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PULCHOWK CAMPUS

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

by

Pragya Shrestha

A THESIS

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The undersigned certify that they have read and recommended to Institute of Engineering for acceptance, a thesis entitled **"Study on waiting time for street crossing by Person with disability- A case study of midblock crossing at Jorpati and Sanothimi."** submitted by Pragya Shrestha in partial fulfillment of the requirement for degree of Master of Science in Transportation Engineering.

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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 finding shows that pedestrians with disabilities as compared to pedestrians without disabilities must wait a lot longer. Beside status of disability, 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 behavior, Survival Analysis, Hazard Ratio

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LIST OF SYMBOLS

M	Male
F	Female
HR	Hazard Ratio
PDF	Probability Density Function

LIST OF ABBREVIATIONS

BIA	Boddhisatva In Action
CBS	Central Bureau of Statistics
JICA	Japan International Cooperation Agency
LOS	Level of Service
NFDN	National Federation of Disabled Nepal
SOS	Save Our Soul
WHO	World Health Organization
PWD	Pedestrian With Disability
SPSS	Statistical Package for the Social Sciences

CHAPTER 1: INTRODUCTION

1.1 Background

WHO estimates that 1.3 billion people experience significant disability, which represents 15% of the world's population, or 1 in every 7 people (WHO, 2023). It was reported in the 2021 census that 2.2% of the total Nepalese population is disabled which accounts 6,47,744 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 (CBS, 2021). Although the number is underestimated, it needs to be addressed. Disability is the condition of difficulty in carrying out daily activities normally and in taking part in social life due to problems in parts of the body and the physical system as well as obstacles created by physical, social, cultural environment and by communication (definition-and-classification-of-disability-in-nepal_english.). In context of Nepal, among 6,47,744, 2.2% of person with disability it 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%), Hemophillia (0.8%), Autism (0.8%), Multiple Disability (8.8%) (CBS, 2021). Researcher, Planners, organizations working on disability estimates that the national figure is low than the estimated. There is a widespread misconception that accessibility is only important for persons with disabilities. In Kathmandu only 5% of infrastructure is considered accessible (The Prospects and Situation of Accessibility in Nepal, 2018) .In spite of this, we do not take into account the fact that every individual may have limited access to infrastructure during his or her lifetime, either temporarily or permanently. Pedestrian facility in Kathmandu is in worse condition and is not user friendly to person with disability. About 94% of Road in Kathmandu valley has no existing facility for person with disabilities (https://walkabilityasia.org/kathmandu-nepal/).

1.2 Problem Statement

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 (Geruschat et al., 2003). Before Pedestrian begin to cross the road, they have to determine time gaps between vehicles and relate them to so called critical gap i.e. time in second below which a pedestrian will not attempt to begin street crossing (US-HCM, 2010). If available gap is greater than critical gap, pedestrian will cross otherwise will not be able to cross the street. Various factor plays role while crossing the road. Physical Limitation of persons with disability is one of the factors (Oxley et al., 2005). It may be inability of Person who is blind to recognize the oncoming vehicle, Inability of Wheel Chair user to travel through difficult and uneven pavement. Drivers are also not generally used to slowing down when approaching zebra crossings (Hamed, 2001). Similarly when they decide to cross the street, they have to handle more information and be more cautious than people without disabilities. Further issue is related to overall lower walking rate of people with disabilities. Pedestrian and vehicle interaction also plays decisive role. These all factor causes delay. Traffic signals are typically timed to accommodate pedestrians based on assumed walking speed. The study can help traffic engineers and urban planners better understand how to build and optimize pedestrian infrastructure and signal timings to meet the needs of individuals with disabilities, thereby improving safety and effectiveness.

1.3 Objective of Study

The objectives of this research paper are enlisted as below:

1. To examine waiting time for street crossing by pedestrian with disability.
2. To examine possible relationship between waiting time and other co-variants (Gap, Vehicles encountered, Status of disability, Pedestrian Speed and Gender)

1.4 Scope of Study

The scopes of study are:

- To determine overall time taken by pedestrian with disability to cross the street including walking towards kerb, waiting time and crossing time.
  These are to be studied through video graphic survey.
- Questionnaire survey to understand the general behavior of pedestrian with disability.
- To perform Statistical Survival analysis for establishing the relation between waiting time and selected predictors.
  Selected predictors include:
  1. *Person with Physical disability*
  2. *Person with visual disability*

  The selected predictors are compared with pedestrian without disability.

3. To perform Statistical Cox-Proportional Hazard Model for establishing the relation between waiting time and multiple co-variates (Gap, Vehicles encountered, Status of disability, Pedestrian Speed and Gender)

1.5 Limitation of Study

The project report has been prepared while recognizing and working within specific limitations, including the following:

- The study does not encompass all form of disabilities; it focuses exclusively on only two distinct groups: individuals with physical impairments and individuals with visual impairments which were contrasted with individual without disability.
- The study's scope is limited to the examination of just two midblock crossings: midblock crossing at Jorpati and midblock crossing at Sanothimi, chosen for the purpose of this research.
- Within the study area, the investigation is restricted to individuals with similar types of disabilities i.e. pedestrian with physical disability and pedestrian without disability in case of Midblock crossing at Jorpati and pedestrian with

visual impairment and pedestrian without disability in case of Midblock crossing at Sanothimi.

- Study does not involve an equal representation of pedestrians with and without disabilities which was in the ratio of 1:4.

CHAPTER 2: LITERATURE REVIEW

2.1 Factors affecting Road crossing behavior

Earlier study provides fact about behavior of street crossing behavior of pedestrian. Effect of age, Vehicular speed and time constraint affects road crossing behavior (Lobjois & Cavallo, 2007). Time gap is processed by all age group but is not primary determinant for crossing (Oxley et al., 2005). The experiment performed among age group (20-30, 60-70, 70-80) showed unsafe decision making process among 60-70 years group (Lobjois & Cavallo, 2007). Larger gap was accepted by elderly aged group when they were not subjected to time constraint (Lobjois & Cavallo, 2007). Reduced information processing capacity, physical limitations may be the reason behind this (Holland & Rabbitt, 1992). Judgment of pedestrian who is blind is also affected by perceptual limits of auditory motion perception (Guth et al., 2013).

2.2 Method of Data Collection

It is riskier to conduct experiment among pedestrian with disability. Participants were followed by experimenter and used hand signal to indicate start crossing street (Ashmead et al., 2005). Generally two methods are used for street crossing study-indicator method and crossing method. With the crossing method, participants cross the road, whey they judge road is safe to do so. With indicator method, pedestrian simply judge when would be able to cross the road (Salamati et al., 2011).

2.3 Street crossing behavior among people with disability

At midblock crossing, driver do not have behavior of yielding which makes more difficult for Person with disability (Pecchini & Giuliani, 2015). The experiment conducted in midblock 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 (Pecchini & Giuliani, 2015). State of disability and average traffic gap were fit better. Hazard ratio showed

that probability reduced to half to have shorter waiting time compared to people without disability while it was same for pedestrian who is deaf. Differing in 1 second of traffic gap, pedestrian is likely to cross street 3times as compared to other situation (Pecchini & Giuliani, 2015). Pedestrian who are blind make the decision based on the auditory information (Guth et al., 2013). In all condition pedestrian who is blind took approximately 5 second longer than the sighted pedestrian and reported presence of gap (Guth et al., 2013). Study suggest that the vehicle volume plays an important role and affects the accessibility of pedestrian and is affected by other sources of noise (Ashmead et al., 2005). It took 3-4 second longer to report the crossable gap than sighted pedestrian (Ashmead et al., 2005).

2.4 Accessibility in Public Places

Pedestrian facility in Kathmandu is in worse condition and is not user friendly to physically disabled person. About 94% of Road in Kathmandu valley has no existing facility for person with disabilities (https://walkabilityasia.org/kathmandu-nepal/). In Kathmandu valley, about 40% journeys are made on foot (MoPIT/JICA, 2012). Despite of this roads are not accessible. Person with disability feels unsafe to cross road and even use sidewalk or pedestrian bridge because of physical obstruction, broken pavement or inappropriate placement of bus stop. Tactile pavements and ramps are also difficult to use by Person with disability (City, 2020). The survey conducted by NFDN shows that 92% people with disability are unsafe while crossing street (Source et al., 2004).

2.5 Summary of Literature Review

Research is generally found to be conducted in presence of volunteer which may be either indicator method or crossing method. Different factor plays role in street crossing which may be status of disability, Traffic Gap, Gender, Age, Physical Limitation, Traffic Volume, Pedestrian speed, Vehicular speed etc. physical limitation is also the factor which causes delay in crossing the road. Similarly, Pedestrian who is disabled is found to have higher waiting time than those who are not disabled. Different other factors are also responsible for it. Traffic gap is other important factor

affecting road crossing behavior. Similarly research shows age group and traffic volume as also the factor affecting road crossing behavior.

CHAPTER 3: METHODOLOGY

3.1 Research Design

The research involves Site selection, Data Collection through Video graphic Survey and Questionnaire survey, Data analysis, Interpretation and Conclusion.

- Site Selection

The process of choosing our site was initially based on desk study involving examination of existing data, map and journal research. Afterward field survey was conducted to verify and finalize selected midblock section. The selected midblock sections were those which were generally used by pedestrian with disabilities.

- Video graphic Survey

To gather data on pedestrian movement, Gopro 7 camera was used to conduct video graphic Survey. *(Refer figure 3.1)* This method allowed capturing the pedestrian flow and observing their behavior in real time. During the video time taken by pedestrian to cross the road was recorded to cross the road from one end to another.

Figure3. 1: Video graphic Survey

- Questionnaire Survey

In addition to video graphic survey, questionnaire survey was conducted *(Refer figure 3.2)* to understand general behavior of person with disabilities. This likely includes general behavior of pedestrian, frequency to sports and commercial activity.

Figure3. 2: Questionnaire Survey

- Data Analysis

Data collected from both video graphic survey and questionnaire survey was then extracted and entered to excel sheet. Later on IBM SPSS Statistics-2022 software was used for further analysis. As our study is time to event analysis survival analysis is used. These methods are often used in research to study time to an event.

