Proceedings of 14th IOE Graduate Conference
Peer Reviewed
Year: 2023 Month: December Volume: 14
ISSN: 2350-8914 (Online), 2350-8906 (Print)

Study on waiting time for street crossing by Person with disability - A case study of mid block crossing at Jorpati and Sanothimi.

Pragya Shrestha [a], Anil Marsani [b]

[a, b] *Transportation Engineering Program, Department of Civil Engineering, Pulchowk Campus, IOE, Tribhuvan University, Nepal*
[a] shresthapragya089@gmail.com

Abstract
Individuals with disabilities often find Nepal's road challenging to navigate independently. They require volunteers, particularly when it comes to crossing the street. When they approach a junction, the majority of drivers don't seem to slow down their vehicles. As a result, pedestrians experience anxiety when crossing the roadway.The purpose of this study is to examine how pedestrians with disabilities start to cross the street successfully, with a focus on two groups: pedestrians with physical disabilities and pedestrians who are blind, who were contrasted with pedestrians without disabilities. Mid block crossings of Jorpati and Sanothimi were chosen for the study's objectives. A video camera was used to record the behavior of pedestrian crossings, and survival analysis and the hazard ratio were used to analyze the data. To better understand the overall behavior of pedestrians with disabilities, a questionnaire was also filled out. Further criteria taken into account for study included the status of the disability, the traffic gap, the pace of the pedestrians, the gender, and the number of vehicles encountered.Participants in mid block crossings of Jorpati were primarily physically disabled, whereas Sanothimi's pedestrians were primarily blind. The study findings shows that pedestrians with disabilities as compared to pedestrians without disabilities, must wait a lot longer. Another contributing element for the waiting time was the traffic gap and the vehicle encountered.

Keywords
Pedestrian with disabilities, Road crossing, Roadway, Mid Block Crossing, Traffic gap, Pedestrian behaviour, Survival Analysis, Hazard Ratio

1. Introduction

WHO estimates that 1.3 billion people experience significant disability, which represents 15% of the world's population [1]. It was reported in the 2021 census that 2.2% of the total Nepalese population is disabled which accounts 1,24,100 population, with 50% being children and youth. Persons with disabilities account for 1.5% (i.e. 30,687) of the Kathmandu district's population, 1.4% (i.e. 5,970) of the Bhaktapur district's population and 1.5% (i.e. 7954) of the Lalitpur district's population. Although the number is underestimated, it needs to be addressed.

In context of Nepal, among **1,24,100**, 2.2% of person with disability is categorized as Physical disability (37.1%), Low vision (17.1%), Blind (5.4%), Deaf (7.9%), Psycho-Social (4.3%), Hard of hearing (8%), Deaf and Blind (1.6%), Speech Impairment (6.4%), Intellectual Disability (1.8%), Hemophilia (0.8%), Autism (0.8%), Multiple Disability (8.8%) [2].

In Kathmandu only 5% of infrastructure is considered accessible [3]. About 94% of Road in Kathmandu valley has no facility for person with disabilities [4]. People with disabilities are at risk when crossing the street and generally waiting for traffic to pass than people without disabilities which results in delay.

Delay experienced when crossing the street is one of the main parameter for evaluating **Level of Service (LoS)** of pedestrian facility. Entire Road crossing behavior includes walking towards kerb, standing at kerb and crossing the street [5]. Before Pedestrian begin to cross the road, they have to determine time gaps between vehicles and relate them to so called **Critical Gap** *(time in second at which a pedestrian will not attempt to begin street crossing)* [6].

Various factor plays role while crossing the road. Physical Limitation of persons with disability is one of the factors [7]. Drivers are also not generally used to slowing down when approaching zebra crossings [8]. Similarly when they decide to cross the street, they have to handle more information and be more cautious than people without disabilities.

1.1 Objective of Study

The objectives of this research paper is enlisted as below:

1. To explore waiting time for street crossing by pedestrian with disability.
2. To identify possible relationship between waiting time and other co-variants.

2. Literature Review

Effect of age, vehicular speed and time constraint affects road crossing behavior. Time gap is processed by all age group but is not primary determinant for crossing [7]. Larger gap was accepted by elderly when they were not subjected to time constraints [9]. Reduced information processing capacity, physical limitations may be the reason behind this [10].

