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Development of Bicycle Safety Index Models for Safety of Bicycle Flow at 3-Legged Junctions on Urban Roads under Mixed Traffic Conditions

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Abstract

In Urban areas of developing countries like India, there have been a rapid increase in the bicycle volumes and traffic-bicycle conflicts during the last few decades. To enhance bicycle safety under mixed traffic conditions, there is a need to improve the bicycle facilities on the urban roads at un-signalized 3-legged junctions. The present study aims to develop bicycle safety index models using variables like bicycle volumes, bicycle speed (km/min), bicycle markings and Bicycle safety ratings. The data was collected at locations of different 3-legged junctions in the central business district area of Srinagar City in India.. At these selected locations, bicycle volume count and bicycle average speeds (km/hr) were observed during peak hours. Bicycle flows were categorized based on different age groups, gender, bicycle speed and direction. The bicycle safety index models were calibrated and validated using the collected data. The model results confirm estimation of correct bicycle safety levels at un-signalized 3-legged junctions. The study will also be helpful to improve the existing bicycle facilities, bicycle flows (bikes/hour) and also, to provide bicycle safety measures at un-signalized 3-legged junctions on urban roads in mixed traffic environment.

Peer-review under responsibility of WORLD CONFERENCE ON TRANSPORT RESEARCH SOCIETY.

Keywords: Bicycle safety index model, Bicycle flows, Bicycle speed, Bicycle safety ratings

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1. Introduction

In Urban areas of developing countries like India, there have been a rapid increase in the bicycle volumes and traffic-bicycle conflicts during the last few decades. To enhance bicycle safety under mixed traffic conditions, there is a need to improve the bicycle facilities on the urban roads at un-signalized 3-legged junctions. The present study aims to develop bicycle safety index models using variables like bicycle volumes, bicycle speed (km/hr), bicycle markings and bicycle safety ratings for safety of bicycle flow at 3-leggedjunctions on urban roads under mixed traffic conditions. The behaviour of bicyclists at the day time condition of bicycle flow is also studied at these junctions. The data was collected at locations of different 3-legged junctions in the central business district area of Srinagar City in India.. At these selected locations, bicycle volume count and bicycle average speeds (km/hr) were observed during peak hours. Bicycle flows were categorized based on different age groups, gender, bicycle speed and direction. The bicycle safety index models were calibrated and validated using the collected data.

2. Literature Review

The Bicycle Intersection Safety Index (Bike ISI) was proposed by Carter et al. (2007) which considered only un-signalized intersections and did not focus on the street segment. proposed A model for evaluation of on-street bicycle facilities was also developed by Hallett et al. (2006).Many government agencies are working to enhance the safety of cycling so as to reduce the significant burden on health from bicycle accidents (European Commission, 2010) and to motivate people for cycling for the lack of safety is a deterrent to cycling (Horton et al., 2007; Fishman et al., 2012). The latter is vital because daily regular exercise by cycling has significant health benefits, e.g. Dutch people have half-a-year-longer life expectancy due to cycling (Fishman et al., 2015). It is therefore an important consideration that how cycling safety can be improved. This workhas focused on Netherlands which, together with Denmark, has the lowest fatality rate for cyclists (Pucher and Buehler, 2008a). The paper describes the high level of cycling safety in Netherlands.

Video techniques, direct observation and questionnaires are the commonly used methods for collection of data. Simulations, regression analyses and point systems are used commonly to evaluate Bicycle Level of Service (BLOS) models (Asadi-Shekari et al., 2013a). Dixon (1996) employed a point system to determine the BLOS, which is helpful for rating street conditions for cyclists. The weights of various variables are chosenarbitrarily in Dixon’s model, and there are no different score categories for various conditions (Asadi-Shekari et al., 2013 a) and b). A point system is simple to evaluate and interpret for a street valuator and can include many indicators. This system can be further developed and improvised to fulfil the objectives of new studies by avoiding bias and connect with the process of design (Asadi-Shekari and Zaly Shah, 2011; Asadi-Shekari et al., 2014; Moeinaddini et al., 2013).