The entire framework of research is presented in *figure 3.3.*

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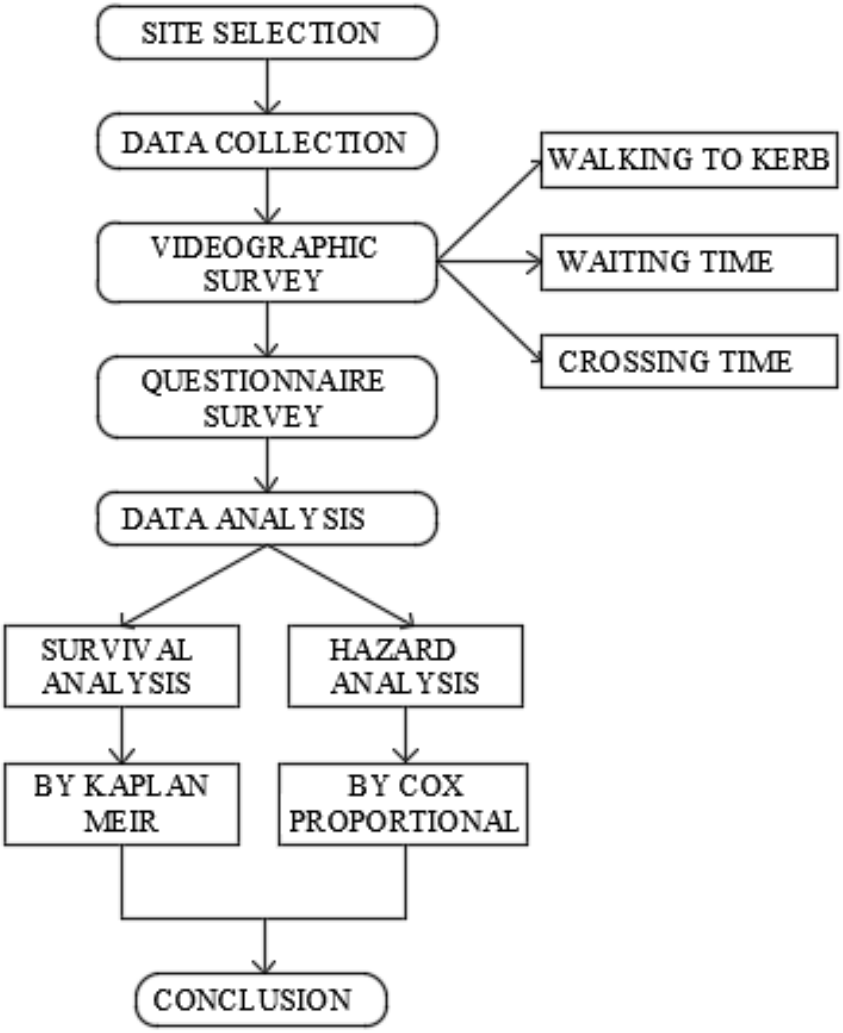


Figure3. 3: Framework of Research

Before conducting survey, preliminary information about individuals with disabilities was gathered from the organizations they were affiliated with and field data was collected. Initially infrastructural survey was conducted which includes:

1. Width of side walk
2. Presence or absence of zebra crossing
3. Length of cross walk
4. Presence or absence of tactile pavement
5. Presence or absence of drain cover
6. Lane number
7. Presence or absence of kerb ramp

3.2 Study Area

The selected midblock sections were 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 3.4]*.
- Midblock Crossing at Sanothimi *[Refer Figure 3.9]*.

- **Site 1 - Midblock Crossing at Jorpati**

According to the preliminary desk study, one of the chosen sites for the study was Jorpati due to its status as the most densely populated area with individuals with disabilities in the Kathmandu district (Source et al., 2004). This selection was subsequently corroborated through on-site verification using field data and information obtained from the Khagendra Nawa Jeevan Kendra, ensuring precise identification of the midblock crossing.

It is densely populated area which is easily accessible to transportation. It is surrounded by Mulpani at East, Bauddha at West, Gokarneshwor at North and Koteshor at South.

The general description of site is listed in *Table 3.1*.

Table3. 1: General Site Description of Midblock Section at Jorpati

Road Category	F026 (Chabahil - Sankhu - Jhule – Chautara)
Easting	340386
Northing	3067414

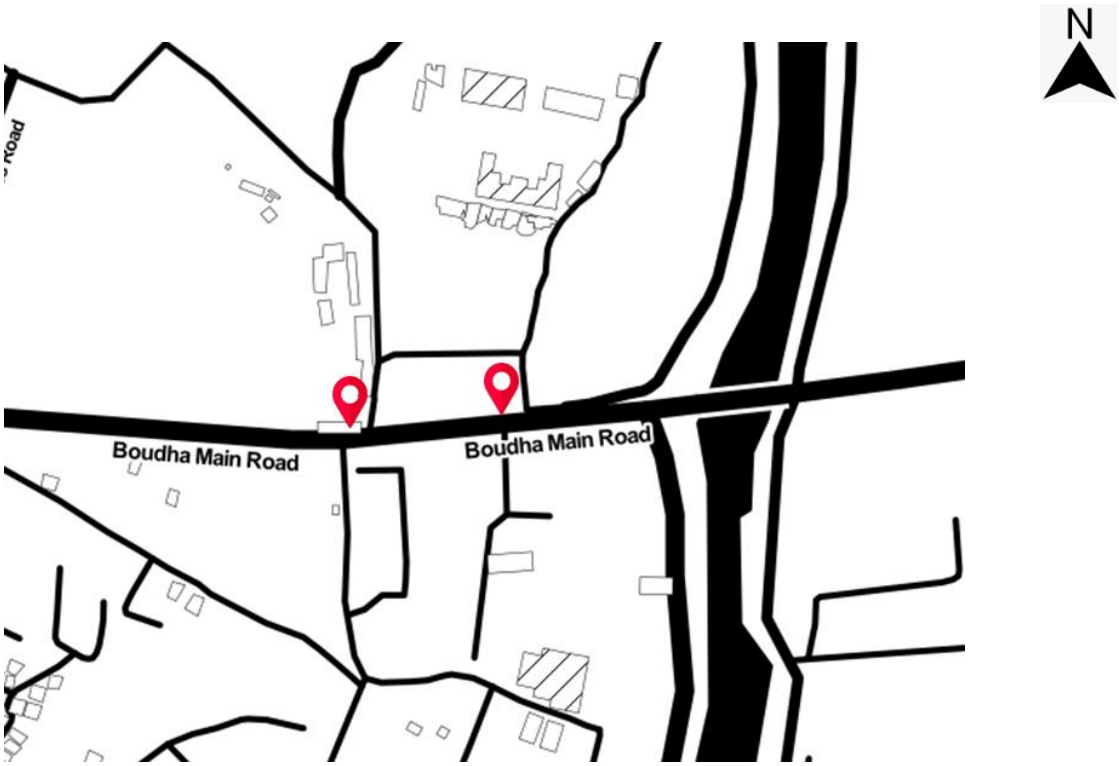


Figure3. 4: Location Map of midblock crossing at Jorpati

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 Jorpati including Khagendra Accessible Road is a four lane road with pedestrian crossing and sidewalks along both side of road with tactile pavement. Kerb ramps facilitate the transition between the road and the sidewalk. Notably, on-road parking was observed, which presented challenges for road users.

The preliminary observations have been documented and are listed in *Table 3.2.*

Table3. 2: Initial Observation along Midblock Crossing at Jorpati

Number of Vehicle	1900	Veh/hr/2lane/direction
Two wheeler : Car/Taxi/MicroBus: Large Vehicle	18:3:1	Per hour
Number of Lane	4	Lanes
Length of Carriageway	18	m

Speed Limit	30	kmph
Average Instantaneous Speed	42	kmph
Length of Side walk	2.5	m

General infrastructural condition can be further viewed from *figure 3.5, 3.6, 3.7 and 3.8.*

Figure3. 5: Midblock Crossing at Jorpati

Figure3. 6: Faded Transverse marking along Midblock crossing at Jorpati

Figure3. 7: Onside Parking along the road of Jorpati

Figure3. 8: Side Walk along with Tactile Pavement along Jorpati Road

- **Site 2 - Midblock Crossing at Sanothimi**

As per desk study, another site selected was Midblock section of Sanothimi. The site location consists of both residential and institutional area. Sanothimi Campus being primarily used for education by people with disabilities, this location consists of a significant number of people who are blind. They are specially engaged in marketing and they are moving around and conducting business activities. Based on information gathered from both local residents and the individuals themselves, a midblock crossing was chosen as the focus of the study. It is densely populated area and is easily accessible to public vehicle. The site is located 5.4km from Kathmandu. It is surrounded by Purano Thimi at East, Pepsicola at West, Gatthaghar at South and Mulpani at North. The general description of site is further enlisted in *Table 3.3.*

Table3. 3: General Site Description of Midblock section at Sanothimi

Road Category	F086 (Sinamangal-Manohara-Thimi-Sallaghari)
Easting	340177
Northing	3063041

Figure3. 9: Location Map of midblock crossing at Sanothimi

It is 4-lane road with side walk on both sides. However, the tactile pavement on the sidewalks is damaged. Notably, there were no observed kerb ramps to facilitate the transition between the road and the sidewalk.

The preliminary observations have been documented and are listed in *Table 3.4*

Table3. 4: Initial Observation along Midblock Crossing at Sanothimi

Number of Vehicle	1590	Veh/hr/2lane/direction
Two wheeler : Car/Taxi/MicroBus: Large Vehicle	42:4:1	Per hour
Number of Lane	4	Lanes
Length of Carriageway	18	m
Speed Limit	30	kmph
Average Instataneous Speed	44.22	kmph
Length of Side walk	1.5	m

Figure 3.10, 3.11 and 3.12 show infrastructural condition nearby midblock crossing at Sanothimi.

Figure3. 10: Midblock Crossing at Sanothimi

Figure3. 11: Sidewalk along with Tactile pavement along Sanothimi Road

Figure3. 12: Condition of Drainage cover along the Road

Site wise comparison has been made in *table 3.11*.

3.3 Data Analysis

- **Site1-Midblock Crossing at Jorpati**

Data were collected for 30 days during 4:00PM-7:00 PM as high flow was observed during this period. Total of 335 data were collected at midblock crossing of Jorpati. Among them 76 pedestrian are disabled and rest are without disability. Since the point of interest of study was crossing, only data related to crossing was further analyzed. Among them 259 pedestrian without disability crossed the street and 76 pedestrian with disability crossed the street. Pedestrian with disability were further categorized as Wheel chair user *(Refer figure 3.13 and 3.14)*, Clutch user *(Refer figure 3.15)*, physically impaired pedestrian *(Refer figure 3.16)*, Pedestrian who is dwarf *(Refer figure 3.17)* and Pedestrian who is blind *(Refer figure 3.18)*. Data from visually impaired pedestrians and dwarfs were excluded from analysis due to their small numbers. Among 76 pedestrian only 73 pedestrian with disability and them 259 pedestrian without disability were taken for further analysis.

Figure3. 13: Wheel Chair User

Figure3. 14: Wheel Chair User

Figure3. 15: Clutch User

Figure3. 16: Pedestrian who is Dwarf

Figure3. 17: Pedestrian who is Physically impaired

Figure3. 18: Pedestrian who is blind

Table3. 5: Number of Pedestrian under the Study along Midblock crossing at Jorpati

Category	**Number**
Wheel Chair User	60
Clutch User	4
Physically Impaired Pedestrian	9
Pedestrian without disability	259
Total	**332**

From field observation it was seen that 3 different pattern of crossing were observed along 200m length. *(Refer Figure 3.19)* So data were recorded along three different sections. It was not found that the pedestrians followed the same path for crossing the street. Number of zigzag options was used for road crossing. Despite presence of pedestrian crossing, they were not utilized regularly to cross the street

Figure3. 19: Number of Crossings observed in midblock section at Jorpati

Field data collected from video graphic survey is extracted in excel. *(Refer Table 3.6)* Data extracted from video are time taken to walk to kerb, waiting time and 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. Uncensored data is coded as 1 while censored data is coded as 0 while recording the data. All the time taken was measured in second.

Video graphic Survey was then followed by questionnaire survey. *(Refer Table 3.8)* Among 76 no. of pedestrian with disability only 73 participated in questionnaire survey. Questionnaire survey includes general behavior of Person with disability. Most of them were wheel chair user. They were either student or worker in BIA. Most of them leave nearby Khagendra Nawa Jeevan Center and generally prefer wheel chair for day to day travel.

From the questionnaire survey conducted, generally behavior of pedestrian was analyzed. Majority of recorded pedestrian, (85%) belonged to age group 20-40 years. i.e. economic group. *(Refer Table 3.13)* It is observed during field survey that it is difficult for wheel chair user to travel in Public Vehicle. Most of the pedestrian with disability recorded were male. They were mostly engaged in some type of profession specially Thanka Painting, Tailoring and Handicraft in BIA. It was found that most of them were involved in some type of sports activities mainly Basketball, Cricket and Swimming. It was found that for very short distance, they generally travel with wheel chair. But for long travel they generally travel through public bus. Some of them use scooter and some of them even use Pathao. There were reported instances of hesitation of some pathao driver to provide service to person with disability. The

survey noted that the commercial areas were not accessible making it difficult to navigate and make choices while buying goods.

