safety an important issue [10]. It is worth noting that the Jordanian government implemented a new traffic law and intensified police activities in 2008 [4]. Furthermore, beginning in 2008, the Jordanian government adopted a traffic safety strategy that includes the following measures: 1. Implementing the new traffic law of 2008, 2. Enhancing enforcement methods and the quality of traffic cops, 3. Coordinating with other traffic safety authorities, and 4. Implementing intense traffic awareness campaigns through the media and educational institutions [6].

Several studies have been conducted in the past to analyze the characteristics and trends of traffic accidents in Jordan [6]. For example, according to the findings of a study by Al-Omari [11], the elderly and children play the most significant role in pedestrian accidents, with males accounting for the majority of fatalities. Pedestrian accidents occurred at greater rates on Thursdays between 12:00 and 15:00 throughout July, according to the time factor. The majority of pedestrian accidents occurred on roads with specific speeds of 40-60 km/h, with the high participation of small passenger cars and trucks.

3. The Black Spot Identification

The identification, analysis, and treatment of road crash Black Spots are widely regarded as one of the most effective approaches to road crash prevention. Several studies have reported large reductions in the number of crashes when safety measures were introduced at these locations [12]. Black spots are sometimes referred to as dangerous road sites, accident-prone sites, dangerous accident sites, problem sites, hotspots, or promising sites [13]. No standard definition exists of black spots [14, 15]. However, based on an OECD report [16] and more recent work [17-20] a distinction can be made between the following common definitions of black spots:

(1) Numerical definitions (Accident number, Accident rate, Accident rate and number).
(2) Statistical definitions (Critical value of accident number, Critical value of accident rate).
(3) Model-based definitions (Empirical Bayes, Dispersion value).

The official Norwegian definition of a black spot is an example of a basic numerical definition: "Any place with a maximum length of 100 meters where at least four injury accidents have been recorded in the last five years" is defined as a black spot [21]. On the other hand, a statistical definition of a black spot is based on comparing the number of accidents that have been documented to a normal amount for a similar sort of site. For example, if the number of accidents recorded in a given period is considerably higher than the typical number of accidents for this sort of intersection, the junction will be categorized as a black spot. A statistical definition of a black spot may be close to a model-based definition, depending on how the typical number of accidents is approximated.

4. Methodology

The data required for this study first include traffic volume, which were obtained from the Greater Amman Municipality. The second is the accident reports, which are obtained from the Central Traffic Department. Since all traffic volumes collected were hourly volumes, there was a need to convert them into annual average daily traffic. Hence the first step in the analysis was to prepare the data to be suitable for use in all analyses. In this case, the volume of traffic was increasing to the average annual daily traffic using a local expansion factor that is generated from multiple automated inventory locations over a 3-year period. This was followed by the generation of traffic volumes for the entire analysis year period from the current enumeration year using a specific growth rate achieved by the Greater Amman Municipality, and the growth rate that was used for the city of Amman, after executing the previous step and processing all the data to in the next step of the analysis, we obtained the average annual daily traffic at traffic sites in the study area for the year 2014-2016. In addition, the accident number was

obtained at the same location for the same period. These data provide the primary data required for all analysis for this study.

5. Data Collection

Two types of data are collected and used in the analysis, type 1 traffic volume: Average Annual Daily Traffic (AADT) which is the average of 24 hours of each day of the year, Average Daily Traffic (ADT) which is also an average of 24 hours calculated but over several days over a year and less than a year, and the Peak Hour Volume (PHV) is the maximum number of vehicles or the maximum volume of traffic passing through a point on the highway during a consecutive 60-minute period. The volume data needed to achieve the study objectives is average annual daily traffic (AADT), but the available is Peak Hour Volume (PHV) which is collected every 15 minutes during the peak period time. Table 1 shows a sample of traffic volume data taken from GAM for (Sport city) intersection.