To facilitate a safe network for cyclists, there is an urge to have practical tools for street evaluation (Asadi-Shekari et al., 2013a). Bicycle Level of Service (BLOS) models can be employed to assess the level of service experienced by a bicyclist on a street (Petritsch et al. 2007). Davis (1987 and 1995) developed a Bicycle Safety Index Rating (BSIR) is one of the primary systematic attempts to propose bicycle safety models (Cheryl, 2003). In the BSIR model, some important factors such as the slope and marking had not been considered. Sorton and Walsh (1994) proposed that levels of stress were a function of three important factors including peak hour traffic volume, curb lane width and speed limit. This model further did not consider some essential facilities and infrastructure such as pavement and bike lane conditions. Landis et al. (1997) suggested thatpavement surface conditions and bicycle lane striping are important variables in the quality of service. They also did not include various bicycle facilities and furniture such as signals and slope. Harkey et al. (1998) gave the Bicycle Compatibility Index (BCI) in which the pavement condition is not to be considered as a significant factor to ensure safe cycling. Landis et al. (2003) proposed a tool to estimate the perceived hazard for bicyclists riding through an intersection in which no control for the absence or presence of a bicycle lane was considered (Krizek).

3. Study Methodology

The present study aims to develop bicycle safety index models using variables like bicycle volumes, bicycle speed (km/hr), bicycle markings and bicycle safety ratings. The data was collected at un-signalized 3-legged junctions in the CBD area of the city where high bicycle flow was observed in day time. At these selected locations, bicycle volume count and bicycle average speeds (km/hr) were observed during peak hours. Bicycle flows were categorized based on different age groups and gender. Flows are categorized based on bicycle speed and direction. The study methodology is presented as a flow chart shown in Figure 1.

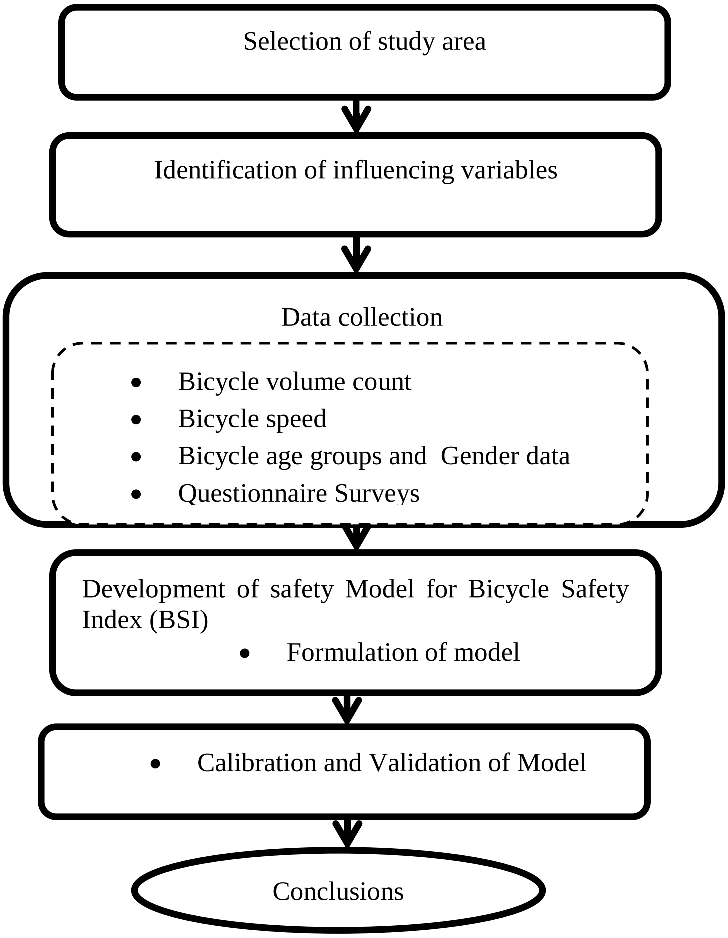

Figure 1. Flow Chart showing the study methodology.

4. Selection of Study Area and Sites

The selected locations of high bicycle flow and location of junctions along with the relevant codes for these locations are given in Table 1.