- **Site2-Midblock Crossing at Sanothimi**

Data were collected for 10 days during 9:00 AM to 11:00 AM as high flow of disabled pedestrian was observed during this period. Total of 202 data were recorded from video graphic survey. Among them 154 of them were Pedestrian without disability and 48 of them were pedestrian who is Blind *(Table 3.6).*

Figure3. 20: Pedestrian who is Blind (Walking in group)

Figure3. 21: Pedestrian who is Blind (Walking with volunteer)

Figure3. 22: Pedestrian who is Blind (without volunteer)

Table3. 6: Number of Pedestrian under the study along Midblock Crossing at Sanothimi

Category	**Number**
Pedestrian who is Blind	48
Pedestrian without Disability	154
Total	**202**

Three different pattern of crossing along 125m was observed during field observation. It can be seen in figure *3.23.*

Figure3. 23: Number of Crossings observed in midblock section at Sanothimi

So data were recorded along three different Road section. Despite presence of pedestrian crossing, they were not utilized regularly to cross street. Field data collected from video graphic survey is extracted in excel. *(Refer Table 3.8)* Data extracted from video are time taken to walk to kerb, waiting time and 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 data were uncensored data. All the time taken was measured in second.

Video graphic Survey was then followed by questionnaire survey. *(Refer Table 3.9)* Among 48 participants who were blind only 40 participated in questionnaire survey.

From the questionnaire survey conducted, generally behavior of pedestrian was analyzed. Majority of recorded pedestrian, (93%) fell within age group 20-40 years which is generally considered as economic group. *(Refer Table 3.14).* An overwhelming number of Pedestrian was observed to rely upon Public Vehicle for their commuting need and for marketing. Most of the pedestrian with disability recorded were male. Among this group significant numbers of pedestrian was

identified as student and were involved in marketing of *Dhup*. A noteworthy observation was that most of them were involved in some type of sports activities with cricket being most commonly mentioned sports. Given their involvement in marketing, it was also apparent that they frequented commercial centers as a part of their regular activities.

The data collected were extracted and entered into Microsoft Excel Sheet from the both, questionnaire survey and the video graphic survey of both site. 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.

3.3.1 Survival Analysis

Survival Time can be defined as time of occurrence of a given event. It measures the time to Response. In the study, this response is the initiation of a pedestrian crossing the street. Survival analysis performed in the study describes probability that the pedestrian has not successfully started to cross street till the duration t. It is expressed as in *equation 3.1*

$$\boldsymbol{S(t) = P(T > t) = 1 - P(T < t) = 1 - F(t) = \sum_{t}^{\infty} f(x)dx} \quad (3.1)$$

S(t) is a non-increasing function of time t with properties

S(t)=1 for t=0

S(t)=0 for t=∞

This means Probability of surviving at least time zero is 1 and that of surviving infinite time is 0.

In the context of our study, this means that at the onset (time zero), the probability of pedestrians not initiating street crossing is certain (1), and as time progresses, this probability diminishes.

“T” represents time until an event of interest occurs.

“t” represents specific time at which probability is evaluated.

f (t) represents PDF of continuous random variable T.

f (x) represents PDF of another continuous random variable x

Selected predictor for the analysis is pedestrian with disability and pedestrian without disability. Time of interest is waiting time. The analysis can be performed using Kaplan-Meir Estimation. Uncensored data is a type of data in which event of interest has been fully observed. It is coded as 1 in our data sheet. Censored data is type of observation in which exact event of interest is not known and it is coded as 0 in our data sheet.

This is non-parametric model that involves product limit of conditional probability for estimating approximated survival function. 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. Kaplan Meir curves are plotted stepwise starting with 1 at the beginning and 0 at the end. Since survival at the beginning is 100% and survival at last is 0.

3.3.2 Cox Proportional Hazard Model

The Cox Proportional Hazards Model is a statistical model used in survival analysis to investigate the relationship between the time until an event occurs (survival time) and several covariates or predictors. It is used to establish the relation between one or more explanatory variables. Other internal and external factor also plays role while crossing the road. The model is used to evaluate simultaneous effect of several factors on survival. The factors that are considered are status of disability, age, gender, time gap, vehicles encountered, pedestrian speed etc. It is expressed as in *equation 3.2.*

$$(\boldsymbol{h}(\boldsymbol{t},\boldsymbol{x1}))/(\boldsymbol{h}(\boldsymbol{t},\boldsymbol{x2})) = (\boldsymbol{ho}(\boldsymbol{t},\boldsymbol{\alpha})\mathbf{exp}(\boldsymbol{\beta x1}))/(\boldsymbol{ho}(\boldsymbol{t},\boldsymbol{\alpha})\mathbf{exp}(\boldsymbol{\beta x2})) \quad (3.2)$$

t represents survival time

h(t) is hazard function determined by set of co-variates (x1,x2)

$\beta 1$, $\beta 2$ is the measure of impact

H0 is called baseline hazard

h(t,x1) represents hazard rate at time t for an event of interest where x1 is a covariate

h0(t,α) is Baseline hazard at time t.

exp (β1,x1) and exp (β2,x2) is the effect of covariates x1 and x2 on hazard rate

This means that subject at any instant of time subject 1 will be exp[β(x1-x2)] times more likely to start to successfully cross the street than subject 2.

For the study, the Cox model results indicate the impact of different disability categories (wheelchair user, clutch user, physically impaired, pedestrian who is blind) on the hazard of initiating street crossing. For example, a negative coefficient for a disability category would imply a lower hazard (or longer waiting time) compared to the reference category (pedestrians without disabilities).

Hazard function gives the conditional failure rate. It is defined as probability failure during small period of time. The hazard function describes how the risk of the event changes over time and the covariates influence this risk. A positive coefficient β for a covariate indicates an increase in the hazard, suggesting an increased risk of the event occurring, while a negative coefficient implies a decrease in the hazard, indicating a reduced risk. In the study, where the event of interest is the initiation of a pedestrian crossing the street, the hazard would represent the instantaneous rate at which pedestrians, based on their characteristics (such as disability status), start to cross the street at any given moment.

It can be expressed as in *equation 3.3.*

$$h(t) = \frac{lim\Delta t \to 0\ P(an\ individual\ fails\ in\ the\ time\ interval\ (t,t+\Delta t)\ given\ the\ individual\ has\ survived\ to\ t)}{\Delta t} \qquad (3.3)$$

Hazard ratio is the ratio of hazard calculated for one individual characteristics and the hazard calculated for another individual characteristics. Hazard function may increase, decrease or remain constant.

If HR=1, No effect

If HR<1, Reduction in Hazard

IfHR>1, Increase in Hazard

CHAPTER 4: ANALYSIS AND DESIGN

4.1 Overview

The data collected were taken for survival and hazard analysis. Waiting time and Status of Disability was used for Kaplan Meir Estimation. Further relation of waiting time was analyzed with other co-variates- status of disability, gender; pedestrian speed, vehicle gap and vehicles encountered are taken into consideration for further analysis.

As per information obtained from first site, following coding has been considered for the further analysis.

- Uncensored event is coded as 1 while censored data 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 the further analysis in case of Site1-Midblock crossing at Jorpati.
- Similarly, Pedestrian who is blind is coded as 1 and Pedestrian without disability is coded as 0 in case of Site2-Midblock crossing at Sanothimi.
- Male pedestrian is coded as 1 and Female pedestrian is coded as 2.
- For the combined study of site, Site 1 was coded as 1 and site 2 was coded as 2.

4.2 Survival Analysis

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.

Site1-Midblock Crossing at Jorpati

Hypothesis testing was performed with null hypothesis.

H_0= There is no difference in waiting time between the Status of disability i.e. Pedestrian with disability (Wheel Chair User, Clutch User, Pedestrian with Physical impairment) and Pedestrian without disability.

For 95% confidence interval,

Null hypothesis is rejected if p<=0.05

Null hypothesis is not rejected if p>0.05

The significance value obtained from all three methods of chi-square tests are less than 0.05 *(Table 4.1)* which means that null hypothesis is rejected. 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. However, the analysis does not offer evidence regarding whether all groups exhibit a significant difference or if any specific pair of groups demonstrates a significant distinction.

Table4. 1: Chi-Square Test

	Chi-Square	df	Sig.
Log Rank (Mantel-Cox)	53.764	3	.000
Breslow (Generalized Wilcoxon)	59.019	3	.000
Tarone-Ware	58.203	3	.000

From the field data it was observed that wheel chair user, Clutch user, Pedestrian with physical impairment and Pedestrian without disability takes 1 second to 80 second, 2 second to 6 second, 3 second to 60 second and 0 second to 36 second before successfully crossing the road. It is summarized in *Table 4.2.*

Table4. 2: Minimum and Maximum Waiting Time taken by Pedestrian at Midblock Crossing of Jorpati

Code	Catagory	Waiting Time (sec)	
		Minimum	Maximum
1	Wheel Chair User	<=1	80
2	Clutch User	2	30
3	Pedestrian with Physical Impairment	3	60
4	Pedestrian without disability	<=1	36

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

For Wheel Chair User *(Refer Table 4.3)*

- At time t=1 second, 95% of pedestrian has not still started crossing street.
- At time t = 4 sec, 50.9% of pedestrian has not still started crossing street.
- Similarly at t=40 second, still 4.5% pedestrian has not still started crossing street.

For Clutch user *(Refer Table 4.4)*

- At time t=4 second, 50% of pedestrian has not still started crossing street.
- This decreases to 25% at t=6 second.

For physically impaired pedestrian *(Refer Table 4.5)*

- At time t=4 second, 44.4% of pedestrian has not still started crossing street.
- By t=41 second, still 11.1% pedestrian has not still started crossing street.

For Pedestrian without disability *(Refer Table 4.6)*

- At t=4 second, 20.1% pedestrian has not still started to cross street
- At t=25 second, 7% pedestrian has not still started to cross the street.

Table4. 3: Cumulative Proportion of Wheelchair user that has not crossed the road at a given time

Time (sec)	Cumulative proportion surviving at time	Standard Error
<=1	0.95	0.028
2	0.916	0.036
3	0.645	0.062
4	0.509	0.065
5	0.475	0.065
7	0.39	0.064
8	0.373	0.063
9	0.356	0.062
10	0.322	0.061
11	0.288	0.059
12	0.254	0.057
15	0.238	0.055
17	0.221	0.054
18	0.204	0.052
21	0.187	0.051

Time (sec)	Cumulative proportion surviving at time	Standard Error
24	0.17	0.049
28	0.153	0.047
29	0.102	0.039
34	0.085	0.036
39	0.068	0.033
40	0.045	0.029
41	-	
60	-	
80	-	

Table4. 4: Cumulative Proportion of Clutch user that has not crossed road at a given time

Time (sec)	Cumulative proportion surviving at time	Standard Error
2	0.75	0.217
4	0.5	0.25
6	0.25	0.217
30	-	

