International Journal of Transportation and Logistics Research
https://www.sciltp.com/journals/ijtlr

Article

Evaluating Road Infrastructure Safety in Bamenda, Cameroon: A Data-Driven Approach Using Reactive Safety Performance Indicators and iRAP Star Ratings

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How To Cite: Dubila, D.O.; Wounba, J.F.; Fondzenyuy, S.K.; et al. Evaluating Road Infrastructure Safety in Bamenda, Cameroon: A Data-Driven Approach Using Reactive Safety Performance Indicators and iRAP Star Ratings. *International Journal of Transportation and Logistics Research* **2025**, *1*(1), 3. https://doi.org/10.53941/ijtlr.2025.100003

Received: 8 May 2025
Revised: 6 June 2025
Accepted: 17 June 2025
Published: 24 June 2025

Abstract: With over 1000 road traffic fatalities recorded annually in Cameroon, the absence of the implementation of effective road safety measures remains a pressing concern. This study assesses the safety of road infrastructure in Bamenda using a data-driven approach that combines reactive safety indicators with iRAP star ratings to identify high-risk crash locations. After analysis of crash data and site visits, four indicators, with three being reactive (crash frequency, crash rate and injury severity index) and one proactive (iRAP star ratings) were calculated. The correlation between these indicators were also evaluated. Out of 64 evaluated sites (40 road segments and 24 intersections) with varying risks, 4 locations were identified for priority interventions as they had the highest risk based on all indicators. These sites had a mix of vehicle types with vulnerable road users, poor road geometry and unsafe road sides and speeding risks. The correlation between indicators varied, indicating the complementary nature of reactive and proactive assessments. The study highlights the added value of integrating the two approaches, both historical crash data and forward-looking infrastructure assessments to comprehensively identify and prioritize hazardous locations. The findings offer practical guidance for policymakers and urban planners to implement targeted, cost-effective safety interventions where resources are scarce. This approach supports the principles of the Safe System framework and can significantly contribute to reducing road traffic injuries and fatalities in low- and middle-income countries.

Keywords: road safety; crash data analysis; road safety assessments

1. Introduction

Road transport dominates global passenger and freight movements and poses severe safety challenges, accounting for 97% of transport-related fatalities and reducing global GDP by 3% annually due to healthcare and productivity losses [1,2]. Road crashes claim the lives of up to 1.19 million people annually [3] with the burden of road crashes being borne by low- and middle-income countries (LMICs) who register the between 90 to 93% of the road deaths [4]. This high number of crashes in LMICs is usually attributed to poor road infrastructure and poor road user behavior leading to high-risk road conditions [1].

Unlike in LMICs, regions such as the EU have been experiencing a downward trend in road crashes due to the extensive implementation of the safe system approach [5] whose holistic framework emphasizes that human error is inevitable and that road systems should be designed to accommodate this reality [6]. The Safe System approach integrates four key elements: safe roads and roadsides, safe speeds, safe vehicles, and safe road users. By addressing these components collectively, it aims to create an environment where serious injuries and fatalities are minimized. Safe infrastructure, is quite important as infrastructure characteristics greatly contribute to the occurrence and severity of road crashes [7].

Evaluating the safety of road infrastructure can be categorized into two main methods: reactive and proactive approaches. Reactive approaches, such as crash data analysis, safety audits, black spot analysis, and before-and-after studies, rely on historical accident data to identify high-risk locations but are limited by underreporting and lack of preventive insight [8,9]. Reactive road safety indicators, derived from historical crash data, are widely used to assess high-risk locations. Crash frequency is a fundamental metric for hotspot identification [10], while crash rate normalizes crash data by exposure, such as traffic volume, to reduce bias in high-traffic areas [11]. Injury severity density provides a more nuanced risk assessment by combining crash frequency and severity [12]. In low- and middle-income countries (LMICs), these indicators have been applied with adjustments for data limitations [13], though inconsistencies arise when exposure data, such as traffic volume, is unreliable, justifying the need for complementary proactive methods. Proactive methods, including road safety inspections (RSIs), predictive modeling, behavioral observations, conflict analysis, and surrogate safety measures (SSMs) [14,15], aim to predict and mitigate risks before crashes occur, though they may require more resources and advanced technology [16]. Each approach has strengths: reactive methods provide evidence-based prioritization, while proactive strategies enable early hazard detection and prevention. However, challenges like data quality, privacy concerns, and implementation costs must be considered. The International Road Assessment Programme (iRAP) offers a standardized, infrastructure-based approach to evaluating road safety risks, with its effectiveness supported by multiple studies. Research in India demonstrated a strong correlation between iRAP star ratings and actual crash rates [17], while a study in South Africa confirmed its usefulness in prioritizing safety interventions [18]. Despite the strengths of proactive indicators like iRAP, few studies have explored the integration of reactive and proactive approaches. However, a Brazilian study showed that combining police-reported crash data with iRAP assessments improved the accuracy of hotspot detection [19], suggesting potential benefits from a combined analytical framework. This study fills a gap by rigorously testing indicator consistency in an urban African setting, where data quality challenges persist.

