Identification of Accident-Prone Locations in Greater Amman

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A study was conducted to identify and rank dangerous traffic locations in Greater Amman, the capital of Jordan. Accident frequency, accident rate, critical rate, and accident seriousness measures were incorporated to develop a technique for ranking these sites for future improvement. It was proven that the use of accident frequency as the sole criterion for identifying or ranking hazardous locations may be misleading.

Jordan is a Middle Eastern country. It has about 3 million inhabitants in an area of 96 000 km^2. Traffic accidents are a major cause of loss of life and wealth in Jordan (*1*). In 1988 the country had about 242,000 registered vehicles and 5 500 km of paved roads (*2*). From 1983 through 1988 the country experienced an average of 16,000 accidents, 9,000 injuries, and 424 deaths per year (*3*).

Amman, the capital of Jordan, has been facing rapid population growth and migration from rural areas. It has about 35 percent of the country's population (1 million) and 82 percent of its registered vehicles. Traffic accidents in the city count for 53 percent of those in Jordan as a whole (*3*).

No sound traffic safety program has been established in Amman. All safety measures are taken by the police department on the basis of experience and intuition, with little knowledge of basic traffic accident analyses procedures and the essentials of traffic safety programs implementation.

Because of these concerns and others mentioned in the literature (*1–4*), and also to establish a base for further traffic safety research, a study was carried out as part of a comprehensive traffic safety project. The project aims to improve traffic safety in Amman through enhancing traffic control systems, implementing safety countermeasures, and distinguishing hazardous locations. The objective of this study was to identify accident-prone locations in Greater Amman and to establish a ranking system for these locations for future improvement funding.

DATA ACQUISITION

Accident records were obtained from police department files. Any site that had 10 or more accidents per year was selected. On that basis, 28 intersections and nine roads were found to need further investigation. The naming and numbering system of Greater Amman streets is under development. Some of the sites still have common names. Following is a full description of the study locations:

- *Site 1.* Central vegetable supermarket entrance;
- *Site 2.* Military hospital entrance from King Abdullah Street, Marka;
- *Site 3.* Elled Society intersection: intersection of Nablus and Al-Jalil streets, Jabal Al-Hussien;
- *Site 4.* Custom Triangle: Madaba and Sahab roads intersection near Al-Jumrock;
- *Site 5.* Al-Basheer Hospital entrance from Al-Taj Street, Al-Ashrafieh;
- *Site 6.* Al-Marbat Bridge: end of Estiklal Street at Al-Mahattah;
- *Site 7.* Driving and vehicle license department entrance from King Abdullah Street, Marka;
- *Site 8.* Television Triangle;
- *Site 9.* Ain Gazal intersection: end of Ain Gazal Road at Al-Jaish Street (intersection of Al-Jaish and Biet Ummer streets);
- *Site 10.* Marka Shneller Bridge;
- *Site 11.* Palace Mountain entrance from Wadi Al-Haddadeh (King Hussien Ben Ali Street);
- *Site 12.* Middle East intersection: intersection of Yarmouk and Prince Hassan streets;
- *Site 13.* Abdoun Triangle, Wadi Abdoun;
- *Site 14.* Al Nasha intersection: intersection of King Abdullah, Yarmouk, and Al-Estiklal streets;
- *Site 15.* West Broadcasting Triangle at Nauor Road;
- *Site 16.* Qal'ah intersection: intersection of Khalid Ben Al-Walid and King Hussein Ben Ali streets;
- *Site 17.* Al-Taj intersection: end of Al-Taj Street at King Abdullah Street;
- *Site 18.* Al-Hussien Medical Center entrance;
- *Site 19.* Samir Al-Refa'i School intersection: intersection of Prince Mohammed and Al-Ma'amoon streets;
- *Site 20.* First Circle, Jabal Amman (roundabout);
- *Site 21.* Abdoun intersection near Abdoun supermarket;
- *Site 22.* Seventh Circle, Al-Sowaifieh (signalized intersection);
- *Site 23.* Second Circle, Jabal Amman (roundabout);
- *Site 24.* Fifth Circle, Jabal Amman (signalized intersection);
- *Site 25.* Sixth Circle, Um Odeinah (signalized intersection);
- *Site 26.* Wadi Sakrah intersection: intersection of Al-Sharif Naser Ben Jamil, Al. Sharif Shaker Ben Zaid, Kendy, and Ben Sinai streets;
- *Site 27.* Third Circle, Jabal Amman (roundabout);

