Assessment of road infrastructures in Iraq according to safe system requirements: case study Old Baquba-Baghdad rural road sections

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Abstract: Safe system is a new vision recommended by global organisation interested in achieving safer road system in the world. Methodologies have been developed to consider this approach in assessing the safety level of new and existing road infrastructures in most of the world countries. In Iraq, most of the conducted studies investigated the road safety level at aggregated national scale. However, there are no studies consider the safe system approach in assessing the road safety situation. Therefore, this paper aims to assess the road safety level at road section scale according to the safe system approach. For this, international methodologies were reviewed to select the most appropriate one. The international road assessment programme (iRAP) was selected as it has been recommended by the UN and WHO. The old Baquba-Baghdad rural road which is a two way-two lane road was selected for this study. The necessary data was collected from a previous study and from field observations, and then was processed using the iRAP programme to quantify the risk scores and the star rating of head-on overtaking crashes for vehicle occupants as this is the most common crashes recorded at the selected sections. The results showed that the star rating of the study road is one to two which reflects the dangerous situation. Therefore, four countermeasures were suggested to improve the level of safety, three of them has been already implemented which are upgrading some sections to four lane road with separated physical median and improving the skid resistance of the road surface. The results of assessment after improvement showed that the implemented improvements may reduce the fatalities rate by about 60% and upgrade the star rating to 3 in some sections and less in others. Therefore, it is recommended to upgrade the two lanes sections to four lanes and extend the physical separation median to all these sections which will eliminate the risk of the head-on overtaking crashes as the results of the assessment produced.

Keywords: road safety; Head-on overtaking, iRAP

1. Introduction

In this section, the road safety concept will be presented at global and local scales.
1.1 Road safety in a global scale

Road safety has been recognised as a global considerable issue. The annual rate of fatal accidents in the world is about 1.2 million people; the majority of them are in the low and middle income countries [1]-[4]. The United Nations launched, in 2011, the global plan of the decade of actions on road safety 2011-2020, in which, it has been recommended to take lessons from the successful practices in countries that have achieved significant decline in the fatal accidents such as Sweden and the Netherlands [3][4]. These practices have based on a new vision, called safe system, which considers the human factor is not the major factor for increasing the road risk. The safe system concept is based on that vehicles and road infrastructures have roles in accommodating the mistakes of the road users and, then, reduce the likelihoods and severity of the road accidents. Therefore, the global practises focus on improving the road infrastructure and vehicle design to achieve safer road system for drivers and vulnerable road users as well as enhancement the enforcement system to improve the driver behaviour [3][4].

1.2 Road Safety in Iraq

Iraq; which is classified as a middle income country located in the Middle East region, has the second highest rate of accidents among the Middle East countries with a rate of 32 per 100000 people in 2010 [1]-[5]. This rate is the double of the global average road fatalities and the triple of the deaths from the acts of terrorism [6], [7]. Despite that, the response of Iraq to the global plan of road safety is insignificant because of the continued insecurity and conflict problems [8][9]. This has led a lack of comprehensive road safety strategic plan and road safety legislation, irregular road safety audit, and rapid growth in vehicle [7]. Statistics shows that about 5.66 million vehicles were registered in 2015, five times the number of vehicles registered in 2007 [10]; and approximately one in ten Iraqi people has their own car [5].

Several researches have been conducted to study the road safety issue in Iraq. The main focus of the most recent studies was the statistical review of road accidents at aggregated scale. The findings of these studies have stated the increase in the rate of total accidents and the fatal accidents within the last three decades [11-15]. Figure (1) shows the trend of the total registered accidents and the fatal accidents from 1994 to 2018. It can be seen that the highest rate of fatal accidents has been occurred in the last decade while the less rate was registered in the years (2005-2008) when Iraq faced its worst security conditions and most of the occurred accidents was not registered officially.

