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Identification of Hazardous Intersections Based on Crash Severity Level: Case Study Baghdad City

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Abstract

Identifying the most hazardous intersections is essential in road safety management to prioritize road safety interventions. The equivalent property damage only (EPDO) measure is highly recommended because it reflects the severity levels of road crashes. The main challenge in using this measure is the estimation of crash cost. In Iraq, there has yet to be any previous attempt to estimate the crash cost according to their severity level. Therefore, this research aims to identify the most hazardous intersections according to a developed EPDO for Iraq conditions. The methodology of the work is divided into two stages. The first stage is an estimation of the crash's cost. Three methods have been used for gathering crash cost data: the willing-to-pay approach for estimating the life quality cost, the human capital for finding the production loss costs, and the restitution approach for estimating medical treatment costs, vehicle damage costs, and administrative costs. In the second stage, the EPDO (Iraq) is developed. The results show a significant correlation between the rank of intersections according to the EPDO scores and crash frequency.

Keywords: Crash cost; EPDO; Human capital approach; Restitution approach; Simple ranking; Willing-to-pay approach.

1. Introduction

Despite the actions taken in developed nations, traffic crashes worldwide have risen. They significantly deplete both the human spirit and the economy. Despite having less than half of the world's vehicles, middle- and low-income countries account for the majority of all road traffic deaths [1]-[3]. Traffic issues are highly connected with road safety issues; increased traffic flow has led to increased road crashes. This is more obvious at intersections as they are the most hazardous spots in the road networks [4]-[6].

In Iraq, vehicles have increased significantly in the past decade, with the same old roads causing many congestion problems. The number of registered vehicles in 2022 was about 2 million in Baghdad City, about 38% of the total vehicles registered in Iraq; this makes Baghdad City have the highest percentage of vehicles among other governments [7]- [10]. According to the Central Statistical Organization's annual report of traffic crashes registered in police stations with the cooperation of the Ministry of the Interior Affairs [10], the capital city (Baghdad) witnessed a significant increase in the number of residents caused by interior immigration followed by the needs of these people to all types of service. The registered crash number in Baghdad City in 2022 was 1053 crashes out of a total of 11523 crashes in all governments, which is more than the registered crashes in 2021 by 7.5% and more than the registered crashes in 2020 by 29% [10]. Therefore, steps and plans are necessary to find solutions and proposals to decrease the number of road crashes, address the causes by diagnosing the risky places, and investigate the most critical elements that cause traffic crashes [11], [12].

Methodologies have been developed to identify intersections with the highest crashes using various safety performance measures [13]. The most frequently used performance measures of road safety are crash frequency and crash rate [13], [14]. Despite these measures being used to estimate the likelihood of crash occurrences, it has been demonstrated that these measures need to be more accurate in reflecting the severity level of roads. Therefore, more comprehensive measures were developed to incorporate the factors of the likelihood and severity of road crashes [14], [15].

Some research was carried out in Iraq to assess the existing levels of road safety [5], [9], [11], [12], [16]. Previous works have yet to consider the estimation of crash costs. Therefore, this research is the first step toward estimating crash costs according to their severity level and using the EPDO as a performance measure for road safety analysis to consider the severity level of crashes.

The aim of this work is to identify the most hazardous intersections according to crash severity level. Two objectives were set: to estimate the cost of crashes in Iraq according to their level, which can be used to develop the EPDO for Iraq conditions, and to apply the developed EPDO (Iraq) to rank intersections and compare the results with the rank according to conventional performance measures.

Due to differences in the factors and road geometric characteristics contributing to crashes in each facility type, this work will only focus on estimating crash costs for selected intersections in Baghdad City, Iraq. The selected intersections are based on the availability of access crash data, which is also limited to being applied to Iraqi conditions.

