

School Zone Road Safety Assessment Along Urban Roads with Different Traffic Characteristics: A Case Study of Kathmandu Valley

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Abstract

Kathmandu Valley has emerged as Nepal's major educational and socio-economic center and it has experienced rapid urban expansion and unplanned growth of educational institutions, resulting in increased road safety concerns around school areas. Inadequate road and pedestrian infrastructure, high traffic volumes, and high vehicle operating speeds have significantly increased the risk for school children. This study, titled "School Zone Road Safety Assessment Along Urban Roads with Different Traffic Characteristics: A Case Study of Kathmandu Valley", assesses the safety performance of selected school zones using the International Road Assessment Program (iRAP)'s Star Rating for Schools (SR4S) methodology. Field observation was conducted to determine the key safety parameters as described by the SR4S coding guide. The assessment revealed that both school zones performed below the internationally recommended 3-star safety benchmark. It is majorly due to high traffic volume, uncontrolled vehicle speed, and sub-standard infrastructure. Based on the assessment, the study recommends scenario-based interventions that are easy to implement, such as installing speed limit signs, enforcing stricter parking regulations, enhancing curve geometry, and improving road markings and signage, to improve overall road safety.

Keywords: SR4S, Pedestrian infrastructure, traffic volume, operating speed, iRAP, Sub-standard infrastructure, scenario-based intervention

1. Introduction

Kathmandu Valley has experienced rapid and unorganized urbanization, which has put immense pressure on its roads, and road design around schools has not been sufficient to compensate for this rapid urban urbanization.

Worldwide, there are about 1.19 million deaths due to road traffic crashes every year which makes the road traffic injuries the leading cause of death for children and young adults (aged 5-29 years). Among these, most of the deaths occur in low and middle-income countries and involve vulnerable road users such as pedestrian [1]. Despite Nepal's commitment towards the UN Decade of Action for Road Safety and Sustainable Development Goals, there is still a lack of implementation of this approach at local level, particularly in school zones.

Over the past decade, Nepal has experienced a disproportionate increase in traffic accidents. Macro-level analysis from the database of the national police reveals that the number of road accidents increase from 8,484 during the fiscal year 2012/13 to 24,537 during the fiscal year 2021/22, demonstrating a significantly high compound annual growth rate (CAGR) of 11.2% [2]. Although the absolute measure of casualties was at 2,883 annually by 2022, historically speaking, national targets, for instance, the goal to halve deaths under the National Road Safety Action Plan 2013-2020, were never achieved due to ineffective local countermeasures [2]. This systemic crisis is deeply rooted in engineering omissions and a reactive traffic safety culture. While design guidelines exist for national,

rural, and urban roads, critical geometric safety parameters including curve radii, sight distances, and gradient limits are routinely overlooked during construction phases, especially along complex hill roads and high-density urban corridors [2]. Global frameworks established by the American Association of State Highway and Transportation Officials (AASHTO) prove that while pure roadway geometric design flaws trigger only 3% of crashes, this figure escalates to 34% when factoring in the broader roadside environment—such as missing sidewalks, hidden intersections, and lack of traffic calming measures [2].

This systemic failure to account for roadside environments is particularly hazardous for school zones, where School-going children lack the fully developed cognitive capacity to accurately judge vehicular approach speeds, making them highly susceptible to high-volume, high-speed traffic configurations.

In Nepal, although the issue of road safety has been receiving growing consideration from policymakers, the actual implementation of evidence-based and context-relevant safety initiatives at the community level is still weak. Problems such as the lack of adequate pedestrian facilities, the absence of sidewalks, weak traffic-calming strategies, and inconsistent regulation of speed limits in school zones still persist. These problems result in higher risk exposure for children traveling to schools every day. Moreover, there is limited application of systematic assessment tools that can objectively evaluate pedestrian safety performance and guide targeted interventions.

In this context, the International Road Assessment Program (iRAP) Star Rating for School (SR4S) is a standardized tool that helps in the assessment of pedestrian safety by measuring infrastructure-related risk factors including traffic speed, crossings, and sidewalk provision, etc. but its use in Nepal is limited. This research will employ the SR4S tool for evaluation of the safety performance of two school zones, namely Aadarsha Secondary School and N.K. Singh Memorial EPS School.