![Figure 1. The trend of road accidents in Iraq from 1994 to 2018 (Source: [11]-[15])](image)

Other studies investigated the most affected factors on the rate of traffic accidents [5][10][16]-[18]. Most of these studies showed that the road user behaviour, road factors, and vehicle factor are the most contributed factors as the global reports stated [3], [4]. Other previous and older studies published since 2005 have been extensively reviewed by Asad [10]. These studies either used descriptive models or
predictive models [19] to analyse the trends of traffic accidents and the contributed factors. A few studies in Iraq investigated the roadway factor and its variables that affect the road safety. Al-Dulemi [20] investigated the contribution of road geometry of a rural road in Iraq and the vehicle speed in the declining road accidents rate. He found that the lane marking is the most significant variable. Al-Taeie [21] investigated the effect of the gap and lag length at un-signalled intersection on the rate of accidents. Jrew et al. [22] considered more variables to reflect the road factors for 20 roads in Erbil. The most correlated variables found in this study were the road length, lane width, number of lanes, traffic density, number of speed calming, number of pedestrian bridges and crosswalks, and the availability of median. Aldoski et al [23] have investigated the road attributes factor in addition to traffic characteristics in terms of surface condition and the geometric design elements while others [17], [18] used the road functional classification and the lighting to represent the road factor.

It can be seen that most of the published studies considered the trend of traffic accidents, the investigation of the general main factors at aggregated scale. However, a few studies have been conducted to assess the level of road safety at road network scale. The main reason is the lack of the needed data with details regarding the exact location of the accidents. Aldoski et al. [23] have argued that the available official data are not sufficient to conduct the road safety studies and investigate the effect of the road condition factor. Therefore, the researchers need their private efforts to have long term difficult processes and collect the needed data from enormous amount of accidents reports. Jameel and Evdorides [24] stated that the available crash data in Iraq are suitable for descriptive and predictive models at aggregated scale; more details are needed regarding the geographical and exposure details to conduct more studies at disaggregated level.

2. The aim and objectives of the study

The lack of road safety studies at road network level is a clear gap in the road safety research in Iraq. Therefore, there is a need to focus more on investigating the road infrastructure variables and driver behaviour variables at specific road network class such as arterial road, collector and intersections. Furthermore, there is no research considered safe system vision. Moreover, the new global programmes of assessing the safety level of road infrastructures have no application in Iraq. These can draw new lines for road safety studies in Iraq.

Therefore, this study aims to assess the road safety level according to the safe system vision at road sections scale. The supporting objectives are:

1. To review of the validated methodologies of road safety level assessment based on the new vision and adopt the most suitable one.
2. To identify the road attributes affected the road safety and accommodate the road user mistakes.
3. To apply and calibrate the selected methodology of road safety assessment.
4. To suggest countermeasures to improve the level of road safety.

3. Methodology of the study

To achieve the aim and objectives of this study, the following steps will be carried out:

1. Selection of the study road which should depend on some criteria:
   a. The availability of the crash data. To calibrate the selected methodology, the theoretical results will be compared with the actual rate of crashes. Therefore, there is a need to choose road sections that their crash data for at least three years are available.
   b. Consistency: the selected road sections should be as consistent as possible in terms of the road function, area type, land use, uniform types of vehicles, and geographic conditions.
2. Collecting the needed data, the needed data represents the input variables of the selected methodology. They are classified into crash rate, road attributes and traffic data.
   a. The crash rate: collected for at least three years to calibrate the adopted methodology. The details required for accident data are: the number of fatal crashes or fatalities; the causes and types of crashes; and the road user class: pedestrian, vehicle driver, vehicle rider, motorcyclists, or cyclists.
   b. Road attributes which can be collected from previous studies or from the field observation
   c. The traffic volume in terms of AADT or ADT and operating speeds.
3. Processing the selected methodology. The collected road attributes data will be coded according to the standard codes of the selected methodology. Then, they will be processed to get the estimated rate of fatalities.
4. Calibrating the selected methodology. The results of (3) will be used to find the coefficient of calibration that can be used to adjust the selected methodology to the local conditions.
5. Suggesting the countermeasures to improve the level of road safety and analysing the suggested countermeasure to select the best one.