1.1. The Severity Categorization of Crashes

The severity levels of road risk are classified into fatal crash, which has at least one fatal within 30 days since the crash data; injury crash, which has at least one injury without fatalities; and property damage only (PDO) crash, which has neither fatalities nor injuries [17], [18]. Montella et al. [18] define serious injuries as more sustained injuries. They categorize the PDO into two levels: PDO level 1 is slight, and the vehicle can work, while PDO level 2 is when a vehicle crashes and cannot leave the site. In some works [19], the fatalities and injuries are integrated into one measure: fatalities and serious injuries (F+S) crash or severe crash. In other words, injury crashes are classified into multi-levels. KABCO is a classification in which K refers to fatal crashes; A, B, and C refer to three levels of injuries (serious, minor, and possible injuries), and O refers to PDO crashes [20]. The Department of Transportation in the United States (USDOT) establishes a scale for non-fatal injury levels with the use of the maximum abbreviated injury scale (MAIS) [21], [22]. The Abbreviated Injury Scale (AIS) is another measurement used to classify injuries into six levels: 1 is very minor and six untreatable injuries.

1.2. The Equivalent Property Damage Only (EPDO)

Equivalent property damage only (EPDO) is one of the measures adopted by the Highway Safety Manual (HSM) [13] to reflect the varying levels of crash severity. It is highly recommended by many road safety agencies and experts [23]. In this measure, crash costs of each severity level are used to find the weighting of crashes and the crash cost equivalent to the PDO type. The EPDO measure's main advantages are simplicity, straightforwardness, and not counting the traffic data [24]-[26]. It provides a more complete picture of road safety by considering the frequency and severity of issues. Washington et al. [27] show that unreported PDO crashes resulted in challenges in using the EPDO measure, but Oh et al. [28] demonstrated the EPDO results in a lower error because the heavier weights are assigned to fatal and serious injuries in crashes. It is also considered a continuous variable. However, the estimated weights of crashes are based on the estimated crash cost by severity levels. The estimated cost of crashes is the main challenge of EPDO score estimation as it varies with time and location [28].

2. Crash Cost Estimation in Previous works

The estimated cost for fatal crashes used by the World Bank [22] is about $40056, while various countries and works use different estimated costs, and various classifications of injuries are also used. Some are shown in Montella et al. [18], and others are reviewed and listed in Table 1.

Road safety agencies in some countries, such as the USA and the UK, have tried for years to estimate crash costs [21], [29]. Despite that, many countries still do not have guidelines and standards for finding the national crash cost. In addition, there are no universally recommended national crash cost values [21], [24].

The consequences of road crashes have been considered when estimating their cost. The crash expenses are classified into five categories: property damage, administrative, medical, human, and production loss costs. Litman divided Crash costs into non-market and market expenses [30]. Property damage, missed income, medical expenses, emergency response time, and crash prevention costs are all included in the market cost. Human and lost quality of life expenses are examples of non-market costs. Other experts classified crash costs into direct and indirect costs.

The direct costs include emergency services, fire services, medical services in and out of hospitals, productivity loss, insurance administration, workplace costs due to an employee's absence, legal costs, congestion impact costs due to travel delay, and property damage costs. The indirect cost includes the cost of quality of life. It may consist of the value of voiding the risk of death or injury, such as deciding to purchase safer protective equipment [21], [24], [27], [31].

Table 1. Estimated crash cost in the reviewed works

Authors	Fatal crashes		Injury crashes		PDO crashes	
	Cost	Weight	Cost	Weight	Cost	Weight
Dowell et al. [29]	-	12	-	3	-	1
Lloyd [32]	£1,751,150	771	£78,930	35	£2,270	1
National Safety Council [33]	$430000	179	$40800	17	2400	1

Montella [19] National Research Council [13]	$4008900	542	Major $216000 Minor $79000 Slight $44900	29 11 6	$7400	1
Sen et al. [34] Bandyopadhyaya and Mitra [35]	RS.535489	33	Major RS. 242736 Minor RS.18855	15 1.16	RS 16200	1
Washington et al. [27]	$3366388	1330	Major $2402997 Minor $27852	949 11	$2532	1
Flores et al. [24]	$5543800	509	$134600	12	$10900	1
Ma et al. [14]	$4113956	607	$144291	21	$6783	1
Haghighi and Karimi [36]	-	9.5	-	3.5	-	1
MORPC [20]	(F+SI) $315578	38	Visible $54470 Possible $36920	7 4	$8320	1
Wang et al. [37] Federal Highway Administration (FHWA) [38]	$4008900	542	$82600	11	$7400	1

Three common approaches are used to estimate crash cost, restitution cost, human capital cost, and Willing-to-pay approach [22]. The restitution costs (RC) approach calculates the expenses of the resources required to return victims of traffic crashes to their pre-crashes state. It covers the price of medical care, auto maintenance, and administrative expenses. The human capital (HC) approach often estimates costs associated with output loss. This approach usually accounts for human output or productivity but fails to account for the indirect cost. The willingness to pay (WTP) method calculates the economic worth in situations where there isn't a market price, such as the price of a diminished standard of living. It can be used to estimate the value of the severe injury or to estimate values that should be paid to avoid accidents. However, it still needs to be a comprehensive method because it needs to consider some parameters [39]-[41].