Table1.Thedetails of study locations

Code	Location Name	Type of junction
L-N	Nishat garden	3-legged Un-signalizedjunctions
L-KU	Kashmir university	3-legged Un-signalizedjunctions
L-NIT	NIT gate	3-legged Un-signalizedjunctions

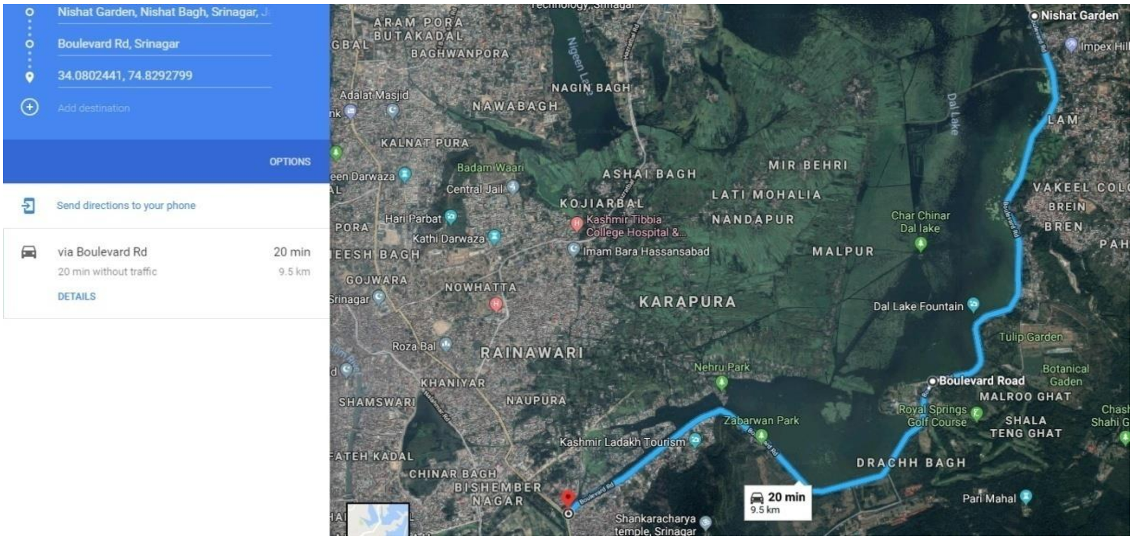

Figure 2. Boulevard road stretch (length of 9.5 km).
(Source: Google Earth)

Figure 3. Un-signalized junctions at Nishat Garden.

Figure 4. Street view of Kashmir University (Source: Google Earth).

Figure 5. Un-signalized 3-legged junctions and 3D Street view of Kashmir University.
(Source: Google Earth)

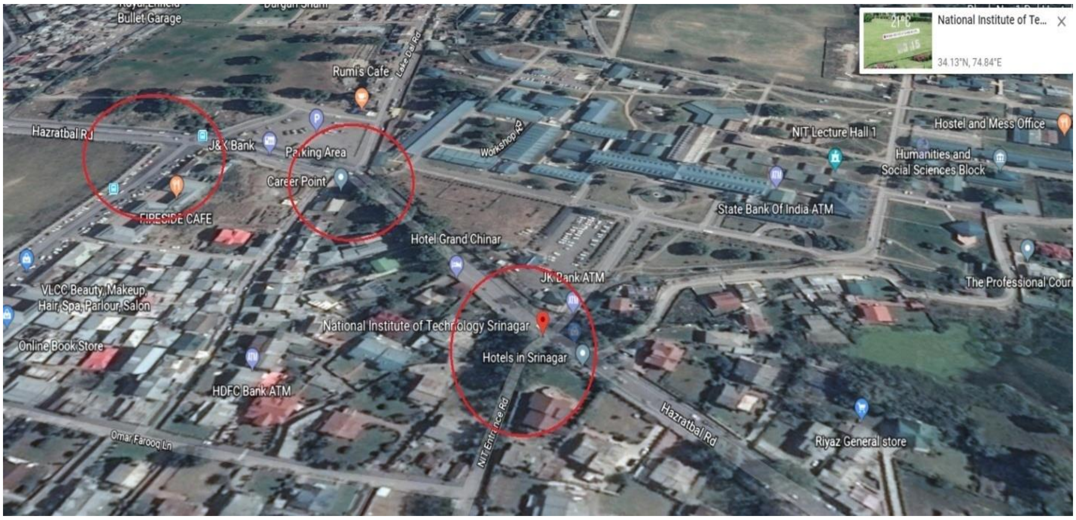

Figure 6.Un-signalized junctions and 3D Street view of NIT Srinagar Gate.
(Source: Google Earth)

5. Data Collection

5.1 Questionnaire survey

The questionnaire used in survey are given in Appendix at the end.

