Proceedings of 8th IOE Graduate Conference
Peer Reviewed
ISSN: 2350-8914 (Online), 2350-8906 (Print)
Year: 2020 Month: June Volume: 8

Assessing Safety Level of Bus Stops A Case Study of Kathmandu Ring Road (Kalanki - Koteshwor Section)

Sunita Pandey [a], Saroj Acharya [b]

[a, b] *Department of Civil Engineering, Pulchowk Campus, IOE, TU, Nepal*
Corresponding Email: [a] sunitapandey.tm@gmail.com [b] ssaroj.ach@gmail.com

Abstract
Bus stop is the point of interaction among passengers and bus. A bus stop is a designated place where buses stop for passengers to board or leave a bus. Road safety is a major concern in emerging countries such as Nepal and bus stops are the major points of concern as they act as interfaces where the pedestrians interact with vehicles. However, it is a challenge to evaluate bus stop safety in the context of developing countries as reliable crash data near bus stops are generally unavailable. The safety level of five existing bus stops located along a ring road section (Kalanki – Koteshwor) in the Kathmandu and Lalitpur Metropolitan city, Nepal were evaluated in this study. The unsafe acts were identified and causal factors for those unsafe acts were identified. The weightage of each causal factor of each unsafe act was calculated as product of degree of danger of unsafe act and the contribution factor of causal factor. Degree of danger of unsafe act was determined by Analytical Hierarchal Process and contribution factor for unsafe act was determined through expert scoring survey. The study showed that Kalanki, Gwarko and Satdobato Bus stops are unsafe. Similarly Dhobighat and Balkhu bus stops found to be relatively safer. The result was validated using the actual crash data near those bus stops from traffic police. The comparison between the safety level value determined from this methodology and the actual crash data shows a fair correlation between each other.

Keywords
Bus Stop, Safety Level, Bus Stop, Prioritization, Design Deficiency, Management Deficiency, Emerging Countries

1. Introduction

Bus stops are the interface where buses stop for passengers to get on and off the bus. Bus stops should provide required facilities for safe boarding and safe alighting of passengers. The size and nature of a bus stop may vary from a bus stop with no facilities for passengers to a highly facilitated bus stop offering a wide range of facilities. And the level of safety offered by them also vary from most hazardous to very safer bus stops. Bus stop layout should enable easier, safer and smooth flow of bus and passengers. Safety in and around bus stop is very important but is neglected in context of Nepal.

Many of the bus stops do not have proper facilities which include these components. Improper management (i.e. lack of maintenance and enforcement) which results in physical obstructions in the bus stops are the major issues of concern. It is observed that these deficiencies in and around bus stops lead to violations, such as encroachment of bus user into the roadway while accessing and waiting for the bus, crossing the road at undesirable locations, loading/unloading of passengers at multiple points on the roadway, etc. Then it leads to the vehicle-pedestrian conflicts and ultimately to crashes. Some cases are minor and casualties have no any injury. While, in some cases level of severity of crash is very high causing many deaths. So, it is very important to improve the safety standards at the bus stops.

2. Research Objectives

The main objective of this research is to assess the safety level of the bus stop and prioritize bus stops regarding their need for safety improvements. The specific objectives of this research are:

- To identify unsafe acts which leads to crashes

along with their degree of danger
- To identify casual factors which contribute to unsafe acts along with their contribution index
- To find out the safety level of each bus stop in study area

3. Literature Review

3.1 Introduction

Road safety has emerged as a global concern, and bus stops are the major points of concern as they act as interfaces where pedestrians interact with transit vehicles. The bus stop must be acknowledged as a part of the overall transit environment. Factors such as the location ,design , maintenance, and general appearance of bus stops affect the public perception and safety and security of bus stops. In order to achieve a safe and sustainable infrastructure at bus stops, it is necessary to assess safety level of bus stops and suggest safety improvement measures.