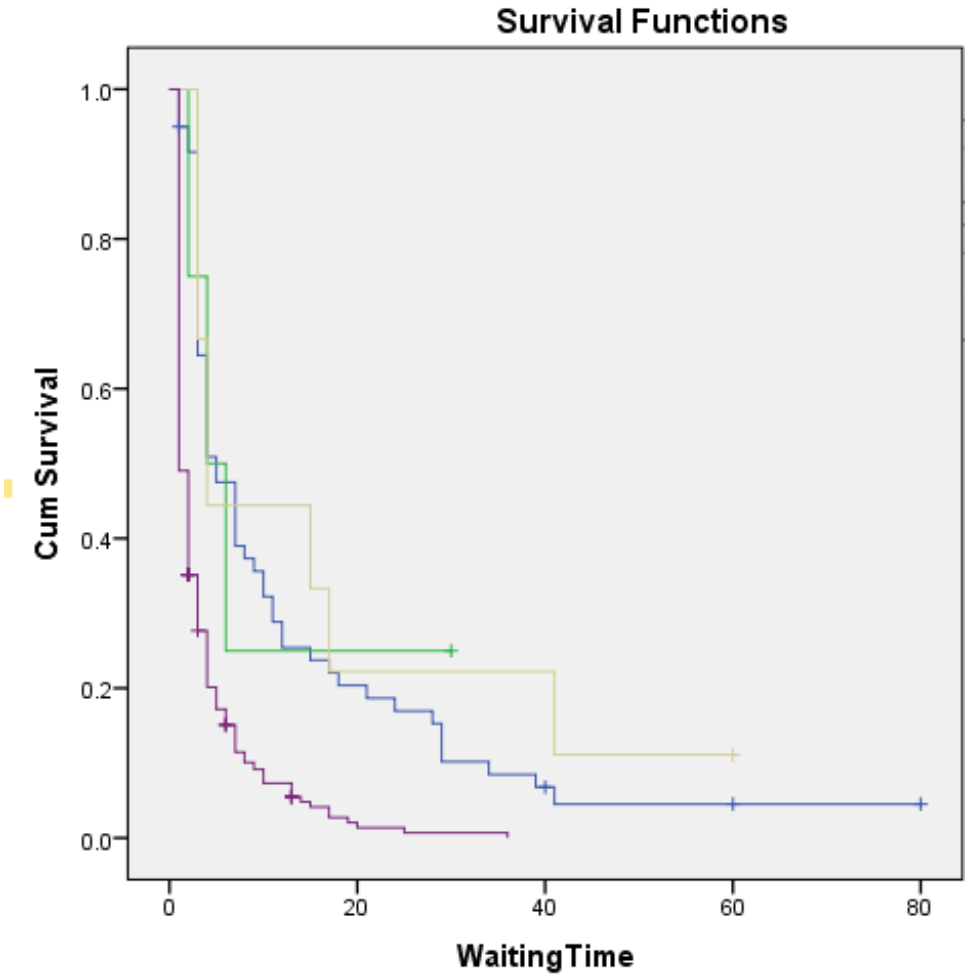
Table4. 5: Cumulative Proportion of Pedestrian with Physical impairment that has not crossed road at a given time

Time (sec)	Cumulative proportion surviving at time	Standard Error
3	0.667	0.157
4	0.444	0.166
15	0.333	0.157
17	0.222	0.139
41	0.111	0.105
60	-	

Table4. 6: Cumulative Proportion of Pedestrian without disability that has not crossed road at a given time

Time (sec)	Cumulative proportion surviving at time	Standard Error
<=1	0.49	0.031
2	0.351	0.03
3	0.277	0.028
4	0.201	0.025
6	0.151	0.023
7	0.114	0.021
8	0.101	0.02
9	0.092	0.019
10	0.073	0.017
13	0.055	0.015
14	0.048	0.015
15	0.041	0.014
17	0.027	0.012
19	0.021	0.011
20	0.014	0.009
25	0.007	0.007
36	0	0

It can be observed from the graph *(figure 4.1)* that the curve representing Wheel Chair User, Clutch User and Physically Impaired Pedestrian exhibit overlapping pattern. 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.



Code	Catagory
	Wheel Chair User
	Clutch User
	Physically Impaired Pedestrian
	Pedestrian without Disability
	Wheel Chair User-Censored
	Clutch User-Censored
	Physically Impaired Pedestrian-Censored
	Pedestrian without Disability-Censored

Figure4. 1: Cumulative Survival vs Waiting Time

In essence data suggest that individual without disabilities experience a noticeably different waiting time compared to those with disabilities. Hence from this graph we can say that Pedestrian without disability has significantly different waiting time than Pedestrian with disability.

It can be further elaborated from *Table 4.3, 4.4, 4.5 and 4.6* pedestrian with disability show greatest delay. This can be confirmed by mean values and median waiting time too from *table 4.7.*

Table4. 7: Mean Waiting Time and Median Waiting Time (Midblock Crossing at Jorpati)

Status	Mean				Median	
	Estimate	Std. Error	95% Confidence Interval		Estimate	Std. Error
			Lower Bound	Upper Bound		
Wheel Chair	12.994	2.344	8.400	17.588	5.000	1.022
Clutch User	10.500	5.673	.000	21.620	4.000	2.000
Physically Impaired	16.667	6.435	4.054	29.279	4.000	.745
Without Disability	3.575	.334	2.921	4.229	1.000	.
Overall	6.129	.695	4.766	7.491	2.000	.234

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

Site2-Midblock Crossing at Sanothimi

In order to identify whether the status of disability is significantly different or not in case of midblock crossing at Sanothimi, chi square test is performed.

Hypothesis testing was performed with null hypothesis.

H_0= There is no difference in waiting time between the Status of disability i.e. Pedestrian who is Blind and Pedestrian who is not disabled

For 95% confidence interval,

Null hypothesis is rejected if p<=0.05

Null hypothesis is not rejected if p>0.05

The significance value obtained from all three tests are less than 0.05 (Table 4.8) which means that null hypothesis is rejected. It provides the evidence that there is significant difference in waiting time between Pedestrian who is blind and pedestrian without disability.

Table4. 8: Chi Square Test

	Chi-Square	df	Sig.
Log Rank (Mantel-Cox)	33.233	1	.000
Breslow (Generalized Wilcoxon)	31.932	1	.000
Tarone-Ware	34.702	1	.000

From the field data it was observed that pedestrian who is blind and pedestrian without disability takes 1 second to 41 second, and 1 second to 28 second before successfully crossing the road. It is summarized in *Table 4.9*

Table4. 9: Minimum and Maximum Waiting Time taken by Pedestrian at Midblock Crossing of Sanothimi

Code	Catagory	Waiting Time (sec)	
		Minimum	Maximum
1	Pedestrian who is Blind	<=1	41
2	Pedestrian who is not Blind	<=1	28

. The data highlights distinct pattern for different pedestrian group.

For Pedestrian who is Blind (Refer Table 4.10)

- At time t<=1 second, 91.7% of pedestrian has not still started crossing street.
- At time t=15 second, 31.3% of pedestrian has not still started crossing street.
- At time t=36 second, 2.1% pedestrian has not still started crossing street.

For Pedestrian who is not Disabled (Refer Table 4.11)

- At time t<=1 second, 75.3% of pedestrian has not still started crossing street.
- At time t=15 second, 1.9%of pedestrian has not still started crossing street.
- This decreases to 0. 6% at t=22 second.

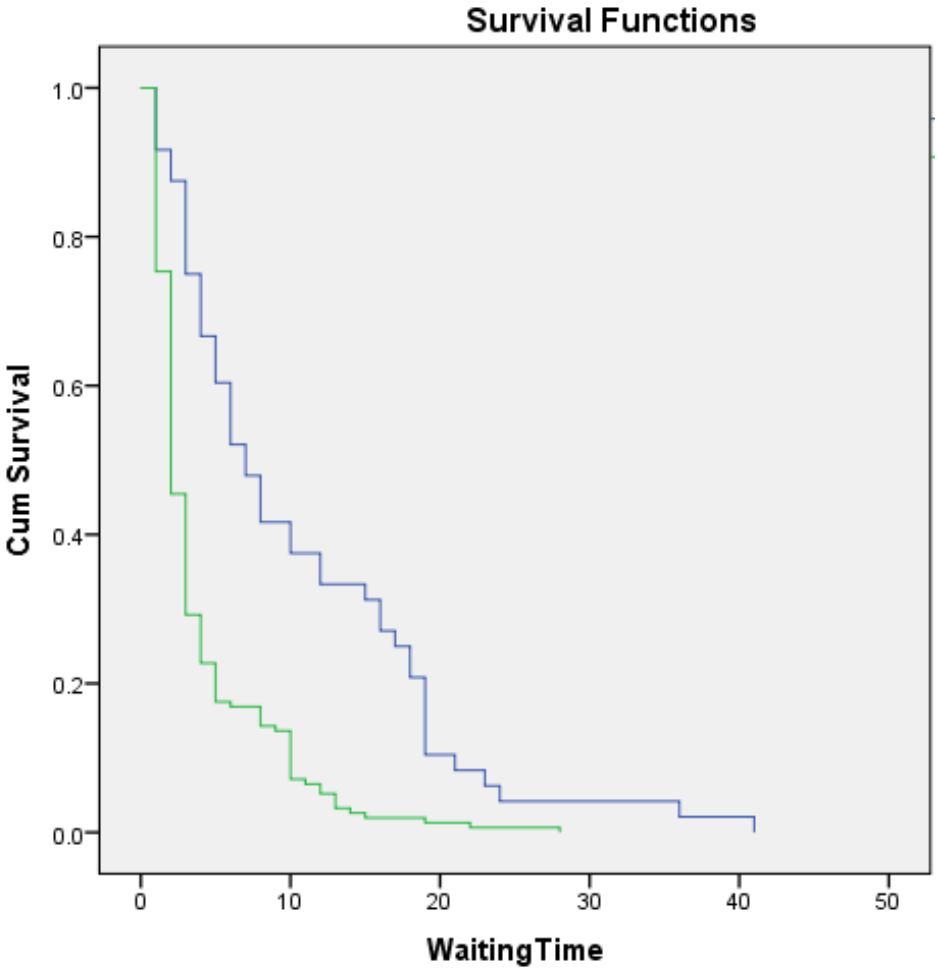
Table4. 10 : Cumulative proportion of Pedestrian who is Blind that has not crossed road at a given time

Time (sec)	Cumulative proportion surviving at time	Standard Error
1	0.917	0.04
2	0.875	0.048
3	0.75	0.063
4	0.667	0.068
5	0.604	0.071
6	0.521	0.072
7	0.479	0.072
8	0.417	0.071
10	0.375	0.07
12	0.333	0.068
15	0.313	0.067
16	0.271	0.064
17	0.25	0.063
18	0.208	0.059
19	0.104	0.044
21	0.083	0.04
23	0.063	0.035
24	0.042	0.029
36	0.021	0.021
41	0	0

Table4. 11: Cumulative proportion of Pedestrian without disability that has not crossed road at a given time

Time (sec)	Cumulative proportion surviving at time	Standard Error
1	0.753	0.035
2	0.455	0.04
3	0.292	0.037
4	0.227	0.034
5	0.175	0.031
6	0.169	0.03
8	0.143	0.028
9	0.136	0.028
10	0.071	0.021
11	0.065	0.02
12	0.052	0.018
13	0.032	0.014
14	0.026	0.013
15	0.019	0.011
19	0.013	0.09
22	0.006	0.006
28	0	0

It can be also observed from the graph *(figure 4.2)* that the curve representing Pedestrian who is Blind and Pedestrian without disability does not exhibit overlapping pattern. This indicates that aforementioned pedestrians are significantly different in terms of waiting time before initiating crossing.



Code	Catagory
	Pedestrian without disability
	Pedestrain who is Blind

Figure4. 2: Cumulative Survival vs. Waiting Time

Delay in waiting time can be further confirmed by mean values from *table 4.12.*

Table4. 12: Mean Waiting Time and Median Waiting Time (Midblock Crossing at Sanothimi)

	Mean				Median			
			95% Confidence Interval				95% Confidence Interval	
Status	Estimate	Std. Error	Lower Bound	Upper Bound	Estimate	Std. Error	Lower Bound	Upper Bound
Pedestrian who is Blind	10.479	1.308	7.916	13.042	7.000	1.154	4.739	9.261
Pedestrian without disability	3.922	.343	3.249	4.595	2.000	.174	1.659	2.341
Overall	5.480	.450	4.599	6.361	3.000	.225	2.560	3.440

- Among Pedestrian who is blind, average waiting time is 10.479 second with a median waiting time of 7 second.
- Among Pedestrian without disability, average waiting time is 3.922 second with a median waiting time of 2 second.