2. Research Objective

The major objective of the study is to assess the safety condition of the schools of Kathmandu valley and recommend Scenario-based interventions for improvement of the safety status.

3. Study Area

The research was conducted within two Schools of Kathmandu Valley, selected for their varying traffic volume, road configuration, infrastructure and pedestrian-vehicular interaction.

First School is Aadarsha Secondary School (27°40'54.0"N 85°22'33.8"E), located in Madhyapur Thimi, Bhaktapur and close to Purano Bato (Bhaktapur Road). It operates from 10:00 AM to 4:00 PM and accommodates about 1,500 students from Grade 1 to Grade 12.

Second School selected is N.K. Singh Memorial EPS School (27° 41 '20.5"N 85° 20' 27.9"E) located in Min Bhawan, New Baneshwor, Kathmandu. This school runs from 9:30 am to 4:00 pm accommodating around 2000 students from Grade 1 to Grade 10.

4. Literature Review

The School Star Rating (SR4S), created by the iRAP, is a data-driven instrument aimed at assessing the safety of areas around schools and the routes children take to travel. The approach evaluates road infrastructure, traffic conditions, crossing facilities, vehicle speeds, and pedestrian safety measures to create safety ratings from one to five stars, with higher ratings indicating safer conditions. Several studies have demonstrated the ability of SR4S to identify infrastructure deficiencies and support the prioritization of safety improvements.

SR4S has been found effective in identifying unsafe school environments and assisting authorities in selecting targeted safety improvements [3].

Similarly, the implementation of pedestrian crossings, school warning signs, and speed management measures has been shown to significantly improve safety ratings around schools [4].



Figure 1. Map and road section of Aadarsha Secondary School

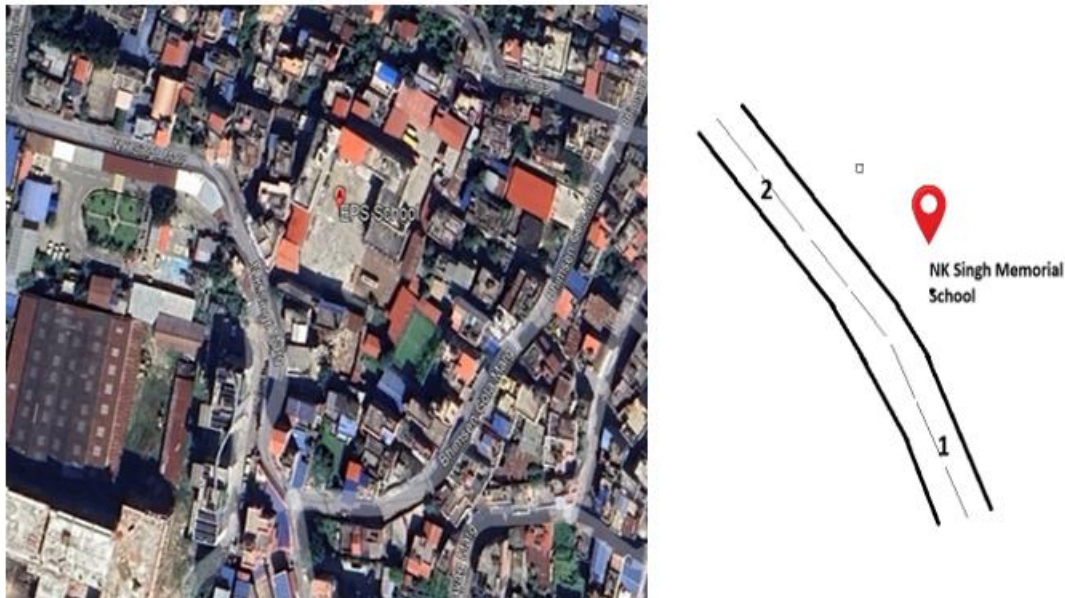


Figure 2. Map and road section of NK Singh Memorial EPS School

In India, low-cost engineering interventions, including raised pedestrian crossings, road markings, and improved signage, were found to substantially enhance school zone safety ratings while reducing crash risks [6].