At the Midblock crossing, driver do not have behavior of yielding which makes more difficult for Person with disability to cross the road [11]. The experiment conducted in mid block

crossing among wheel chair user, people who are deaf and person without disability found greatest delay among wheel chair user while no significant difference was observed among people who are deaf [11].

Pedestrian who is blind make the decision based on the auditory information [12]. In all condition pedestrian (blind) took approximately 5 second longer than the sighted pedestrian and reported presence of gap [12]. Study suggest that the vehicle volume plays a major role and affects the accessibility of pedestrian and are affected by other sources of peripheral noises [13].

3. Methodology

3.1 Site Selection

The criteria of choosing the site was initially based on desk study involved factors like examination of existing data, map and journal research. Afterwards, the field survey was conducted to conclude desk study and finalize the mid block section. The selected mid block sections are those which were generally used by pedestrian with disabilities. Out of many, two primary sites were selected for this study purpose:

- Midblock Crossing at Jorpati [Refer **Figure 1**].
- Midblock Crossing at Sanothimi [Refer **Figure 2**].

Midblock Crossing at Jorpati: The location consists of both

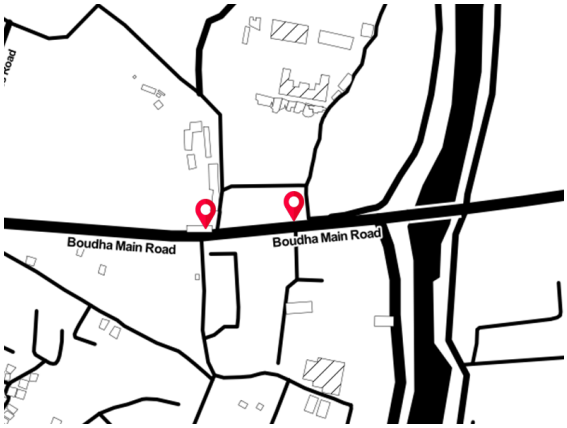

Figure 1: Midblock Crossing at Jorpati [Site I].

residential and commercial area. The organizations involved in providing different facilities for persons with disabilities (Nepal Disabled Association, Khagendra New Life Centre, Khagendra Nawa Jeevan Secondary School, Nepal Orthopedic Hospital, Bodhisatva in Action Institute and S.O.S) are all located in around this vicinity. So, there is large number of people with disability residing nearby this area. Road network of Khagendra Accessible Road is a four lane road with pedestrian crossing and sidewalks along both side with tactile pavement. Kerb Ramp is present between road and sidewalk. On side parking was observed along the road making difficult for general road user. From video graphic survey, 1900 vehicle per hr per 2 lane were clocked with the ratio of 18:3:1 [Two wheeler : Car/Taxi/MicroBus: Large Vehicle].

Mid block Crossing at Sanothimi: The site location consists of both residential and institutional area. Sanothimi Campus being primarily used for physical activity and education by people with disabilities. This location consists of a significant number of people who are blind. They are specially engaged in marketing and conducting business activities. This Mid block crossing has 4-lane road with side walk on both sides with broken tactile pavement. From video graphic survey, 1590 vehicle per hr per 2 lane were clocked with the ratio of 42:4:1 [Two wheeler : Car/Taxi/Micro Bus : Large Vehicle].

Figure 2: Midblock Crossing at Sanothimi [Site II].

Kerb ramps were not observed between road and sidewalk. Unmanaged drain cover were observed along the crosswalk making difficult for the pedestrian to cross the street.

3.2 Data Collection

At the Mid block crossing in Jorpati, data were collected for 30 days between 4:00 PM to 7:00 PM, as well as for 10 days between 9:00 AM to 11:00 AM at mid block crossing Sanothimi, when there are a high volume of disabled pedestrians.

Total of **332** data were collected at mid block crossing of Jorpati. Among them **76** pedestrian are disabled and rest are without disability which were taken for further analysis. Pedestrian with disability were further categorized as **Wheel chair user, Clutch user, Physically Impaired Pedestrian, Dwarf and Blind.** Data from visually impaired pedestrians and dwarfs were excluded from analysis due to their small numbers.Similarly, Total of **202** data were recorded from video graphic survey at Mid block crossing at Sanothimi. Among them **154** were Pedestrian without disability and **48** of them were pedestrian (blind).