4.3 Cox Proportional Model

Cox-Proportional Hazard models were then implemented to obtain relation of disability with different covariates.

Different factors gap, Vehicles encountered, Status of disability, Pedestrian Speed and Gender were taken for analysis. Co-variates with negative coefficient show reduction in hazard while positive coefficient shows increase in hazard with increase in co-variates. For 95% confidence interval, accepted limit is less than 0.05.

Site1-Midblock Crossing at Jorpati

Hypothesis testing was performed with null hypothesis.

H_o= There is no difference in waiting time between the selected predictors (gap, Vehicles encountered, Status of disability, Pedestrian Speed and Gender)

For 95% confidence interval,

Null hypothesis is rejected if p<=0.05

Null hypothesis is not rejected if p>0.05

For the further analysis regarding status of disability, Pedestrian with disability were compared with Pedestrian without disability

Table4. 13: Catagorical Variable Coding

		Frequency	(1)	(2)	(3)
Status	1=Wheel Chair	60	1	0	0
	2=Clutch User	4	0	1	0
	3=Physically Impaired	9	0	0	1
	4=Without Disability	259	0	0	0

Among the status of disability, *Base Line Hazard function* was taken as pedestrian without disability.

It has been further coded as

1=Wheel Chair User

2=Clutch User

3=Physically Impaired Pedestrian

Remaining variables are taken as only continuous variable.

Coefficient is estimated for each type of predictors.

From the *table 4.14* we can say that

1. Vehicles Encountered, sig<0.05
2. Status of Disability, sig<0.05
3. Pedestrian Speed, sig>0.05
4. Gender, sig>0.05
5. Gap, sig<0.05

Table4. 14: Coefficient Estimation of Cox-Proportional Model

	B	SE	Wald	df	Sig.	Exp(B)	95.0% CI for Exp(B)	
							Lower	Upper
Vehicles Encountered	-.172	.043	16.411	1	.000	.842	.774	.915
Status			43.043	3	.000			
Status(1)	-1.007	.166	36.961	1	.000	.365	.264	.505
Status(2)	-1.178	.593	3.946	1	.047	.308	.096	.984
Status(3)	-1.219	.378	10.377	1	.001	.296	.141	.621
Pedestrian Speed	-.053	.202	.069	1	.793	.948	.638	1.409
Gender	.072	.118	.378	1	.539	1.075	.853	1.354
Gap	.075	.020	14.252	1	.000	1.077	1.037	1.120

From above data, we can say that Pedestrian Speed and Gender are not significant variable in terms of waiting time. While Vehicles encountered, Status of disability and Traffic Gap is only the significant variable. So these parameters are further checked upon as omnibus test of Model coefficient as in *Table 4.15.*

Table4. 15: Omnibus Test of Model Coefficient

	Overall (score)			Change From Previous Step			Change From Previous Block
-2 Log Likelihood	Chi-square	df	Sig.	Chi-square	df	Sig.	Chi-square
3074.911	71.259	5	.000	74.866	5	.000	74.866

The Omnibus Test of Model Coefficient shows that the considered variables are significantly different.

To assess whether the proportional hazards assumption holds good for model and evaluate the overall model fit Log-Log Survival curve is plotted as shown in *figure 4.3.* Visual inspection shows that the curves are roughly parallel which means proportional hazard assumption holds good.

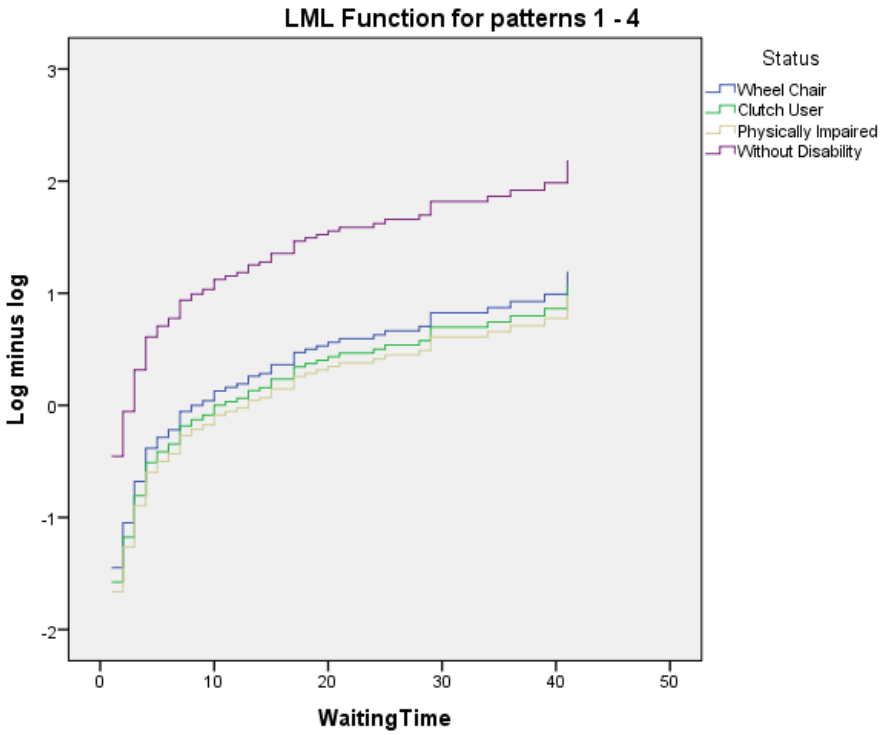


Figure4. 3: Log minus Log Curve

Further, only the significant variables are checked upon as in *Table 4.16.*

Table4. 16 : Coefficient Estimation of Cox-Proportional Model with significant variable

	B	SE	Wald	df	Sig.	Exp(B)	95.0% CI for Exp(B)	
							Lower	Upper
Vehicles Encountered	-.170	.040	18.205	1	.000	.844	.780	.912
Status			44.646	3	.000			
Status(1)	-.993	.162	37.543	1	.000	.370	.269	.509
Status(2)	-1.121	.585	3.680	1	.050	.326	.104	1.025
Status(3)	-1.209	.373	10.481	1	.001	.299	.144	.621
Gap	.077	.019	16.398	1	.000	1.081	1.041	1.122

This analysis revealed:

- Wheel chair user has 63% less likelihood of start crossing the street than Pedestrian without disability.
- Physically impaired Pedestrian has 70.1% less likelihood to start crossing the street than the Pedestrian without disability.
- Increase in 1 vehicle encountered, hazard of starting to cross street decreases by 15.6%.
- 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%.

Site1-Midblock Crossing at Sanothimi

Hypothesis testing was performed with null hypothesis.

H_o= There is no difference in waiting time between the selected predictors (gap, Vehicles encountered, Status of disability, Pedestrian Speed and Gender)

For 95% confidence interval,

Null hypothesis is rejected if p<=0.05

Null hypothesis is not rejected if p>0.05

For the further analysis regarding status of disability, Pedestrian with disability were compared with Pedestrian without disability.

It has been further coded as in *Table 4.17.*

Table4. 17: Catagorical Variable Coding

		Frequency	(1)
Status	1=Pedestrian who is Blind	48	1
	2=Pedestrian without disability	154	0

From the *table 4.3.6* we can say that

1. Vehicles Encountered, sig<0.05
2. Status of Disability, sig<0.05

3. Pedestrian Speed, sig>0.05
4. Gender, sig>0.05
5. Gap, sig>0.05

From *table 4.18*, we can say that Pedestrian Speed, Gender and Gap are not significantly different in terms of waiting time.

Table4. 18: Coefficient Estimation of Cox-Proportional Model

	B	SE	Wald	df	Sig.	Exp(B)	95.0% CI for Exp(B)	
							Lower	Upper
Vehicles Encountered	-.314	.075	17.482	1	.000	.730	.630	.846
Status	-.633	.213	8.793	1	.003	.531	.350	.807
Pedestrian Speed	.306	.340	.812	1	.367	1.358	.698	2.643
Gap	.004	.020	.030	1	.862	1.004	.965	1.044
Gender	.061	.145	.178	1	.673	1.063	.799	1.414

Vehicles encountered and Status of disability is only the significant variable. So these parameters are further checked upon as omnibus test of Model coefficient *(Table 4.19).* The omnibus test is likelihood-ratio chi-sqaure test.

Table4. 19: Omnibus Test of Model Coefficient

-2 Log Likelihood	Overall (score)			Change From Previous Step			Change From Previous Block
	Chi-square	df	Sig.	Chi-square	df	Sig.	Chi-square
1742.210	50.514	2	.000	52.364	2	.000	52.364

The table further shows that sig<0.05 with predictor status of disability and vehicle encountered which fits better.

To assess whether the proportional hazards assumption holds good for model and evaluate the overall model fit Log-Log Survival curve is plotted as in *figure 4.4.* Visual inspection shows that the curves are roughly parallel which means proportional hazard assumption holds good.

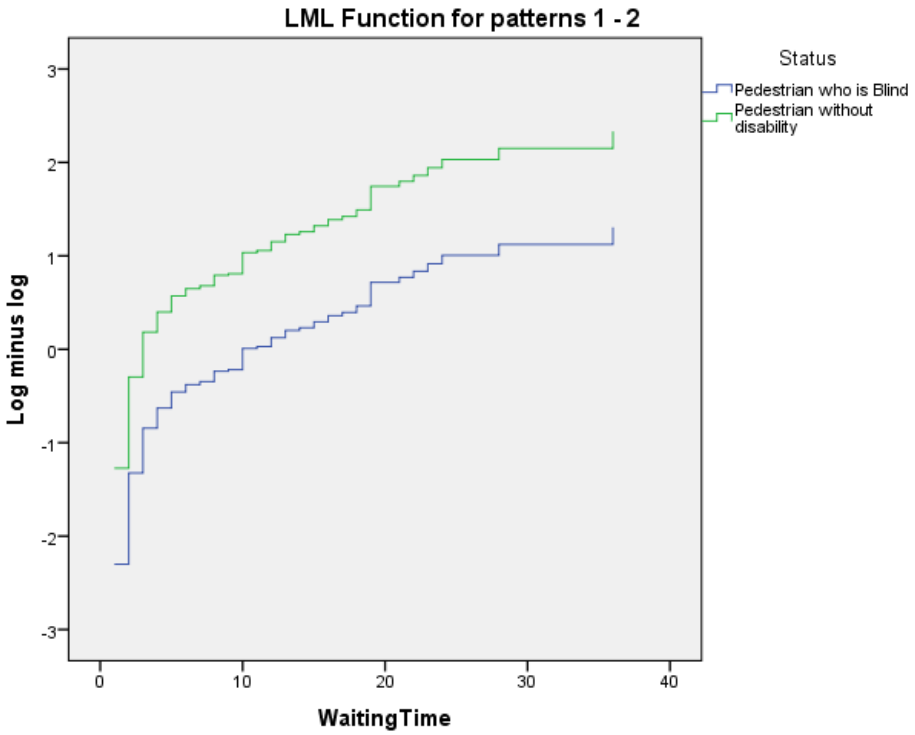


Figure4. 4: Log minus Log Curve

So the significant variables are further taken for the analysis as shown in *Table 4.20.*

Table4. 20: Coefficient Estimation of Cox-Proportional Model for significant variable

	B	SE	Wald	df	Sig.	Exp(B)	95.0% CI for Exp(B)	
							Lower	Upper
Vehicles Encountered	-.338	.069	23.969	1	.000	.713	.623	.817
Status	-.732	.179	16.776	1	.000	.481	.339	.683

This analysis revealed:

- Pedestrian who is blind has 51.9 % less likelihood of start crossing the street than Pedestrian without disability.
- Increase in 1 vehicle encountered, Pedestrian is 28.7% less likely to start crossing street.