Location name: NIT Srinagar gate junction

The details of data collected at NIT Srinagar gate junction along with the flow directions for bicyclists of different age groups and gender are given in Table 2.

Table 2. The details of data collected at NIT Srinagar gate junction.

Location	Flow directions	Male	Female	children	Old people
Collected samples	Ku- nit Nit-Ku	120 100	66 53	51 45	58 60
Gender	Classified bicycle	male	Female	children	Old people
Total	both	220	119	96	118

Location name: Kashmir University junction

The details of data collected at Kashmir University junction along with the flow directions for bicyclists of different age groups and gender are given in Table 3.

Table 3. The details of data collected at Kashmir university junction.

Location	Flow directions	male	Female	children	Old people
Collected samples	Ku- Lb Lb-Ku	90 103	86 53	71 65	83 70
Gender	Classified bicycle	male	Female	children	Old people
Total	both	193	139	136	153

Note: Ku = Kashmir university, Lb = Lalbazar road

Location name: NishatGarden Road junction

The details of data collected at Nishat Garden Road junction along with the flow directions for bicyclists of different age groups and gender are given in Table 4.

Table 4. The details of Data Collected atNishatGarden Road junction.

Location	Flow directions	male	Female	children	Old people
Collected samples	Nishat-BR BR-Nishat	82 43	66 54	51 65	74 56
Gender	Classified bicycle	Male	Female	children	Old people
Total	both	126	120	116	130

Where BR – Boulevard Road

5.2 Bicycle Volume Data Collection

Location one: Nishat Garden Road junction

The bicycle volume data collected at Un-signalized 3-legged Nishat Garden Road junction on different week days is given in Table 5.

Table 5. The details of Bicycle volume count data collected at Nishat Garden Road junction.

S.No	Name of Day (weekly data)	Bicycle volume count (bike/hr)
1	Monday	100
2	Tuesday	78
3	Wednesday	61
4	Thursday	74
5	Friday	68
6	Saturday	149
7	Sunday	334
	Weekly average bicycle flow	123
	Total	864

Location two: Kashmir University junction

The bicycle volume data collected at Un-signalized 3-legged Kashmir University Road junction on different week days is given in Table 6.

Table 6.The details of Bicycle volume count data collected at Kashmir university road junction .

S.No	Name of Day (weekly data)	Bicycle volume count (bike/hr)
1	Monday	85
2	Tuesday	72
3	Wednesday	58
4	Thursday	60
5	Friday	65
6	Saturday	109
7	Sunday	234
	Average bicycle flow	98
	Total	683

Location three: NITSrinagarGate junction

The bicycle volume data collected at Un-signalized 3-legged NIT Srinagar Road junction on different week days is given in Table 7.

Table 7. The details of Bicycle volume count data collected at Kashmir University Road junction.

S.No	Name of Day (weekly data)	Bicycle volume count (bike/hr)
1	Monday	105
2	Tuesday	68
3	Wednesday	65
4	Thursday	54
5	Friday	149
6	Saturday	123
7	Sunday	194
	Average bicycle flow	108
	Total	754

Table 8. Bicycle flow, time of survey, date of survey and Information of selected sites.

Bicycle flow Identify location	Time of survey	Bicycleflow (bike/hour)	Bicycle c/m length(m) Yes-1 No-0	Presences of bicycle crossing marking	Bicycle Proper waiting area	Date of survey
L-N	5:00 to 6:00pm	125	No-0	No- 0	Yes	28/04/18
L-NG	5:00 to 6:00pm	100	No-0	No-0	Yes	30/04/18
L-KU	5:00 to 6:00pm	110	No-0	No- 0	Yes	01/05/18

Table 9. Bicycle flow, time of survey, date of survey and Information of selected sites.

Bicycle flow Identify location	Time of survey	Bicycle flow (bike/hour)	Bicycle c/m length(m) Yes-1 No-0	Presences of bicycle crossing marking	Proper waiting area	Date of survey
L-N	6:00 to 7:00 am	85	No-0	No- 0	Yes	28/04/18
L-NG	6:00 to 7:00 am	102	No-0	No- 0	Yes	30/04/18
L-KU	6:00 to 7:00 am	120	No-0	No- 0	Yes	01/05/18

Table 10. Bicycle flow, time of survey, date of survey and Information of selected sites.