The city of Bamenda, the headquarters of the North West region of Cameroon, suffers from a significant level of road infrastructure degradation, with a large number of drivers and motorists who speed, increasing risks to road users [13,20] hindering safe mobility and highlighting the need for more forgiving road infrastructure. Previous road safety intentions in Cameroon have mostly used reactive. Crash frequency and injury severity density have been used to understand crash patterns and high-risk areas on two lane undivided highways [21,22], while in Cameroon iRAP methods have only been used to ensure safer school journeys (pedestrian focused). The aim of this study is to assess road infrastructure safety performance in Bamenda, Cameroon, using a data-driven approach (combining safety performance indicators mainly crash frequency, crash rate, and injury severity density) and iRAP star ratings to quantify the risk of crash locations. This multi-indicator strategy captures both historical crash data and infrastructure-related risk factors, ensuring decisions reflect a broader spectrum of safety challenges.

2. Materials and Methods

Official road traffic crash data for Bamenda town for the period January 2022 to May 2024 recorded by North West Regional Unit for Highway and Circulation was obtained alongside road features (geometry and operational characteristics) during site visits.

To identify high risk areas, crash data was first used to pinpoint accident-prone zones. Police crash reports were documented in paper form which were then digitalized. The information obtained from multiples sources (crash reports, official documents and online sources) were verified and validated by site visits as the high-risk areas. The site visit comprised observations, interviews and the researchers' experience, examination of behavior influential factors such as road geometry, degradations, signalization, and road user behavior. Crash details (injuries, fatalities, property damage) for each user type were identified.

Three reactive or crash-based indicators (crash frequency CF, crash rate CR, and injury severity density ISD) and one proactive road assessment method (iRAP star ratings) where used to quantify the risk.

The crash frequency was calculated for each location according to Equation (1) and compared to a critical value ($CF_{CR} = CF_{AVERAGE} + 20\%$) [23]. $CF_{AVERAGE}$ represents the average crash frequency. Locations whose CF are greater than or equal to the critical value are high priority for intervention.

$$CF = \frac{N}{T} \tag{1}$$

where:

CF—Average annual frequency of crashes;

N—Number of road crashes in the period of T years;

T—number of years

Crash rate represents the number of observed crashes per unit of traffic volume. It is the ratio of crash frequency to exposure, which is typically the traffic volume. The crash rate [23] is calculated for the locations according to Equation (2) and compared to a critical crash rate (CR_{CR} = $CR_{AVERAGE}$ + 20%). $CR_{AVERAGE}$ represents the average crash rate. Locations whose CR are greater than or equal to the critical value are high priority for intervention'.

$$CR = \frac{1000000 \times CF}{AADT \times 365} \quad (2)$$

where:

CF—Crash frequency;

AADT—Average annual daily traffic

Unlike the crash frequency and the crash rate, the injury severity density ranks crashes according to weighted points using Equation (3).

$$ISD = \frac{\alpha F + \beta I + \omega MD}{T \times L} \quad (3)$$

where:

α, β, ω—weightage points

F—Number of Fatality crashes

I—Number of Injury crashes

MD—Number of Material damage only crashes

L—Length of section studied

T—number of years

The weighted points used were adapted according to a framework by Mesic et al. [24] for studies in developing countries. The collected crash data had only 3 categories of severity (fatal, injured, and material damage), hence the weighted points were used as were 6 for fatal, 3 for injury and 1 for material damage (property damage only) crashes. The ISD values are then compared to a threshold, which is calculated using Equation (4). Locations with ISD values greater than or equal to the threshold are rated high priority for intervention and the rest safe.

$$ISD_{THRESHOLD} = max(X, M) \quad (4)$$

X—Average of ISD values

M—Median of ISD values

The iRAP star ratings indicator (from the iRAP assessments) is based on star rating scores (SRS) calculated for each 100 m of road for four different road user categories (vehicles, pedestrians, motorcyclists, and bicyclists). Star ratings (from 1 star to 5 stars) are assigned according to the star rating scores, with 5 stars being the safest road conditions for that particular user.