Converting the volume data to annual average daily traffic will generate data related to annual average traffic; related to the year of enumeration and analysis of the data required for the years 2014 to 2016 to generate accurate data during the analysis period, and this is done by using the study area's growth rate. The second type of main data collected is traffic accident frequency for the analysis period 2014 to 2016. This data was collected directly from the traffic department, including fatal accidents, injury accidents, and property damage accidents. Table 2 shows a sample of accidents data collected from the central traffic department and contains the number of accidents in the location of the Al-Dawriat signalized intersection during the years from 2014 to 2016. (Note that these numbers are on three types property damage accidents, injuries accidents, and fatalities accidents).

The data summarized in the Table 2 revealed that the total yearly number of accidents is reduced during the three years. Consequently, the number of total injuries reduced, where the most of the injuries were slight and nearly 30% of them were classified as serious. Fortunately, there are no fatalities resulting from these injuries. These results indicated that the strategies that are applied to reduce the number of injuries are applied effectively. On the other hand, the number of property damage resulting from accidents also reduced in the number of accidents.

Table 1. A sample of traffic volume data taken from GAM for (Sport city) intersection

Time	Number of Vehicle				
	Station A	**Station B**	**Station C**	**Station D**	**Station E**
7:30 – 8:30	1036	23	620	23	1801
2:30 – 3:30	569	12	720	13	2092
5:30 – 6:30	432	15	685	28	2054

Table 2. Sample of traffic accident data for Al-Dawriat signalized

No. of Accident		2014	2015	2016	**Total**	**Rate**
Injuries	Serious Injuries	18	13	12	**43**	**14.33**
	Slight Injuries	64	23	53	**140**	**46.67**
Fatalities		0	0	0	**0**	**0.00**
Property Damage		222	158	79	**459**	**153.00**
Total		**304**	**194**	**144**	**642**	**214.33**

Table 3. Study area segments

Location		Location	
ID	**Location Name**	**ID**	**Location Name**
S1	From tabarbor signal to al_mashgel circle	S16	From akef al-fayez street to university bridge
S2	From al-mashgel circle to tabarbor signal	S17	From university bridge to akef al-fayez street
S3	From al husien prince to al mashgel circle	S18	From university bridge to al-madenaa steer
S4	From al- aqsa street to al_mashgel circle	S19	From al-madena street to university street
S5	From al mashagel circle to jordan street	S20	From university bridge to mosique university
S6	From jordan street to al shfaaiterchange (al-shahed)	S21	From university mosque to al-dawriat signal
S7	From al-shfaaiterchange to a; -zamakhshre signal	S22	From al_dawriat to al-jubeha signal
S8	From al-zamakhshre to interchange al_shfaa	S23	From al-jubeha to al-dawriat signal
S9	From al-zamakhshre to sport city circle	S24	From al-jubiha signal to al-manhal signal
S10	From sport city to al-zamakhshre	S25	From al-manhal signal to al-jubeha signal
S11	From alia queen street to al-shheed street	S26	From al-dawriat to signal to swelih circle
S12	From alia queen to sport city circle	S27	From yajoz and jordan streets to al-shafaa interchange
S13	From al-madena street to al-raay signal	S28	From jordan university to yajoz street
S14	From al-raay signal to al-madina circle	S29	From yajoz and Jordan streets to al-manhal signals
S15	From al-raay signal to university bridge	S30	From al-manhal to yajoz and Jordan steers

Figure 1. Study area segments

The study area included a well-distributed seven intersections and thirteen road segments in Amman city, which represented a good variation in the daily traffic volume number of legs on the control types. The seven intersections are Dawar al-mashgel intersection, sport city intersection, Sweileh circle intersection, al-shafaa interchange section, university hospital section, university mosque intersection, and al-dawriat Al-Dawriat signal intersection. Table 3 shows the selected 30 segments in Amman city.

Figure 1 shows a map of the geographical locations of the intersections selected for the study, distributed as evenly as possible over several parts of Amman.