Similarly the data collected from questionnaire survey is also analyzed.

Combined Analysis of Sites- Cox Proportional Hazard Model

Two sites were then analyzed differently i.e. Midblock crossing at Jorpati and Midblock crossing at Sanothimi. Data collected from two sites were combined to unified data set. Dependent variable is waiting time. Covariates considered are Traffic gap, Gender, Status of disability, Pedestrian speed, Vehicles encountered and Site. Here only the pedestrian with disability were taken for analysis. To facilitate the analysis each site was coded numerically: 1 for midblock crossing at Jorpati and 2 for Midblock crossing at Sanothimi.

Table4. 21: Coefficient Estimation of Cox-Proportional Model

	B	SE	Wald	df	Sig.	Exp(B)	95.0% CI for Exp(B)	
							Lower	Upper
Vehicles Encountered	-.248	.097	6.527	1	.011	.780	.645	.944
Status	-.102	.189	.291	1	.590	.903	.623	1.308
Pedestrian Speed	-.054	.344	.024	1	.876	.948	.483	1.859
Gap	.000	.041	.000	1	.991	1.000	.923	1.084
Gender	-.099	.202	.240	1	.624	.906	.609	1.346
Site	-.551	.549	1.005	1	.316	.577	.197	1.692

The analysis revealed that:

- Site is not a significant variable.

Crossing Time

The crossing time for pedestrian was noted and hence the crossing speed was calculated for individual. The average pedestrian crossing speed is shown in *table 4.22* for midblock crossing at Jorpati and in *table 4.23* for midblock crossing at Sanothimi.

Table4. 22: Average Road crossing speed at Jorpati

Status	Average Crossing Speed (m/s)
Wheel Chair User	0.88
Physically Impaired Pedestrian	0.806
Clutch User	0.77
Without Disability	1.21

Table4. 23: Average Road crossing speed at Sanothimi

Status	Average Crossing Speed (m/s)
Pedestrian who is Blind	0.98
Without Disability	1.32

4.4 Model Interpretation

Initially, analysis revealed a connection between specific type of Pedestrian and their waiting time. Here the Event is defined as pedestrian starting to cross the street. Similarly, waiting time is defined as the time elapsed from pedestrian arrival at the crossing point to the moment they actually begin to cross. Another variable upon the analysis is Status of disability. Waiting time is analyzed among different pedestrian group. In case of Midblock crossing at Jorpati, *Wheel chair user, Clutch User, Physically impaired pedestrian and pedestrian without disability* is considered. While in case of Midblock crossing at Sanothimi, *Pedestrian who is blind and pedestrian who is not blind* is considered for the survival analysis. Analysis involves studying time interval between events and accounting for both uncensored and censored event. In this study, uncensored event is the event in which pedestrian is observed actively waiting to initiate a street crossing. Similarly censored event is the event in which pedestrian is observed waiting but is not waiting to initiate the street crossing. Instead, they are waiting for reasons other than crossing the street, such as talking, waiting for friends, or environmental conditions. Here the observation period varies in the study because pedestrian began crossing at different time during study. Survival analysis having the limitation, it cannot contribute to multiple covariates. So, Multivariable Cox-Proportional Hazard model is used for further analysis considering additional factors including traffic gap, encountered vehicles, gender disability status and pedestrian speed were also taken into analysis. The analysis incorporates both categorical (e.g., type of disability, Site infrastructure) and continuous (e.g., gender, pedestrian speed, traffic gap, vehicle encountered) predictors into the model, allowing researchers to examine the effects of these variables on waiting times.

Independent variable taken into consideration is:

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

We utilized the Cox proportional hazards model, a powerful statistical tool for modeling time-to-event data, to investigate waiting times, which are integral to pedestrian safety and urban planning. Normal distribution generally is not suitable for waiting time analysis as it cannot handle skewed data, censored data, and non-

normality. Right-skewed nature of data as seen in *figure 4.5 to figure 4.10*, allows us to take a crucial step in selecting an appropriate statistical approach i.e. survival analysis that aligns with the underlying characteristics of your dataset and allows for meaningful and accurate analysis of waiting times for pedestrian street crossings.

We obtain median waiting time and mean waiting time from both the site. Mean waiting time represents mean of waiting time for different group of pedestrian while Median waiting time is middle value in a sorted list of waiting time. Median time is less sensitive to extreme value. The Cox model enabled us to estimate survival probabilities, which represent the likelihood of pedestrians initiating street crossing at various time points. One of the most common and intuitive ways to assess proportional hazards is by plotting the log-log survival curves for different levels of a predictor variable. If the curves are roughly parallel over time, the assumption is likely met. Coefficient “B” represents estimated effect of each predictor variable on the hazard rate. Exponentiated Coefficients (Exp(B)) represent the hazard ratio (HR) associated with each predictor. The hazard ratio is a measure of how much the hazard rate changes for a one-unit change in the predictor.

CHAPTER 5: CONCLUSION AND RECOMMENDATION

5.1 Conclusion

The study focuses on understanding pedestrian waiting time and associated factors during street crossing. The application of survival analysis, particularly through cox-proportional hazard model provided insight into dynamic relation between different types of pedestrian and waiting time. The study found that Pedestrian with disabilities i.e. Wheel chair user, clutch user, physically impaired pedestrian and pedestrian who is blind requires high waiting time as compared to pedestrian without disability. The observation aligns with the hypothesis that individual with disabilities often require more time to assess traffic condition and ensure safety before initiating street crossing. **The median waiting time for disabled pedestrians is 3-6 seconds longer than those without disabilities.** This can be further verified from hazard analysis. **When subjected to similar traffic and environmental conditions, it is estimated that out of 100 pedestrians without disabilities who initiate crossing the street, only 29-38 pedestrians with physical disabilities are expected to start crossing, while 48 pedestrians who are blind are expected to commence their street crossing.** We can further say that the probability of crossing street for pedestrian who is blind is more than the pedestrian with physically disabled pedestrian. It may be because individuals with physical disabilities, who may use mobility aids or have other limitations, might need more time to navigate and evaluate the environment before initiating street crossing while pedestrian who is blind lacks the decision making power resulting anxiety and aggressiveness while crossing the street. This proposes that blind pedestrians, due to their reliance on other senses and possibly lacking visual cues, may exhibit a different behavior characterized by more assertiveness or urgency when crossing the street.

Similarly, the study observed variations in road crossing speeds, averaging 0.98 m/s for pedestrians who are blind, 0.88 m/s for wheelchair users, 0.806 m/s for physically impaired pedestrians, and 0.77 m/s for clutch users. It's worth noting that the road crossing speed for pedestrians without disabilities was higher at 1.265 m/s. This contrast in speeds suggests that individuals without disabilities tend to cross the road at a faster pace compared to those with specific mobility challenges or impairments.

Furthermore analysis revealed the significance of additional factors traffic gap and Vehicle encountered. Traffic gap was significant factor in case of Site 1 i.e. Midblock crossing at Jorpati. It was demonstrated that increased traffic gap positively influences likelihood of pedestrian, including those with disabilities starting to cross the street which showed that with **increase in traffic gap of 1 sec, likelihood of pedestrian to cross street increases by 8.1% while it is not a significant variable in case 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 road. While unique challenge faced by pedestrian who is blind and their lack of decision making power shows the aggressive behavior while crossing the street showing less variation in crossing street due to variation of traffic gap. Due to this reason, traffic gap in Midblock crossing at Jorpati is a significant variable and not a significant variable in Sanothimi. Another reason may be due to heavy volume of traffic as well as high number of heavy vehicle in Jorpati as compared to Sanothimi. Pedestrians accept larger gaps when facing larger vehicles (Yannis et al., 2013). It is important to mention that illegal parking in midblock crossing at Jorpati made pedestrians more careful and acceptant of larger gaps.

Similarly number of vehicles encountered is another significant variable upon analysis which influences negatively upon likelihood of pedestrian, including those with disabilities starting to cross the street**. It means that unit increase in traffic volume leads to decrease in likelihood of crossing street by 15.6% in site 1 and 28.7% in site 2.** As traffic volume increases at Site 2, pedestrians are even less likely to initiate crossing the street compared to Site 1. This may be due to high instantaneous speed in Site 2 compared to site 1. However Pearson correlation coefficient was also tested *(Table 5.1 and Table 5.2).* Overall, based on this Pearson correlation analysis, there appears to be no significant linear relationship between the number of vehicles encountered and the gap for pedestrians at the midblock Crossing at Jorpati (Site 1) and midblock Crossing at Sanothimi (Site 2). The correlation is close to zero, suggesting that changes in one variable are not associated with linear changes in the other variable.

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 suggesting that other factor: vehicles encountered and traffic gap play a more substantial role in determining waiting time.

5.2 Recommendations for future Research

The study was primarily aimed to have better understanding about the behavior of pedestrian with disability especially when they cross the road. Only pedestrian with physical disability and pedestrian who are visually impaired were selected for analysis for the study purpose and were conducted on only two midblock crossing. Although the conclusion presented is not authorized because of limited field data, it presents good basis for more investigation.

Further following task are recommended for future studies on similar topic:

- Expanding the study area to include other midblock crossing in various locations can provide insight into how different infrastructural element could affect pedestrian behavior.
- A large sample size with different pedestrian group could provide more significantly better result. This can help researcher better understand difference in behavior among the pedestrian with different type of disability.
- Extend analysis period to cover longer time frame so that large group of pedestrian could be incorporated. This further helps to capture seasonal variation, time variation and traffic volume variation that influences the pedestrian behavior.
- Co-variates taken for the analysis was status of disability, gender, vehicle encountered, traffic gap, pedestrian speed and site. Other co-variates such as vehicular speed, age group, driver-pedestrian interaction can be taken for analysis.
- In order to arrive at precise conclusion, it is advisable to examine various type of disabilities within same location. This enables comparison of waiting time among different type of disability.

REFERENCES

1. Ashmead, D. H., Guth, D., Wall, R. S., Long, R. G., & Ponchillia, P. E. (2005). Street crossing by sighted and blind pedestrians at a modern roundabout. *Journal of Transportation Engineering*, *131*(11), 812–821. https://doi.org/10.1061/(ASCE)0733-947X(2005)131:11(812)
2. City, K. M. (2020). *INSTITUTE OF ENGINEERING Accessibility in Public Spaces for Persons with Disability- A Case of Kathmandu Metropolitan City*. *8914*, 383–393.
3. Geruschat, D. R., Hassan, S. E., & Turano, K. A. (2003). Gaze behavior while crossing complex intersections. *Optometry and Vision Science*, *80*(7), 515–528. https://doi.org/10.1097/00006324-200307000-00013
4. Guth, D. A., Long, R. G., Wall Emerson, R. S., Ponchillia, P. E., & Ashmead, D. H. (2013). Blind and sighted pedestrians' Road-crossing judgments at a single-lane roundabout. *Human Factors*, *55*(3), 632–642. https://doi.org/10.1177/0018720812459884
5. Hamed, M. M. (2001). Analysis of pedestrians' behavior at pedestrian crossings. *Safety Science*, *38*(1), 63–82. https://doi.org/10.1016/S0925-7535(00)00058-8
6. Holland, C. A., & Rabbitt, P. M. A. (1992). People's awareness of their age-related sensory and cognitive deficits and the implications for road safety. *Applied Cognitive Psychology*, *6*(3), 217–231. https://doi.org/10.1002/acp.2350060304
7. Lobjois, R., & Cavallo, V. (2007). 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*, *39*(5), 934–943. https://doi.org/10.1016/j.aap.2006.12.013
8. MoPIT/JICA. (2012). the Federal Democratic Republic of Nepal Data Collection Survey on Traffic Improvement in Final Report October 2012 Data Collection Survey on Traffic Improvement in. *Final Report:Collection Survey on Traffic Improvement*, *October*.
9. Oxley, J. A., Ihsen, E., Fildes, B. N., Charlton, J. L., & Day, R. H. (2005). Crossing roads safely: An experimental study of age differences in gap selection by pedestrians. *Accident Analysis and Prevention*, *37*(5), 962–971. https://doi.org/10.1016/j.aap.2005.04.017
10. Pecchini, D., & Giuliani, F. (2015). Street-crossing behavior of people with disabilities. *Journal of Transportation Engineering*, *141*(10). https://doi.org/10.1061/(ASCE)TE.1943-5436.0000782
11. Salamati, K., Schroeder, B., Rouphail, N. M., Cunningham, C., Long, R., & Barlow, J. (2011). Development and implementation of conflict-based assessment of pedestrian safety to evaluate accessibility of complex intersections. *Transportation Research Record*, *2264*, 148–155. https://doi.org/10.3141/2264-17
12. Source, B. A. S., American, T., Teacher, B., By, P., & Teachers, B. (2004). *The Prospects and Situation of Accessibility in Nepal* (Vol. 66, Issue 5).
13. US-HCM. (2010). *Highway Capacity Manual (HCM) 2010 National Research Council Board, Transportation Research*.

