Evaluation of Before and After Measures to Curb Distracted Walking

Final Report

by

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DISCLAIMER

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16. Abstract

Walking is one of the most common non-motorized modes of transportation. It is a convenient way to move from one place to another if other modes of transport are limited, and it is healthy. However, distracted pedestrians have become an increasing problem, and the main culprit is cellular devices. Cellphones have taken over many people's lives, and an average person cannot go without the usage of their cell phone in a day. Cellphones are used everywhere, like workplaces, homes, driving, and walkways. Every year pedestrians are endangered from texting, talking, or listening to music on their cellphones while walking. Data from the National Highway Traffic Safety Administration (NHTSA) shows that pedestrian fatalities range from approximately 4,110 to 6,080 from 2008 through 2017. In this study, the countermeasures to distracted pedestrian walking behavior are investigated. These research findings will help transportation and enforcement officials to enforce adequate safety measures when curbing distracted walking problem. The outcomes of this study are expected to provide essential information for the public on the effects attributed to distracted walking and the safety of pedestrians.

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EXECUTIVE SUMMARY

Walking is one of the most common non-motorized modes of transportation. It is a convenient way to move from one place to another if other modes of transport are limited, and it is healthy. However, distracted pedestrians have become an increasing problem, and the main culprit for distraction is cellular devices. Cellphones have taken over many people's lives, and an average person cannot go without the usage of their cell phone in a day. Cellphones are used everywhere, like workplaces, homes, driving, and walkways. Every year pedestrians are endangered from texting, talking, or listening to music on their cellphones while walking.

Data from the National Highway Traffic Safety Administration (NHTSA) shows that pedestrian fatalities range from approximately 4,110 to 6,080 from 2008 through 2017. This study investigates the warning traffic signs as countermeasures to distracted pedestrian walking behavior. The design and the findings of this study will help transportation professionals and agencies, and enforcement agencies put in efficient measures to reduce distracted walking and enhance public safety. Further outcomes of this study is to present vital details to the travelling public on the effects of distracted walking on pedestrian safety.

CHAPTER 1
Introduction

1.1 Background

Walking is the most prevalent mode of transportation in the world. Active transportation is good for our health (CDC, 2005), but it is also for the environment as it reduces pollution from combustion engine vehicles by replacing driving trips. Walking can likewise help diminish traffic-related congestion problems. Even with these benefits, walking can be dangerous if one is not paying attention to their surroundings. A pedestrian is one of the most vulnerable road users (Mamun et al., 2015). While walking, pedestrians sometimes multi-task by texting, talking or listening to music (J. Mwakalonge et al., 2015). Distractions come in various aspects: electronics, music, and books. However, when we think of distractions in transportation terms, we think of distracted driving because it occurs. Still, just like drivers, pedestrians have consistently been occupied with multitasking with handheld devices, snacking, tuning into music, or reading while at the same time walking. The impacts are comparable to the distracted drivers. Nevertheless, distracted walking does not receive the same penalties and attention as distracted drivers.

Past studies indicate that a positive association exists between distraction and the unsafe walking behavior of pedestrians' (White et al., 2014; Hyman et al., 2010; J. Nasar et al., 2008). However, available pedestrian injury crash data suggests that distracted walking does not have direct impact on public health. It could be attributed to incomplete and insufficient research information on distracted walking causes and at the worst scenario it causes pedestrian safety problems. As mobile devices continue to be part of our intimate and commercial life, the injuries and fatalities incidences, including distracted drivers and pedestrians, are anticipated to increase. Thus, a need to advise and assess possible measures arises to reduce distracted walking impacts and to improve road users' safety.

As per the 2020 NHTSA's Fatality Analysis Reporting System (FARS), about 53,494 people have died in motor vehicle-related crashes (NHTSA, 2020). Statistics says in 2019, there were 6,205 pedestrian fatalities, and on average, there is one pedestrian fatality every 85 minutes (USDOT NHTSA, 2019a). Compared to 2010, the overall pedestrian-related crashes increased by 5% in 2019. Additionally, pedestrian fatalities have increased by 62% in urban areas and decreased by 4.8% in rural areas. Also, pedestrian injuries have increased by 1.3% since 2018.

1.2 Importance of reducing distracted walking

Walking is an efficient transport mode that offers many public health benefits. Walking reduces the rate of greenhouse gas emissions that are directly associated with global warming, change in climate, and undesirable air quality. Trips made by walking instead of driving help to alleviate problems related to traffic congestion. However, similar to other transportation modes, the interactions among pedestrians and other road users such as motorists and bicyclists create safety-related issues in the same space. Distracted pedestrians while walking has a high risk of being involved in a crash compared to when not distracted. Similar to drivers, pedestrians have always been involved in multi-tasking while walking like especially using handheld devices, listening to music, eating snacks, or reading. The negative impacts of distracted walking and distracted driving are usually similar (Hyman et al., 2010; J. Nasar et al., 2008). As mobile electronic use continues to rise, the instances of crashes involving distracted pedestrians are likely to increase. Even though distracted pedestrians pose potential safety issues, limited research has evaluated the effectiveness of curbing distracted walking safety problems. The Governors Highway Safety Association published a report that noted crash statements and evidence of pedestrian accidents where distraction had a direct association (Hedlund, 2010). In the last decade, various researchers have explored the effects of distracted walking to ensure the safety of pedestrian.