Several researchers have worked on study on safety level of bus. Pulugurtha and Vanapalli [1] developed a GIS based methodology to assist decision makers in identifying and ranking bus stops in high auto pedestrian collision concentration area. High – collision bus stops are identified by overlaying the bus stop coverage and collision concentration map. Hazaymeh [2] also performed a similar study to enhance public transportation service in an identified area by determining bus stops that may cause risk for pedestrians or vehicles. It also describes a step-by-step approach for validation of bus stop safety using the geoprocessing tools available with ArcGIS 9.2. Truong and Somenahalli [3] developed a GIS approach based on analysis of spatial auto correlation of pedestrian-vehicle crash data to profile pedestrian-vehicle crash hot spots and to identify and rank unsafe bus stops in pedestrian-vehicle crash hot spots areas. Most of the methodologies developed by researchers require crash data for the evaluation of safety level of bus stops. However, in countries like Nepal, either the accident data is not available, or it is not reliable [4]. Agarwal, Patil and Mehar evaluated the Road Safety Hazardous Locations Using Analytical Hierarchy Process without the use of accident data. The methodology presents a hierarchical structural for identification of safety factors. Analytical hierarchy process (AHP) is used to determine the weight of the different identified safety factors. The Safety Hazardous Index is developed using weight of safety factors and condition rating of safety factors. Similar methodology can be used to assess safety level of the bus stops by identifying the design and management deficiencies where reliable accident data is not available [5]. The present work aims to investigate whether design and management deficiencies of bus stops have any effect on safety of passengers and pedestrians. It is also aimed to evaluate safety level of bus stops by identifying design and management deficiencies.

3.2 Unsafe acts and causal factor

The activities performed by bus users, drivers and pedestrians that may result in vehicle- pedestrian is known as unsafe acts. Based on the review on available literature [5, 6, 7, 8, 9, 10, 11] the unsafe acts are encroachment of bus users to the roadway, slipping or falling when entering buses, crossing road in front of a stopped bus, crossing road at locations where sight distance with bus is inadequate, parking of private vehicles at bus stops, crossing road at undesignated locations, motorist using cell phones while driving, passengers run towards the bus while bus approached, pedestrians standing at street to wait bus, loading/unloading of passengers at multiple locations other than the designated bus stop locations. There are multiple reasons that contribute to these unsafe acts. These reasons are known as the causal factors of those unsafe acts. Based on the review on available literature [5, 6, 7, 8, 9, 10, 11] absence of waiting area, absence of sidewalk facility, presence of street vendors along the sidewalk, Inadequate lighting in the waiting area/ sidewalk, lack of proper drainage, encroachment of sidewalk by parked vehicles/street vendors, unhygienic walking environment , locating crosswalk at far-side of the loading area, locating bus stop at nearside of the intersection, on street parking, locating the waiting area immediately after a curve or at the crest of a hill, physical obstruction, invisible crosswalk marking, vehicle not stopping at a safe distance from the crosswalk, inadequate capacity of the loading area, bus not stopping at the designated loading area, unreasonably high dwell time are the potential factors which may contribute to such unsafe act.

3.3 Crash study in Nepal

Road accident stands as a major killer in Nepal. Many accidents go unreported mainly because the parties involved settle the matter themselves. Accidents with

minor injury or damage to vehicles are often settled at the accident site and are not reported to police. Only accidents causing human injury are reported. Annual Accident Data according to Nepal Traffic Police is shown in Table 1

Table 1: Annual Accident Data in Nepal[12]

SN	Fiscal Year	Total Accident	Fatality	Serious	Normal
1	065/66	2765	137	720	2448
2	066/67	4104	146	748	3116
3	067/68	4914	171	553	3632
4	068/69	5096	148	396	3317
5	069/70	4770	147	246	3431
6	070/71	4672	143	229	3481
7	071/72	4999	133	233	3643
8	072/73	5568	166	275	3901
9	073/74	5530	182	201	3914
10	074/75	6381	194	219	4333
11	075/76	8918	254	317	5913

