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Safety Evaluation of National Highway Using International Road Assessment Programme: A Case Study of NH14 (Rupani-Rajbiraj Section)

Mohan Dhoja K.C.[a], Jalendra Yadav[b*]

[a]*Nepal Engineering College, Chagunarayan-4, Bhaktapur and 10210,Nepal*
[b]*NUGIP, Putalibazar, Syanja and Nepal*

Abstract

Road surface issues, human errors, mechanical problems are all contributing to Nepal's growing number of road fatalities, despite an action plan. In spite of the increase in road construction, safety measures are limited on the road, resulting in road fatalities. To reduce road fatalities to half by 2030, the Government of Nepal has committed to achieving UN Sustainable Development Goal (SDG) target 3.6. Consequently, road users such as vehicle occupants, motorcyclists, pedestrians, and cyclists should have a minimum three-star rating. The iRAP believes that achieving 3 stars on the road will reduce fatalities by half.

Researchers conducted this research in NH14 (Rupani-Rajbiraj section) in order to determine the existing star rating and score for the section. According to the official letter issued by the traffic police administration, six crash-prone locations were provided for the study. Using the iRAP methodology, the researcher studied three crash-prone areas among six.

Existing road conditions vary from two to three-stars for vehicle occupants, motorcyclists, pedestrians, and bicyclists. Star rating score (SRS) is found in the varying range of 6.85 to 17.29 for vehicle occupants, 9.61 to 21.82 for motorcyclists, 32.77 to 57.5 for pedestrians and 27.23 to 45.78 for bicyclists. In analyzing the results of all three studied locations, not a single location meets the target. All the three locations area can be improved by maintaining of damaged road, improving the delineation and providing the speed limit of the vehicle for reducing the risk of crash type like run-off either side of carriageway, head-on collision due to loss of control and while overtaking, crash at intersection, moving along the road, crossing through and side of the road. There is now a 3 stars rating for vehicle occupants, motorcycles, pedestrians, and bicyclists. Star Rating Score is found in the varying range of 5.74 to 8.9 for vehicle occupants, 8.28 to 11.27 for motorcyclists, 17.11 to 38.03 for pedestrians and 11.51 to 26.31 for bicyclists.

Keywords: Fatalities; Star rating; Star rating score; Sustainable Development Goal

1. Introduction

Road crashes are the eighth leading cause of death for people worldwide with one person dying on the roads every 25 seconds, nearly 3,700 per day, over 1.35 million per year and as many as 50 million injuries every year. (Sakarya & Of, 2018) Road traffic injuries are the leading cause of death among young people, aged 5–29 years world-wide. (Sakarya & Of, 2018) (World Bank & World Health Organization, 2013)

* Corresponding author. Tel.: +977-9851168091
E-mail address: mohandhoj@gmail.com

Road crash fatalities and injuries are a growing problem in Nepal. The number of road fatalities in Nepal is increasing alarmingly despite an action plan. Nepal has pledged to reduce road fatalities by 50 percent and developed the Nepal Road Safety Action Plan (2013-20) to meet its global commitment of SDG target 3.6. (Plan, 2013) However, road fatalities in Nepal have been increasing at an alarming rate and reached 2,541 deaths in fiscal year 2017-18, which is equivalent to a rate of 8.59 per 100,000 populations. (Sakarya & Of, 2018) During the recent decades several major efforts have been made to improve the highway safety at various level. Numerous road fatalities have been found due to different factors related to road surface, human error, mechanical problem etc. till date. Loss of life and property due to the crash is undefined. In fiscal year 2020, 10030 numbers of crash, 153 numbers fatality, 240 numbers serious injuries and 6684 numbers normal injuries has been recorded in Nepal. (Nepal Police, 2018).

The rate of motor-related crashes in Nepal is found increasing day by day. At the same time construction of new roads is increasing day by day. Some roads have been constructed without considering the safety factors. This question has raised whether to construct roads in more quantity without considering the safety factor or construct less but safer roads. Hence the road going to be constructed in near future should be designed safe prior to construction and study should be conducted for each constructed road for making safer roads. Causes of road traffic crashes are multifactorial, arising from three sources: driver-related (speeding, drinking, overloading, and overworking), vehicle-related (mechanical and old vehicles) and road-related (narrow, steep, graveled, not repaired). Road crashes are reducible. Road safety experts believe that, with the right action, up to 5 million lives could be saved and 50 million injuries can be prevented in the coming 10 years. This would represent a reduction of about 50% on the predicted global death toll by 2020. (Amro et al., 2015) (Plan, 2013)

The Rupani-Rajbiraj road section is the section of NH14 that connects the E-W highway with Saptari, Rajbiraj's district headquarters. Rajbiraj is the center hub for the higher education, marketing, governmental major offices like court, land revenue office and medical facilities. Thus attraction of people for fulfilling their needs is high towards Rajbiraj and most of them travel through Rupani- Rajbiraj Road. Road edge is deteriorated with potholes in different sections. Lack of delineation, safety signs and signal, road marking and pedestrian crossing. Several losses of life and injuries have been found during road crashes along the Rajbiraj-Rupani road section. Six locations have been identified as fatal areas by the traffic police office in written reports. .(Traffic Police Office Rajbiraj ,Saptari Nepal Letter Date:7, 2020) To save life and property damage due to road crashes is a burning issue nowadays. Therefore, finding the star rating and star rating score of the selected location will help to make required improvements to make a better and safer road. There are three study areas: -Unique hospital area, Raipur area and Nahar chowk area (Gahil pump area)