Medical treatment costs account for about 4% to 15% of the total [22], [42]. They include the costs of ambulances, emergency care, and in- and non-hospital treatment [22]. The cost varies with the severity of road crashes, as serious injuries require long-term treatment, which is higher than slight injuries.

Production loss is caused by road injuries and the inability to work. It accounts for about 9% to 26% of the total cost [29], [42]. It is computed by estimating time spent in treatment without a job, the time needed to find a new job for injuries, and the remaining working years until retirement for fatalities. The standard indicator for production loss due to job loss is the average wage [22], [42]. Human cost is the intangible cost of quality of life. It accounts for a significant proportion of the total costs (65%). For estimating the human cost, the Value of a Statistical Life (VSL) to Gross Domestic Product (GDP) per capita was developed and used commonly to estimate the human cost. Equation (1) has been developed for fatalities [43].

$$VSL = 70 \times (GDP\ per\ capita) \quad (1)$$

The human costs for serious and slight injuries are estimated at 13% and 1% respectively [22].

Property damage includes damage from vehicles, which accounts for about 90% of total property damage, and damage to roads and roadsides [22].

Administrative costs include police, insurance, fire service, and legal fees. They account for about 4% of the total cost. They also include the time officers spend at the crash location and during investigations, indicated by their wages and equipment costs [22].

3. Methods

To achieve the paper's objectives, two stages have been followed, as shown in Fig. 1. In the first stage, the EPDO (Iraq) formula will be developed by determining the weights of the crashes according to their severity. For this, crash costs have been estimated. In the second stage, the developed EPDO (Iraq) will be used to find the EPDO scores for eight intersections in Baghdad City. The results will be used to identify hazardous intersections and compare them with the ranks of intersections according to conventional performance measures, which are crash frequency and crash rate. The details of each step will be explained in the further subsections.

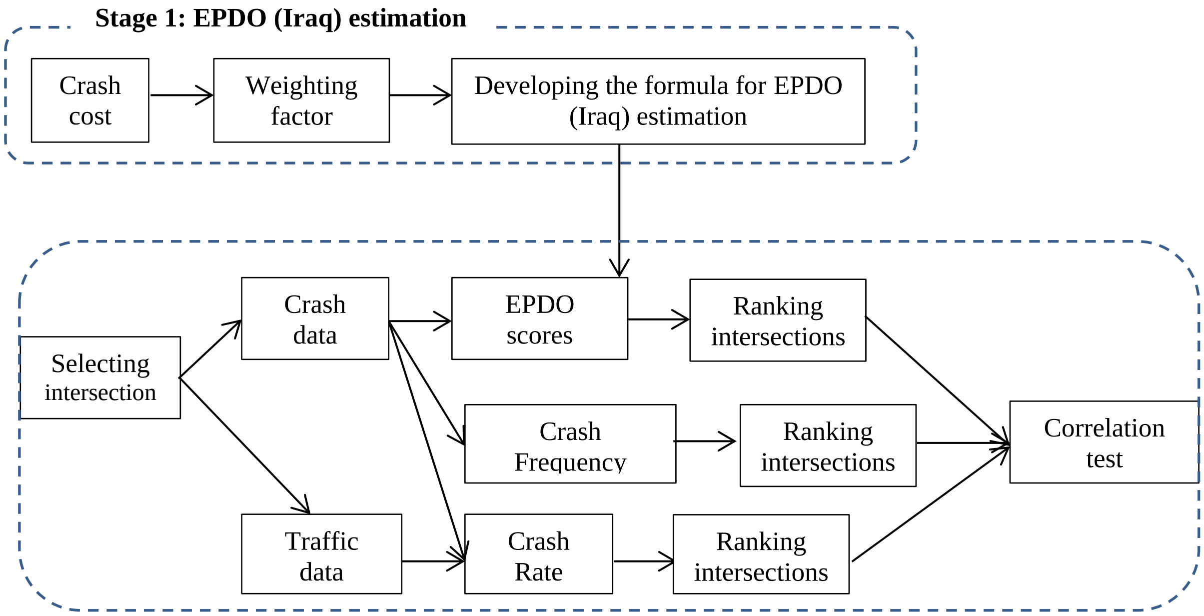

Figure 1. The methodology of the work

4. Crash Cost Estimation

The approach to cost data collection differs between cost components, as shown in the following subsections. The cost components are medical treatment, vehicle damage, administration, production loss, and quality of life.