6. Data Analysis and Result

The needed data were collected and evaluated for

analysis; these modifications included converting data from hourly volumes to annual volumes, which means expanding the peak hour volume (PHV) to average annual daily traffic (AADT). All that is done using the data in Table 4 from several automated traffic count locations over 3 years. We can see in the hour column the 24-hour of the day and in the second column the percent of ADT for each hour, so we can calculate the ADT for a location using this table by dividing the hourly volume by the percent of ADT for the counting hour from Table 4.

Table 4. Percent of ADT

Hour	Percent of ADT	Hour	Percent of ADT
00:00	0.92%	13:00	6.55%
01:00	0.48%	14:00	7.11%
02:00	0.23%	15:00	7.68%
03:00	0.13%	16:00	7.27%
04:00	0.09%	17:00	7.00%
05:00	0.18%	18:00	6.51%
06:00	1.47%	19:00	5.83%
07:00	5.06%	20:00	4.61%
08:00	6.98%	21:00	3.66%
09:00	5.86%	22:00	2.67%
10:00	5.85%	23:00	1.91%
11:00	5.95%		
12:00	6.00%		

The previous analysis of the average annual daily traffic for the counted years drives us into the next step of preparing data to get the annual traffic AADT for the analysis period years 2014 to 2016. The estimation of AADT for the years of analysis was calculated using the growth rates recommended by Greater Amman Municipality. Greater Amman Municipality engineers calculated these growth rates.

6.1. Accident's Frequency

In this study, the 30 segments were ranked using different methods. The first method was the accident frequency method, which uses the number of accidents within the intersection to indicate the priority of safety improvement. The frequency is used mainly in comparisons between different locations within the study period. In current study, the data for 3 years were used in this analysis by taking the average accident number for each location. Table 5 shows the results of the accident frequency method for the study area intersection during the period 2014 to 2016. The results revealed that only one location has an accident frequency of zero, which shows that the traffic volume of this location may be low compared with the other locations. The volume of traffic for each site differs from one location to another, and therefore the comparison between these locations must take into account this difference. So it can be concluded that this method's limitation is that it does not consider traffic volume, so it is not an accurate indicator of the safety level of the intersections.

Table 5. Result of accident frequency method through the years 2014-2016.

Location	2014	2015	2016	Average	Rank
S1	465	379	344	396	28
S2	333	375	260	323	25
S3	179	135	65	126	3
S4	157	138	257	184	11
S5	313	349	231	298	23
S6	151	270	122	181	9
S7	258	126	182	189	12
S8	0	0	0	0	1
S9	237	93	345	225	15
S10	223	145	173	180	8
S11	366	325	408	366	27
S12	445	392	371	403	29
S13	254	238	181	224	14
S14	154	201	189	181	10
S15	164	206	136	169	5
S16	162	232	140	178	7
S17	333	326	160	273	18
S18	333	250	244	276	20
S19	370	257	194	274	19
S20	569	565	322	485	30
S21	348	319	143	270	17
S22	243	133	152	176	6
S23	304	194	145	214	13
S24	252	179	248	226	16
S25	389	254	195	279	21
S26	487	323	114	308	24
S27	443	279	171	298	22
S28	386	413	174	324	26
S29	151	130	155	145	4
S30	74	99	51	75	2

In determining the criteria used in the identification of black spots; Jordan Traffic Institute (2009-2011) studies review some of the techniques that can be used, based on their results; the criteria for determining the black spot's locations used in this study were Weighted Injury Accidents (WIA), using the following equation:

$$WIA = W + I + A \quad (1)$$

Where WIA, Weighted Injury Accidents, W is a number of fatality accidents multiplied by 3, I is a number of injury accidents multiplied by1, A is a number of property damage multiplied by1/3.

So, the Weighted Injury Accidents were used as the second method to take the study area intersections and road segments. The data for 3 years were used in this analysis by taking the average accident data for every location. Table 6 shows the results of the accident severity method for the study area segments during the period 2014 to 2016. This method is a good indicator of the severity of accidents at the intersection; however, it does not reflect the change in traffic volume or exposure data.