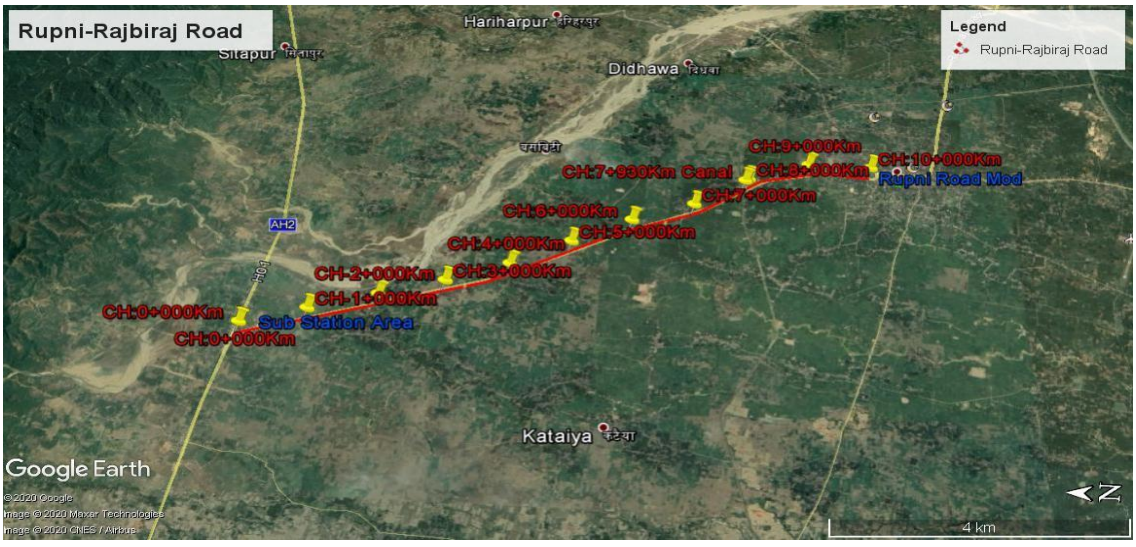

Figure 1: Location of study area (Google Earth, 2022)

Objectives

The main objective of the study is to conduct safety evaluation of the crash prone area at Rupani-Rajbiraj road section of NH14. The specific objectives of the study are:

- To determine the star rating (SR) and star rating score (SRS) at crash prone area of Rupani- Rajbiraj road section of NH14
- To identify the types of crash risk for the road users at study location.
- To identify the possible measures for improving the star rating to a minimum of 3 stars

2. Methodology

2.1 Theory

Star Ratings are based on road inspection data and provide a simple and objective measure of the level of safety which is 'built-in' to the road for vehicle occupants, motorcyclists, bicyclists and pedestrians. Five-star roads are the safest while one-star roads are the least safe. (iRAP, 2021) Star Ratings can be completed worldwide, in urban and rural areas and without reference to detailed crash data, which is often unavailable in low-income and middle-income countries, or is sparse in high-performing high-income countries striving for vision zero outcomes. (iRAP, 2019) (iRAP, 2021) (Rogers et al., 2012)

Table 1. Star rating of roads

Star Rating	Pedestrian	Bicyclist	Motorcyclist	Vehicle
★	No sidewalk, No safe crossing, 60km/h traffic	No cycle path, No safe crossings, Poor road surface, 70 km/h traffic	No motorcycle lane, undivided road, trees close to road, winding alignment, 90km/h traffic	Undivided road width, narrow centerline, trees close to road, winding alignment, 100 km/h traffic
★★★	Sidewalk present, pedestrian refuge, street lighting, 50km/h traffic	On-road cycle lane, good road surface, street lighting, 60km/h traffic	On-road motorcycle lane, undivided road, good road surface, >5m to any roadside hazards, 90km/h traffic	Wide centerline separating oncoming vehicles, >5m to any roadside hazards, 100km/h traffic
★★★★★	Sidewalk present, signalized crossing with refuge, street lighting, 40km/h	Off-road dedicated cycle facility, raised platform crossing of major roads, street lighting	Dedicated separated motorcycle lane, central hatching, no roadside hazards, straight alignment, 80km/h traffic	Safety barrier, separating oncoming vehicles and protecting roadside hazards, straight alignment, 100km.h traffic

(Sakarya & Of, 2018)

UN Global Action mandates member countries to develop their individual national plans for the decade from 2011 - 2020 incorporating interventions under the following broader themes: Road safety management, Safer roads and mobility, Safer vehicles, Safer road users, Post-crash response. To comply with the call made by

the UN Global Action Plan, Road and Traffic Unit, the Department of Roads has started the preparation of Nepal Road Safety Action Plan (2011–2020). And this document has been anticipated representing Nepal's national action plan on Road Safety. (Plan, 2013) (Report,2020)