The data extracted from **Video graphic Survey** includes *Time taken to walk to kerb, Waiting time and Mid block Crossing time, Identification of event* (i.e. whether it is censored event or uncensored event), *Number of Vehicle encountered, Available gap, Gender and status of disability.* All the time taken are measured in second.

The Questionnaire Survey was conducted after the video graphic survey, to understand general behavior of person with disabilities. This likely includes *general behaviour of pedestrian, frequency to sports and commercial activity.* Likewise, In mid block crossing at Jorpati, Among **76** no. of pedestrian with disability only **73** participated and, among **48** no. of pedestrian who were blind only **40** participated in questionnaire survey.

The data collected were extracted and entered into an Microsoft Excel Sheet from the both, questionnaire survey and the video graphic survey. For further data analysis and interpretation, **IBM SPSS Statistics-2022**, software was used. In light of the nature of our research, **Survival Analysis** and **Hazard Analysis** was applied which are frequently used for time to an event. The Survival Analysis is conducted through Kaplan Meir method whereas, The Hazard Analysis is conducted through Cox Proportional Method. The framework of Research is as shown in **Figure 3.**

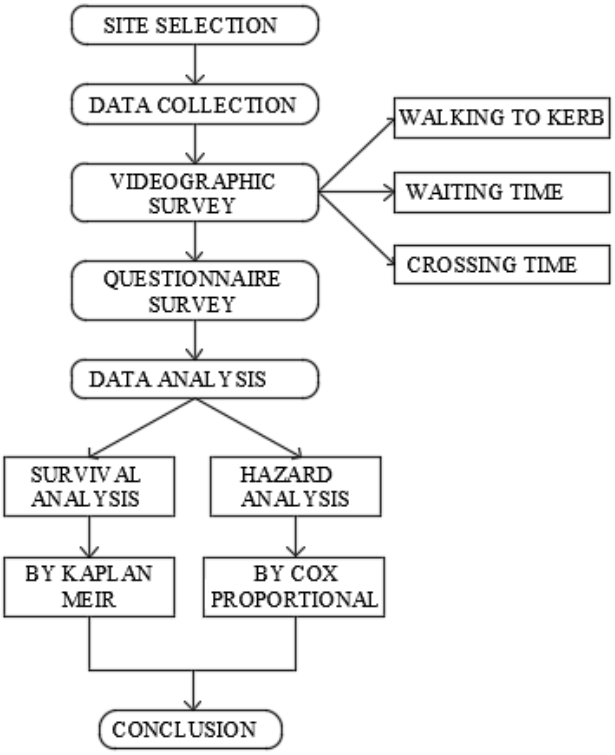

Figure 3: Research Framework.

4. Analysis

4.1 Overview

The data collected were taken for survival and hazard analysis. Here the **Event** is defined as pedestrian starting to cross the street. Similarly, **Waiting Time** is the dependent variable upon the analysis which is analyzed among different pedestrian group for the survival analysis. Survival analysis has the limitation that it cannot contribute to multiple co-variates. So, Multi variable Cox-Proportional Hazard model is used for further analysis. Likewise, Independent variables were taken into consideration are:

1. Pedestrian Characteristics - Status of Disability, Pedestrian Speed.
2. Traffic Related Variables - Traffic Gap, Vehicles encountered.

As per information obtained from **Site-I and II**, further consideration has been made for analysis, which are as follows:

- Uncensored event [1] is coded as 1 while Censored event [2] is coded as 0.
- Wheel Chair user, Clutch user, Pedestrian who is physically impaired and pedestrian without disability is coded as 1, 2, 3 and 4 respectively for **Site-I.**
- Pedestrian who is blind is coded as 1 and Pedestrian without disability is coded as 0 for **Site-II.**
- Male pedestrian is coded as 1 and Female pedestrian is coded as 2.
- For the combined study of site, **Site-I** was coded as 1 and **Site-II** was coded as 2.