The correlation of the four indicators was investigated using the Spearman's test with the correlation coefficient *r* and the significance of correlation coefficients *t*, which are applicable for samples with a size of 8 or more. Correlation is significant at 0.05 level and for a two-tailed test. The computations for these tests are based on Equations (5) and (6).

$$r = 1 - \frac{6\sum d^2}{n(n^2 - 1)} \quad (5)$$

$$t = \frac{r\sqrt{(n-2)}}{(1 - r^2)} \quad (6)$$

where:

r—Spearman's correlation coefficient and ranges from −1 to 1

d^2—difference between rank *n* and rank *n* + 1

n—sample size.

The Spearman's correlation coefficient strength (ranging from −1 to 1) is shown in Table 1.

https://doi.org/10.53941/ijtlr.2025.100003

Table 1. Spearman's correlation coefficient strengths.

Range of r	Correlation Strength
0.00–0.19	Very weak
0.20–0.39	Weak
0.40–0.59	Moderate
0.60–0.79	Strong
0.80–1.0	Very strong

3. Results

The statistical analysis of crash records showed that 182 crashes were recorded in 40 segments and 24 intersections within the 2-year period (January 2022 to May 2024). Of these crashes, 30 fatalities, 73 injuries and 146 property-only damages were recorded. These crashes involved 13 pedestrians, 73 motorcycles and 202 cars (155 light and 52 heavy vehicles). From the crash data, some crashes couldn't be localized because not all crash reports contained identifiable location details.

Tables 2 and 3 respectively show the safety risk for straight road sections and intersections for the various crash locations respectively. The critical values for CF, CR and ISD obtained are indicated in the table (in the header). Locations with corresponding values greater than the critical values are high priority for intervention locations.

Table 2. Risk values for crash frequency, crash rate, injury severity density and star ratings for road sections.

Section Code	Street Name	CF	CR	ISD	Vehicle Occupants SR
	Critical Values	**1.4500**	**3.4250**	**0.0439**	-
S1	Afrique Nouvelle Hill	0.4167	2.8539	0.0042	★★☆☆☆
S2	Alakuma HOB	0.4167	2.8539	0.0458	★★☆☆☆
S3	Ayaba Street	0.4167	1.9026	0.0042	★★★☆☆
S4	Azam	0.4167	1.9026	0.0167	NA
S5	Bayelle	0.4167	2.8539	0.0250	★★☆☆☆
S6	Che Street	0.4167	2.8539	0.0042	★☆☆☆☆
S7	Commercial Avenue Afriland	2.9167	2.2831	0.1167	★☆☆☆☆
S8	Commercial Avenue Total	1.2500	0.9785	0.0625	★☆☆☆☆
S9	Cow Street	1.6667	4.5662	0.0333	★☆☆☆☆
S10	Fishpond Hill	1.2500	4.2808	0.0958	★★★☆☆
S11	Fons Street	0.4167	2.8539	0.0208	★☆☆☆☆
S12	Food Market: Congelcam	2.0833	5.7078	0.0500	★★★☆☆
S13	Ghana Street	0.4167	1.6308	0.0250	★★★☆☆
S14	Hotspot Road	0.4167	2.2831	0.0042	★★★☆☆
S15	Mbengwi park	0.4167	2.8539	0.0250	★☆☆☆☆
S16	Meta Quarters	1.2500	8.5616	0.0292	★★★☆☆
S17	Mile 1 Police	1.2500	1.7123	0.0292	★★☆☆☆
S18	Mile 2 Nkwen	1.6667	4.5662	0.0750	★★☆☆☆
S19	Mile 3 Nkwen	2.9167	7.9909	0.0833	★★★☆☆
S20	Mile 4 Nkwen	3.7500	10.2740	0.1250	★★★☆☆
S21	Mile 5 Nkwen	0.8333	4.5662	0.0250	★★☆☆☆
S22	Mile 6 Mankon	0.8333	2.2831	0.0250	★★☆☆☆
S23	Mile 90 Road	0.4167	2.2831	0.0208	★★☆☆☆
S24	Mulang Fire Brigade	0.4167	1.6308	0.0042	★★★☆☆
S25	Ndamukong Street	0.8333	5.7078	0.0458	★★★☆☆
S26	New Layout	0.4167	2.2831	0.0042	★★★☆☆
S27	New Road	2.5000	9.7847	0.1208	★☆☆☆☆
S28	Njieforbi Ascent	0.4167	0.7610	0.0042	★★☆☆☆
S29	Nso Boys	0.8333	1.5221	0.0208	★★★☆☆
S30	Ntarinkon Market	0.8333	1.1416	0.0292	★★★☆☆
S31	Old Moghamo	0.8333	0.9132	0.0458	★★★☆☆
S32	Old Town–Water side	0.8333	1.1416	0.0208	NA
S33	Regional Hospital Entrance	0.8333	0.7610	0.0417	★☆☆☆☆
S34	Small Mankon	0.8333	1.5221	0.0375	★★★☆☆
S35	Solidarity Orphanage	0.4167	2.2831	0.0250	★☆☆☆☆
S36	Sonac Street	0.4167	0.4566	0.0042	NA
S37	Upstation Hill	7.0833	7.7626	0.1667	★☆☆☆☆
S38	Upstation Regional Delegation	2.0833	8.1539	0.0875	★★★☆☆
S39	Upstation Tradex	3.7500	5.1370	0.1292	★★☆☆☆
S40	Welcome to Bamenda	0.4167	1.1416	0.0208	★★★☆☆