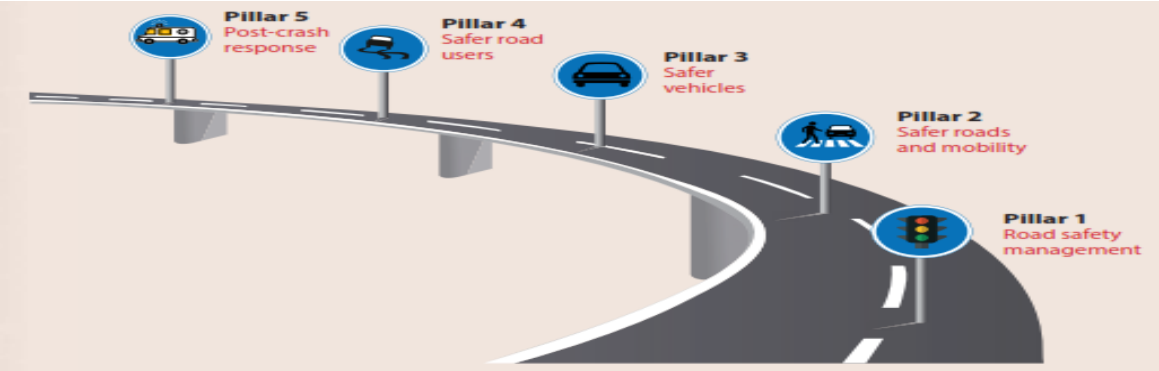

Figure 2 : Pillars of road safety (Consunji et al., 2018)

2.1.1 Study variables

The main purpose of the study is to evaluate and identify possible measures for improving to a minimum of 3 stars rating for the study section.

The study variables for star and star ratings evaluation are categorized into two categories. These are dependent variables and independent variables.

Dependent Variables

- ❖ Star rating and star rating score

Independent Variables

- ❖ Standard cross section of road
- ❖ Roadside attributes
- ❖ Mid-block
- ❖ Intersections
- ❖ Traffic Flow
- ❖ VRU facilities and land use
- ❖ Speeds

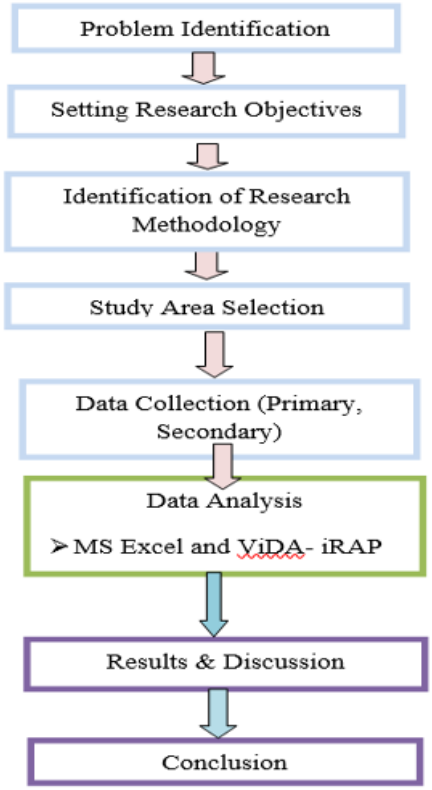

Figure 3: Research methodology of flowchart

Data Collection

To achieve the aim of the study different types of data are required and the data are categorized as; Primary data and Secondary data. The main primary data are: Traffic Count, Pedestrian peak hour Flow, Bicyclist peak hour flow, VRU facilities and land use, Operating Speed.

Data Analysis

MS-Excel and ViDA (Visualize, Design, Assess) software is used for data analysis in order to safety evaluation of the road section. ViDA (meaning 'life' in Spanish) is iRAP's online software. (International Road Assessment Programme [iRAP], 2022) ViDA is used to perform all iRAP star rating and safer road investment plan analyses. This study is use ViDA software for free. Referring the inventory data sheet of the study area, analysis has been made following the steps shown in processing diagram