4. Road safety assessment tools
Assessment and rating road infrastructures and vehicles according to the level of road safety has been recommended by the United Nations and the WHO in their published road safety reports and the global plan of the decade of action (2011-2020) [3][4][25]. Therefore, several methodologies and models have been developed to quantify the risk level of roads infrastructure and propose countermeasures to reduce the expected rate of crashes. However most of these models have been developed based on local specification and conditions. In addition some of these programmes are based on the historical crash data; such as The MAAP (Microcomputer Accident Analysis Package), SafetyNet and the Guidelines for Safety Analysis of Road Networks (ESN) models [26]. This makes these programmes not useful for most of the low and middle income countries because of the lacking of adequate historical crash database. Other programmes have been developed to assess the risk level of roads based on the roadway and traffic conditions [27]; such as the International Road Assessment Programme (iRAP) [28], Highway Safety Manual (HSM) [29] and the Road Safety Risk Manager (RSRM™) [30].

The iRAP has been used widely worldwide and recommended recently by the WHO and the UN. It is applied in about 90 countries because its methodology considers the concept of the safe system vision [31]. In addition, the iRAP star rating, which is resulted from its methodology of processing the roadway data, is incorporated as a quantified strategic target. For example, 3stras is adopted globally to achieve the goals of the Decade of Actions on Road Safety plan and the Sustainable Development Goal (SDG) [4][25][32][33]. Furthermore, the iRAP is widespread worldwide; many local versions have been produced such as the European Road Assessment Programme EuroRAP, the Australian Road Assessment Programme AusRAP, and the New Zealand Road Assessment Programme KiwiRAP. Moreover, the iRAP methodology has been extended to develop an investment plan for safer roads to take into accounts the restrained budget of the low and middle-income. It has been extended to consider also different road user groups including vulnerable road users in addition to vehicle occupants [26][27].

The methodology of iRAP is based on 60 variables reflecting the crash avoidance concept to quantify the likelihood of occurring accidents and the crashworthiness concept to quantify the severity level of accidents when a crash occurs of more than ten crash types for four road user groups [28]. The safest road level produced from implementing the design specification according to the safety requirements is rated by 5-stars according to the iRAP methodology [34], [35]. Studies shows that about third to half of the road fatalities are reduced for each iRAP star awarded [35], [36].
Based on the above review, and because there is no previous studies apply iRAP methodology in Iraq, this study choose this methodology to achieve the aim of the study.

5. Selecting the study area

To select a study road according to the criteria mentioned in section 3, the previous studies of constructing and improving roads in Iraq were reviewed. The selected road is the old Baghdad–Baquba road. This road connects the capital Baghdad with Baquba city passing through many suburb areas. The length of the road is about 70 km. For the purpose of this study, five segments were chosen with total length of about 47.2 km. The homogeneity in the geographic, topographic, area type, land use, and functional classification are based on in selecting the road segments. The selected road is an undivided two ways two lanes rural minor arterial; having level terrain with no restrictions on sight distance and free from any side development, entrances and exits. The selected segments are divided into 472 sections each of 100m according to the requirements of iRAP Methodology.

6. Data collection

To process and calibrate the iRAP methodology, the following data were collected:

6.1 Crash rate at the road sections

The sources used in the previous studies were reviewed to collect the needed data. They are the WHO’s reports [3][4], the Central Statistical Organization (CSO) of the Iraqi Ministry of Planning [5], local hospital records [5][8][9], province Traffic Directorate [16], and police records [22], [23]. The last source was used to collect data in a road network nearby to the police station. It may be the most suitable source of data for this study. However, it was difficult to get permission to access the police accident records of the selected study area. Therefore, the previous study of improving the selected road [37] is used as a source of the required accident data. The available data is in the years from 1998 to 2002 were about 11 fatalities distributed per each segments as shown in Table (1). The majority of the recorded crashes is Head-on overtaking (HOC) crash type. The vehicle occupants are the victims of these crashes which considered fatal accidents. Therefore, the iRAP methodology will be used to assess the requirements of reducing the rate of the vehicle occupants HOC.

6.2 Road attributes

The data in this category are used to measure the variables of iRAP methodology which are related to the likelihood and severity of HOC [28], [34]. Previous studies are used to collect these data in 2002 [37] while the field observation is used to collect the current data. The road attributes can be categorised into cross sectional characteristics, vertical alignment, and the surface conditions. The elements of cross section are the number of lanes and the median type. The selected sections have one lane per direction and the two directions were separated by centreline. The longitudinal grade of the road section is less than 4%. The road sections before 2002 was paved with flexible pavement but has low grip surface. Loose gravels and other material were observed along the road. In addition, the road surface was looked as smooth in most of the sections. Therefore, is categorised as poor sealed and the skid resistance in wet weather was in its lowest level.