4.1. Medical Treatment Cost

The RC approach is utilized to estimate the medical treatment cost per crash. Information on the components of the medical cost was collected from the official records of the hospitals. The common cost components for all crash severity levels are the costs of ambulance trips and treatment costs. Interviews with about 262 hospital ambulance drivers were conducted to ask about the average cost of a trip to and from a crash location. The sample size was determined for the population size of 803 ambulances recorded by the Ministry of Health [10] with a confidence interval of 95% and a margin of error of 5%.

The treatment cost, as shown in the previous works, includes medicine costs and the cost of the average duration of hospital stay (2-7 days for slight injuries, 30 days for serious injuries, and 3-5 days for fatalities). Interviews with hospital managers (about 7 managers) were carried out to collect the cost data. In addition, interviews and questionnaire methods were used with causalities or their family members to collect the same data. The sample size was about 390, determined for the unknown population with a confidence interval of 95% and a margin of error of 5%.

The mean of the collected cost data was computed. Equations (2), (3), and (4), developed from the methods explained by the HSM and previous works [13], [22], were used to estimate the medical cost for fatal crashes, serious injuries, and slight injuries. There is no medical cost for PDO crashes.

$$Med_{cf} = Am_{cf} + L_{cf} + M_{cf} \times F_{fc} + hos \times hosc + func \qquad (2)$$

Where Med_{cf} is the medical cost per fatal crash, Am_{cf} is the Ambulance trip cost per fatal crash, L_{cf} is the labor cost per fatal crash, M_{cf} is the medicine cost per day per victim, F_{fc} is the frequency of fatalities, *hos* is the average number of hospitalizations per day per a fatal crash, *hosc* is the hospitalization cost per day, and *func* is the funeral cost.

$$Med_{csi} = Am_{csi} + L_{csi} + M_{csi} \times F_{sic} + hos \times h + treat_d \times treat_c \qquad (3)$$

Where Med_{csi} is the medical cost per seriously injured crash, Am_{csi} is the Ambulance trip cost per seriously injured crash, L_{csi} is the labor cost per seriously injured crash, M_{csi} is the medicine cost per day per each serious injury, F_{sic} is the frequency of injures, *hos* is the average number of hospitalization per day per a seriously injured crash, *hosc* is the hospitalization cost per day, $treat_d$ is the average treatment duration in-house per each serious injury crash, and $treat_c$ is the treatment cost per day.

$$Med_{cli} = M_{cli} \times F_{lic} + hos \times hosc + L_{cli} \qquad (4)$$

Med_{cli} is the medical cost per slightly injured crash, M_{cli} is the medicine cost per day per slight injury, F_{lic} is the frequency of slight injuries, and L_{csi} is the labor cost per slightly injured crash.

4.2. Vehicle Damage Cost

Regarding the estimation of damage to vehicle cost, interviews and questionnaires distributed to car repair workshops and vehicle owners who had experienced road crashes are the most common and valid methods of data collection [44]. The sample size was about 68 people, determined for unknown population size with confidence intervals of 90% and margins of error of 10%. The respondents were asked about the average cost of repairing damaged cars according to vehicle make and mode.

The estimated cost for respondents is for one crash [22], [44]. According to the types of vehicles available in the local market, there are three main types of vehicles: the first one with minimum requirements usually imported from countries like (China and Iran), the second type is manufactured in (Korea), and the third is (USA and Japan). For the type of vehicle according to their size and effect on traffic, there are the passenger cars and the four-wheel drive, which are much safer, with bigger sizes and, of course, more expensive, which is the main point in the calculations. The mean repairing cost is computed without considering the crash severity level and vehicle types.