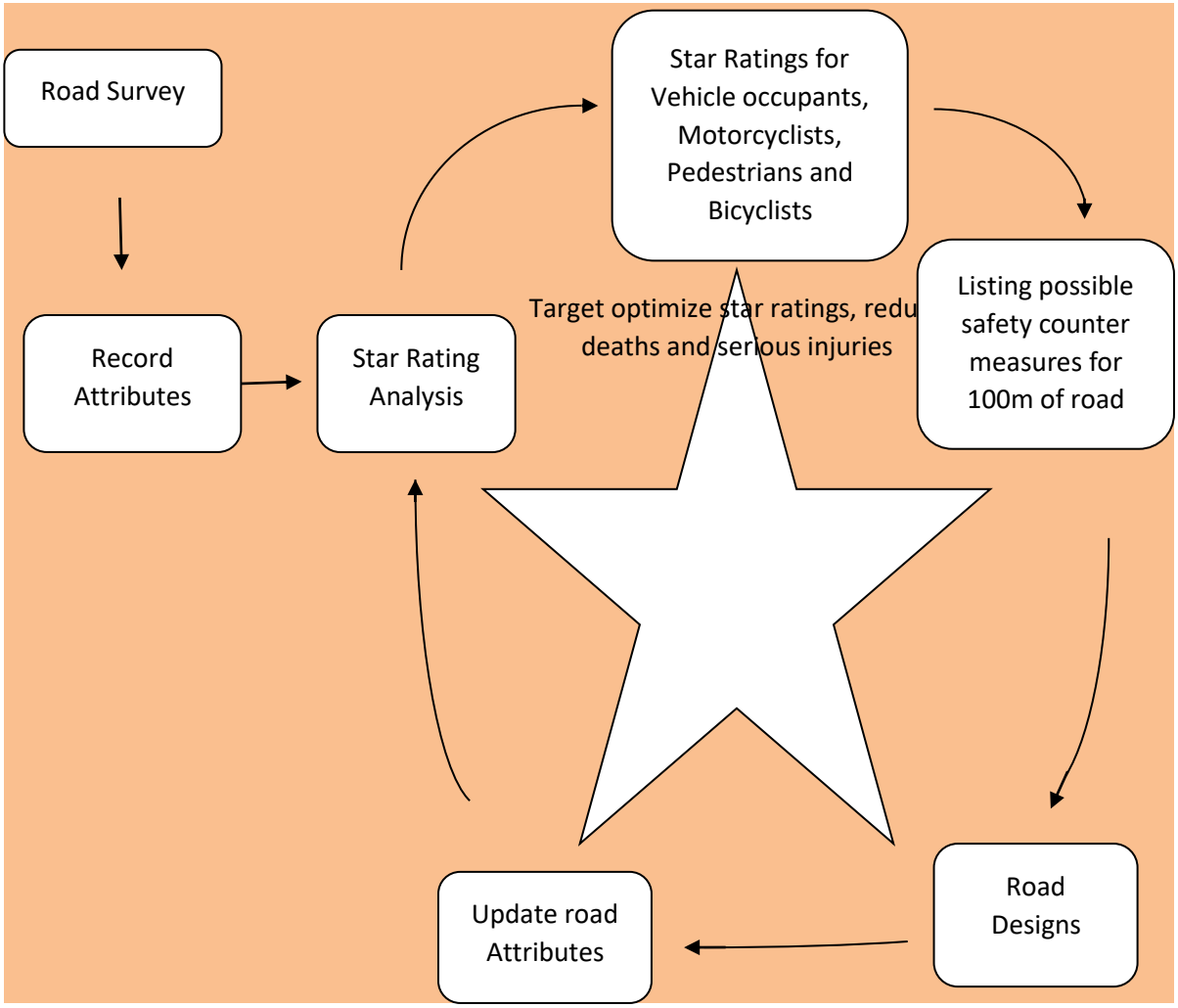

Figure 4: Star rating processing diagram (iRap, 2019)

As per iRAP road is said safer if the star rating for the vehicle occupants, motorcyclists, pedestrians and bicyclists in the study area is 3 star or more. Also the star rating score for the vehicle occupants at least in the range of 5 to< 12.5, for motorcyclists at least in the range of 5 to< 12.5, for pedestrians at least in the range of 15 to<40 and for bicyclists at least in the range of 10 to<30 indicates safer. For complete safety, the star rating of the study section for vehicle occupants, motorcyclists, pedestrians, bicyclists are 5star and star rating score for vehicle occupants, motorcyclists, pedestrians and bicyclists is zero (International Road Assessment Programme, iRAP, 2012) (Rogers et al., 2012) (Ambros et al., 2017) (EuroRAP, 2011). The Higher the star rating, the safer the road is for the users. Star rating score is found increasing if the star rating is low. Higher the star least is the score. Higher the star safer is the road. (EuroRAP, 2011) (iRAP, 2019) (IndiaRAP, 2020)

Table 2. Star rating bands and color

Star Rating (SR)	Star Rating Score (SRS)			
	Vehicle occupants	Motorcyclists	Pedestrians	Bicyclists
5	0 to <2.5	0 to <2.5	0 to <5	0 to <5
4	2.5 to <5	2.5 to <5	5 to <15	5 to <10
3	5 to <12.5	5 to <12.5	15 to <40	10 to <30
2	12.5 to <22.5	12.5 to <22.5	40 to <100	30 to <60
1	22.5+	22.5+	100+	60+

(International Road Assessment Programme, iRAP, 2012)

3. Results & Discussion

In this section, the star rating as well as the star rating score for three study locations, as well as the type of risk of crash at existing and after improvement locations, are presented in tabular and histogram form**.**

The star rating, the star rating score, and the type of crash risk in Raipur

Raipur Area for the vehicle occupants, motorcyclists and pedestrians seems safer whereas bicyclist is found unsafe as the star rating for the vehicle occupants, motorcyclist and pedestrians is 3 star and bicyclist is 2 star. Star rating score for vehicle occupants, motorcyclists, pedestrians and bicyclists are 6.85, 9,61, 32,77 and 30.57 respectively. Figure 5 shows that the risk of crash type for vehicle occupants is run-off passenger side followed by run-off driver side, and head-on loss of control. Risk of crash type for motorcyclists is run-off passenger side followed by run-off driver side, head-on loss of control, intersection and along the road. Risk of crash type for pedestrians is while crossing through the road followed by along the road, and crossing side. Risk of crash type for bicyclists is along the road followed by intersections.