6.3 Traffic data

The needed traffic data are traffic volume by composition and vehicle speed. Traffic volume is expressed in terms of Average daily traffic ADT and the percentages of the traffic composition including pedestrians, motorcyclists and bicycles which were zero in the selected sections because there are no facilities for vulnerable road users. To find the ADT, the traffic volumes were measured for the observed 8 hours per day (7:00am to 3:00pm) for 10 weekdays. The identified peak hours were 7:45 am to 8:45 am. The selected road has been used by a high percentage of heavy vehicles which converted to equivalent number of passenger cars PC to find the ADT. Vehicle speed measurement was carried out
in the location using time mean speed method [38]. The differential in speed is considered not present because there is no difference between the speed limit of the truck and PC.

Table 1 shows the collected data of the selected road sections. These sections are grouped according to the homogeneity of the collected data. For example, the first 160 sections have the same road data but different traffic data than other segments.

| Segments (from section to section) | Actual Fatalities | Median type | Number of lanes | Grade | Skid resistance | Differential speed limits | ADT (vpd) | Operating speed (Km/hr) |
|-----------------------------------|-------------------|-------------|-----------------|-------|-----------------|--------------------------|-----------|-------------------------|
| 1-160                             | 4                 | CL*         | 1               | 0-4%  | Poor sealed    | NP**                     | 5039      | 77                      |
| 161-176                           | 1                 | CL          | 1               | 0-4%  | Poor sealed    | NP                       | 15000     | 76                      |
| 177-258                           | 2                 | CL          | 1               | 0-4%  | Poor sealed    | NP                       | 6460      | 61                      |
| 259-276                           | 1                 | CL          | 1               | 0-4%  | Poor sealed    | NP                       | 20000     | 56                      |
| 277-472                           | 3                 | CL          | 1               | 0-4%  | Poor sealed    | NP                       | 4014      | 60                      |

*aCL=Centre line ,  **NP=Not present

7. Processing the iRAP methodology

To apply the iRAP methodology, the following steps are carried out:

1. The collected data were coded according to the iRAP codes to quantify the risk factor of each variable. For example, the grade of less than 4% is coded as 1 with lower risk factor than higher grades, while the centre line median type is coded as 11 with the highest risk factor among the other median types [28]. The coding of the other variables is shown in Table (2).

2. The results of coding were processed using iRAP programme to obtain the likelihood score and the severity score. The overall score and the star rating were also obtained as shown in Table (2).

3. The star rating scores found in step 2 are used to find the estimated fatalities rate as shown in Table (2). For this step, a growth factor (GF) of the road accidents should be determined at country scale. Therefore, the trend of fatal accidents shown in Figure (1) is used to find the percentage of change of fatal accidents as follows:

The general formula for growth factor is \( (1+r)^n \); where \( r \) is the growth rate and \( n \) is number of years. To find the growth rate between 2002 and 2018 which is the time between the year of the recorded crash data and the year of this study, the base year is 2002 and the target year is 2018. Then, \( n \) equals 16. The growth rate = \( \frac{(2767-1693)/1693}{16} \) = 0.028. Through several trials, this rate is adjusted to 0.0315; the used GF is 1.0315.
Table 2 Data coding and the results of the iRAP Methodology of HOC

| Segments (from section to section) | Median type | Number of Lanes | Grade | Skid resistance | Differential speed limits | Operating speed (Km/hr) | The likelihood score*1 | The severity score*2 | The overall score*3 | Star rating*4 | Estimated fatalities*5/100 m |
|-----------------------------------|-------------|-----------------|-------|-----------------|--------------------------|------------------------|------------------------|---------------------|---------------------|---------------|-----------------------------|
| 1-160                             | 11          | 1               | 1     | 3               | 1                        | 10                     | 2                     | 100                 | 0.61                | 2             | 0.001                      |
| 161-176                           | 11          | 1               | 1     | 3               | 1                        | 10                     | 2                     | 100                 | 1.28                | 1             | 0.007                      |
| 177-258                           | 11          | 1               | 1     | 3               | 1                        | 7                      | 2                     | 100                 | 0.61                | 2             | 0.001                      |
| 259-276                           | 11          | 1               | 1     | 3               | 1                        | 6                      | 2                     | 100                 | 1.82                | 1             | 0.014                      |
| 277-472                           | 11          | 1               | 1     | 3               | 1                        | 7                      | 2                     | 100                 | 0.61                | 2             | 0.001                      |