NA = Star ratings not applicable for that location.

Table 3. Risk values for crash frequency, crash rate, injury severity density and star ratings for intersections.

Intersection Code	Intersection Name	CF	CR	ISD	Vehicle Occupants SR
	Critical Values	**1.2764**	**2.2076**	**3.4201**	**-**
I1	Azire New Church	1.6667	9.1324	5.0000	★☆☆☆☆
I2	Blue Moon Junction	1.2500	1.7123	5.4167	★☆☆☆☆
I3	Brasseries Junction	0.8333	1.5221	0.8333	★★☆☆☆
I4	CCC Junction	0.4167	0.7610	1.6667	★☆☆☆☆
I5	Council Junction	0.4167	1.1416	2.0833	★★★☆☆
I6	Cowboy Junction	0.4167	2.2831	2.5000	★☆☆☆☆
I7	Depot Guinness	1.2500	1.7123	4.5833	★☆☆☆☆
I8	Finance Junction	5.0000	3.4247	16.6667	★★☆☆☆
I9	Foncha Junction	0.8333	1.1416	2.9167	★☆☆☆☆
I10	Governor Junction	1.2500	4.2808	6.2500	★☆☆☆☆
I11	Main Market Entrance	0.4167	0.5708	0.4167	★☆☆☆☆
I12	Mbingo Annex	0.8333	0.7610	2.5000	★★☆☆☆
I13	Mile 1 Junction	0.8333	1.1416	3.3333	★☆☆☆☆
I14	Ngeng Junction	0.8333	0.7610	3.7500	★☆☆☆☆
I15	Nkwen Palace Entrance	0.4167	1.6308	0.4167	★☆☆☆☆
I16	Ntarinkon Ni John Entrance	0.4167	2.8539	2.5000	★☆☆☆☆
I17	Old Council Nkwen	0.4167	2.8539	0.4167	NA
I18	Old Town–Firewood Market	1.2500	3.4247	6.6667	★☆☆☆☆
I19	Saint Mary Hospital Entrance	0.4167	0.5708	2.0833	★☆☆☆☆
I20	Savanna Junction	0.8333	0.4566	0.8333	★★☆☆☆
I21	Upstation Admiralty Junction	0.8333	5.7078	2.9167	NA
I22	Upstation GRA	0.8333	1.1416	2.5000	★☆☆☆☆
I23	Upstation Monument	1.2500	1.7123	1.2500	★☆☆☆☆
I24	Veterinary Junction	2.9167	2.2831	4.5833	NA

NA = Star ratings not applicable for that location.

Areas where iRAP star ratings were not applicable are areas which do not have the minimum requirements to be assessed. For unpaved or severely deteriorated road surfaces, iRAP star ratings cannot be calculated.

Using the crash frequency, out of the 64 locations evaluated, 16 were identified as high priority for intervention (3 road segments and 13 intersections). These high-risk locations are shown in Figure 1. The crash rate, considering the traffic volume, identified 22 high priority for intervention locations (9 segments and 13 intersections) which are shown in Figure 2. The injury indicator also identified 22 high priority for intervention locations (8 segments and 14 intersections). The high priority for intervention locations according to ISD are shown in Figure 3.

Contrary to the other indicators, only 18 locations were found to be safe (3-star) using iRAP star ratings (17 segments and 1 intersection) where 14 are 2-star, 26 are 1-star and 6 don't have star ratings. These locations are shown in Figure 4 with different colors. Orange areas represent 3-star, red represents 2-star and black represents 1-star. Areas where star ratings are not applicable are not represented.