Table 6. Result of accident severity index method for the years 2014 to 2016.

ID Location	Fatal	Injury	Property Damage	WIA	Rank
S1	3	11	48	179	25
S2	2	11	31	142	18
S3	0	8	30	68	3
S4	1	6	67	112	9
S5	2	20	100	183	26
S6	3	26	37	110	7
S7	0	12	77	123	13
S8	0	0	0	0	1
S9	0	16	73	134	15
S10	0	12	73	116	11
S11	0	48	83	210	28
S12	0	37	96	223	29
S13	0	23	71	137	16
S14	0	20	56	111	8
S15	1	29	64	120	12
S16	0	12	53	103	5
S17	0	15	79	154	20
S18	0	44	83	177	24
S19	0	22	66	150	19
S20	1	47	111	271	30
S21	0	21	49	137	17
S22	0	14	60	108	6
S23	0	15	47	112	10
S24	0	20	53	124	14
S25	2	52	55	169	22
S26	0	23	75	168	21
S27	2	69	38	177	23
S28	2	64	49	189	27
S29	1	39	35	99	4
S30	0	9	30	51	2

6.2. Accident Rates

The accident rate method is the rate of accidents number of the exposure data, which can be traffic volume, population, etc. Accident rates are considered one of the most effective techniques used in identifying the black spot at the road network; it takes into account the accident number or accident severity and the traffic volume, population, or vehicles kilometers to find. Additionally, Vehicle Accident Rate is derived by multiplying the number of vehicle accidents by 1,000,000 miles and dividing by the mileage driven for a given period of time (a calendar year). Accident rates per million entering vehicle (MEV) for an intersection can be calculated according to the following equation:

$$R = A\ (1000000) / ADT \times N \times 365 \quad (2)$$

Where: R is the accident rate for one million entering vehicles, ADT is the average daily traffic entering the intersection, and N is the time period in a year.

It is a result that represents the variety of exposure data. However, it is insufficient to determine the relation between that exposure data and the accident frequencies since this method implies a linear relationship between the number of accidents and the exposure data, which is an unreasonable assumption. In this study, the traffic volume represents the exposure data used in the accident rates calculations. Traffic flow varies over time and is normally expressed as a volume with respect to the duration of measurement (vehicles per time). Besides, the traffic

volume type is the average annual daily traffic resulting from the volume data conversion.

Several types of accident rates are used: total number of accident rates, fatalities accident rates, property damage accidents, and injuries accident rates. The data for 3 years is used in this analysis by taking the average accident data and volumes data for every location. Table 7 shows the fatalities accident rate method results for the study area of 30 segments from 2014 to 2016. This rate is defined as the average number of fatalities in accidents through 2014, 2015 and 2016 divided by the average traffic volume for the same period. The rates multiply by 106 to simplify the analysis (make it readable). This rate is not a robust indicator of safety performance because multiple locations have the same safety level (no fatal accident). The results revealed that 50% of the study area segments have no fatalities in their accidents, which indicates the safety rate in this location when compared with the other locations in the current study.

Table 7. Fatalities accident rate per million vehicles for the years 2014 to 2016

ID Location	Fatalities Accident Rate	Rank
S1	36.8	26
S2	27.9	25
S3	0.0	1
S4	11.4	23
S5	47.3	27
S6	85.1	30
S7	7.7	19
S8	0.0	2
S9	0.0	3
S10	0.0	4
S11	4.2	16
S12	0.0	5
S13	0.0	6
S14	0.0	7
S15	13.7	21
S16	0.0	8
S17	0.0	9
S18	4.4	17
S19	0.0	10
S20	10.4	20
S21	0.0	11
S22	0.0	12
S23	0.0	13
S24	0.0	14
S25	27.1	24
S26	0.0	15
S27	72.5	28
S28	77.7	29
S29	17.4	22
S30	5.4	18