4.2 Survival Analysis

Survival Time can be defined as time of occurrence of a given event. It measures the time to response. Survival analysis performed in study describes probability that the pedestrian has not successfully started to cross street till the duration t.

$$S(t) = P(T > t) = 1 - P(T < t) = 1 - F(t) = \sum_{t}^{\infty} f(x)dx \quad (1)$$

Where,

$S(t)$ is a non-increasing function of time "t".
"T" represents *time until an event of interest occurs.*
"t" represents *specific time at which probability is evaluated.*
$f(t)$ represents *PDF*[3] *of continuous random variable T.*
$f(x)$ represents *PDF*[4] *of another continuous random variable* x

Kaplan Meir Estimation was used for Survival Analysis. In order to identify whether the status of Disability is significantly different or not, **Chi square test** *(Log Rank Test, Breslow Test along with Tarone-Ware Test)* were performed.

Hypothesis testing was performed with **null hypothesis.**

H_o= There is no difference in waiting time between the Status of disability.

(Wheel Chair User, Clutch User, Pedestrian with Physical impairment and Pedestrian without disability for **(Site-I)** and Pedestrian who is blind and pedestrian without disability **(Site-II)**.

For 95% confidence interval,

Null hypothesis is rejected if, $p \leq 0.05$

Null hypothesis is not rejected if, $p > 0.05$

Site-I (Mid block Crossing at Jorpati)

The significance value obtained from all three tests are less than 0.05 **(from Table-1)** which means that null hypothesis is rejected.

[1] Data in which event of interest has been fully observed
[2] Observation in which exact event of interest is not known
[3] Probability Density Function
[4] Probability Density Function

Table 1: Chi-Square Test of **Site-I**

Description	Chi-Square	df	Sig.
Log Rank (Mantel-Cox)	53.764	3	0.000
Breslow (Generalized Wilcoxon)	59.019	3	0.000
Tarone-Ware	58.203	3	0.000

It provides the evidence that there is significant difference in waiting time between Wheel Chair User, Clutch User, Pedestrian with Physical impairment and Pedestrian without disability. From the field data it was observed that **Wheel chair user, Clutch user, Pedestrian with physical impairment** and **Pedestrian without disability** takes **1 to 80 sec.; 2 to 6 sec.; 3 to 60 sec. and 0 to 36 sec.** before successfully crossing the road respectively. The relation between waiting time and cumulative survival can be seen from **Figure 4.**

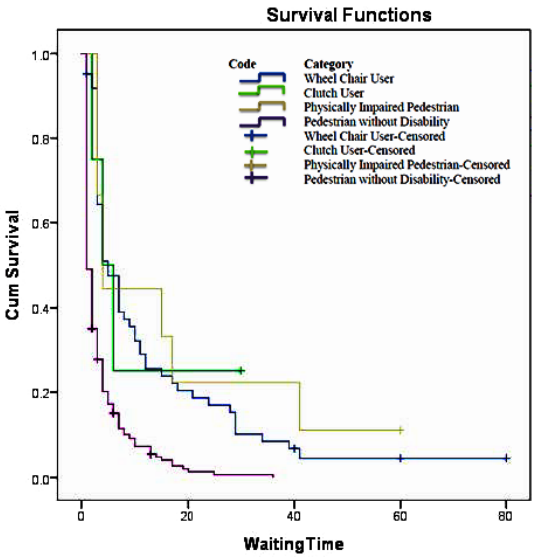

Figure 4: Cumulative Survival vs Waiting Time (in Sec) of Site-I.

The above figure highlights distinct pattern for different pedestrian group. Few of these are enlisted below:

1. **For Wheel Chair User:**
   (a) At time t = 4 sec, 50.9% of pedestrian has not still started crossing street.
   (b) At t = 40 sec, 4.5% pedestrian has not still started crossing street.
2. **For Clutch User:**
   (a) At time t = 4 sec, 50% of pedestrian has not still started crossing street.
   (b) This decreases to 25% at t = 6 second.
3. **For Physically Impaired Pedestrian:**
   (a) At time t = 4 sec, 44.4% of pedestrian has not still started crossing street.
   (b) By t = 41 sec, 11.1% pedestrian has not still started crossing street.
4. **For Pedestrian without Disability:**
   (a) At time t = 4 sec, 20.1% pedestrian has not still started to cross street
   (b) At t = 25 sec, 7% pedestrian has not still started crossing street.