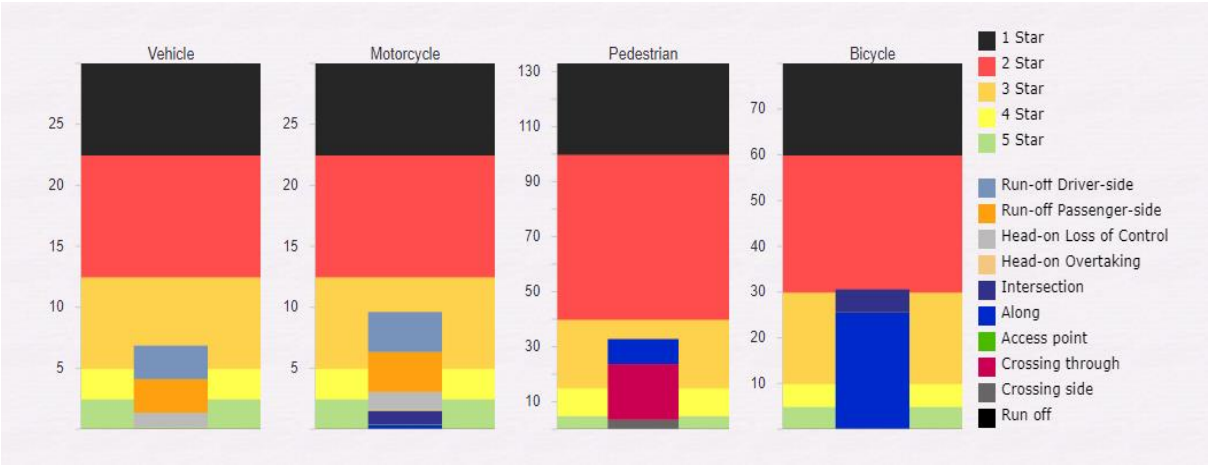

Figure 5: Existing star rate score and risk of crash type at Raipur area

Table 3. Existing star rating score and star rating score of Raipur area

Description	Star Rating				Remarks
	Vehicle occupants	Motorcyclists	Pedestrians	Bicyclists	
Star rating	3	3	3	2	Existing condition
Star rating score	6.85	9.61	32.77	30.57	

The counter measure is applied focusing on improving the star rating of bicyclists to achieve minimum 3 stars. A number of delineating factors could be improved, such as: center lines, lane markers, edge lines, guideposts, delineators, road studs, and hazard markers, as well as signage (on the road and posted). (Department of, 2022) (*Prevent Pedestrian Crashes : Parents and Caregivers of Elementary School Children*, n.d.)

Bicyclists are found safe as the star rating and star rating score is improved to 3 star and 26.31 respectively. From Table 4 it is clear that all the users are safe as the star rating and SRS for the users at Raipur area is improved to 3 star and 5.74, 8.28, 31.26 and 26.31 respectively. Figure 6 shows that the risk of crash type for vehicle occupants, motorcyclists, pedestrians is subsequently reduced by 16%, 14% and 5% respectively in compared to the existing result though the users were in safer range; whereas risk of crash type for bicyclist along the road is reduced by 14% in compared to the existing result to achieve the SDG target.

Table 4. Star rating and star rating score of Raipur area after improvement

Description	Star Rating				Remarks
	Vehicle occupants	Motorcyclists	Pedestrians	Bicyclists	
Star Rating	3	3	3	3	After applying counter measures
Star Rating Score	5.74	8.28	31.26	26.31	

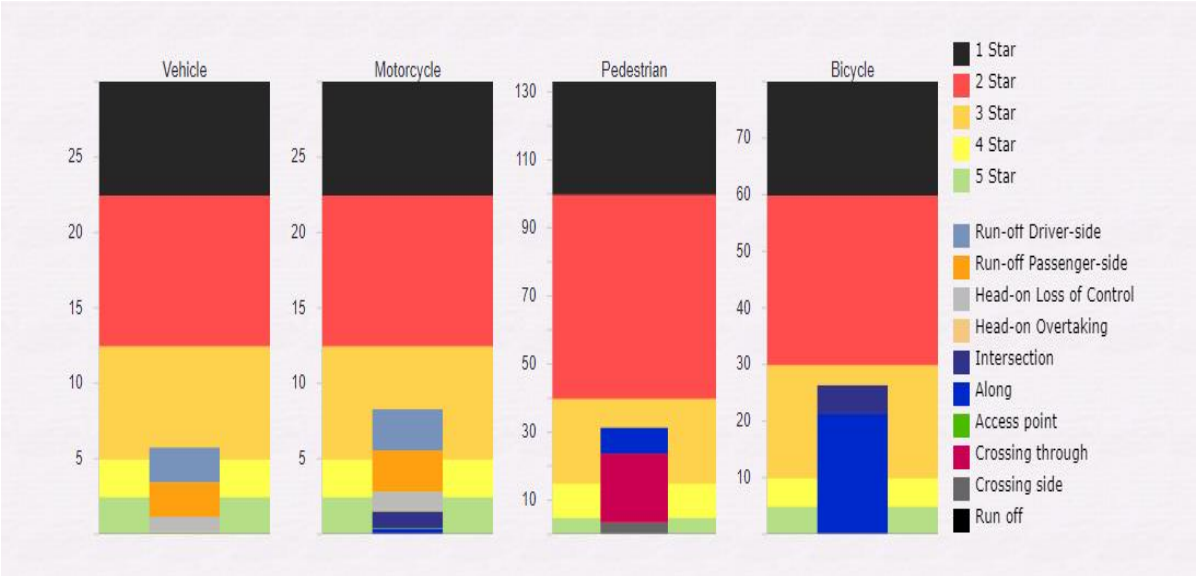

Figure 6: Star rate score and risk of crash type at Raipur area after improvement