Bicycle flow Identify location	Time of survey	Bicycle flow (bike/hour)	Bicycle c/m length(m) Yes-1 No-0	Presences of bicycle crossing marking	Proper waiting area	Date of survey
L-N	8:00 to 9:00 am	135	No-0	No- 0	Yes	28/04/18
L-NG	8:00 to 9:00 am	126	No-0	No- 0	Yes	30/04/18
L-KU	8:00 to 9:00 am	115	No-0	No- 0	Yes	01/05/18

Table 11. Average bicycle volume (bike/weekly) and Average bicycle speed (km/hr).

S.No	Location name	Average bicycle volume for weekly (bike/weekly)	Average bicycle speed(km/hr)
1	L-KU = Kashmir university	683	15.5
2	L-N= Nishat garden	864	15.4
3	L-NG= NIT Gate	754	15.2
	Average of all the locations	767	15.3

6. Development of safety model for Bicycle safety Index (BSI)

Multiple linear regressions technique was adopted to decide if a multiple linear relationship might occur that can calculate the mean rating obtained for each respondent in the field survey (questionnaire). The general frame work of the multiple linear regression is given below.

$$Y = \beta_o + \beta_1 x_1 + \beta_2 x_2 + \ldots\ldots\ldots\ldots + \beta_n x_n \text{.................. equation (1)}$$

Where, Y = dependent variable, $X_{1\text{-}n}$ = explanatory variables, $\beta_{1\text{-}n}$ = estimated parameters from model, β_o= constant

6.1 Formulation of BSI model

Variable code	Variable description
BSSI $_{Score}$ =Y=	bicycle safety index score through questionnaire survey (rating 1 to 5), (code; 1 = Highly safe, 2 = Safe , 3 = Average, 4 = Risk, 5 = High risk)
ABPM = X_1=	Availability or presences of bicycle pavement marking facilities (yes =1; No =0)
BPWA =X_2=	Bicycle proper waiting area (pavement marking box /coloured area for bicyclists to pull in front of waiting traffic and the coloured box is reduce car- bike conflicts at junctions) (code; yes =1; No =0)
PBL =X_3=	Presence of bicycle lanes (code; yes =1; No =0)

BRS = X_4=	Availability of bicycle rental schemes (awareness of bicycle rental schemes programme for implementing to lower income people to encourage use of cycling mode and improving the physical activity of peoples)
ABPS = X_5=	Availability of bicycle parking station, (code; yes =1; No =0)
ABV = X_6 =	Average bicycle volume (bike/hr)

6.2 Calibration and Validation of BSI Model

By using the identified data collected for various variables, the model was calibrated and the results obtained are shown in Tables 12-15.

Table 12. Analysis of Variance results.

	DF	SS	MS	F	P
Regression	6	41.379	6.897	11.111	0.0226
Residual	1	0.621	0.621	0.000	0.0000
Total	7	42.000	6.00	0.000	0.0000

Table 13. The details of variables and SSIncr and SSIncr values.

variables	SSIncr	SSIncr
ABPM	10.800	27.270
PBL	5.486	0.149
BPWA	0.114	2.000
ABPS	9.600	7.906
BRS	12.000	4.832
ABV	3.379	3.379

The dependent variable BSSI can be predicted from a linear combination of the independent variables:

Table 14. The details of variablesandp –values.

Variables	P value
ABPM	0.095
PBL	0.071
BPWA	0.032
ABPS	0.017
BRS	0.021
ABV	0.025

The following appear to account for the ability to predict BSSI ($P < 0.05$):

Normality Test (Shapiro-Wilk) Passed ($P = 0.045$)

Constant Variance Test: Passed ($P = 0.0619$)

Power of performed test with alpha = 0.050: 1.000

Table 15. Multiple Linear Regression Results for BSI Model.