4. Methodology

Kathmandu has a Ring road of length 27.3 km. It encircles the core city of Kathmandu Metropolitan City and Lalitpur Metropolitan city. Recently, the Kalanki- Koteshwor Section has been upgraded to a six lane road. The safety along this section has been a major concern as there has been an increase in number of accidents in this section after upgrading. During the upgrade a number of bus stops were constructed along this section. So, the study was conducted on bus stops along the Kalanki - Koteshwor section of Ring Road of Kathmandu valley.
There is no reliable accident data for this section for evaluating the safety level of this section. The safety level of the bus stops along this road section can be assessed in absence of accident data using analytical hierarchical process(AHP) [5]. The methodology can be summarized in following steps :

- Identification of unsafe acts in and around the bus stops and their causal factors.
- Estimation of the weightage of causal factors using AHP.
- Assessment of presence of causal factors at the bus stops.
- Determination of safety levels of bus stops.
- Validation of safety levels using crash data if available.

4.1 Identification of unsafe acts in and around the bus stops and their causal factors

Field observation was conducted along the Kalanki-Koteshwor section in Kathmandu ring road to identify the unsafe acts and their causal factors.

Out of the unsafe acts listed from literature review, five important unsafe acts in and around bus stops were identified in the study area based on field observations are encroachment of bus users to the roadway (Figure 1 a), crossing road in front of a stopped bus (Figure 1 c), crossing road at locations where sight distance with bus is inadequate ((Figure 1 b), crossing road at undesignated locations (Figure 1 c), loading/unloading of passengers at multiple locations other than the designated bus stop locations (Figure 1 d).

The causal factors for unsafe acts in and around bus stops were identified in the study area based on field observations and listed as below.

4.1.1 Encroachment of the bus users to the roadway (u1)

Bus users may encroach the roadway when they walk by using carriageway instead of using sidewalk or wait for the bus on the carriageway rather than at the waiting area. The factors which predominantly contribute to this unsafe act include: Absence of/ inadequate waiting area (u1f1)(Figure 1 a), absence of/inadequate sidewalk facility (u1f2)(Figure 1 a), lack of lighting facility along the sidewalk (u1f3)(Figure 1 b), lack of drainage facility (u1f4)(Figure 1 a), untidy surrounding (u1f5)(Figure 1 a), encroachment of sidewalk by parked vehicles (u1f6)(Figure 1 a) and presence of street vendors along the sidewalk (u1f7)(Figure 1 b).

4.1.2 Crossing road in front of a stopped bus (u2)

Field observations revealed that, in several cases, pedestrians attempt to cross road in front of a stopped bus immediately after alighting from the bus . As a result, pedestrians were unable to see the vehicle approaching in the same direction as that of the stopped bus. Locating crosswalk at far-side of the loading area (u2f1)(Figure 1 d) and locating bus stop at nearside of the intersection (u2f2)(Figure 1 d) are the potential factors contributing to this unsafe act.

Figure 1: Status of Bus Stops along Kalanki-Koteshwor section of Kathmandu Ring Road

4.1.3 Crossing road at locations where sight distance with bus is inadequate (u3)

In several cases, sight distance may become inadequate for the bus drivers to stop the bus at a safe distance from the pedestrians who are either waiting for the bus in the travel way or are crossing the road in front of the bus stop. Factors which may contribute to such unsafe acts include: On street parking (u3f1)(Figure 1 a), locating the waiting area immediately after a curve or at the crest of a hill (u3f2)(Figure 1 a), lack of lighting facility at bus stop (u3f3), and physical obstruction (u3f4)(Figure 1 b).