14. WHO. (2023). *No Title*. Fact Sheet. https://www.who.int/news-room/fact-sheets/detail/disability-and-health
15. Yannis, G., Papadimitriou, E., & Theofilatos, A. (2013). Pedestrian gap acceptance for mid-block street crossing. *Transportation Planning and Technology*, *36*(5), 450–462. https://doi.org/10.1080/03081060.2013.818274

Internet Sources

1. (2021). Retrieved from CBS.
2. *definition-and-classification-of-disability-in-nepal_english.* (n.d.). Retrieved from https://rcrdnepa.files.wordpress.com/2010/09/.
3. *https://walkabilityasia.org/kathmandu-nepal/*. (n.d.). Retrieved from Walkability Asia.
4. JICA. (2012).

APPENDIX A: Sample Questionnaire

Table3. 7: Sample Data collection from Videographic Survey (Site1: Midblock Crossing at Jorpati)

S.N.	Direction	Walking to Kerb (sec)	Waiting Time (sec)	Crossing Time (sec)	Pedestrian Speed (m/s)	Censored/ Noncensored	No of Vehicles encountered	Gap (Sec)	Gender	Status	Remarks
1	Right	4	3			1	0		F	Wheel Chair	
2	Left	3	2			1	0		M	Wheel Chair	
3	Left	5	2			1	0		M	Wheel Chair	
4	Crossing	4	21	20	0.9	1	0	5	M	Wheel Chair	
5	Crossing	3	15	16	1.13	1	0	5	M	Wheel Chair	
6	Left	4	9			1	0		M	Wheel Chair	
7	Crossing	4	12	16	1.13	1	0	5	M	Wheel Chair	
8	Crossing	5	6	16	1.13	1	0	5	M	Clutch	
9	Left	3	33			0	0		F	Wheel Chair	Wind
10	Right	6	3			1	0		M	Wheel Chair	
11	Crossing	3	12	27	0.67	1	2	8	M	Wheel Chair	
12	Left	3	3			1	0		M	Wheel Chair	
13	Crossing	7	15	15	1.2	1	1	3	F	Physically impaired	
14	Left	3	3			1	0		F	Wheel Chair	

Table3. 8: Sample Data collection from Videographic Survey (Site2: Midblock Crossing at Sanothimi)

S.N.	Walking to Kerb (sec)	Waiting Time (sec)	Crossing Time (sec)	Pedestrian Speed (m/s)	Censored/ Noncensored	No of Vehicles encountered	Gap (Sec)	Gender	Accept/Reject	Status	Remarks
1	2	2	13	1.38	1	0	2	M	0	Without disability	
2	1	1	15	1.2	1	0	14	M	1	Without disability	
3	1	1	15	1.2	1	0	14	M	1	Without disability	
4	2	1	12	1.5	1	0	10	F	1	Without disability	
5	2	1	12	1.5	1	0	10	F	1	Without disability	
6	2	1	12	1.5	1	0	10	F	1	Without disability	
7	2	13	16	1.13	1	3	6	F	0	Without disability	
8	2	13	16	1.13	1	3	6	F	0	Without disability	
9	2	13	16	1.13	1	3	6	F	0	Without disability	
10	2	3	13	1.38	1	0	1	M	0	Without disability	
11	2	1	10	1.8	1	0	9	M	1	Without disability	
12	2	1	10	1.8	1	0	9	M	1	Without disability	
13	2	10	12	1.5	1	0	14	M	1	Without disability	
14	2	12	16	1.13	1	1	14	M	1	Without disability	

Table3. 9: Sample Data collection from Questionnaire Survey (Site1: Midblock Crossing at Jorpati)

S.N.	Age	Gender	Status of Disability	Employment	Preferred mode of Transportation	Frequency to sports centre	Frequency to commercial centre
1	23	M	Wheel Chair	Student	Wheel Chair	Weekly	Weekly
2	21	M	Wheel Chair	BIA-Staff	Public Vehicle	Weekly	Weekly
3	24	M	Wheel Chair	BIA-Staff	Taxi	Weekly	Weekly
4	23	M	Clutches	BIA-Staff	Taxi	-	Weekly
5	27	M	Wheel Chair	Student	Wheel Chair	Occasionally	Monthly
6	28	F	Physical Impairment	BIA-Staff	Public Vehicle	-	Weekly
7	20	M	Wheel Chair	Student	Wheel Chair	Weekly	Weekly
8	20	M	Wheel Chair	Student	Wheel Chair	Weekly	Weekly
9	21	M	Wheel Chair	Student	Wheel Chair	Weekly	Weekly
10	45	F	Wheel Chair	BIA-Staff	Wheel Chair	-	Weekly
11	30	F	Wheel Chair	BIA-Staff	Walking	-	Weekly
12	32	M	Wheel Chair	Residence at Khagendra	Wheel Chair	-	Weekly
13	23	M	Wheel Chair	Student	Wheel Chair, Public Vehicle Long Tour	Weekly	Weekly

Table3. 10: Sample Data collection from Questionnaire Survey (Site1: Midblock Crossing at Sanothimi)

S.N.	Age	Gender	Status of Disability	Employment	Preferred mode of Transportation	Frequency to sports centre	Frequency to commercial centre
1	22	M	Blind	Student	Public Vehicle	Daily	Weekly
2	24	M	Blind	Student	Public Vehicle	Daily	Twice a Week
3	20	M	Blind	Student	Public Vehicle	Daily	Weekly
4	25	M	Blind	Student	Public Vehicle	Daily	Weekly
5	23	M	Blind	Student	Public Vehicle	Daily	Monthly
6	19	M	Blind	Student	Public Vehicle	Monthly	Daily
7	28	M	Blind	Student	Public Vehicle	Never	Daily
8	24	M	Blind	Marketing	Public Vehicle	Never	Daily
9	32	F	Blind	Marketing	Public Vehicle	Never	Daily
10	21	F	Blind	Student	Public Vehicle	Weekly	Daily
11	25	M	Blind	Student	Public Vehicle	Weekly	Daily
12	32	M	Blind	Marketing	Public Vehicle	Never	Monthly
13	32	M	Blind	Marketing	Public Vehicle	Never	Weekly
14	44	F	Blind	Marketing	Public Vehicle	Never	Weekly
15	35	M	Blind	Worker	Public Vehicle	Never	Weekly
16	36	M	Blind	Worker	Public Vehicle	Never	Weekly
17	22	M	Blind	Student	Public Vehicle	Weekly	Weekly
18	28	M	Blind	Student	Public Vehicle	Weekly	Weekly
19	21	M	Blind	Student	Public Vehicle	Weekly	Weekly
20	24	F	Blind	Student	Public Vehicle	Weekly	Weekly

APPENDIX B: Summary of Data

Table3. 11: Site wise comparison

Indicator	**Site-1(Midblock Crossing at Jorpati)**	**Site-2 (Midblock Crossing at Sanothimi)**
Number of Lane	4	4
Length of Carriageway (m)	18	18
Length of Side Walk (m)	2.5	1.5
Number of vehicle/hr/2lane	1900	1590
Speed Limit	30	30
Average Instataneous Speed (kmph)	42	44.25
Tactile Pavement	√	Broken Pavement
Crosswalk	Faded Marking	Unfaded Marking
Onside Vehicle Parking	√	X
Drainage Cover	Managed	Unmanaged *(figure 3.2.8 and 3.2.9)*

Table3. 12: Sample size calculation for PWD

Status of Disability	**Kathmandu**	**Bhaktapur**	**Lalitpur**
Person who is Blind	720	230	331
Person with low vision	2955	362	614
Person who is Physically disabled	6082	1310	2868
Total	10145	1982	3886

Total number of PWD=16013

1. Person with Physical disability

Population size (N) =10260

Confidence Level=95%

Margin of Error (e) =5%

Population proportion (p) =3%

$$Sample\ size\ (n) = \frac{((z * z) * p * (1 - p))/(e * e)}{1 + (\frac{z * z * p * (1 - p)}{e * e * N})}$$

n=45

2. Person who is Blind

Population size (N) =5212

Confidence Level=95%

Margin of Error (e) =5%

Population proportion (p) =3%

$$Sample\ size\ (n) = \frac{((z * z) * p * (1 - p))/(e * e)}{1 + (\frac{z * z * p * (1 - p)}{e * e * N})}$$

n=45

Table3. 13: Summary of Field Data (Site 1: Jorpati)

Age	Percentage
<20 years	8%
20 to 40 years	85%
>40 years	7%

Gender	Percentage
Male	64%
Female	36%

Status of Disability	Percentage
Wheel Chair	79%
Clutch	5%
Physical impairment	10%
Blind	3%
Dwarf	1%

Employment	Percentage
Student	37%
Worker	56%
Retired	5%
Other	1%

Status of Disability	Walking Speed (m/s)
Wheel Chair	1.022
Clutch	0.940
Physically impaired	0.932

Weekly Frequency rates for sports centres	Percentage
Weekly	19%
Monthly	3%
Occasionally	45%
Never	33%

Weekly Frequency rates for commercial centres	Percentage
Daily	5%
Weekly	32%
Twice a week	49%
Thrice a week	1%
Monthly	8%
Online	1%
Never	3%

Preferred mode of Vehicle	Percentage
Wheel Chair	15%
Public Vehicle	33%
Taxi	29%
Pathao	1%
Scooter	14%
Sajha Yatayat	8%

Table3. 14: Summary of Field Data (Site 2: Sanothimi)

Age	Percentage
<20	5%
20-40	93%
>40	3%

Gender	Percentage
Male	63%
Female	38%

Employment	Percentage
Student	58%
Worker	40%
Other	2%

Preferred mode of Vehicle	Percentage
Public Vehicle	100%

Weekly Frequency rates for commercial centers	Percentage
Daily	25%
Weekly	35%
Monthly	18%
Never	23%

Weekly Frequency rates for sports centres	Percentage
Daily	38%
Weekly	40%
Twice a Week	3%
Monthly	18%
Never	3%