Variables	Model estimate	Coefficients	Standard error	t value	P value	VIF
Constant	β_o	19.738	4.063	4.858	0.0012	0.00
ABPM	β_1	-9.276	1.399	-6.628	0.0095	5.916
PBL	β_2	0.483	0.987	0.489	0.0071	3.138
BPWA	β_3	2.000	1.114	1.795	0.0324	1.750
ABPS	β_4	-4.552	1.275	-3.569	0.0174	4.914
BRS	β_5	-4.310	1.545	-2.790	0.0219	7.209
ABV	β6	-0.0966	0.0414	-2.333	0.0258	2.069

a. Dependent variable: BSSI

From Table 15, it can be seen that the calculated t value and p value should be effect on the positive and negative influence of the model.This represents that the model variables are significant at 98.5% confidence interval.

6.3Bicycle Safety Index (BSI) model results

The primary structure of the bicycle safety score index model is expressed in the following mathematical expression,

$$BSSI_{Score} = 19.738 - (9.276 * ABPM) + (0.483 * PBL) + (2.000 * BPWA) - (4.552 * ABPS) - (4.310 * BRS) - (0.0966 * ABV)$$

After calculating BSSI Score and OBSI score for a given selected locations and particular timing of a bicycle flow at day time condition (5 to 9 am).

$$BSSI_{Score\ (L\text{-}N)} = 11.904$$

$$\text{Similarly}\quad BSSI_{Score\ (L\text{-}NG)} = 13.068$$

$$\text{Similarly}\quad BSSI_{Score\ (L\text{-}KU)} = 11.1328$$

$$\sum BSSI_{Score} = BSSI_{Score\ (L\text{-}N)} + BSSI_{Score\ (L\text{-}NG)} + BSSI_{Score\ (L\text{-}KU)}$$

$$\sum Ave\ BSSI_{Score} = 12.0356$$

$$OBSI_{Score} = (\sum Average\ BSSI_{Score}) / \text{Number of selected locations (N)}$$

$$OBSI_{mean\ Score} = 12.0356 / 3 = 4.016$$

$$OBSI_{mean\ score} = 4.016$$

From table.19 as per rating analysis, we infer that the given selected locations fall under risky to high risky conditions. BSSI $_{Score}$ = Y= bicycle safety score index through questionnaire survey (rating 1 to 5), X_1 = ABPM = Availability or presences of bicycle pavement marking facilities, X_2 = PBL = Presence of bicycle lanes, X_3 = BPWA = bicycle proper waiting area (pavement marking box /coloured area for bicyclists to pull in front of waiting traffic and the coloured box is reduce car- bike conflicts at junctions), X_4 = ABPS =Availability of bicycle parking station, X_5 = Availability of bicycle rental schemes,(awareness of bicycle rental schemes programme for implementing to lower income people to encourage use of cycling mode and improving the physical activity of peoples); X_6 = Average bicycle volume, OBSI = overall bicycle safety score index,BSSI $_{Score\ (L\text{-}N)}$,BSSI $_{Score\ (L\text{-}NG)}$ and BSSI $_{Score\ (L\text{-}KU)}$ = bicycle safety score index for nishat garden, NIT gate and Kashmir university.The stepwise regression technique was performed in sigma plot 13.0 At 98.5 % confidence interval and the results are shown in Table 16. The R^2 value for proposed model is 0.985 ($R^2$of 0.985 indicates that the regression line perfectly fits the data), which specifies that 98.5 % of the variation in the predicted, dependent variable has been explained by explanatory variables and this denotes the perfect accuracy level of the proposed model prediction.

7. Safety model for Bicycle safety Index (BSI)

The Bike ISI model consists of three equations that determine the safety index score for a single bicycle crossing. The model is presented in Table 16 below. A detailed description of the variables follows the Table 16.

Bike ISI models and variable descriptions are given below:

Equation (1):Through bike ISI=

1.13+0.019MAINADT+0.815MAINHISPD+0.650TURNVEH+0.470(RTLANES*BL)+ 0.023(CROSSADT*NOBL)+0.48(SIGNAL*NOBL)+0.200 PARKING

Equation (2):Right turn bike ISI=

1.02+0.027MAINADT+0.519RTCCROSS+0.200PARKING

Equation (3): Left turn bike ISI= Bike ISI = 1.100 + 0.025MAINADT + 0.836BL +0.485SIGNAL + 0.736(MAINHISPD*BL)+0.380(LTCROSS*NOBL) +0.200PARKING

Figure 7. The different kinds of equations for bicycle safety at day time condition.

Table 16. Bike ISI models and variable descriptions are given below.