*1 Likelihood score of HOC = Number of lane F*grade F*skid resistance F*differential speed F 
*2 Severity score of HOC = Median type F 
*3 Overall score of HOC = likelihood score x severity score x operating speed F x External flow F 
F= risk factor, External flow F= factor quantifying the risk coming from the opposing direction [28] 
*4 from iRAP bands [28];   *5 Estimated overtaking fatalities= the overall score*ADT*GF*365/10^9

8. Calibrating the iRAP methodology

In order to adjust the iRAP models with the local conditions, the iRAP methodology is calibrated by comparing the results of estimated fatalities with actual fatalities. It can be noticed that the iRAP model is significantly underestimated in all the sections. Therefore, a calibration factor will be calculated to adjust the estimated fatalities to actual fatalities. For this, the estimated fatalities and the actual fatalities are aggregated for all sections; the overall estimated fatalities equal 0.85 when the overall recorded fatalities equals 11. The calibration factor CF equals 11/0.85=12.94. The determined CF will be used in processing the iRAP methodology for improvement the road sections.

9. Improvement the level of the road safety

To upgrade the road safety level of the study road, some countermeasures are suggested according to the iRAP countermeasures list that related to HOC. It will focus on the countermeasures that produced higher risk factors which are the skid resistance, number of lanes and median type. The suggested countermeasures can be implemented individually, choose one countermeasure only as a single solution, or as a multiple countermeasures. Based on this, the suggested solutions are:

1. Proposal 1, improving the skid resistance of the pavement surface through covering the road surface with adequate asphalt overlay to keep the optimum friction between vehicle tires and the pavement surface. This solution has been already implemented.

2. Proposal 2, adding a lane per direction in some sections. The lane has been already constructed in the sections 7-16, 165-177, 260-270, and 470.

3. Proposal 3, replacing the centreline median type with curbs as physical separation in the sections upgraded to divided four lanes as follows:
   - Sections 6-16 with physical concrete separation of width 1m.
   - Sections 165-177, 261-262, 266-269, and section 470 with curb of width less than 1m.

4. Proposal 4, upgrading the remaining sections to four lane road, two lanes in each direction, and replacing the centreline in these sections with other available types. The recommended types by iRAP are the flexible post, bollard, curbs, concrete barrier, or metal barrier.

The new data are coded; then, they processed according to the iRAP methodology with the determined CF to find the new scores and the estimated fatalities after improvement. The saving in the number of fatalities after implementing each proposal is computed by dividing the difference between the actual fatalities number in (1998-2002) and the new estimated fatalities to actual fatalities. The results
represent the saving life rates. The proposal producing highest saving life rate is considered the best solution. The results are shown in Figure (2). Table (3) shows the results of the new star ratings with aggregated star ratings for all section.

![Figure 2](image)

**Figure 2.** The results of % saving life produced by each proposal of improvement.

It can be noticed that:

1. Improving the skid resistance of the road surface leads to reduce the likelihood score of HOC crashes to the half. The other half is resulted from the effect of the number of lane.
2. Adding one lane in each direction reduces the likelihood of the HOC significantly where it was applied. This means that the undivided two way two lane roads have higher probability of overtaking crashes.
3. Adequate type of median can eliminate sever risk of overtaking crashes because it will eliminate the chances for vehicles to conflict with the opposing vehicles.
4. Improving some sections only have no significant effect on the aggregated safety level of all the section.
5. Implementing multiple countermeasures produces significant decline in the rate of fatalities and safest condition in terms of star ratings when it is applied at all section.