In Nepal, SR4S has been applied to evaluate school environments and identify deficiencies in road safety infrastructure. The findings highlighted the practical significance of SR4S as a decision-support tool for identifying high-risk school zones and prioritizing road safety investments [7]-[8].

Consequently, SR4S, together with its associated methodologies such as iRAP and (Virtual Road Assessment Program) ViDA, has become one of the most widely adopted approaches for evaluating road safety around school zones in Nepal [7]-[8].

The findings from Nepal are consistent with studies conducted in India, the Philippines, Iran, and Indonesia, which collectively demonstrate the effectiveness of SR4S in improving school road safety through evidence-based interventions [9], [6], [4], [3].

Previous studies indicate that operating speed, pedestrian pathway availability, crossing facilities, traffic calming measures, and appropriate road signage are significant predictors of school safety ratings [4], [10].

The effectiveness of interventions such as speed humps, improved road delineation, the presence of traffic warden, and enhanced school zone signage in improving SR4S ratings and reducing pedestrian crash risk has also been reported in previous studies [9], [6], [4].

A study conducted in four schools—three from Kathmandu and one from Nuwakot, revealed the effectiveness of SR4S-based interventions in improving school zone safety. Following the recommended measures, the star ratings of Gateway, Chamunda, Souvenir, and Joseph schools increased from 3, 1, 2, and 4 stars to 4, 3, 4, and 5 stars, respectively [7].

An evaluation of road infrastructure and traffic risks around United School in Lalitpur, Nepal, utilizing the International Road Assessment Programme (iRAP) Star Rating for Schools (SR4S) methodology, demonstrates that a reduction in vehicle speeds to 30 kmph significantly improves pedestrian safety for students [11].

A study conducted at Apple International School and Jaya Multiple Campus in Kathmandu Valley used the SR4S methodology to evaluate school zone safety and determined the effectiveness of interventions such as 30 km/h speed limits, child-crossing signs, pedestrian-crossing signs, and zebra crossings with stop lines, while both schools initially received a 3-star rating, with risk factors of 27.64 and 33.86, and improved from 3 stars to 4 stars, while the corresponding risk factors decreased significantly [12].

These all findings demonstrate the effectiveness of targeted infrastructure and traffic management interventions in improving school zone safety and increasing SR4S ratings.

5. Methodology

The methodology followed for the study purpose is as follow:

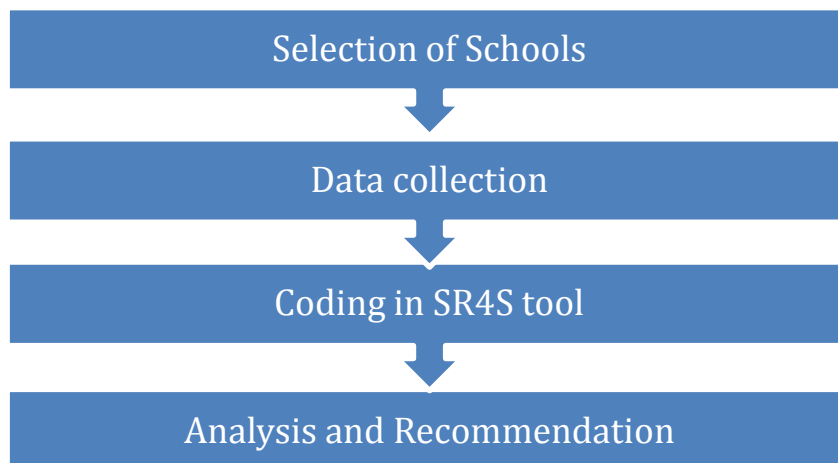


Figure 3. Flowchart for the methodology

5.1 Selection of Schools

Initially, a preliminary desk study was conducted to identify major educational institutions across the Kathmandu Valley. After that, two specific schools—one from the Kathmandu district and one from the Bhaktapur district

were selected based on their variation in geographical location, road infrastructure, and operational traffic characteristics. The final selection includes a varying matrix of study environments, encompassing a semi-urban setting and an urban core. It also represents both public and private institutional types. Furthermore, these sites include varying parameters, including distinct traffic volumes, vehicular operating speeds, varying lane configurations, and contrasting levels of existing pedestrian and roadside safety facilities.