4.3. Administrative Cost

The administrative cost does not vary with the severity levels of crashes. It consists of police costs and fire service costs. The total administration cost per crash is the number of officers multiplied by the hourly wage [22], [44]. Equation (5) has been developed and used to estimate administrative costs.

$$Administrative\ cost = Tfserv. \times Wag. + Tpol. \times Wag. \quad (5)$$

where *Tfserv* is the time fire service men spend in hours per crash, *Wag.* is the average wage per hour, and *Tpol* is the time police officers spend in hours per crash.

4.4. Production Loss

The indications of cost of production loss resulting from job loss are the average age of the causalities, the mean wage value, and the average retirement age. In the case of fatalities and serious injuries (F+S), the remaining years until retirement are multiplied by the average wage value. For slight injuries, the number of days of absence from work due to a crash is multiplied by the average wage [22], [44]. Equations (6) and (7) were used to estimate production loss cost.

$$Production\ loss_{(F+S)} = rem.years \times \frac{Wage}{year} \quad (6)$$

Where *rem. Y* and ears are the remaining years until retirement. Wage/ year is the mean wage per year.

$$Production\ loss_{(slight\ injuries)} = absence\ from\ work\ days \times \frac{Wage}{day} \quad (7)$$

4.5. Quality of Life Cost

Equation (1) estimates the quality-of-life cost for fatal crashes. The GDP per Iraqi capital is 4224.25. Equation (1) is multiplied by 0.13 for serious injuries and 0.01 for slight injuries [20]. The total cost for each crash severity level is calculated by summating the estimated cost according to cost components, as shown in Table 2.

4.6. The Results of Cost Estimation

The results of cost estimation according to cost components and severity levels are shown in Fig. 2. It can be seen that the human cost, which represents the quality-of-life cost, is the majority of fatal crash costs as it accounts for about %86 of fatal crashes, followed by the production loss cost which is about %13 of fatal crash costs. The other cost components account for only %1. The production loss accounts for the highest percentages of serious and slight injury crash costs, with %73 and %62 for serious and slight injury crash costs, respectively, while the human cost accounts for about %10 and %13 for serious and slight injury crash costs, respectively. The vehicle damage cost accounts for the majority of the PDO cost.

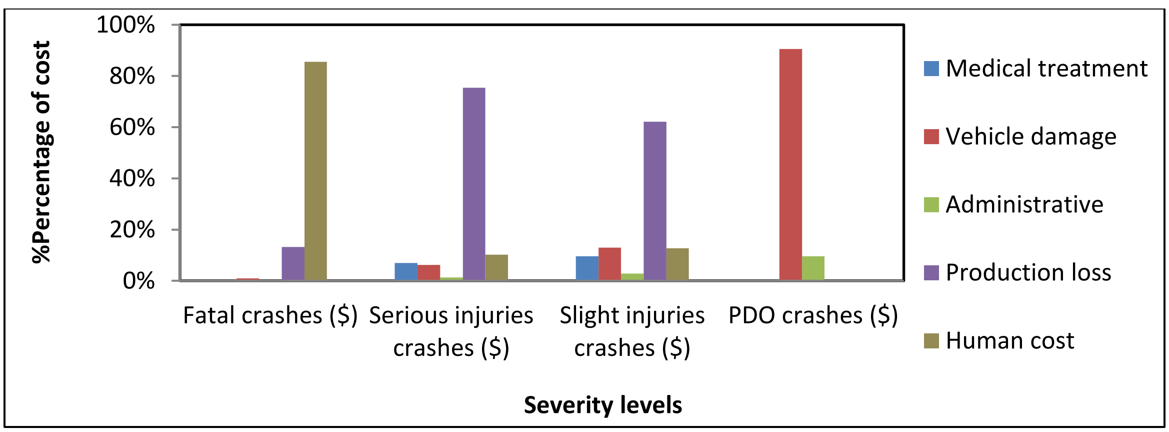

Figure 2. The percentages of the estimated cost according to cost components and severity levels

The total cost of fatal crashes is less than the fatal crash cost estimated by previous works in various countries and cities; this is almost due to the difference between the local and other countries' conditions.

5. Weighting Factors and Epdo $_{(Iraq)}$ Estimation

EPDO score is determined by weighting variables, which are determined by comparing the crash cost by severity to the crash cost solely for property damage, as per the HSM [13]. The weighting factor for every crash severity level is determined by Equation (8).

$$Weighting\ factor_i = \frac{Crash\ cost_i}{PDO\ crash\ cost} \quad (8)$$

Where i is the severity level (fatal, serious injuries, slight injuries, and PDO crashes).