4.1.4 Crossing road at undesignated locations (u4)

The following factors may force bus user to cross road at undesirable locations by not using the provided crosswalk facility, while accessing/departing the bus stop ,inadequate width of the crosswalk (u4f1)(Figure 1 a), locating crosswalk far away from the bus stop (u4f2)(Figure 1 d), invisible crosswalk marking (u4f3), and vehicle not stopping at a safe distance from the crosswalk (u4f4)

4.1.5 Loading/unloading of passengers at multiple locations other than the designated bus stop locations (u5)

Passengers, in some cases, are forced to board/alight the bus at multiple locations along the roadway which expose them to the traffic at different locations along the roadway as they are unable to access the pedestrian facilities immediately . Inadequate capacity of the loading area (u5f1)(Figure 1 a), bus not stopping at the designated loading area (u5f2)(Figure 1 d), unreasonably high dwell time (u5f3)(Figure 1 c), and lack of drainage facility (u5f4)(Figure 1 a) are the potential factors which may contribute to such unsafe act.

4.2 Estimation of the weightage of causal factors (wj)

A model is developed to relate the safety level of bus stops to the unsafe acts and its causal factors. The model developed [4] to assess the safety level of the bus stops may be expressed as:

$$S = 10(1 - \sum_{i=1}^{n} x_i * w_i)$$

Where, S : safety level of a bus stop,
x_i : a dummy variable representing the presence (x_i=1)

or absence (x_i=0) of a causal factor in a bus stop,
w_i : weightage of the causal factor.

Weightage of the causal factor can be expressed mathematically as: $W_i = c_{ip} * d_p$ Where, c_{ip} : contribution index, which indicates the relative contribution of ith causal factor to the pth unsafe act, d_p : degree of danger associated with the pth unsafe act.

There may be more than one causal factor for the same unsafe act; as a result, the relative contribution of each causal factor to the respective unsafe act will be different, and it has been denoted as contribution index (cij). An expert scoring survey was conducted to determine the relative contribution of each causal factor to the corresponding unsafe acts. The questionnaire was given to the experts and they were asked to give their score (out of 10) on the contribution of each factor to the unsafe act. The normalized score of the factors was taken as the contribution index of the causal factors.

Similarly, different unsafe acts will have different degrees of danger. Therefore, dj indicates the degree of danger associated with jth unsafe act. An AHP survey questionnaire was developed to facilitate a pairwise comparison on the degree of danger among the five unsafe acts.A panel of 10 experts (same experts for both scoring and AHP method) including traffic engineers, safety engineers and researchers of transportation engineering were approached for conducting the survey. After conducting the pairwise comparison survey, the response from each expert was transformed into a standardized matrix. The responses obtained from the experts was checked for consistency and those responses with a consistency ratio of less than 0.1 will be accepted. After checking the consistency, normalized matrix was formed by performing AHP computations on standardized matrix.

4.3 Assessment of presence of causal factors at the bus stops

A field observation is conducted to investigate the presence or absence of causal factors at the bus stops. The value of xi is assigned to be 0 or 1 for absence presence of corresponding causal factor respectively.

4.4 Determination of safety level of bus stops

The safety level of the bus stop is a function of three important parameters [5] : causal factor (xi),contribution index (cip), and degree of danger (dp).Therefore, by considering all three parameters, the safety level equation can be modified as follows:

$$S = 10(1 - \sum_{i=1}^{n} \sum_{p=1}^{j} x_i * c_{ip} * d_p)$$

4.5 Validation of safety levels using crash data

This stage includes validation of safety levels of bus stops using crash data obtained from the secondary sources. A correlation analysis will be carried out to study whether the safety levels are significantly correlated with crash data at certain significant level.

5. Data Analysis and Results

5.1 Determination of Degree of Danger of Unsafe Acts

An AHP survey questionnaire was developed to facilitate a pairwise comparison on the degree of danger among the five unsafe acts.