In order to validate the ranking indicators, assuming that the indicators used are adequate, they should generate similar and coherent results: qualitatively (general description of the road network, in terms of safety performance) and also quantitatively (crash site ranking). The ranking correlations are shown in Table 4 for the intersections and segments. These results of Spearman's test and the observation of the scatter plots suggest the possibility of different strengths and directions of correlation between the various indicators.

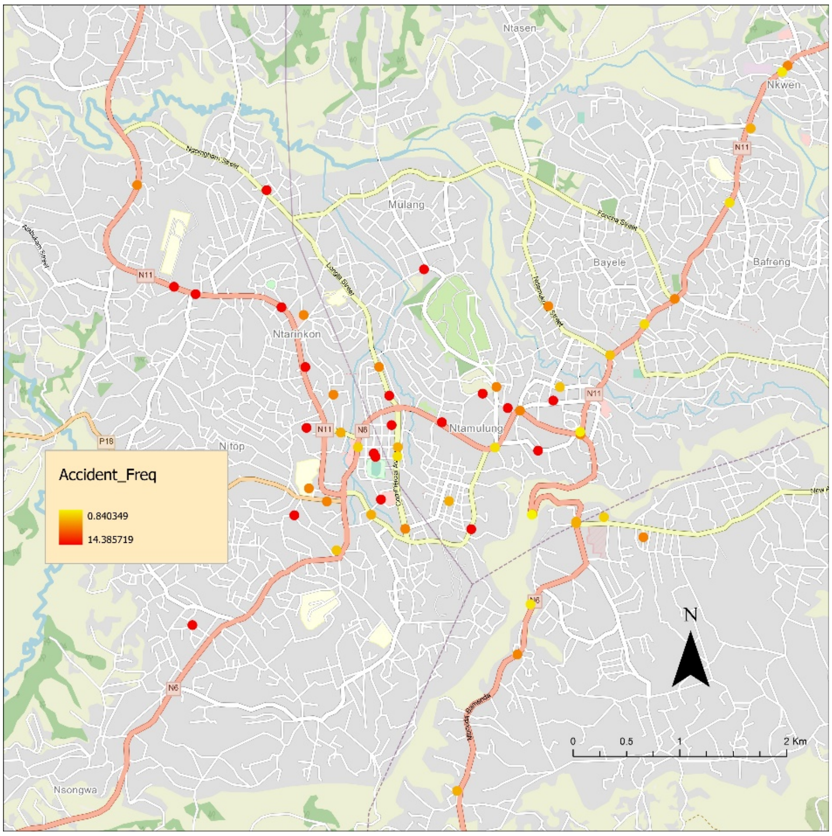

Figure 1. Crash risk map showing hotspots for crash frequency.

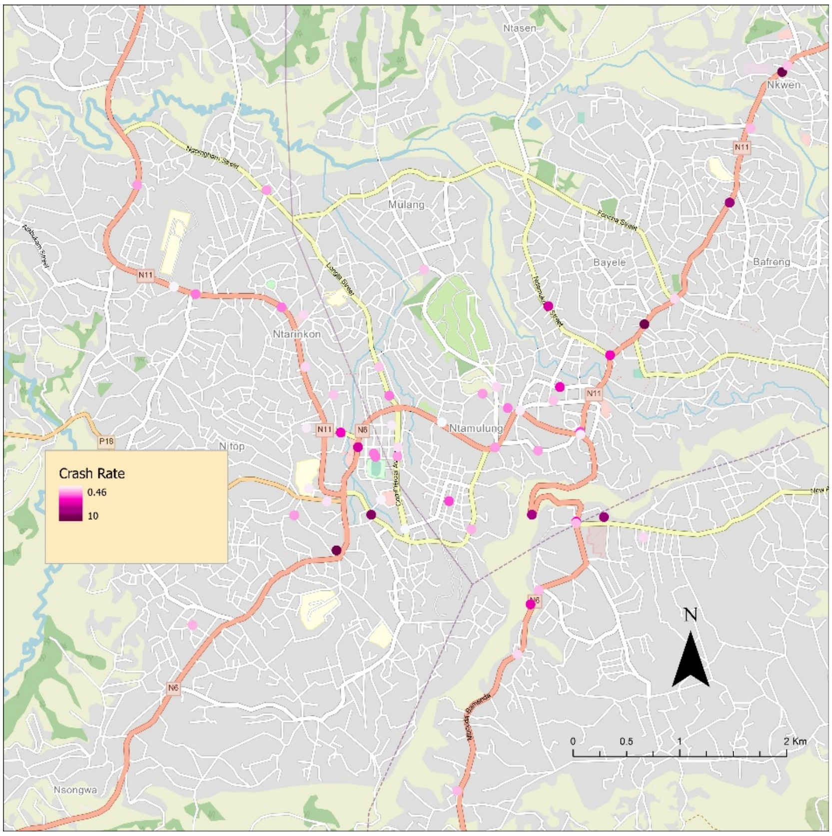

Figure 2. Crash risk map showing hotspots for crash rate.