5.2 Data collection

Direct visual assessments were carried out to evaluate fixed qualitative and quantitative road features like longitudinal grade, presence of medians/centerlines, road surface condition, curve types and Pedestrian infrastructures like sidewalk, pedestrian channelization barriers, and designated crossing facilities on main and side roads. Measuring tape was used for measuring the lane and sidewalk width.

Traffic volume and composition were evaluated using the videography method. Continuous video recordings were captured at school front gates during operational hours, and the recorded footage was processed for post fieldwork to classify and count traffic volumes. The peak hour flow was assumed to be 10% of the total traffic volume, following the calculation approach adopted by Khatiwada et al. (2025).

Spot speeds of 100 vehicles traveling in the school zones in both directions of travel were captured under free-flow conditions using Radar Gun. The 85th percentile speed derived from the cumulative frequency distribution curve was taken as the operating speed of the vehicle. Speed limits are observed through posted speed limit signs. In the absence of those signs, 40kmph is used for urban type zones.

5.3 Coding in SR4S tool

These field-observed parameters were subsequently coded into the SR4S tool to calculate the star rating of each School. The training and the coding guidelines provided by the iRAP were followed for the purpose. The SR4S tool uses its own safety algorithm, weightage parameters, and formula to calculate a risk-based score, which is then converted into an easily interpretable 1-to-5-star rating.

5.4 Analysis and Recommendation

Finally obtained ratings were compared to the recommended value. Iterative simulations were performed in the Demonstrator Mode within the SR4S tool for potential upgrades. Upgrades were recommended by considering ease of execution.

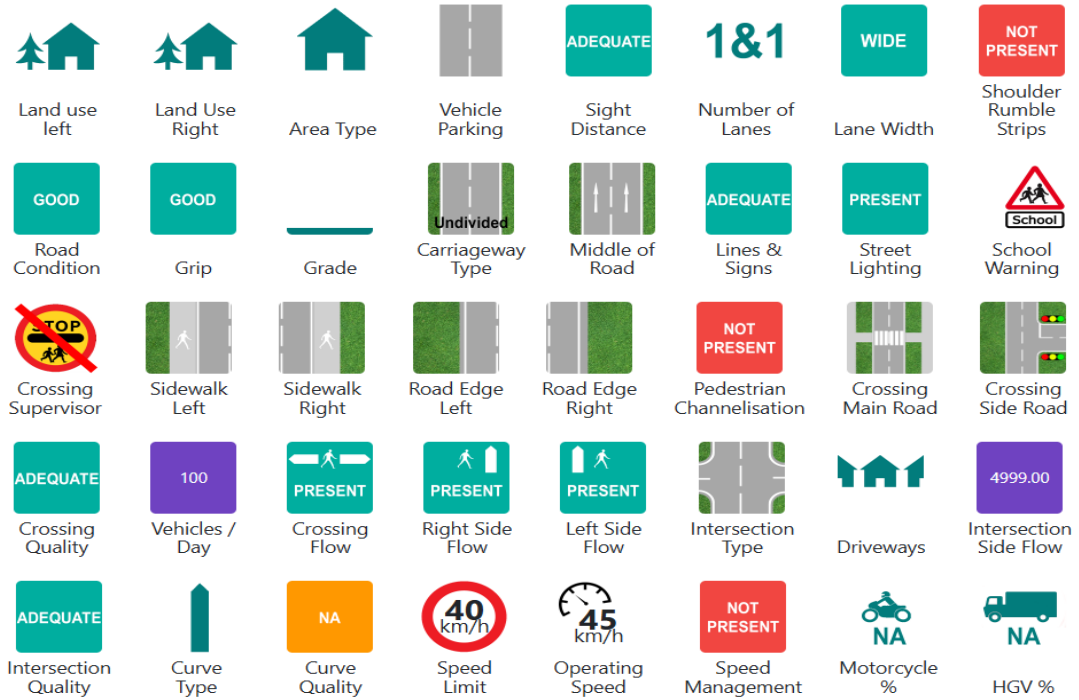


Figure 4. Interface of the SR4S tool including parameters

6. Collected data

6.1 Parameters Recorded during field observation

Physical and operational parameters observed during the March 2025 field assessment are documented as follow:



Figure 5. Surrounding N.K. Singh Memorial EPS School



Figure 6. Surrounding of Aadarsha Secondary School

Table 1. Parameters required for SR4S

Parameters	Aadarsha Secondary School	N.K. Singh Memorial EPS School
Location	Sanothimi, Bhaktapur	Min Bhawan, Baneshwor, Kathmandu
Road Name	Purano Bato	NK Singh Marg
Section	In front of school	In front of School
Land use	left: School, Right: Farming	Left: Commercial Right: School
Area Type	Rural Town	Urban
Vehicle Parking	N/A	present on one side
Sight Distance	Adequate	poor
No. of Lanes	Two in direction of travel	One in direction of travel
Lane Width	wide	Medium
Shoulder Rumble	Not present	Not present
Road Surface Condition	Good	Good
Grip	Good	Good
Grade	$0 \leq \text{Grade} \leq 7.5\%$	$0 \leq \text{Grade} \leq 7.5\%$
Carriageway Type	Not present	Not Present
Median	Centerline Only	Centerline Only
Lines and Sign	Adequate	Adequate
Street Lightning	Present	Present
School Warning	Not present	Not present
School Crossing Supervisor	N/A	Present
Sidewalks	Behind Barrier	0-1m away
Road edge	0 to 1m	0-1m wide
Pedestrian Channelization	Not present	Not present
Crossing on main & side road	Present on main and side road	Not present
Crossing Features	Marked	None
Crossing Quality	Adequate	No crossing
Intersection present	Present	Not present
Intersection Type	3-legged	Not present
Turn Lane	N/A	N/A

Parameters	Aadarsha Secondary School	N.K. Singh Memorial EPS School
Location	Sanothimi, Bhaktapur	Min Bhawan, Baneshwor, Kathmandu
Driveways	Commercial access	Commercial access
Intersection quality	Poor	N/A
Curve	No Curve	Present
Curve Type	Straight	Moderate
Curve Quality	No curve	Poor
Speed Limit	40 kmph	40 kmph
Operating Speed	50 kmph	30 kmph
Speed Management	Not present	Not present
Vehicle per Day	42270	5230
Motorcycle %	61-80%	81-99%
Heavy vehicle %	0-5%	0-5%
No of students	1500	2000

6.2 Traffic volume and Speed Observation

Table 2. shows the traffic volume and operating speed of the vehicle in each School.



Table 2. Traffic volume and speed of each School

S.N.	Name of School	Total Flow (vehicle/day)	Intersecting flow (vehicle/day)	Operating speed (kmph)
1.	Adarsha Secondary School	42270	13600	50
2.	N.K Singh School	5230	NA	32

7. Result and Discussion

Following the initial field assessment and subsequent data coding in the SR4S application, the star ratings for each school were generated.

Table 3. Calculation of Star rating

S.N.	Name of School	Star Rating	Decimal Score	Significance
1.	Adarsha Secondary School		1	Very Low Safety
2.	N.K Singh School		1.5	Very Low Safety

The application of the SR4S tool revealed a severe safety vulnerability with both schools failing to achieve the minimum international 3-star safety benchmark. Aadarsha Secondary School achieved a baseline score of 1.0 Star, indicating a state of "Very Low Safety." While the school zone features a basic marked crosswalk and a sidewalk situated behind a barrier, its rating was severely depressed by a massive daily traffic burden of 42,270 vehicles, an intersecting lane volume of 13,600 vehicles, and an operating speed of 50 kmph that vastly exceeds the designated 40 kmph urban limit.