For example, the weighting factor for a fatal crash is calculated by dividing the crash cost ($345583) by the PDO crash cost ($3315). Table 2 shows the results of calculating EPDO weight factors for all crash severity levels.

Equation (9) calculates each intersection's EPDO (Iraq) score (j).

$$\mathrm{EPDO}_{\mathrm{Iraq_j}} = 104.2 \times \mathrm{f_F} + 14.7 \times \mathrm{f_{SI}} + 7 \times \mathrm{f_l} + \mathrm{f_{PDO}} \quad (9)$$

Where f_F, f_{SI}, f_l, and f_{PDO} are the frequency of fatal, serious injuries, slight injuries, and PDO crashes, respectively.

6. Intersections Selection and Data Collection

Eight intersections in Baghdad (the capital of Iraq) were chosen, as shown in Fig. 3, which represents an overview of the area under work. Fig. 4 shows each intersection under study separately. These intersections suffer from daily congestion because of their important location, as they are located near garages and important shopping centers. High traffic volume and interference between pedestrians, motorcyclists, and vehicles frequently lead to many crashes. An example is Al-Khalafa Square, located in the Bab Al-Muadham area, close to the Bab Al-Muadham garage, many faculties, and the nearby markets.

Moreover, it is relatively close to many hospitals, such as the Medical City Hospital, which makes obtaining crash data and their severity possible. The rest of the intersections have almost the same properties (as location). The selection of these intersections was mainly based on the availability of the recorded crash data.

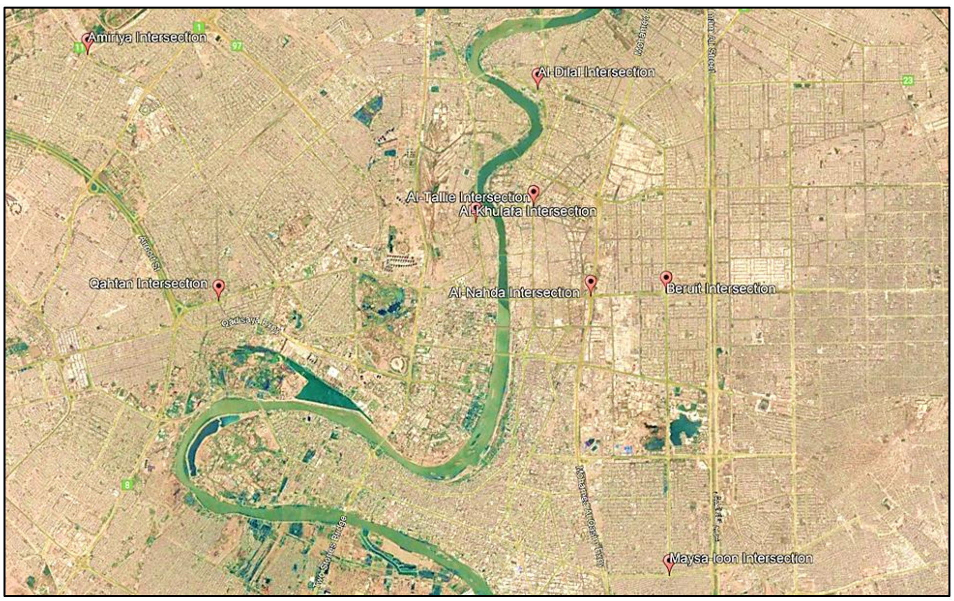

Figure 3. The Study area

a. Al-Nahda Intersection

b. Al-Khulafa Intersection

a. Al-Dilal Intersection

b. Beruit Intersection

c. Al-Tallie Intersection

d. Qahtan Intersection

e. Amiriya Intersection

f. Maysa-loon Intersection

Figure 4. Intersections under study

6.1. Traffic Data

A survey of traffic data was carried out to collect traffic volumes during peak hours, 7:00-9:00 A.M. and 1:00-3:00 P.M. for five working days. They were collected manually by a team of observers. Traffic data is necessary to find the average daily traffic (ADT), which is used to estimate the crash rate measure for the selected intersections. The hourly traffic volume at peak hour is converted to the ADT by dividing it by the K factors (10% for urban areas) and the number of days. The estimated ADT is shown in Table 3. The needed data for this research is classified into crash and traffic data.