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• *Site 28.* Fourth Circle, Jabal Amman (signalized intersection);
• *Site 29.* Mesdar and Prince Hassan streets;
• *Site 30.* Thirtieth and Osama Ben Zaid streets;
• *Site 31.* King Abdullah Street, Marka;
• *Site 32.* Bayader Wadi-Essair Main Street;
• *Site 33.* Kalid Ben Al-Walid Street, Jabal Al-Hussien;
• *Site 34.* Al-Estiklal Street;
• *Site 35.* Yarmouk Street;
• *Site 36.* Gardens and Wasfi At-Tel streets, Tla' Al-Ali; and
• *Site 37.* University and Queen Alia roads west of University Bridge.

Traffic counts were carried out on the selected sites during the summer season (July to October) and were extrapolated for the rest of the year using expansion factors. The expansion factors were determined using average monthly transportation petrol sales in the city, obtained from Jordan Petroleum Refinery Company (*5*). Intersection data were sorted into two groups depending on traffic stream characteristics, such as daily variation in traffic volume, trip purpose, geographic location, percentage of heavy vehicles, and type of intersection control.

METHODS FOR IDENTIFICATION OF ACCIDENT-PRONE LOCATIONS

A literature review revealed that there was no specified method for verification of accident-prone locations. However, methods for identification of hazardous locations have been investigated by many researchers.

Maher and Mountain (*6*) adjudged the method of ranking sites according to their annual accident total (AAT) as being simple and attractive. Plass and Berg (*7*) compared and evaluated conventional and opportunity-based accident rate expressions. Chira-Chavala and Mak (*8*) developed an algorithm to identify accident factors that are overrepresented at a site. Higle and Witkowski (*9*) developed a Bayesian model for identification of hazardous locations. Al-Esa et al. (*10*) measured the degree of hazard at urban intersections by the number of traffic conflicts. Lin (*11*) reviewed different methods used for identifying accident-prone locations and developed a model using a ranking system that combines the results of four classical methods. A brief description of these methods follows.

Accident Frequency Method

In the accident frequency method the number of accidents within a specific time period is used to determine the priority sequence for safety or improvement funding.

Accident Rate Method

The accident rate method projects the accident rate on the basis of exposure data, such as the traffic volume or the length of the road section being considered.

Accident Possibility Method

The accident possibility method is also called the quality control method. It is based on the critical accident rate (RC), as shown in the following equation:

$$\mathrm{RC} = \mathrm{Ra} + K(\mathrm{Ra}/M)^{0.5} + 1/2M \quad (1)$$

where

Ra = average accident rate for the group that contains the site under study,
K = statistical rate factor with specified significance level (for confidence level = 95 percent, $K = 1.645$), and
M = exposure in million entering vehicles (MEV) or 100 million vehicle-km (for road sections).

Accident Seriousness Method

The accident seriousness method is used to compare accidents at different locations by assigning weights to each accident depending on its severity. The equivalent total accident number (ETAN) is calculated for all sites and used for the ranking system.

DATA ANALYSIS

Accidents recorded in 1988 were analyzed. Accident data for the previous year were also available, but because significant intersection improvement plans had been undertaken during that year, analogous criteria between the years could not be achieved.

Calculations of accident rates in accordance with the four methods previously discussed were incorporated to find a combined method that could be used to identify accident-prone locations.

Calculations in agreement with the first three methods are presented in Table 1. The table shows the accident frequency, accident rate (R), critical rate (RC), and danger factor (DF) for the sites under study. The accident rate is the accident frequency divided by the exposure. The critical rate was calculated using Equation 1 with a confidence level equal to 95 percent ($K = 1.645$). The danger factor is the accident rate divided by the critical rate (DF = R/RC).