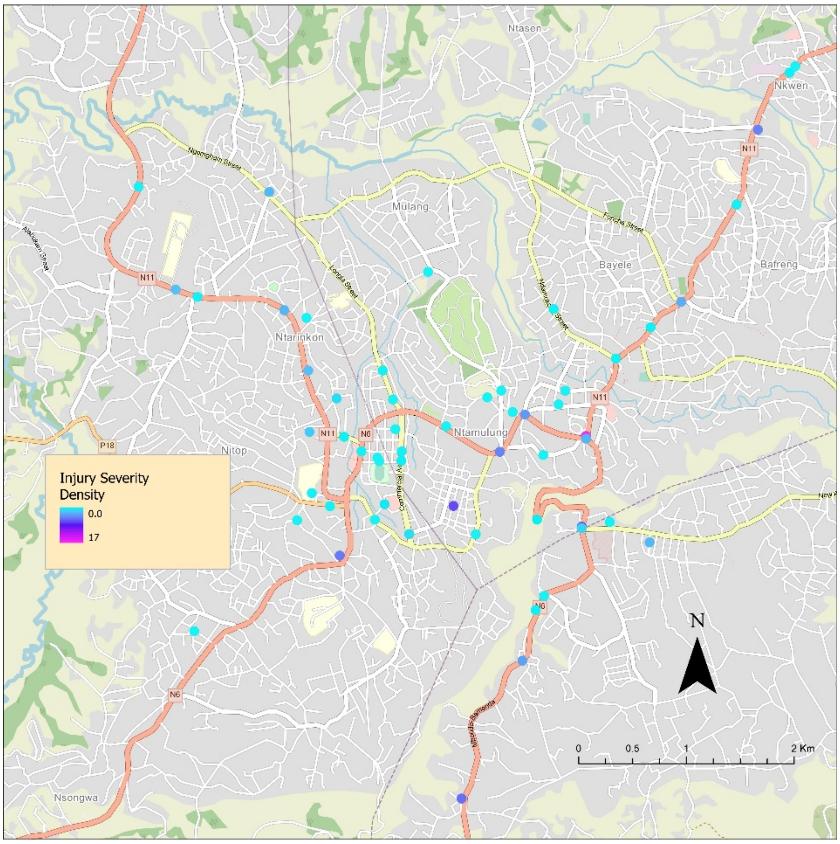

Figure 3. Crash risk map showing hotspots for injury severity density.

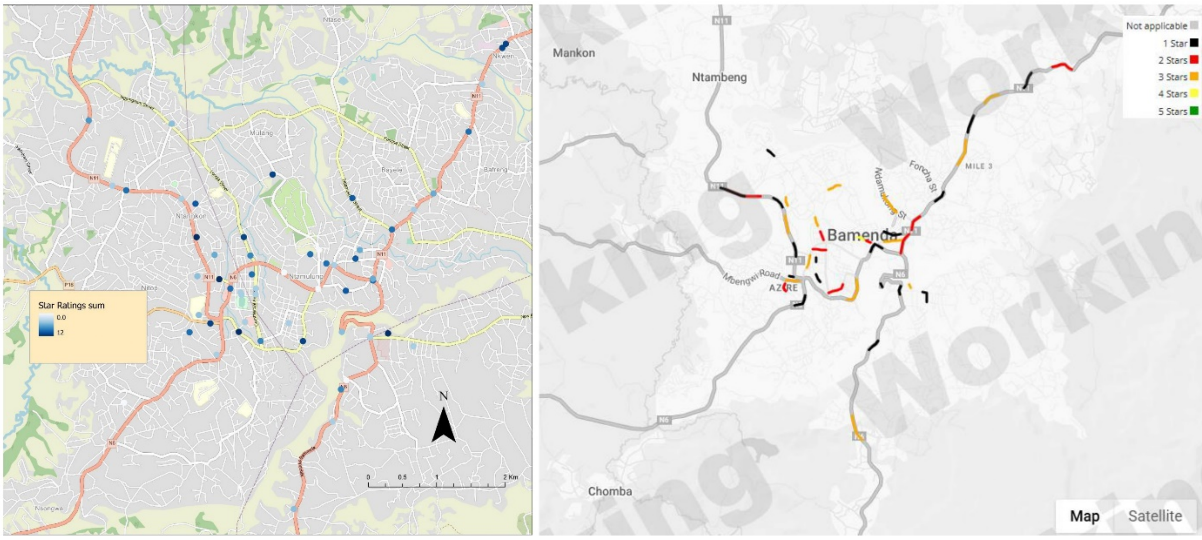

Figure 4. Crash risk map showing the star ratings (black, red and orange sections indicate 1-, 2- and 3-star areas respectively).