Table 2. The estimated cost is according to cost components and crash severity, total cost, and the EPDO weight

Cost components	*Fatal crashes ($)*	*Serious injuries crashes ($)*	*Slight injuries crashes ($)*	*PDO crashes ($)*
Medical treatment	745	3384	2227	-
Vehicle damage	3000	3000	3000	3000
Administrative	647	647	647	315
Production loss	45493	36768	14454	-
Human cost	295698	4997	2957	-
Total	345583	48796	23285	3315
EPDO (Iraq) Weight	104.2	14.7	7	1

Table 3. The collected crash data for the selected three intersections

Severity / Int.	Intersection name	Fatal	Injury (A)	Injury (B)	PDO	Total crashes	ADT
1	Al-Nahda	13	48	37	75	173	28,000
2	Al-Khulafa	9	28	32	84	153	24,429
3	Al-Dilal	5	30	27	60	122	23,000
4	Beruit	15	18	30	108	171	32,150
5	Al-Tallie	10	16	24	75	125	21,480
6	Qahtan	17	32	39	92	180	26,785
7	Amiriya	8	17	22	69	116	19,550
8	Maysa-loon	21	50	25	110	206	33,620

6.2. Crash Data

The recorded crashes in the last three years at the selected eight intersections are needed to find the performance measures' scores. They were collected from the records of the nearest hospitals and police stations. Based on the available information, they are classified into four levels, as shown in Tables 2 and 3: fatal, serious injury (injury A), slight injury (injury B), and property damage only (PDO). The collected crash data is exhibited in Table 3.

It is noted that the weight of fatal crashes is quite larger than the weight of injured crashes. This is the same result in previous works shown in Table 1. Despite that, the obtained weights are nearly the same as those in previous works [13], [19], [27]; other works got higher values.

7. Hazardous Intersections Identifications

7.1. Using EPDO Scores

Equation 9 has been used to calculate the EPDO(Iraq) scores for the three selected intersections. The results are shown in Table 4. The selected intersections are evaluated according to the EPDO(Iraq) scores using a simple ranking method (National Research Council, 2010) to highlight the most hazardous intersection, as shown in Table 4. The intersection with the highest EPDO(Iraq) score is the riskiest, followed by the second-highest EPDO(Iraq) score, and so on.

7.2. Using Conventional Performance Measures

The most hazardous intersection is also identified according to crash frequency and crash rate performance measures to compare the results with those according to EPDO scores. Total and severe crashes (fatal and serious injuries crashes (F+S)) are considered in calculating both measures, as shown in Table 4.

Regarding the crash rate, the million entering vehicles (MEV) for the years the crash data were collected is three years

(National Research Council, 2010). Equation 10 is used to compute the MEV, and Equations 11 and 12 calculate the total crash rate and F+S crash rate, respectively (National Research Council, 2010).

$$MEV = ADT \times 3 \times 365 \times 10^{-6} \quad (10)$$

$$Total\ crash\ rate\ (i) = \frac{Crashi\ total}{MEV(i)} \quad (11)$$

$$(F+S)crash\ rate\ (i) = \frac{(F+S)\ i}{MEV(i)} \quad (12)$$

Where *crash total* is the total recorded crashes at intersection i. *(F+S)i* is the recorded fatal and serious injured crashes at intersection i.

Table 4. The performance measures scores

Intersection No.	EPDO$_{(Iraq)}$ score	Total crash frequency	F+S crash frequency	MEV	Total crash rate	F+S crash rate
1	2394.20	173	61	30.66	5.64	1.99
2	1657.40	153	37	26.75	5.72	1.38
3	1211.00	122	35	25.19	4.84	1.39
4	2145.60	171	33	35.20	4.86	0.94
5	1520.20	125	26	23.52	5.31	1.11
6	2606.80	180	49	29.33	6.14	1.67
7	1306.50	116	25	21.41	5.42	1.17
8	3208.20	206	71	36.81	5.60	1.93

7.3. Ranking Intersections

The results of ranking the evaluated intersection according to the EPDO score, crash frequency (total and (F+S) crashes), and crash rate (total and (F+S) crashes) are shown in Table 5. The Average-of-Rank is also calculated by averaging the rank of each intersection according to all the considered measures. The aggregated rank is also determined by ranking the intersections according to the Average-of-Rank shown in Table 5.