The star rating, the star rating score and the type of crash risk in Unique hospital area

Unique hospital area is unsafe as the star rating of the vehicle occupants, motorcyclist, pedestrians, and bicyclist is less than 3 stars and the star rating score for vehicle occupants, motorcyclist, pedestrians and bicyclist are 15.12, 20.53, 57.5 and 45.78 respectively. Figure 7 shows that the risk of crash type for vehicle occupants is run-off passenger side followed by run-off driver side, and head-on loss of control. Risk of crash type for motorcyclists is run-off passenger side followed by run-off driver side, head-on loss of control, along the road and head-on overtaking least. Risk of crash type for pedestrians is while crossing through the road followed by along the road. Risk of crash type for bicyclists is only along the road.

Table 5. Existing star rating and star rating score of Unique hospital area

Description	Star Rating				Remarks
	Vehicle occupants	Motorcyclists	Pedestrians	Bicyclists	
Star rating	2	2	2	2	Existing condition
Star rating score	15.12	20.53	57.5	45.78	

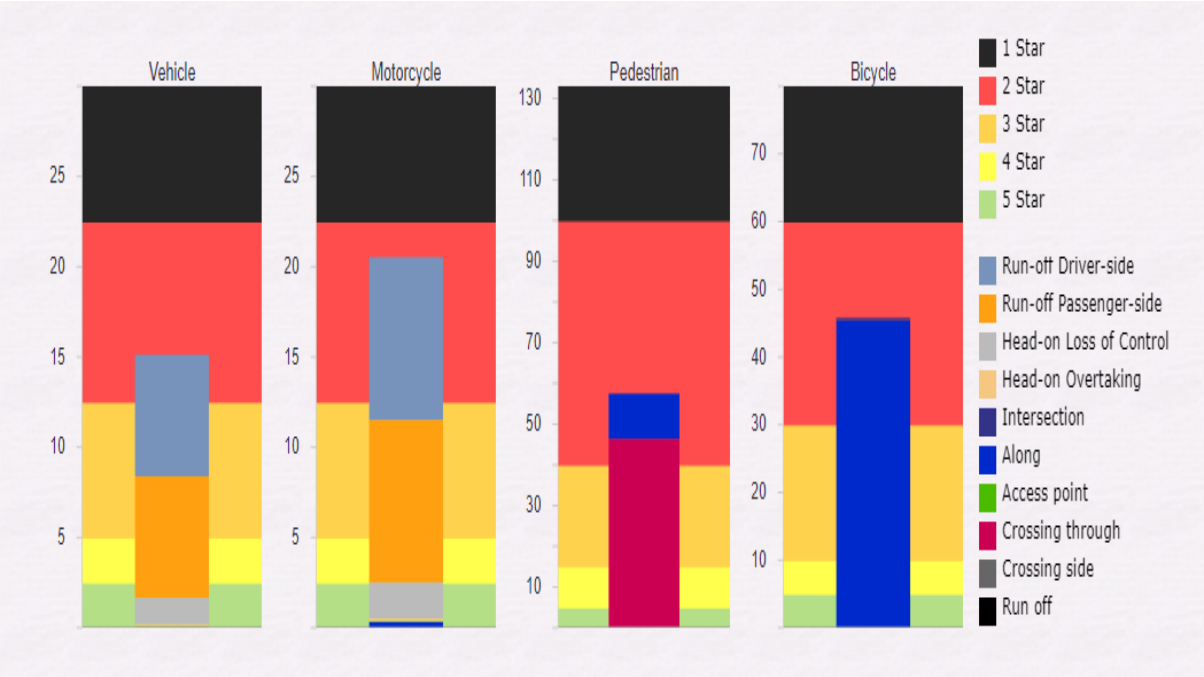

Figure 7: Existing star rate score and risk of crash type at Unique hospital area

The counter measure is applied focusing to improve the star rating of vehicle occupants, motorcyclist, pedestrians and bicyclist to achieve minimum 3 stars. Repair and maintenance of the damaged road edge pavement along with improved delineation will ensure the road section is safe for all road users. (Department of, 2022) (*Prevent Pedestrian Crashes : Parents and Caregivers of Elementary School Children*, n.d.) The table 6 clearly reflects the safer road section. Existing condition star rate and star rating score is improved to 3 star and 7.62, 9.36, 38.03 and 21 respectively for the vehicle occupants, motorcyclist, pedestrians and bicyclist. Figure 8

shows that the risk of crash type for vehicle occupants, motorcyclists and bicyclists is nearly reduced by half whereas pedestrians are reduced by 34% in comparison to the existing result to achieve the SDG target.