After conducting the pairwise comparison survey, the response from each expert was transformed into a standardized matrix. The normalized matrix was formed by performing AHP computations on standardized matrix. Finally, dp values of unsafe acts were obtained by taking the arithmetic mean of rows of the normalized matrix. The calculation of degree of danger is summarized as below.

Table 2: Degree of Danger of Unsafe Acts

SN	Unsafe Act	Degree of Danger
1	Encroachment of bus users to the roadway (u1)	0.07
2	Crossing road in front of a stopped bus (u2)	0.12
3	Crossing road at locations where sight distance with bus is inadequate (u3)	0.38
4	Crossing road at undesignated locations (u4)	0.39
5	Loading/unloading of passengers at multiple locations other than the designated bus stop locations (u5)	0.03

"Crossing at undesignated locations (u4)", "crossing

road at locations where sight distance with bus is inadequate (u3)" and "crossing road in front of a stopped bus (u2)" were found to be the most dangerous with dp values 0.39, 0.38, 0.12 respectively, whereas "loading/unloading of passengers at multiple locations other than the designated bus stop locations (u5)" and "encroachment of bus users to the roadway (u1)" were found to be least dangerous with dp values 0.03 and 0.07 respectively.

5.2 Determination of Contribution Index of the Causal Factors

An expert scoring survey was conducted to determine the relative contribution of each causal factor to the corresponding unsafe acts. The questionnaire was given to the experts and they were asked to give their score (out of 10) on the contribution of each factor to the unsafe act. The normalized score of the factors was taken as the contribution index of the causal factors.

Table 3: Contribution Index of the Causal Factors

Unsafe Act	Causal Factors	Contribution Score (0-10)	Normalized Score
(u1)	u1f1	8	0.17
	u1f2	8	0.17
	u1f3	5	0.11
	u1f4	5	0.11
	u1f5	5	0.11
	u1f6	8	0.17
	u1f7	8	0.17
(u2)	u2f1	8	0.5
	u2f2	8	0.5
(u3)	u3f1	6	0.23
	u3f2	8	0.31
	u3f3	5	0.19
	u3f4	7	0.27
(u4)	u4f1	3	0.11
	u4f2	8	0.3
	u4f3	8	0.3
	u4f4	8	0.3
(u5)	u5f1	7	0.28
	u5f2	9	0.36
	u5f3	6	0.24
	u5f4	3	0.12

5.3 Determination of Weightage of the Causal Factors

As mentioned earlier, weightages (wi) of the causal factors were obtained by taking the product of contribution index the (cip) and degree of danger values (dp). Initially, weightages given by the individual experts were calculated, and then the arithmetic means of these individual weightages were reported as the weightages of causal factors.

Table 4: Weightage of the Causal Factors

Unsafe Act	di	Causal Factors	cij	Weightage wi=cij*di
(u1)	0.07	(u1f1)	0.17	0.012
		(u1f2)	0.17	0.012
		(u1f3)	0.11	0.008
		(u1f4)	0.11	0.008
		(u1f5)	0.11	0.008
		(u1f6)	0.17	0.012
		(u1f7).	0.17	0.012
(u2)	0.12	(u2f1)	0.5	0.061
		(u2f2)	0.5	0.061
(u3)	0.38	(u3f1)	0.23	0.089
		(u3f2)	0.31	0.118
		(u3f3)	0.19	0.074
		(u3f4)	0.27	0.103
(u4)	0.39	(u4f1)	0.11	0.043
		(u4f2)	0.3	0.116
		(u4f3)	0.3	0.116
		(u4f4)	0.3	0.116
(u5)	0.03	(u5f1)	0.28	0.009
		(u5f2)	0.36	0.012
		(u5f3)	0.24	0.008
		(u5f4)	0.12	0.004

It was found that "Locating the waiting area immediately after a curve or at the crest of a hill (u3f2)" got maximum weightage (11.81%), followed by "Locating crosswalk far away from the bus stop (u4f2)", "Invisible crosswalk marking (u4f3)", "Vehicle not stopping at a safe distance from the crosswalk (u4f4)" with weightage 11.58%. "Lack of drainage facility (u5f4)" was found to have the least weightage (0.39%)

5.4 Calculation of Safety Level of Bus Stops

After obtaining the weightage of the causal factors, the presence/absence of the causal factors (whether xi is 1 or 0) in each bus stop were checked by visiting aforesaid traffic corridor and found as below.