Table 1 indicates that sites with a higher accident frequency are not necessarily those with higher accident rates or a higher danger factor. This finding goes against the prevailing judgment used by personnel of the police department, who consider sites with high accident frequency as more dangerous. (This phenomenon is addressed later in Table 3.) On the other hand, no valid relationship could be found between traffic volume and the accident frequency, accident rate, or danger factor, which indicates that these measures are not necessarily proportional to traffic volume. The table also indicates that Sites 1–5 (unsignalized intersections) and Sites 29–32 are accident-prone locations according to the quality control method criteria. These sites have a danger factor greater than 1 and need imperative modifications. On the other hand, none of the Group 2 sites (signalized intersections) are in this cate-

TABLE 1 TRAFFIC VOLUME AND ACCIDENT RATES

SITE NO.	LENGTH (KM)	AADT (VEH.)	EXPOSURE (MIL.VEH.)	NO.OF ACC.	RATE (R)	CRITICAL RATE(RC)	DANGER FACTOR(DF)
GROUP 1							
1		18964	6.922	33	4.77	3.25	1.47
2		21612	7.888	33	4.18	3.15	1.33
3		14434	5.268	24	4.56	3.47	1.31
4		29083	10.615	34	3.20	2.97	1.08
5		15192	5.545	20	3.61	3.42	1.05
6		51845	18.923	50	2.64	2.71	0.98
7		27885	10.178	18	1.77	3.00	0.59
8		34734	12.678	20	1.58	2.88	0.55
9		40053	14.619	22	1.50	2.81	0.53
10		32960	12.030	16	1.33	2.91	0.46
11		23310	8.508	12	1.41	3.10	0.45
12		58320	21.287	25	1.17	2.67	0.44
13		26955	9.839	13	1.32	3.02	0.44
14		50916	18.584	20	1.08	2.72	0.40
15		19302	7.045	10	1.42	3.23	0.44
16		33294	12.152	12	0.99	2.90	0.34
17		37872	13.823	10	0.72	2.84	0.25
GROUP 2							
18		27792	10.144	29	2.86	3.00	0.95
19		35513	12.962	25	1.93	2.87	0.67
20		27989	10.216	16	1.57	2.99	0.52
21		29724	10.849	16	1.47	2.96	0.50
22		58793	21.459	27	1.26	2.66	0.47
23		42927	15.668	17	1.08	2.78	0.39
24		66361	24.222	23	0.95	2.62	0.36
25		58721	21.433	20	0.93	2.66	0.35
26		58242	21.258	19	0.89	2.67	0.34
27		65340	23.849	21	0.88	2.63	0.34
28		47597	17.373	15	0.86	2.74	0.31
ROAD SECTIONS							
29	1.5	26869	14.711	43	2.92	2.18	1.34
30	0.9	18337	6.024	27	4.48	3.35	1.34
31	1.5	29614	16.214	57	3.52	2.77	1.27
32	1.3	33143	15.726	45	2.86	2.78	1.03
33	1.6	35132	20.517	33	1.61	2.68	0.60
34	2.5	25577	23.339	29	1.24	2.63	0.47
35	3.5	34892	44.575	43	0.96	2.46	0.39
36	2.6	36254	34.405	24	0.70	2.52	0.28
37	2.0	53895	39.343	17	0.43	2.49	0.17

gory, which emphasizes the positive safety effect of traffic control signals.

Calculations in agreement with the accident seriousness method are presented in Table 2. The table exhibits the total number of accidents, deaths, and injuries that resulted at each site during the study period. The ETAN values presented in the table were calculated using the following equation

$$\text{ETAN} = aF + bJ + \text{TAN} \qquad (2)$$

where

F = number of persons who died on the site,
J = number of persons injured on the site,
TAN = total accident number on the site, and
a and b = calibration factors.

The factors a and b were calibrated by trial and error. Values from 9 to 15 were assigned for a, and values from 3 to 5 were assigned for b. The ETAN was calculated for all possible combinations of a and b values. After each operation, the sites were ranked in ascending order according to their ETAN values. However, no significant differences were found between the ranks for the values of a and b within the range presented. The best values were obtained from the operation that gives closer ranks to those based on the other three methods of rating. It was found that a = 12 and b = 3 are typical values. The software package Lotus 1–2–3 was used to facilitate the computations.

Table 3 presents the ranks of the sites according to the four accident rating methods. The four ranks of each site were added to produce the danger index (DI). Priority or final ranking was then obtained on the basis of the DI. There is no significant difference between the ranks $R3$ and $R4$ because the danger factor (on which $R4$ is based) is dependent on the accident rate (on which $R3$ is based). The table also indicates that the final ranking, which is based on the DI, agrees better with $R3$ and $R4$. As mentioned previously, this finding agrees with the discussion on Table 1, which indicated that sites of higher accident frequency are not more dangerous. This evidence is focused by examining the second and last columns in Table 3. Clear examples are Sites 12, 20, and 27.