Table 6. Star rating and star rating score of Unique hospital area after improvement

Description	Star Rating				Remarks
	Vehicle occupants	Motorcyclists	Pedestrians	Bicyclists	
Star rating	3	3	3	3	After applying counter measures
Star rating score	7.62	9.36	38.03	21	

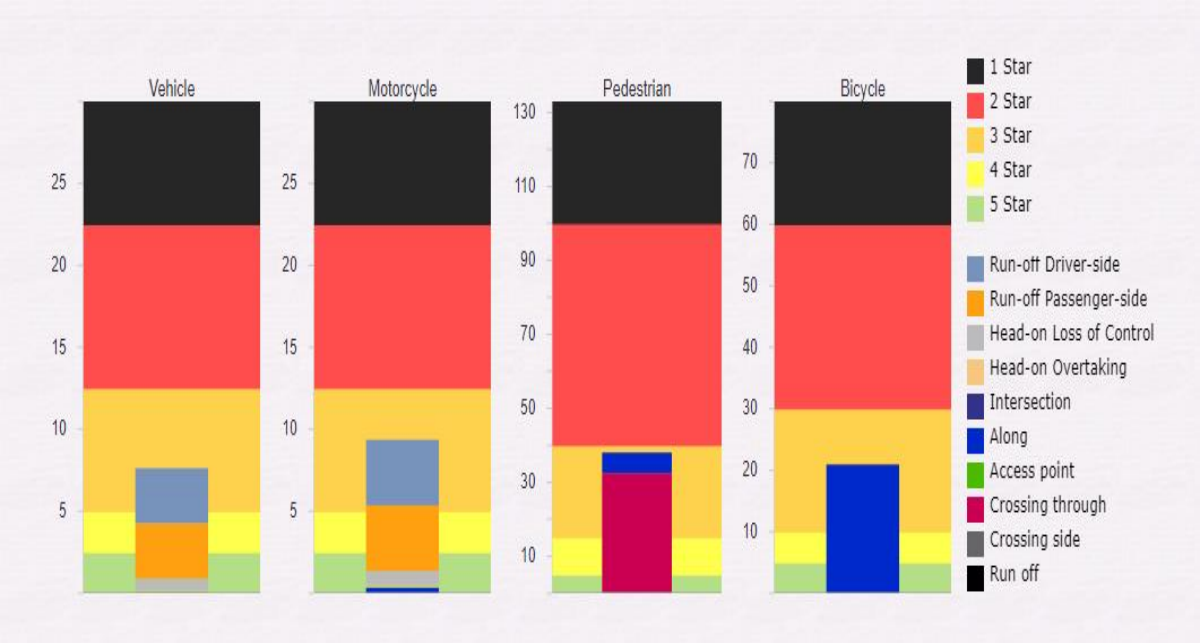

Figure 8: Star rate score and risk of crash type at Unique hospital area after improvement

The star rating, the star rating score and the type of crash risk in Nahar chowk area (Gahil pump area)

Nahar chowk area for the vehicle occupants and motorcyclist is unsafe as the star rating for this user in the section is less than 3 stars and star rating score for vehicle occupants and motorcyclist is 17.29 and 21.82 respectively. But pedestrians and bicyclist users are safe as the star rating and star rating score of the users are 3 stars and 36.74, 27.23 respectively. Counter measures should be taken for making the vehicle occupants and motorcyclist safe.

Table 7. Existing star rating and star rating score of Nahar chowk area (Gahil pump area)

Description	Star Rating				Remarks
	Vehicle occupants	Motorcyclists	Pedestrians	Bicyclists	
Star rating	2	2	3	3	Existing condition
Star rating score	17.29	21.82	36.74	27.23	

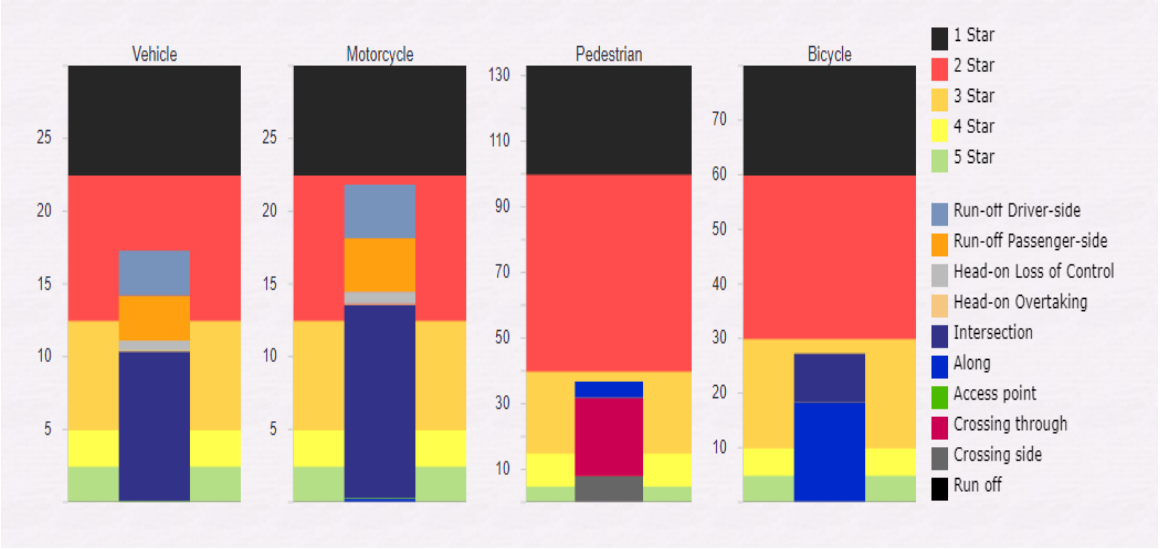

Figure 9: Existing star rate score and risk of crash type at Nahar chowk area (Gahil pump area)