The survival curve for wheel chair users, clutch users and physically impaired pedestrians exhibit **Overlapping pattern** as shown in **Figure 4.**

This indicates that aforementioned pedestrians are not significantly different in terms of waiting time before initiating Crossing. On the contrary, Pedestrian without disability experience noticeably different waiting time compared to those Pedestrian with disabilities which can be further verified from data.This can be further confirmed by mean and median waiting time value, as shown in **Table 2.**

Table 2: Mean Waiting Time and Median Waiting Time for Site-I

Status	Mean		Median	
	Est.	Std. Error	Est.	Std. Error
Wheel Chair	12.994	2.344	5.000	1.022
Clutch User	10.500	5.673	4.000	2.000
Physically Impaired	16.667	6.435	4.000	0.745
Without Disability	3.575	0.334	1.000	-
Overall	**6.129**	**0.695**	**2.000**	**0.234**

Likewise following conclusions can be derived:

- Among Wheel Chair User, Avg. waiting time is **12.994 sec** with a median waiting time of **5 sec.**
- Among Clutch User, Avg. waiting time is **10.5 sec** with a median waiting time of **4 sec.**
- Among Physically impaired Pedestrian, Avg. waiting time is **16.667 sec** with a median waiting time of **4 sec.**
- Among Pedestrian without disability, Avg. waiting time is **3.575 sec** with a median waiting time of **1 sec.**

Site-II (Mid block Crossing at Sanothimi)

The significance value obtained from all three methods of chi-sqaure tests are less than 0.05 **(from Table-3)** which means that null hypothesis is rejected.

Table 3: Chi-Square Test of **Site-II**

Description	Chi-Square	df	Sig.
Log Rank (Mantel-Cox)	33/233	1	0.000
Breslow (Generalized Wilcoxon)	31.932	1	0.000
Tarone-Ware	34.702	1	0.000

It provides the evidence that there is significant difference in waiting time between Pedestrian who is blind and pedestrian without disability.

Similarly, it was found that it takes a blind pedestrian 1–41 seconds and a pedestrian without a disability 1–28 seconds, respectively, to successfully begin for crossing the road which can be seen **(from Figure-5)**

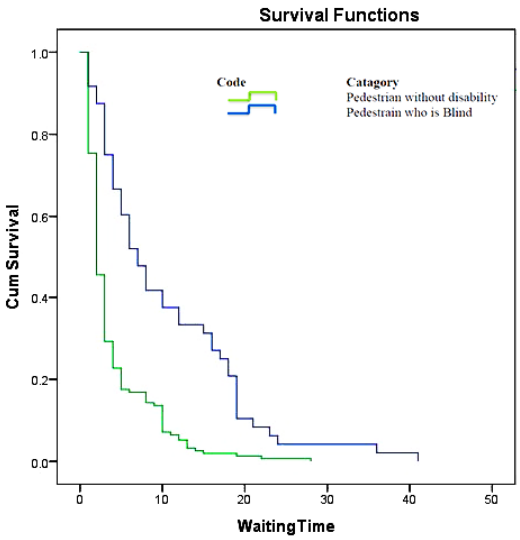

Figure 5: Cumulative Survival vs Waiting Time (in Sec) of Site-II.

(Figure-5) further highlights distinct pattern for different pedestrian group. Few of these are enlisted below:

1. **For Pedestrian (Blind) :**
   (a) At time t = 15 sec, 31.3% pedestrian has not still started crossing street.
   (b) At t = 36 sec, 2.1% pedestrian has not still started crossing street.
2. **For Pedestrian (who is not Disabled) :**
   (a) At time t = 15 sec, 1.9% pedestrian has not still started crossing street.
   (b) At time t = 22 sec, 0.6% pedestrian has not still started crossing street.

From the **Figure-5**, it shows that the curves for pedestrian without disability and pedestrian who is blind **does not exhibit Overlapping pattern.**

This indicates that aforementioned pedestrians are significantly different in terms of waiting time before initiating crossing. This can be further confirmed by mean and median waiting time value, as shown in **Table 4** below:

Table 4: Mean Waiting Time and Median Waiting Time for Site-II

Status	**Mean**		**Median**	
	Est.	**Std. Error**	**Est.**	**Std. Error**
Pedestrian (Blind)	10.470	1.308	7.000	1.154
Pedestrian without Disability	3.922	0.343	2.000	0.174
Overall	**5.480**	**0.450**	**3.000**	**0.225**

Likewise following conclusions can be derived:

- Among Pedestrian (blind), Avg. waiting time is **10.479 sec** with a median waiting time of **7 sec.**
- Among Pedestrian without disability, Avg. waiting time is **3.922 sec** with a median waiting time of **2 sec.**