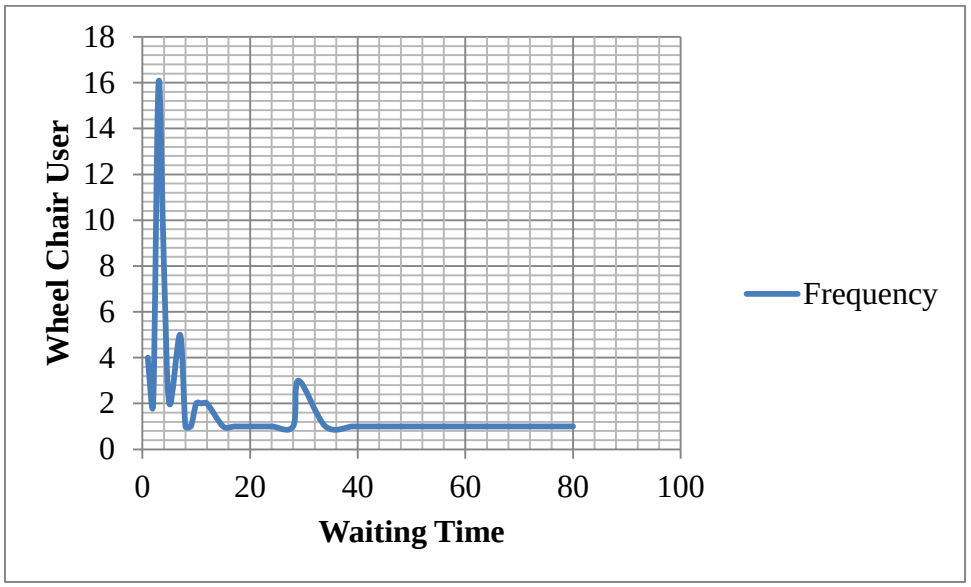


Figure4. 5: Frequency Graph of Waiting time for Wheel Chair User

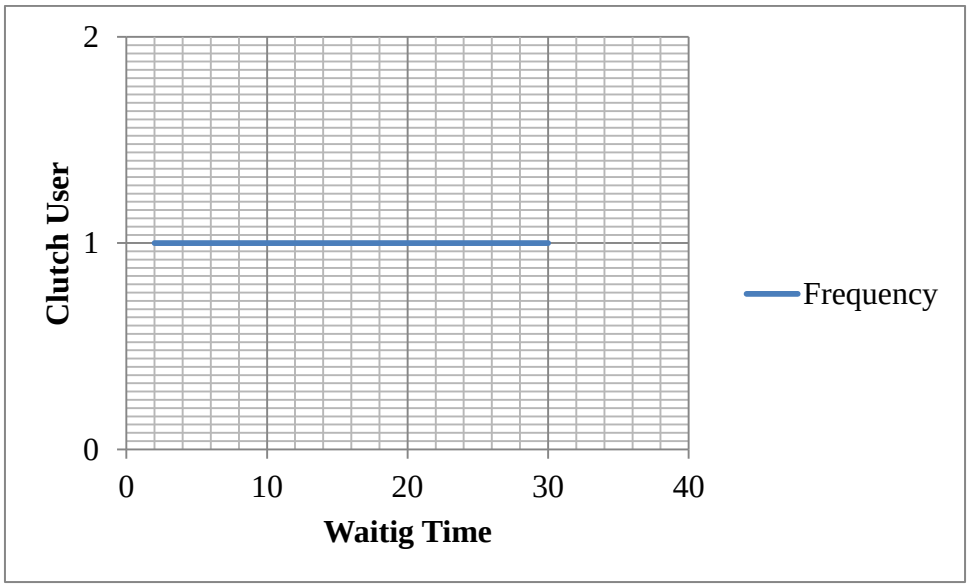


Figure4. 6: Frequency Graph of waiting time for Clutch User

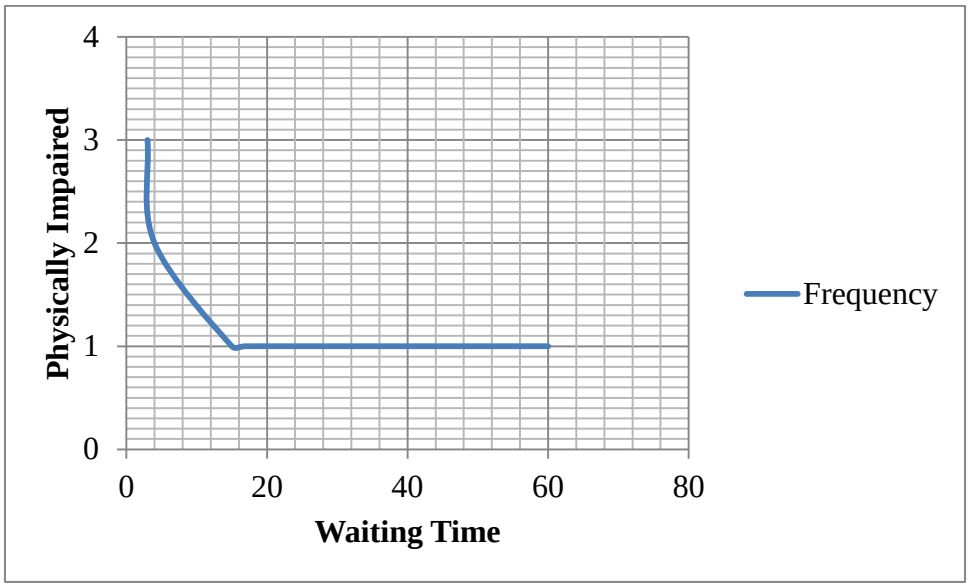


Figure4. 7: Frequency Graph of waiting time for Physically Impaired Pedestrian

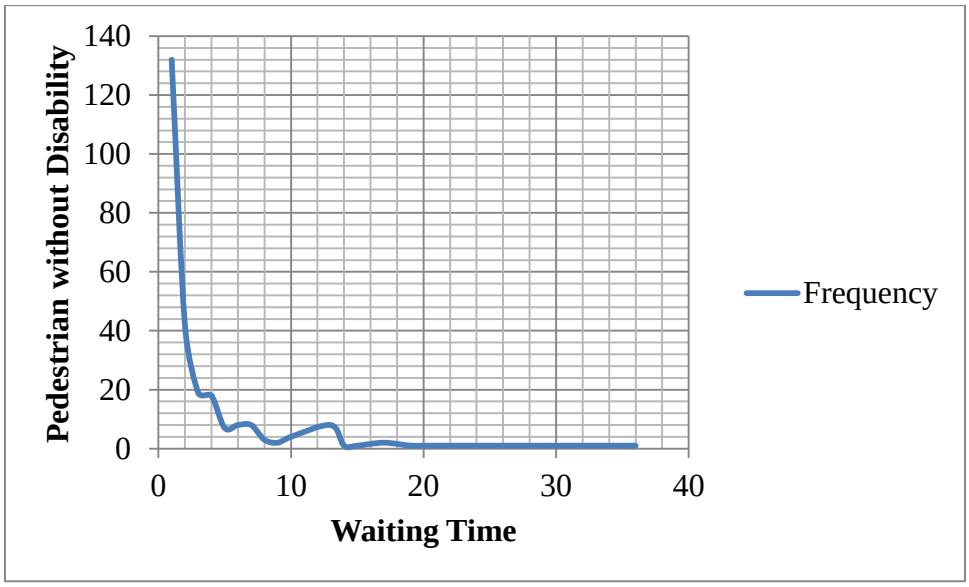


Figure4. 8: Frequency Graph of waiting time for Pedestrian without Disability

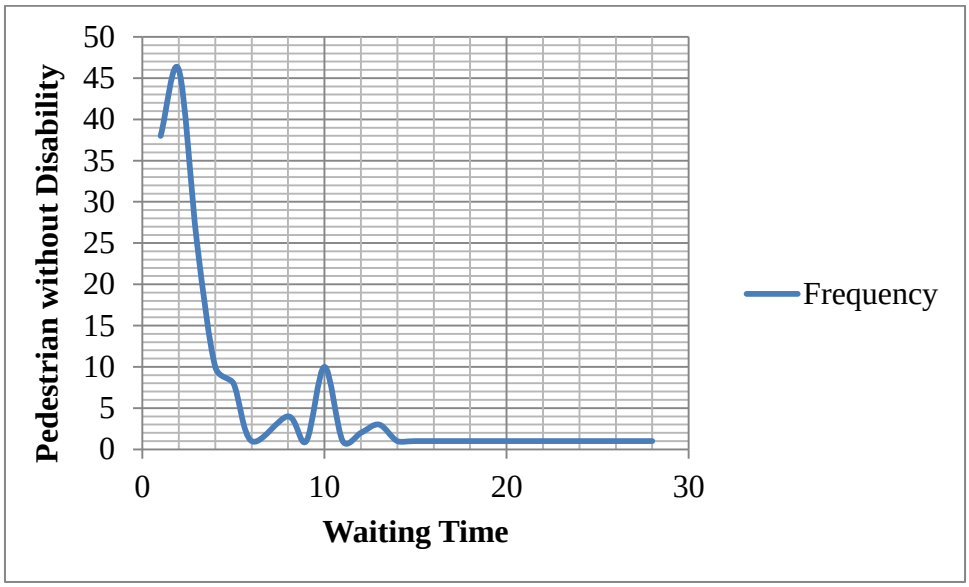


Figure4. 9: Frequency Graph of waiting time for Pedestrian without Disability in Sanothimi

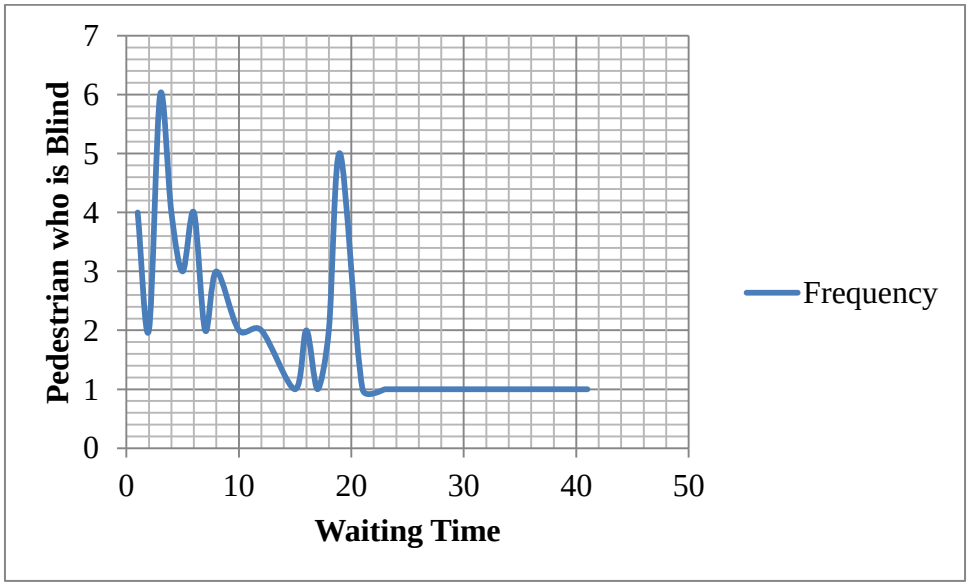


Figure4. 10: Frequency Graph of waiting time for Pedestrian who is blind in Sanothimi

Table5. 1: Pearson Correlation coefficient (Site: Midblock Crossing at Jorpati)

		Vehicles Encountered	Gap
VehiclesEncountered	Pearson Correlation	1	-.044
	Sig. (2-tailed)		.427
	N	332	332
Gap	Pearson Correlation	-.044	1
	Sig. (2-tailed)	.427	
	N	332	332

Table5. 2: Pearson Correlation coefficient (Site: Midblock Crossing at Sanothimi)

		Vehicles Encountered	Gap
VehiclesEncountered	Pearson Correlation	1	-.086
	Sig. (2-tailed)		.223
	N	202	202
Gap	Pearson Correlation	-.086	1
	Sig. (2-tailed)	.223	
	N	202	202