Table 5: Presence of the Causal Factors in Bus Stops

Causal Factors	Kalanki	Balkhu	Dhobi ghat	Satdo bato	Gwarko
(u1f1)	1	0	0	0	0
(u1f2)	0	0	0	0	0
(u1f3)	1	1	1	1	1
(u1f4)	0	0	0	0	0
(u1f5)	1	0	0	0	1
(u1f6)	0	0	0	0	0
(u1f7).	0	0	0	1	1
(u2f1)	1	0	0	0	1
(u2f2)	0	0	0	1	0
(u3f1)	1	1	0	1	1
(u3f2)	1	0	0	0	0
(u3f3)	1	1	1	1	1
(u3f4)	0	0	0	0	0
(u4f1)	1	0	0	0	0
(u4f2)	1	0	0	1	1
(u4f3)	1	0	0	1	1
(u4f4)	1	1	1	1	1
(u5f1)	1	0	0	0	0
(u5f2)	1	1	1	1	1
(u5f3)	1	1	0	1	0
(u5f4)	0	0	0	0	0

Finally, the safety level of each Bus stop was calculated using the above mentioned safety level equation which is summarized as below.

Table 6: Safety Level of Bus Stops

S.N.	Bus Stop	Safety Level
1	Kalanki	2.12
2	Balkhu	6.95
3	Dhobighat	7.91
4	Satdobato	3.9
5	Gwarko	3.9

Safety levels of the bus stops were found to be varying in the range 2.12 to7.91. Dhobighat Bus stop was found to be have highest safety level(7.91) while Kalanki Bus was found to have least safety level(2.12). The safety levels of the bus stops is summarized as below.

5.5 Validation of safety levels values using accident data

This stage includes validation of safety levels of bus stops using crash data obtained from the secondary sources. As accident data at bus stops is not available, the accident data of nearest intersection [13] is used for the validation of safety level of corresponding bus stops. A correlation analysis was carried out to study whether the safety levels are significantly correlated with accident data of nearest intersection. The relation between accidents and safety level gives a coefficient of determination R^2 value of 0.75 (Excluding SN.5). Safety assessment model being a non-predictive model, any R^2 value of 0.60 or more [14] is acceptable to validate the model.

Table 7: Comparison of Values with Accident Data[13]

S.N.	Bus Stop	Safety Level	Accident Data
1	Kalanki	2.12	559
2	Balkhu	6.95	132
3	Dhobighat	7.91	231
4	Satdobato	3.9	647
5	Gwarko	3.9	1124

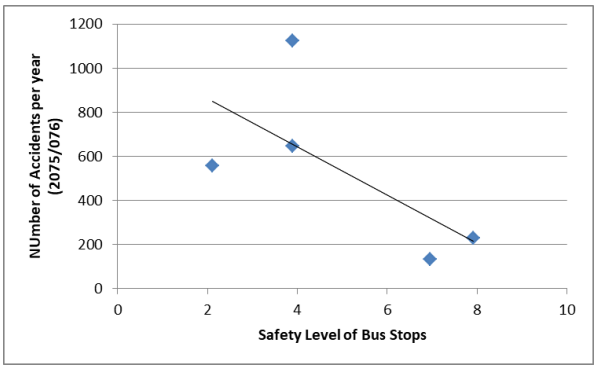

Figure 2: Plot between Safety level of Bus Stops and Number of Accidents

The above graph shows that there is correlation between safety level and actual number of accidents from the traffic police. The bus stops with low safety level value seems to have high number of accidents and the bus stops with high safety level value seems to have low number of accidents. It shows that the safety level determined by the above methodology fairly represents the actual scenario. During this analysis due to time constrain, the analysis was limited to only five bus stops. In further study, safety analysis of all

the bus stops along the Kalanki-Koteshower section of Kathmandu Ring Road could be carried out to get better understanding of the safety level of bus stops along Kathmandu Ring road.