4.3 Cox Proportional Model

Cox-Proportional Hazard model was implemented to obtain relation of disability with different covariates. Different covariates included were State of disability, Average traffic gap, Pedestrian speed and Gender. It is expressed as :

$$\frac{h(t,x_1)}{h(t,x_2)} = \frac{h_0(t,\alpha)\exp(\beta x_1)}{h_0(t,\alpha)\exp(\beta x_2)} \tag{2}$$

where,

t represents Survival Time.
$h(t)$ is *hazard function* determined by set of co-variates (x_1,x_2)
h(t,x_1) represents *hazard rate at time t for an event of interest* where x_1 *is a covariate*
h_0(t,α) is *Baseline hazard at time t.*
exp (β_1,x1) and exp (β_2,x2) is the effect of covariates x1 and x2 on hazard rate

Hypothesis testing was performed with **null hypothesis.**

H_0= There is no difference in waiting time between the selected predictors *(Traffic gap, Vehicles encountered, Status of Disability, Pedestrian Speed and Gender).*

For 95% confidence interval,

Null hypothesis is rejected if $p \leq 0.05$

Null hypothesis is not rejected if $p > 0.05$

Site-I (Mid block Crossing at Jorpati)

Table 5: Coefficient Estimation of Cox-Proportional Model for Site-I

Variable	β	SE	Sig.	Hazard Ratio Exp (β)
Vehicles Encountered	-0.170	0.040	0.000	0.844
Wheel Chair	-0.993	0.162	0.000	0.370
Clutch User	-1.121	0.585	0.050	0.326
Physically Impaired	-1.209	0.373	0.001	0.299
Gap	0.077	0.019	0.000	1.081

From the **Table 5**, we can say that:

1. Vehicles Encountered, $Sig. < 0.05$

2. Status of Disability, $Sig. < 0.05$

3. Gap, $Sig. < 0.05$

From this data, we can say that **Vehicles encountered, Status of disability and Traffic Gap** are major significant variable. So these parameters are further checked upon as Omnibus test of Model coefficient **Table 6**, so as to determine the overall significance of the model as a whole. It aids in figuring out whether any of the model's independent variables are connected to the dependent variable as a whole.

Table 6: Omnibus Test of Model Coefficient for Site-I

-2 Log Likelihood	Overall Score			Change from Previous Step			Change from Previous Block		
	Chi-Square	df	Sig.	Chi-Square	df	Sig.	Chi-Square	df	Sig.
3074.911	71.259	5	0.000	74.866	5	0.000	74.866	5	0.000

This analysis revealed:

1. As compared to pedestrian without disability, wheelchair user is 63% less likely while physically impaired Pedestrian is 70.1% less likely to start crossing the street.
2. Increase in 1 vehicle encountered, likelihood to start crossing street decreases by 15.6%.
3. If same individual crosses the same street differing with increasing average traffic gap of 1 second, pedestrian start to Crossing Street increases by 8.1%.

Site-II (Mid block Crossing at Sanothimi)

From the **Table 7** we can say that

1. Vehicles Encountered, $Sig. < 0.05$

2. Status of Disability, $Sig. < 0.05$

Table 7: Coefficient Estimation of Cox-Proportional Model for Site-II

Variable	β	SE	Sig.	Hazard Ratio Exp (β)
Vehicles Encountered	-0.338	0.069	0.000	0.713
Status of Disability	-0.732	0.179	0.000	0.481

From this data, we can say that **Vehicles encountered and Status of disability** are significant variable. So these parameters are further checked upon as omnibus test of Model coefficient.

The **Table 8** further shows that $Sig < 0.05$ with predictor that status of disability and vehicle encountered fits better.

Table 8: Omnibus Test of Model Coefficient for Site-II

-2 Log Likelihood	Overall Score			Change from Previous Step			Change from Previous Block		
	Chi-Square	df	Sig.	Chi-Square	df	Sig.	Chi-Square	df	Sig.
1742.210	50.514	2	0.000	52.364	2	0.000	52.364	2	0.000

This analysis revealed:

- Pedestrian (Blind) has 51.9% less likelihood of start crossing the street than Pedestrian without disability.
- Increase in 1 Vehicle encountered, Pedestrians are 28.7% less likely to start crossing street.