BikeISI	Safety index values (through, right, left*)*	Variable Description (Rating)
BL	Bike lane presence	0 = none or wide curb lane (WCL) 1 = bike lane (BL) or bike lane crossover (BLX)
CROSSADT	Cross street traffic volume	ADT in thousands
CROSSLNS	Number of through lanes on cross street	1, 2, …
LTCROSS	Number of traffic lanes for cyclists to cross to make a left turn	0, 1, 2, …
MAINADT	Main street traffic volume	ADT in thousands
MAINHISPD	Main street speed limit ≥ 56.3 km/h (35 mi/h)	0 = no 1 = yes
NOBL	No bike lane present	0 = BL or BLX 1 = none or WCL
PARKING	On-street parking on main street approach	0 = no 1 = yes
RTCROSS	Number of traffic lanes for cyclists to cross to make a right turn	0, 1, 2, …
RTLANES	Number of right turn traffic lanes on main street approach	0, 1
SIGNAL	Traffic signal at intersection	0 = no 1 = yes
TURNVEH	Presence of turning vehicle traffic across the path of through cyclists	0 = no 1 = yes

Source: The Federal Highway Administration (FHWA),April 2017 (pedestrian and bicycle safety indices)

7.1 Model data for bicycle safety index at Nishat garden road

The data was collected from different Un-signalized 3-legged junctions in CBD area under mixed traffic conditions. The selected variables and variable description list is given below table 17.

Table 17. Bike ISI model results and variable descriptions.

Bike ISI	Safety index values (through, right, left)	Variable description (Rating)
BL	0 = none	0 = none or wide curb lane (WCL) 1 = bike lane (BL) or bike lane crossover (BLX)
CROSSADT	10012	ADT in thousands
CROSSLNS	2	1, 2, …
LTCROSS	1	0, 1, 2, …
MAINADT	14342	ADT in thousands
MAINHISPD	35 to 50kmph	0 = no 1 = yes
NOBL	0	0 = BL or BLX

		1 = none or WCL
PARKING	0	0 = no 1 = yes
RTCROSS	1	0, 1, 2, …
RTLANES	1	0, 1
SIGNAL	0	0 = no 1 = yes
TURNVEH	1	0 = no 1 = yes

7.2 Results for bicycle Safety Index Model at Nishat garden road

The model results are given below from equation (1), equation (2) and equation (3) for the selected locations.

Equation (1):Through bike ISI=

1.13+0.019MAINADT+0.815MAINHISPD+0.650TURNVEH+0.470(RTLANES*BL)+0.023(CROSSADT*NOBL)+0.48(SIGNAL*NOBL)+0.200 PARKING

Bike ISI = 1.13+ 0.019 (14342) + 0.815 (50)+ 0.65(1)+ 0.47 (1)(0) +0.023(0* 10112)+0.48(0*0)+ 0.200(0)

Through bike ISI $_{score}$ = 314.91 (approximately 315)

Equation (2): Right turn bike ISI=

1.02+0.027MAINADT+0.519RTCCROSS+0.200PARKING

Right turn bike ISI: 1.02+ 0.027(14342) +0.519(1)+0.200(0)

Right turn bike ISI $_{score}$ = 387.753 (approximately 388)

Equation (3): Left turn bike ISI = Bike ISI = 1.100 + 0.025MAINADT + 0.836BL +0.485SIGNAL +

0.736(MAINHISPD*BL)+0.380(LTCROSS*NOBL) +0.200PARKING

Left turn bike ISI = 1.100+ 0.025 (14342) +0.836(0) +0.485(0)+0.736(50*0)+0.200(0)

Left turn bike ISI$_{Score}$ = 359.65 (approximately 360)

7.3 Overall bicycle safety index (OBSI) for the three selected locations were given below

The final results for the three types of turns are given below:

$$\sum \text{Overall bicycle safety index}_{score} = \text{Through bike ISI}_{score} + \text{Right turn bike ISI}_{score} + \text{LeftturnbikeISI}_{Score}$$

$$\sum \text{OBSI}_{Score} = \text{T bike ISI}_{Score} + \text{RT bike ISI}_{Score} + \text{LT bike ISI}_{Score}$$

$$\sum \text{OBSI}_{Average\ Score} / N = (315 + 360 + 388) / 3 = 354.666$$

$$\text{OBSI}_{Score} = 355 \text{ (approximately)}$$

Overall bicycle safety score index (OBSI) for three selected locations in the CBD Area.