6. Conclusions

The methodology used in this study is an effective tool to access the safety level of the bus stops where crash data is not available or is not reliable. This methodology can be used by the road authority to access the safety level of the bus stops and prioritize the improvement of unsafe bus stops. The methodology includes the identification of potential unsafe acts and its causal factors, establishing a model to assess the safety level of bus stops, and prioritization of the bus stops for improvements based on their safety level.

The study showed that Kalanki, Gwarko and Satdobato Bus stops are unsafe. The high accident number from traffic also supports the results. Similarly Dhobighat and Balkhu bus stops are relatively safer. The relatively low accident number in those area supports the result The comparison between the safety level value determined from this methodology and the actual accident data shows a fair correlation between each other. This suggests that the safety level value represents the actual scenario to a good extent. The result from the study can be used by road authorities to prioritise the bus stops for the intervention to improve the safety of the bus stops.

References

[1] Srinivas Pulugurtha and Vinay Vanapalli. Hazardous Bus Stops Identification: An Illustration Using GIS. *JPT*, 11(2):65–83, June 2008.

[2] Khaled Hazaymeh. GIS-Based Safety Bus Stops-Serdang and Seri Kembangan Case Study. *JPT*, 12(2):39–51, June 2009.

[3] Long Truong and Sekhar Somenahalli. Using GIS to Identify Pedestrian-Vehicle Crash Hot Spots and Unsafe Bus Stops. *JPT*, 14(1):99–114, March 2011.

[4] Pradeep Kumar Agarwal, Premit Kumar Patil, and Rakesh Mehar. A Methodology for Ranking Road Safety Hazardous Locations Using Analytical Hierarchy Process. *Procedia - Social and Behavioral Sciences*, 104:1030–1037, December 2013.

[5] Munavar Fairooz Cheranchery, Kinjal Bhattacharyya, Muhammed Salih, and Bhargab Maitra. A proactive approach to assess safety level of urban bus stops. *International Journal of Injury Control and Safety Promotion*, 26(3):260–270, July 2019.

[6] Sanjay Kumar Singh and Ashish Misra. Road accident analysis: A case study of Patna City, 2004.

[7] NJPTA NJPTA. PEDESTRIAN SAFETY AT AND NEAR BUS STOPS STUDY.pdf, 2011.

[8] Kay Fitzpatrick, Daniel B. Fambro, and Angela M. Stoddard. Safety Effects of Limited Stopping Sight Distance on Crest Vertical Curves. *Transportation Research Record*, 1701(1):17–24, January 2000.

[9] Judith Sharples and John Fletcher. Pedestrian Perceptions of Road Crossing Facilities - Research Findings.pdf, 2000.

[10] Center for Transportation Research Center for Transportation Research. Padestrian Safety at Mid block location.pdf, 2006.

[11] Munavar Fairooz Cheranchery, Kinjal Bhattacharyya, Bhargab Maitra, and Manfred Boltze. Assessing Safety Level of Bus Stops in the Absence of Crash Data, 2015.

[12] Nepal Traffic Police. https://traffic.nepalpolice.gov.np/index.php/news/traffic-activities/425-annually-accidental-descriptions, 2020.

[13] Nepal Traffic Police. Database of nepal traffic police, 2020.

[14] Ravichandran Veerasamy, Harish Rajak, Abhishek Jain, Shalini Sivadasan, Christapher P Varghese, and Ram Kishore Agrawal. Validation of QSAR Models - Strategies and Importance. page 9, 2011.