5. Conclusion

The study investigates pedestrian waiting time and factors during street crossings.It was found that pedestrians with disabilities require more time to assess traffic conditions and ensure safety before crossing. The median waiting time for disabled pedestrians is **3-6 seconds longer than those without disabilities** which is further verified from hazard analysis.

In the case of Site I (Jorpati), an increase in traffic gap by 1 sec increases the pedestrian's likelihood to cross the street by 8.1% while it is not a significant variable incase of site 2. Since pedestrian with physical disability due to their mobility limitations needs wider traffic gap while blind pedestrians rely heavily on tactile or audible cues to navigate and cross roads. Similarly their aggressive behavior may be less varied due to traffic gap variation. Heavy traffic volume and high number of heavy vehicles in mid block crossing at Jorpati compared to Sanothimi may also contribute to this difference.

A unit increase in traffic volume leads to a decrease in the likelihood of crossing the street by 15.6% in Site I and 28.7% in Site II. Site I appears to be more favorable in terms of waiting time and high likelihood to start crossing than Site II, possibly due to traffic gap being a significant variable in Site I.

However, when analyzing pedestrians with disabilities, the site as a variable did not exhibit the difference in significance level since both site exhibit similar type of infrastructural pattern.

6. Recommendations

The study aimed to understand how disabled pedestrians behave, especially when crossing the road. It is focused on visually impaired and physically disabled pedestrians, analyzing two midblock crossings.

Extending the study to other intersections could provide insights into how infrastructure components influence pedestrian behavior. A larger sample size with different pedestrian groups could provide better results. Future research should include a larger group of pedestrians and extend the analysis period to cover longer periods to understand seasonal, time, and traffic volume variations. Covariates included in the analysis include disability status, gender, vehicles encountered, traffic gap, pedestrian speed, and location. Further analysis could include additional variables like vehicle speed, age group, and driver-pedestrian interaction. Comparing waiting times for different types of disabilities in the same area is recommended for precise conclusions.

References

[1] World Health Organization, 2023. *https://www.who.int/news-room/fact-sheets/detail/disability-and-health*, 2023. Accessed on 2023-09-05.

[2] National Statistical Office, 2021. *https://censusnepal.cbs.gov.np/results/population#disability*, 2021. Accessed on 2023-07-08.

[3] National Federation of the Disabled – Nepal (NFDN). The prospects and situation of accessibility in nepal: The collection of articles. Technical Report ISBN: 978-9937-9226-3-0, National Federation of the Disabled – Nepal (NFDN), 2018.

[4] *https://walkabilityasia.org/kathmandu-nepal/*. Accessed on 2023-07-15.

[5] D. R. Geruschat, S. E. Hassan, and K. A. Turano. Gaze behavior while crossing complex intersections. *Optometry and Vision Science*, 2003.

[6] MoPIT and JICA. Data collection survey on traffic improvement: Final report. Technical Report 2012, The Federal Democratic Republic of Nepal, 2012.

[7] J. A. Oxley, E. Ihsen, B. N. Fildes, J. L. Charlton, and R. H. Day. Crossing roads safely: An experimental study of age differences in gap selection by pedestrians. *Accident Analysis and Prevention*, 2005.

[8] M. M. Hamed. Analysis of pedestrians' behavior at pedestrian crossings. *Safety Science*, 2001.

[9] R. Lobjois and V. Cavallo. Age-related differences in street-crossing decisions: The effects of vehicle speed and time constraints on gap selection in an estimation task. *Accident Analysis and Prevention.*, 2007.

[10] C. A. Holland and P. M. A. Rabbitt. People's awareness of their age-related sensory and cognitive deficits and the implications for road safety. *Applied Cognitive Psychology*, 1992.

[11] D. Pecchini and F. Giuliani. Street-crossing behavior of people with disabilities. *Journal of Transportation Engineering.*, 2015.

[12] D. A. Guth, R. G. Long, R. S. Wall Emerson, P. E. Ponchillia, and D. H. Ashmead. Blind and sighted pedestrians' road-crossing judgments at a single-lane roundabout. *Human Factors*, 2013.

[13] D. H. Ashmead, D. Guth, R. S. Wall, R. G. Long, and P. E. Ponchillia. Street crossing by sighted and blind pedestrians at a modern roundabout. *Journal of Transportation Engineering*, 2005.