**10. Discussion of the results**

1. To process the iRAP methodology, there has been a need for sufficient data related to road attributes and crash details. However, it has been difficult to collect all the needed data. Therefore, and based on the available data, the limitations of this study are determined as follows: a. The type of road, rural minor arterial road.
   b. The time of study, 1998-2002 to calibrate the selected methodology and current study time to assess and improve the existing conditions of the studied road.
   c. Crash type, HOC type only as it is the most common observed crash type.
   d. Road user group, vehicle occupants only as the selected road is used for vehicle movement only.

2. The only four roadway factors that increase the probability of happening HOC type are the number of lanes, longitudinal grade of the road, differential in speed, and the skid resistance of the pavement surface.
   a. Two lanes two way roads have the highest probability of HOC with the opposing vehicles; therefore, upgrading the road to divided four lanes reduces this probability by a significant amount. This means only the vehicle that are using the lane near the opposing direction have the probability
of HOC. This is stated by the significant improvement in the safety level which reaches to five stars in the upgraded.

b. Regarding the grade of the road, studies stated that the steep downhill or uphill roads cause significant rate of overtaking crashes but grades less than 7.5% have a slight difference of effect than level terrain. As the selected sections have uniform grade of 0%, this factor has no effect on the results of assessment.

c. The clear difference between the speeds of the different types of vehicles needs to be recognised and considered in the design of the roads. Therefore, the drivers should be informed by signs to obey the speed limit of a specified vehicle type. In the selected road, there is no clear difference between the speed of the PC and the trucks. Therefore, there is no need to use these signs.

d. The fourth factor is the skid resistance which has various levels according to the adequacy and type of the road surface. The paved surface is more resistant to the sliding of vehicles resulting from wet surface than unsealed surface. The adequacy of the pavement surface is measured by the percentage of the road length which its surface looks as shiny and smooth by the drivers. This factor has significant effect on the likelihood of the overtaking crashes in the selected sections to upgrade the star rating by one star in the study road sections and save many lives.

6. The median type has significant role in the severity level of the HOC. Separating lanes eliminates the risk of HOC resulted from all other factors because it prevents overtaking vehicles from conflicting with the opposing vehicles. This illustrated the 100% saving life and increasing the star rating to five stars when using physical separation median along the selected section in the proposal 3 and 4.

7. The proposals 1, 2 and 3 have been already implemented; therefore, the existing level of safety are rated between 2 to 5 stars as shown in Table (4). It means there are some sections, where undivided two lanes are not upgraded to four lanes, still have high risk level. Figure (2) shows that the fatalities number might be reduced by about 60% but the severity level is still at it high level. However, there is no accessed accidents data to validate these results. Extending the used physical separated median in the upgraded sections to the remaining sections can reduce the severity and the overall score regarding the HOC as shown in the results of implementing proposal 4.

8. The effect of the traffic flow factor is reflected in the results of the assessment of the selected sections before improvement, Tables (1) and (2), as the values of the risk factors of the likelihood and severity factors were uniform at all sections. For example, the ADT in sections 161-176 is triple the ADT at sections 1-160 while the operating speed was nearly equal. This leads to increase the overall risk factor by about double. This is can be explained by the effect of the external flow coming from the opposing directions that increase the risk of HOC.

9. The effect of speed is not illustrated in this study because the effect of the change in operating speed is aggregated with the effect of the change in the ADT. This can be investigated in roads with uniform ADT and various operating speed.

10. The results of the star rating in Table (4) shows that increasing one star leads to reduce the percentage of fatalities by about 50-60% whereas increasing by three stars leads to reduce this rate to zero. This result enhances the results of the iRAP validation studies (iRAP 2017). While Figure (2) shows that increasing the overall score by 50% leads to increase the saving life by more than 50% and upgrading the star rating by one star.
Table 3. The results of the star rating producing from each proposal