Table 8. Fatalities accident rate per million vehicles for the years 2014 to 2016

ID Location	Injuries Accident Rate	Rank
S1	719.7	9
S2	506.4	7
S3	585.3	6
S4	1245.2	23
S5	3383.5	29
S6	2030.8	25
S7	2056.9	26
S8	0.0	1
S9	827.8	8
S10	1195.6	14
S11	1636.6	17
S12	592.1	3
S13	1769.0	20
S14	2079.4	27
S15	1923.8	22
S16	525.2	2
S17	1953.4	24
S18	1688.5	18
S19	924.4	11
S20	1238.6	15
S21	1596.8	16
S22	1158.5	13
S23	679.3	5
S24	1132.5	12
S25	1733.0	19
S26	861.2	10
S27	3314.1	28
S28	4417.1	30
S29	1922.1	21
S30	619.9	4

Table 8 shows the injuries accident rate method results for the study area of 30 segments from 2014 to 2016. This rate is defined as the average number of injuries accidents through 2014, 2015 and 2016 divided by the average traffic volume for the same period. The rates multiply by 106 to simplify the analysis (make it readable). Based on the results summarized in Table 8, the high injury accident rate due to location accounted for 60%. Generally, these percentages referred to the dangers in these locations, while in current study there is only one location with an accident rate of zero.

Table 9 shows the property damage accidents rate method for the study area 30 segments from 2014 to 2016. This rate is defined by the average number of property damage accidents through 2014, 2015 and 2016 divided by the average traffic volume for the same period. The rates multiply by 104 to simplify the analysis (make it readable). The impact of traffic accidents is not only limited to human and material damage to road users, but also has a clear impact on the property of the accident site.

According to the results of the current study the rates of property damage for the study area ranged from 5.80 – 81.10. The high rate 81.1, found in S28 has the highest injuries accident rate, and it also has high fatalities accident rate with rank 29 in current study. Therefore, this location is classified as a dangerous location according to the accidents that occurred within it.

Table 9. Property damage accidents rate per 10,000 vehicles for the years 2014 to 2016.

ID Location	Property Damage Accident Rate	Rank
S1	41.0	27
S2	33.3	26
S3	13.4	9
S4	18.8	21
S5	50.1	28
S6	36.6	23
S7	23.1	15
S8	0.0	1
S9	12.7	5
S10	13.6	6
S11	29.5	22
S12	12.0	4
S13	24.5	17
S14	28.8	20
S15	15.4	7
S16	9.0	3
S17	36.8	24
S18	19.7	14
S19	19.5	13
S20	25.5	18
S21	45.6	25
S22	15.8	8
S23	16.9	10
S24	23.9	16
S25	27.8	19
S26	18.5	12
S27	58.6	29
S28	81.1	30
S29	18.5	11
S30	5.8	2

Table 10 shows the total number of accidents rate methods for the study area 30 segments from 2014 to 2016. This rate is defined as the average total number of accidents through 2014, 2015 and 2016 divided by the average traffic volume for the same period; the rates multiply by 104 to simplify the analysis (make it readable). The results summarized in Table 10 revealed that the highest accident rate indicated on S28, which has high injuries accident rate, and fatalities accident rate. It is clear from this that the percentage of injuries and deaths increases with the increase in the number of accidents on the roads. On the other hand, the current study contains one location free of accidents.

Table 10. Total accidents rate per 10,000 vehicles for the years 2007 to 2009.