TABLE 2 ACCIDENT SERIOUSNESS AND ETAN VALUES

SITE NO.	LENGTH (KM)	ACC.NO. (TAN)	FATALITIES (F)	INJURIES (J)	ETAN	RANK
			GROUP 1			
6		50	0	26	128	1
9		22	3	22	124	2
2		33	0	20	93	3
1		33	1	16	93	4
7		18	0	18	72	5
4		34	0	11	67	6
12		25	0	9	52	8
8		20	2	4	56	7
3		24	0	7	45	9
5		20	0	6	38	10
11		12	0	8	36	11
10		16	0	5	31	12
16		12	0	5	27	13
14		20	0	2	26	14
13		13	0	3	22	15
15		10	0	2	16	16
17		10	0	2	16	17
			GROUP 2			
18		29	3	39	182	1
19		25	0	13	64	2
22		27	0	10	57	3
27		21	0	7	42	4
24		23	0	4	35	5
26		19	0	5	34	6
21		16	0	5	31	7
23		17	0	3	26	8
25		20	0	2	26	9
20		16	0	2	22	10
28		15	0	2	21	11
			ROAD SECTIONS			
32	1.3	45	1	24	99	1
30	0.9	27	2	10	90	2
31	1.5	57	1	21	88	3
29	1.5	43	2	19	83	4
33	1.6	33	2	11	56	5
35	3.5	43	1	18	31	7
37	2.0	17	1	11	31	8
34	2.5	29	2	8	31	6
36	2.6	24	0	7	17	9

ETAN=12F+3J+TAN For groups 1&2,
For road sections divide by section length in KM .

The DI is used to identify and rank the sites according to their danger significance. It is a measure for a site within the same group and should not be used to compare sites in two different groups. The DI is not a scale of seriousness of the sites within the group; for example, a site having DI = 50 is not five times more dangerous than a site having DI = 10. The only purpose for determining the DI is to use this index for final ranking of the sites for future developments. Thus, the sites within the groups were ranked in ascending order according to their DI. The site that had the lower value of DI was considered more dangerous and was given priority for funding.

CONCLUSIONS

Identification of accident-prone locations is a significant issue that should not be ignored in any traffic safety program. Such locations have been identified in Greater Amman. Sites for which improvements are imperative were also pointed out. Traffic volume studies revealed some significant conclusions that are useful for future studies. However, the following conclusions can be drawn from this investigation:

- Identification of accident-prone locations by the accident frequency method alone may lead to improper judgment.
- Accident-prone locations can be best identified by the quality control method (critical rate).
- Combining more than one method of accident rating is an appropriate technique for priority ranking.
- Seasonal expansion factors indicate that April traffic volume represents the average monthly traffic volume of the year.

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TABLE 3 RANKING OF SITES ACCORDING TO ACCIDENT RATES AND PRIORITY FOR IMPROVEMENT

SITE NO.	FREQUENCY R1 (1)	ETAN R2 (2)	RATE R3 (3)	DF R4 (4)	DANGER INDEX DI (1+2+3+4)	PRIORITY RANKING
GROUP1						
1	3	4	1	1	9	1
2	4	3	3	2	12	2
6	1	1	6	6	14	3
4	2	6	5	4	17	4
3	6	9	2	3	20	5
5	8	10	4	5	27	6
9	7	2	9	9	27	7
7	11	5	7	7	30	8
8	9	7	8	8	32	9
12	5	8	14	12	39	10
10	12	12	12	10	46	11
11	14	11	11	11	47	12
14	10	14	15	14	53	13
13	13	15	13	13	54	14
15	16	16	10	15	57	15
16	15	13	16	16	60	16
17	17	17	17	17	68	17
GROUP2						
18	1	1	1	1	4	1
19	3	2	2	2	9	2
22	2	3	5	5	15	3
24	4	5	7	7	23	4
20	10	10	3	3	26	5
21	9	7	4	4	24	6
23	8	8	6	6	28	7
25	6	9	8	8	31	8
26	7	6	9	9	31	9
27	5	4	11	11	31	10
28	10	11	10	10	41	11
ROAD SECTIONS						
29	3	4	1	1	9	1
31	1	3	3	3	10	2
32	2	1	4	4	11	3
30	7	2	2	2	13	4
33	5	5	5	5	20	5
34	6	6	6	6	24	6
35	4	7	7	7	25	6
36	8	9	8	8	33	8
37	9	8	9	9	35	9

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