As pedestrians and bicyclists already meet the 3-stars rating, the counter measure is applied focusing on improving the star rating of vehicle occupants and motorcyclists to achieve minimum 3 stars. Road safety can be improved by improving delineation and providing a speed limit of 45kmph (85 percentile speed) for vehicles to operate in. (Department of, 2022) Table 8 clearly reflects the safer road section. Existing condition star rating and SRS is improved to 3 star and 8.9, 11.27, 17.11 and 11.51 respectively for vehicle occupants, motorcyclist, pedestrians and bicyclist. Figure 10 shows that the risk of crash type for vehicle occupants and motorcyclists is nearly reduced by half whereas risk of crash type for pedestrians and bicyclist is reduced by 53% and 58% respectively compared to the existing result.

Table 8. Star rating and star rating score of Nahar chowk area (Gahil pump area) after improvement

Description	Star Rating				Remarks
	Vehicle occupants	Motorcyclists	Pedestrians	Bicyclists	
Star rating	3	3	3	3	After applying counter measures
Star rating score	8.9	11.27	17.11	11.51	

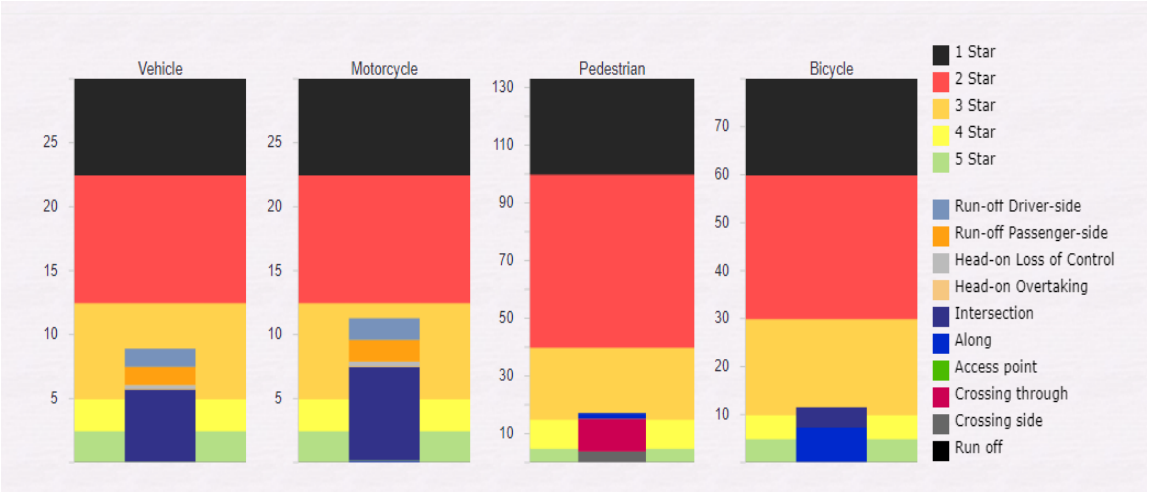

Figure 10: Star rate score and risk of crash type at Nahar chowk area (Gahil pump area) after improvement

4. Conclusion

The researcher identifies the crash prone location and records the various road attributes for finding the star rating and star rating score for the vehicle occupants, motorcyclists, pedestrians and bicyclist at the study location.

The study covers the three locations of selected roads. The three locations are: - Raipur area, Unique hospital area, Nahar chowk (Gahil pump) area. Based on the output results of the software and analysis of researcher following conclusions are drawn:

Star rating and star rating score for different road users at different crash prone locations was found. There were 2 stars to 3 stars for the existing road condition for vehicle occupants, motorcyclists, pedestrians and bicyclists whereas star rating score found in the varying range of 6.85 to 17.29 for vehicle occupants, 9.61 to 21.82 for motorcyclist, 32.77 to 57.5 for pedestrians and 27.23 to 45.78 for bicyclists. Star rating and star rating score of all study locations have not fulfilled the minimum requirement of the safer road. All three locations can be improved at low cost by repairing and maintaining the damaged road, improving the delineation and providing the speed limit of the vehicle. As a result of applying the stated countermeasures, improvements in the star ratings for vehicle occupants, motorcyclists, pedestrians, and bicyclists have been found to be 3 stars. Star rating score is found in the varying range of 5.74 to 8.9 for vehicle occupants, 8.28 to 11.27 for motorcyclists, 17.11 to 38.03 for pedestrians and 11.51 to 26.31 for bicyclists. It has been found that crash risk for different types of road users can be reduced by applying countermeasures, such as runoffs on the driver's side, runoffs on the passenger's side, head-on overtaking, crashes at intersections, crashes while walking along the road, crashes while crossing the road, and crashes while crossing the side of the road under existing conditions. As a result of the study, the road section can be improved to make it safer, minimizing the loss of lives on the road.

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