ID Location	Total Accident Rate	Rank
S1	48.6	25
S2	38.6	23
S3	19.3	6
S4	31.4	21
S5	84.4	28
S6	57.7	26
S7	43.8	18
S8	0.0	1
S9	21.0	5
S10	25.6	8
S11	45.9	20
S12	18.0	4
S13	42.2	17
S14	49.6	22
S15	34.8	12
S16	14.2	3
S17	56.3	24
S18	36.7	14
S19	28.7	11
S20	38.0	16
S21	61.6	27
S22	27.4	10
S23	23.7	7
S24	35.3	13
S25	45.4	19
S26	27.1	9
S27	92.5	29
S28	126.0	30
S29	37.9	15
S30	12.1	2

6.3. Comparing Results

Table 11 summarizes the ranking results of segments and the output of different methods. The safety level at various intersections may be evaluated by comparing methods and the total accident rate; if the two values are similarly high, traffic volume significantly affects accident occurrence when they are different. There are other factors affecting accidents occurrence besides traffic volumes. The results revealed that the dangerous location in study areas found in S5, S6, S21, S27, and S28 based on their rates of fatalities, injuries, and property damage. On the other hand, the locations with less risk were found in S8, S9, S12, S16, and S30.

Table 11. Summary rating results (2014-2016).

ID Location	Freq. Rank	WIA Rank	Fatal. Rank	Inj. Rank	Pro. Rank	Total Rank
S1	28	25	26	9	27	25
S2	25	18	25	7	26	23
S3	3	3	1	6	9	6
S4	11	9	23	23	21	21
S5	23	26	27	29	28	28
S6	9	7	30	25	23	26
S7	12	13	19	26	15	18
S8	1	1	2	1	1	1
S9	15	15	3	8	5	5
S10	8	11	4	14	6	8
S11	27	28	16	17	22	20
S12	29	29	5	3	4	4
S13	14	16	6	20	17	17
S14	10	8	7	27	20	22
S15	5	12	21	22	7	12
S16	7	5	8	2	3	3
S17	18	20	9	24	24	24
S18	20	24	17	18	14	14
S19	19	19	10	11	13	11
S20	30	30	20	15	18	16
S21	17	17	11	16	25	27
S22	6	6	12	13	8	10
S23	13	10	13	5	10	7
S24	16	14	14	12	16	13
S25	21	22	24	19	19	19
S26	24	21	15	10	12	9
S27	22	23	28	28	29	29
S28	26	27	29	30	30	30
S29	4	4	22	21	11	15
S30	2	2	18	4	2	2

According to data summarized in the Table 11, the following intersections were identified as the most dangerous intersections in the study area: From Jordan University to yajoz street, from yajoz and Jordan streets to al-shafaa interchange, from al mashagel circle to Jordan street, From university mosque to al-dawriat signal, from Jordan street to al shfaa interchange (al-shahed). At the same time, the results of the case study showed that the highest safety intersections are from al-zamakhshre to interchange al_shfaa, from al-manhal to yajoz and Jordan steers, from akef al-fayez street to university bridge, from alia queen to sport city circle, from al-zamakhshre to sport city circle.

8. Conclusions and Recommendation

This study seeks to identify the study area's black spots, including 30 segments in seven intersections in Amman city. The case study traffic locations were ranked based on their safety performance using the accident rates method, accident frequency method, and accident severity index method. The study compared the different techniques in ranking the study area intersections and road segments. Accident frequency and accident severity index methods are simple to use and comprehend but they do not account for the varying effects of traffic volumes. In contrast, accident rates consider the accident number or accident severity and the traffic volume, population or vehicles kilometers to find a result representing the variety of exposure data. However, it is still inadequate to find the relation between exposure data and the accident frequencies because it assumes a linear relationship between accident frequency and the exposure data, which is unrealistic.

The lack of data presents a major challenge at the level of indifference analysis. Therefore, the current study recommended that traffic agencies should start traffic data collection programs (accident data or traffic volume data) available for future studies of all research.

REFERENCES

[1] Abuaddous M., Ja'far A., Al-Btoush M. A. K., Alkherret A. J, "Building information modeling strategy in mitigating variation orders in roads projects," Civil Engineering Journal, vol. 6, no. 10, pp. 1974-1982, 2020. https://doi.org/10.28991/cej-2020-03091596.