Table 18. The details of location OBSI score and description.

S. NO	Location	$\sum OBSI_{Score}$	Score/ Rating	Description
1	Nishatgarden	355	3 to 4	Average to Risk condition
2	Kashmir university	342	3 to 4	Average to Risk condition
3	NIT gate	310	3 to 4	Average to Risk condition
	All three locations	$\sum OBSI_{Average\ Score} = 336$	3 to 4	Average to Risk condition

Note: $\sum OBSI_{Score} = \sum$ Overall bicycle safety score index

N = Number of locations / Average of all the locations

8. Conclusions

In urban areas of developing countries like India, there is a lack of cycling safety facilities at Un-signalized 3-legged junctions in CBD area under mixed traffic conditions where the bicycle flow has increased tremendously in the last few decades.The final conclusion according to the codal safety rating level in terms of bicycle safety score index and safety index model is given in thetable 19.

Table 19. The details of safety level ratings.

BSI Rating (Score)	Description
1=100	Highly safe
2=200	Safe
3=300	Average
4=400	Risk
5=500	High risk

According to the BSI rating from above table and bike ISI calculation, Srinagar city comes under 3 equal to Average and 4 equal to Risky, the results of which are shown below using sensitivity analysis for easier comprehension. In Srinagar city of India, the availability of bicycle facilities as per Srinagar Development Authority is 2 to 6 % so there is a lack of bicycle safety facilities at Un-signalized 3-legged junctions on urban roads. Thus, in future there is a scope to study night time travel of bicycle flow on urban roads under mixed traffic conditions and to improve cycle safety conditions at various 3-legged junctions in the city under mixed traffic conditions.

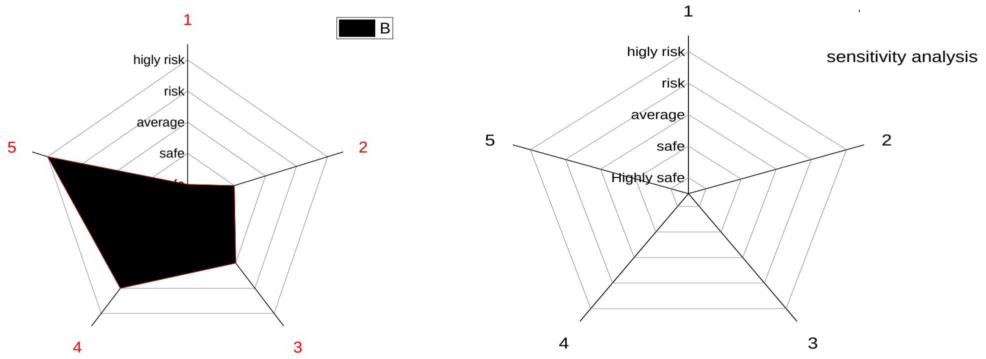

Figure 8. The details of safety ratings & using sensitivity analysis for BSI.

Note: Rating 1= highly safe, Rating 2 = Safe, Rating 3 =average , Rating 4 = risk , Rating 5 = high risk

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Appendix

Sample of questions in Questionnaire Survey format.

Q1.Do you own or have access to bicycle?
(a) Yes (b) no
Q2. For which of the following reasons you have ridden bicycle for transport?
(a) To get to work (b) to get to school/college (c) running errands/going to shops
(c) For exercise (d) for recreational activities (f) for environmental reasons
Q3. Majority of your bicycle trips are for (purpose)?
(a) Work (b) errands (shopping) (c) recreational (d) education
Similarly
Q4.What is the surface condition of roads?
Q5.Is there any traffic signs and traffic signals available for bicyclists?
Q6.Is there any lighting facility available during nights?
Q7.Is there any bicycle lanes available?
Q8.Is there any bicycle parking facility available where you work or study?
Q9. During snowy condition what causes more trouble riding bicycle?
Q10. How comfortable or safe you feel while riding bicycle?
Q11.While riding do you prefer to wear safety kit?
Q12.Other than bicycle infrastructure facilities what prevents you from biking?
Q13.Would the improvements in bicycle infrastructure influence you to bike more often in future?
Q14. Which of the following, if any, discourage you from riding a bicycle for transport more often?

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