Table 4. Ranking correlation strength between all four indicators.

	Intersections						Segments					
	CF–CR	**CF–ISD**	**CR–ISD**	**CF-SR**	**CR-SR**	**ISD-SR**	**CF–CR**	**CF–ISD**	**CR–ISD**	**CF-SR**	**CR-SR**	**ISD-SR**
r	0.4689	0.7511	0.5296	0.0859	0.3622	0.0978	0.5104	0.8627	0.5172	−0.078	−0.1166	−0.092
n	24	24	24	24	24	24	40	40	40	40	40	40
t	2.4900	5.3368	2.9285	0.4043	1.8228	0.4608	3.6592	10.5144	3.7253	0.4823	0.7235	0.5661
df	22	22	22	22	22	22	38	38	38	38	38	38
***p* value**	0.0208	2.3×10^{-5}	0.0078	0.6899	0.082	0.6495	0.0008	8.3×10^{-13}	0.0006	0.6324	0.4738	0.5746

4. Discussion

Out of the 64 locations of interest studied, 52 were classified as high priority for intervention by at least one indicator. Several locations with recorded crashes could not be identified because the location details were poorly recorded. As a result, the missing data. Given that the data was manually collected, it is inevitable that data would be missing. As a result of these missing data, there could be potential biases spatially, affecting risk levels of locations. In the case of this study, the addition of GPS coordinates as a collected feature would eliminate this limitation.

According to crash rate, 3 out of the 24 intersections (I01, I08, I24) are high priority for intervention. These intersections are all unsignalized with: a good road surface that allows for high speeds in an uncontrolled intersection (I01); a small central island and large intersecting traffic volumes (I08); and very poor road infrastructure (I24–several degradations and unpaved surface). Poor infrastructure, characterized by pavement degradation and presence of potholes) often causes drivers to engage in risky manoeuvres leading to crashes. For the non-intersection section, 10 out of the 40 segments are rated high priority for intervention by the crash rate (S07, S09, S12, S18, S19, S20, S27, S37, S38 and S39).

Three segments (S37, S39 and S20) had the worst performance with respect to crash frequency. These segments are characterized by: a mix of light and heavy vehicles with vulnerable road users (motorists and pedestrians) without dedicated facilities (S20); good road surfaces leading to speeding and eventual crashes (S39); and poor road geometry (narrow lanes and sharp curves) with severe road side risks (S37). Segments, S37, S39 and S20, were also noted for being the worst performing in injuries (ISD). High crash rates are associated with the main entrance into the city, where there is a high traffic volume on hilly/mountainous area with narrow lanes and poor designed curves and severe road side risks. Road sides have rock faces, a cliff and trees with no safety barriers.

The star ratings using the iRAP methodology show that 18 of the 64 locations have a good level of safety. There are no locations with 4 or 5 stars (very good or excellent safety conditions). On the contrary the majority are 1 and 2 stars which represent bad and very bad safety conditions. For the not applicable sections, the main reason for the absence of results was the fact that these areas do not qualify for iRAP assessments as they showed extreme degradations and unpaved surfaces.

The data-based indicators and the star ratings individually show the risk level of these locations. By combining the results, the locations with the highest risk can be identified as those locations with high risk in both reactive and proactive approaches. By considering the locations which have the highest risks by all the indicators, 3 locations (S27, S37 and I1) have values greater than the threshold value and 1-star rating. This combination strategy also makes it easy to identify locations which are high priority for intervention by crash data (all 3 indicators) but have a 3-star rating. In these 4 locations, this is indicative of speeding as the infrastructure is good and riders and motorists take advantage and speed. Therefore, areas where all reactive indicators rate as high priority for intervention but iRAP results show 2 or 3-stars or are not applicable should be checked further as there is the possible that the iRAP crash prediction models may not have been calibrated for this specific type of traffic. Although iRAP methodology is not specifically designed to assess intersections, there are several attributes that are included related to the presence of intersections and how they are used.