Table 5. Ranking intersections

Intersection No.	EPDO$_{(Iraq)}$ score	Total crash frequency	F+S crash frequency	Total crash rate	F+S crash rate	Average-of-Rank	Aggregated rank
1	3	3	2	3	1	2.4	3
2	5	5	4	2	5	4.2	4
3	8	7	5	8	4	6.4	6
4	4	4	6	7	8	5.8	5
5	6	6	7	6	7	6.4	7
6	2	2	3	1	3	2.2	2
7	7	8	8	5	6	6.8	8
8	1	1	1	4	2	1.8	1

It can be seen that the three highest hazardous intersections, according to the EPDO scores, are intersections 8 (Maysaloon), 6 (Qahtan), and 1 (Al-Nahda). They are the same diagnosed intersections according to crash frequency when considering and not considering the severity level (F+S frequency). They are also the same diagnosed intersection according to the (F+S) crash rate and the aggregated rank. At the same time, there is a slight difference in the rank of intersections according to the total crash rate.

Intersection 1 is located near big terminals or garages, which represent the origins of many trips to different cities in Iraq and attract many pedestrians. The other two intersections are located in one of the busiest areas in Baghdad City. The MEV values reflect the high traffic volume at the intersections. However, these intersections should be subjected to further work to identify the risk factors and suggest countermeasures.

A T-paired test has been carried out to examine to what extent the ranking of intersections according to the developed EPDO scores differs from the rank according to the conventional measure. The results are shown in Table 6; they show that the correlation between the rank of intersections according to the EPDO and crash frequency is the most significant. The correlation with the rank of intersections according to the (F+S) crash frequency is also significant, but they are less significant when using crash rate.

Table 6. The results of the correlation test

Paired Samples Correlations				
		N	Correlation	Sig.
Pair 1	EPDO & Crash Frequency	8	.976	.000
Pair 2	EPDO & FS frequency	8	.786	.021
Pair 3	EPDO & Crash Rate	8	.619	.102
Pair 4	EPDO & FS rate	8	.524	.183

8. Conclusions

According to the findings of this paper, the conclusions can be drawn from two main points: the crash costs in Iraq and the EPDO(Iraq) application for ranking intersections.

Regarding the crash cost estimation, it has been concluded that the economic losses due to traffic crashes are enormous and lead to many types of harm to individuals, either by fatal results or disabilities that are supposed to benefit society. In addition, the cost of life quality is important to consider in road safety, and any issue leads to living loss. It accounts for about $86 of the fatal crash cost. Production loss cost is also an important indicator of the risk level of road crashes resulting in serious and slight injuries; it accounts for about %73 and $62 for serious and slight injuries crashes, respectively. Vehicle damage cost is the main indicator of the risky level of PDO crashes. The EPDO value was found to be suitable for estimating economic losses from traffic crashes, and it is one of the recommended ways around the world.

Regarding the rank of intersections according to the EPDO(Iraq) score, it has been concluded that the diagnosed highest hazardous intersections are almost the same as those diagnosed when using cash frequency and crash rate measures. There is a significant correlation between the rank of intersections when using the EPDO (Iraq) score and crash frequency. The diagnosed hazardous intersections, Al-Nahda, Qahtan, and Maysaloon, should be further reviewed to determine the risk factors and suggest suitable and effective countermeasures.

These findings are important for decision-makers, especially when the allocated budget for road safety projects is limited. It is essential to identify and select the most hazardous intersection out of all the intersections. The identified intersection should be subjected to further review to identify the risk-contributing factors and suggest interventions to improve safety levels.

For further work, it is recommended that the crash cast be estimated and the EPDO developed for crashes on road segments with different functional classifications and geometric design characteristics.

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Conflict of Interest

The authors declared that there is no conflict of interest.

Author Contribution Statement

Hanan A. Khudhair, Abeer K. Jameel, and Samer M. Alsadik proposed the research problem, developed the theory, performed the computations, verified the analytical methods, and supervised the findings of this work.

Ahmed Al-Bdairi, Raid A. Kraidi, and Hayder Mohammed AL-Taweel discussed the results and contributed to the final manuscript.

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