[2] World Health Organization, "Global status report on road safety 2013: supporting a decade of action: summary," (No. WHO. NMH. VIP 13.01), World Health Organization, 2013.

[3] Peden M., Scurfield R., Sleet D., Mathers C., Jarawan E., Hyder A. A., Jarawan E., "World report on road traffic injury prevention," World Health Organization, 2004.

[4] Al-Masaeid H., "Traffic accidents in Jordan," Jordan Journal of Civil Engineering, vol. 3, no. 4, pp. 331-343, 2009.

[5] Jacobs G. D., Amy Aeron-Thomas, "A review of global road accident fatalities," Paper commissioned by the Department for International Development (United Kingdom) for the Global Road Safety Partnership, 2000.

[6] Bashar A. L., Ghuzlan K., Hasan H., "Traffic accidents trends and characteristics in Jordan," International Journal of Civil & Environmental Engineering IJCEE-IJENS, vol. 13, no. 5, pp. 9-16, 2013.

[7] Al-Masaeid H. R., Al-Mashakbeh A. A., Qudah A. M., "Economic costs of traffic accidents in Jordan," Accident Analysis & Prevention, vol. 31, no. 4, pp, 347-357, 1999. https://doi.org/10.1016/S0001-4575(98)00068-2.

[8] Yearly traffic accidents reports (1998-2010), Jordanian Traffic Institute.

[9] ERSO. Traffic safety basic facts 2011-Roads outside urban areas. Brussels, Belgium: European Road Safety Observatory; 2011.

[10] Kidd D. G., Chaudhary N. K., "Changes in the sources of distracted driving among Northern Virginia drivers in 2014 and 2018: A comparison of results from two roadside observation surveys," Journal of safety research, vol. 68, pp. 131-138, 2019. https://doi.org/10.1016/j.jsr.2018.12.004.

[11] Al-Omari B. H., Obaidat E. S., "Analysis of pedestrian accidents in Irbid City, Jordan," The Open Transportation Journal, vol. 7, no. 1, 2013. https://doi.org/10.2174/1874447801307010001.

[12] Patel S. V., "Study of Black Spots in Greater Mumbai: Enforcement Related Factors,". National Police Academy Journal, vol. LXVII, no. 1, pp. 82-128, 2019.

[13] Sørensen M., Elvik R., "Black spot management and safety analysis of road networks,". Oslo, Norway: Institute of transport economics, 2007.

[14] Hauer E., "Identification of sites with Promise," Transportation Research Record, vol. 1542, pp. 54-60, 1997. https://doi.org/10.1177/0361198196154200109.

[15] Elvik R., "Traffic safety,". Handbook of transportation engineering, 2004.

[16] OECD Road Research Group. "Hazardous road locations– Identification and counter measures," Organisation for economic co-operation and development, 1976.

[17] Persaud B. C., Lyon T., Nguyen, "Empirical bayes procedure for ranking sites for safety investigation by potential for safety improvement," Transportation Research Record, vol. 1665, pp. 7-12, 1999. https://doi.org/10.3141/1665-02.

[18] Hauer E., Kononov J., Allery B. Griffith M. S., "Screening the road network for sites with promise," Transportation Research Record, vol. 1784, no. 1, pp. 27-32, 2002. https://doi.org/10.3141/1784-04.

[19] Vistisen D., "Models and methods for hot spot safety work," Phd-thesis, Department for informatics and math ematical models, Technical University of Denmark, Lyngby, 2002.

[20] Overgaard Madsen J. C., "Skadesgradsbasered

sortpletudpegning - fra crash prevention til losss reduction I de danske vejbestyrelsers sortpletarbejde," Phd-thesis, Traffic Research Group, Department of Development and Planning, Aalborg University of Denmark, Aalborg, 2005.

[21] Statens vegvesen, "Analayse av ulykkessteder," Draft dated October 19, 2006. Vegdirektoratet, Oslo, 2006.