| Sections | Proposal 1 | Proposal 2 | Proposal 3 | Proposal 1+2 | Proposal 1+2+3 | Proposal 4 |
|----------|-----------|-----------|-----------|-------------|--------------|-----------|
| 1-5      | 3         | 2         | 2         | 3           | 3            | 5         |
| 6        | 3         | 2         | 5         | 3           | 5            | 5         |
| 7-16     | 3         | 5         | 5         | 5           | 5            | 5         |
| 17-160   | 3         | 2         | 2         | 3           | 3            | 5         |
| 161-164  | 2         | 1         | 1         | 2           | 2            | 5         |
| 165-175  | 2         | 5         | 5         | 5           | 5            | 5         |
| 176-177  | 2         | 5         | 5         | 5           | 5            | 5         |
| 17-258   | 3         | 2         | 1         | 5           | 5            | 5         |
| 259-260  | 2         | 5         | 5         | 5           | 5            | 5         |
| 261-262  | 2         | 5         | 5         | 5           | 5            | 5         |
| 263-265  | 2         | 5         | 5         | 5           | 5            | 5         |
| 266-269  | 2         | 5         | 5         | 5           | 5            | 5         |
| 270      | 2         | 5         | 5         | 5           | 5            | 5         |
| 271-276  | 2         | 1         | 1         | 2           | 2            | 5         |
| 277-469  | 3         | 2         | 2         | 3           | 3            | 5         |
| 470      | 3         | 5         | 5         | 5           | 5            | 5         |
| 471-472  | 3         | 2         | 1         | 3           | 3            | 5         |
| Aggregated star rating | 3 | 2 | 2 | 2 | 3 | 5 |
| Rise in star rating | 1 | 0 | 0 | 2 | 2 | 3 |

11. Conclusions

1. The aggregated risk level of road, in Iraq, has been increasing in the current decade despite of the global awareness programmes and plans to take actions at national scales declared since 2011. The main reasons behind are:
   a. The significant insecurity and conflicts issues in Iraq have led to ineffective road safety system management and awareness programme.
   b. Lacking of adequate accident recording system and database which are essential to conduct studies and research. This led to a few researches in which majority of them investigated this important issue according to the available data published by the Central Statistical Organization Iraq CSO. This led also to limit the scale of these studies to aggregated national and cities scale.

2. There are no studies in Iraq considered the safe system approach as the new successful approach adopted and recommended by the global organisation such as the UN and the WHO. There are also no studies aimed to assess the road safety issues according to the quantified targets of the Global plan of the Decade of action on road safety.

3. The iRAP methodology is simple to use and understandable in quantifying and reflecting the road safety level and the effect of the contributed roadway factors. It is selected to assess the selected road in this study because its methodology is consistent with safe system approach, it is highly recommended by the UN and the WHO to rate roads, and it has been developed to consider the local condition of countries.
4. The estimated fatalities by iRAP methodology are underestimated which is about 1/12.9 of the actual fatalities. Therefore, a calibration factor of 12.9 is used to adjust the results to the local conditions.

5. The iRAP methodology produces its results in terms of:
   - likelihood score to quantify the probability of happening crashes,
   - Severity score to quantify the severity level of the expected crashes
   - Overall score to quantify the overall risk level
   - Overall star rating to qualify the risk level
   - Estimated fatalities rate to compare with actual rate and calibrate the methodology according to local conditions.

6. Four factors affecting the head-on overtaking crashes, number of lanes, grade, differential in speed, and the skid resistance, while one factor only measure the severity of this crash type which is the median type. The risk of head-on overtaking crashes is eliminated when physical separated curb or other types are used to separate the opposite directions. The traffic volume and speed are important contributed factor of the overall risk score.

12. Recommendation

1. Developing adequate data collection system to record details of accidents that are important to investigate this issue at disaggregated level. These details may be represented by the road attributes considered in iRAP methodology including the exact location of the accident, road surface condition, vehicle type and mode, vehicle condition, number of deaths for each accident, number of injuries and the level of severity.

2. The road safety design specification and the road furniture with recommended safety technologies should be improved in the local roads to consider the safe system approach.

3. The awareness and education programmes, road safety legislation and enforcement system are still very essential to improve the road user behaviour and reduce the intended mistakes that could not be controlled by the road and vehicle design such as wearing seat belts and using mobile phone during driving.

4. Further studies should consider the effect of the following factors on the road safety level:
   - The most common vehicle modes and makes used in Iraq
   - The behaviour of the Iraqi drivers and other road user
   - The factors of other types of crashes
   - The factors affecting the safety of vulnerable road users.

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