The crash frequency and crash rate show closely similar results where differences could be due to difference in traffic volume. These methods are limited in that several factors such as operating speeds are unaccounted for in these two methods. This speeding is a great concern as 54% of global fatalities, particularly in LMICs, where a speeding-related death occurs every 49 s [25,26].

The crash rate and injury severity density have a strong positive correlation showing a very strong association while crash frequency is only moderately correlated with the crash rate and injury severity density. This is highly dependent on the weighting of the factors and further investigation could be done using other weighting methods such as factor analysis [27], analytic hierarchy process [28], budget allocation [29] and data envelopment analysis [30]. Star ratings have a very weak correlation with the other indicators. This could be attributed to the nature of the indicators as the other indicators are reactive while iRAP star ratings are a proactive method.

From our results, it is evident that the four indicators generally come to similar results when identifying risky locations as several locations were shown to be high risk by a combination of methods and the correlations (though some weak). A proposed intervention strategy could be implemented starting with the locations with most risk. Since crash frequency, crash rate and injury severity density depend on crash data, data availability could be a criterion for prioritizing these methods and the star ratings would provide complementary information in such cases. Ensuring safe road infrastructure (pillar of safe system approach) is an evidence-based solution which has the potential to create a more forgiving and resilient transportation system, offering valuable guidance for policy decisions, future research, and interventions aimed at promoting safer road environments [31]. Further research could be carried out to see how these indicators vary for the different road user groups, especially motorists as they have high crash numbers, and how the results from both approaches can be combined.

5. Conclusions

Limited economic resources highly affect the implementation of road safety solutions considering the increasing crashes in LMICs given that these crashes are decreasing in other parts of the world. For the case of Cameroon, past studies have used only reactive methods to calculate indicators to inform road safety decisions. In this paper, a proactive approach was used in addition to the reactive methods to provide a more reliable quantification of risks. This paper aims to assess road infrastructure safety performance in Bamenda, Cameroon, using a data-driven approach (combining safety performance indicators mainly crash frequency, crash rate, and injury severity density) and iRAP star ratings to quantify the risk of crash locations, prioritizing areas for immediate action. Crash data was collected and analyzed from which the crash rate, crash frequency and injury severity density were obtained separately for intersections and straight road sections–these comprised the reactive indicators. iRAP assessments for the crash locations were also obtained. From the results, 52 of the 64 locations (81%) were marked as high priority for intervention by at least 1 indicator. While combining the indicators, 11 high-priority locations were identified from all 4 indicators. The results also show that the reactive indicators high-priority locations were characterized by unsignalized intersections some of which have degraded infrastructure, do not appropriately direct intersecting traffic and speeding, as well as poorly designed curves, narrow lanes and dangerous (unforgiving) road sides. None of these locations had the best star ratings, only medium and low ratings, with some not being rated as they were beyond the scope of iRAP assessments.

The different safety levels were combined and locations were prioritized based on the number of indicators that indicated high priority for intervention and the corresponding star rating. Three locations had all reactive indicators indicating high priority for intervention and a 1-star rating which were considered to be the locations with the highest risk.

Combining historical crash data (reactive) with proactive risk assessments, such as iRAP star ratings, offers a more comprehensive picture of risky locations. The findings of this study underscore the critical need for a comprehensive approach to road safety that integrates both historical data and proactive assessments to prioritize interventions. This has the potential to cause an eventual shift to using both reactive and proactive methods for road safety assessments. These high priority intervention locations would likely produce the most return on investment if safety interventions are implemented. Limitations of this study arising from poor data quality would be greatly improved by investing in quality data for future studies.

Author Contributions

Conceptualization, methodology, writing—original draft preparation, D.O.D.; investigation, data curation, formal analysis, review S.K.F.; writing—review and editing, N.T.L.; methodology, supervision, writing—review and editing, J.F.W.; supervision, review and editing N.G.E. All authors have read and agreed to the published version of the manuscript.

Funding

This research received no external funding.

Acknowledgments

We acknowledge the administrative support of the National Advanced School of Public Works Yaoundé (ENSTP) and the North West Regional Delegation for Highway and Circulation Bamenda Cameroon, for crash record provision. We also acknowledge the use of ViDA (iRAP platform for assessment calculations) for freely using the iRAP methodology to carryout road assessments.

Conflicts of Interest

The authors declare no conflict of interest.

Use of AI and AI-assisted Technologies

During the preparation of this work, the authors used ChatGPT to enhance the language and clarity of the writing. After using this tool, the authors reviewed and edited the content as needed and take full responsibility for the content of the published article.

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