Conversely, N.K. Singh Memorial EPS School generated a baseline rating of 1.5 Stars, also classifying it as highly unsafe. Although it benefits from lower general traffic exposure (5,230 vehicles/day) and an active school crossing supervisor, it lacks any physical marked crosswalk infrastructure. Furthermore, its sidewalk is flushed with the traffic flow (0–1 meter away) without any structural separation, and its risk profile is heavily compounded by a moderate curve configuration and poor sight distance.

After the simulation of the potential upgrades, following changes were seen on both schools:

Table 4. Potential upgrades in each school

Upgrades in Aadarsha Sec. School	Change in Rating	Upgrades in N.K. Singh E.P.S School	Change in Rating
1. Inclusion of School sign	No Change.	1. Speed limit to 30 kmph	1.5 to 1.9
2. Inclusion of Crossing Supervisor	No Change.	2. No Vehicle parking	1.9 to 2.3
3. Intersection quality improvement	No Change.	3. Inclusion of Warning Sign	2.3 to 2.4
4. Operating speed within 40 kmph	1 to 1.7	4. Curve quality enhancement	2.4 to 2.6
		5. Improvement in line and signs	2.6 to 2.8

At Aadarsha Secondary School, minor geometric and infrastructural changes like inclusion of a school sign, the addition of a crossing supervisor, and intersection quality improvements resulted in "No Change" to the numerical safety rating. This lack of responsiveness indicates that in high-speed, high-volume environments, standalone warning signs or minor changes are structurally insufficient to overcome the risks. Conversely, a little

improvement (1 to 1.7) was achieved only after changing the operating speed. This proves that speed management is the critical gatekeeper for high-flow corridors as in Aadarsha Secondary School.

In contrast, E.P.S. School exhibited a highly incremental step-by-step response from 1.5 to 2.8-star rating due to combination of upgrades like Lowering the speed limit, prohibiting vehicle parking on either side of the roadway, addition of School warning signs and enhancement of curve quality, and road markings. This stepwise progression demonstrates that in highly congested, single-lane commercial urban cores, safety is compromised by localized parameters. However, neither of the schools could have an improved rating of 3 from scenario-based interventions only.

8. Conclusion

The study revealed a significant road safety deficiency around Aadarsha Secondary School and N.K. Singh School, with both Schools failing to achieve the internationally recommended 3-star safety benchmark. The obtained star ratings of 1.0 and 1.5 indicate very low safety conditions. It is majorly due to high vehicle speeds, heavy traffic volumes, and inadequate pedestrian facilities. The findings demonstrate that general safety measures, such as school signs, markings, etc. are insufficient to protect vulnerable road users in the complex traffic environment of Kathmandu Valley.

Scenario-based analyses showed that targeted engineering interventions can improve safety performance, but their effectiveness varies depending on road characteristics and traffic conditions.

The results also revealed that scenario-based interventions alone are unable to overcome high volume and speed exposure. Achieving the 3-star benchmark requires more comprehensive infrastructure investments and stronger traffic management measures. Overall, the study highlights the use of SR4S as a practical, data-driven tool for identifying risks, prioritizing the schools and interventions for safer and more sustainable school zones in Kathmandu Valley.

9. Limitations

This study was limited to two schools, which do not fully represent the Kathmandu Valley. A larger number of schools should be assessed across different urban and rural settings to have more generalized findings. The SR4S demonstrator was used for the evaluation of the upgrades rather than the actual implementation, and the study did not incorporate detailed crash records, long-term traffic variations, or road users' behavior.

The general scenario-based interventions could not increase the rating to the safe limit. For Aadarsha Secondary School, study of the infrastructural upgrade like Pedestrian Crossing Bridge and its impact on safety should be studied.

Even if there's a drastic increment of ratings in EPS School from general upgrades, it's still below the safe status. Other infrastructural improvements like road expansion, Sidewalk enhancement, etc. should be studied.

10. Disclaimer

The views expressed in this research article are of authors' personal views and not those of their affiliated institutions.

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