Furthermore, in the aftermath of distracted walking challenges, transportation agencies in the US and outside of the US have devised measures to enhance the safety of distracted pedestrians. However, no anthology of those efforts exists to allow safety practitioners to share skills. Furthermore, this research could not find adequate and precise data for assessing problems associated with distracted walking. Therefore, with distracted pedestrian researching growing, this study aims to evaluate the effectiveness of measures to curb distracted walking using the before and after approach.

1.3 Pedestrian Safety Guideline

Several agencies and organizations have developed safety guidelines for pedestrians. NHTSA developed pedestrian safety guidelines shown below (USDOT NHTSA, 2019b):

1. Be careful, follow the rules and regulations of the roadway, and obey signs and signals.
2. Walk on walkways whenever it is available.
3. Walk with facing the traffic whenever there are no walkways and always keep away from the traffic.
4. Always stay vigilant; never get distracted by electronic devices that make you take off your eyes and ears off the roadway.
5. Use crosswalks or intersections since they are safer. Look in each direction for vehicles.
6. When a crosswalk is not available, find a well-lit region to see the best view of traffic scenarios. Wait for a traffic gap that permits enough crossing time carefully; continue watching for traffic while crossing.
7. Never surmise that a driver will see a pedestrian. Always maintain eye contact with drivers to make sure they have noticed.
8. Prepare to be visible always. For example, wear a bright color cloth during daytime, wear cloth with reflective materials, or use a flashlight during night-time.
9. Watch for vehicles entering or exiting roadways or backing up in parking areas.
10. Never drink alcohol while walking; they weaken your abilities and decisions.

1.4 Research Goals and Objectives

The goals of this study are:

- ✓ To document the several types of measures to curb distracted walking.
- ✓ To propose and evaluate effective measures in reducing the incidences of distracted walking.
- ✓ To conduct several field experiments or simulation modules before and after each message on a sign or pavement markings.
- ✓ Finally, analyze the before and after observations and identify how effective the measures reduce distracted walking.

CHAPTER 2

Literature Review

Several studies have been performed on the perception of distracted walking behavior. Most of the research has engrossed in the causes of distraction and possible measures to mitigate the distraction. The related works on documenting the effectiveness of measures to reduce distracted walking are segmented and explained in the following sections.

2.1 Studies on the Impact of Distracted Pedestrians with Cellular Devices

Bungum et al. (2005) measured distracted pedestrian behavior by measuring cautious behavior of pedestrians looking left and right before crossing the crosswalk while the white proceed light was lit. They recorded the behavior of 866 individuals while walking a 105-foot-wide street assisted by a zebra crosswalk and stoplight at an intersection that is adjacent to a university. The study observed that 5.7% of the pedestrians that were observed crossed the street while wearing headsets or talking on the cell phone, and 15.1% were snacking, smoking or sipping, while on the crosswalk. Hatfield and Murphy (2007) carried out a field observational survey to differentiate the safety of crossing behavior of males and females with and without mobile phone usage. The research found that female pedestrians were likely to not practice cautions behaviour before crossing the roadway. Mobile phone talk was associated with women's lower street crossing pace at signalized intersections and men at unsignalized intersections. These effects evidence that talking over the phone undermines pedestrian safety by reducing cognitive attention.

Another study was conducted by Nasar et al. (2008) to examine the impact of mobile phone usage on the distraction of pedestrians by doing two experiments. During first experiment, 60 participants participated along a fixed path where 50% of them talked over the phone, and the other half did not talk, only waiting for the call that never happened. After the walk, participants were asked to recall the object they observed along the road. The study showed that those not conversing over the phone remembered more objects than those conversing. The analysis concluded that mobile phone use is associated with lower situational awareness. During the second experiment, the study used three observers who recorded the pedestrian crossing behavior and grouped them into those who were using mobile phones, I-pods, and pedestrians who were holding nothing at three different crosswalks. The study found that pedestrians using mobile phones passed perilously into oncoming traffic more than others. Further two separate studies carried by Hyman et al. (2010) studied the impact of inattentive walking. During these studies, participants were grouped based on walking with different activities, like talking on a mobile phone and listening to music while walking and walking without any device or a pair. During the first study, pedestrians using cell phones walked slowly and they changed their directions more regularly and were to a lesser extent likely to recognize other individuals than people without cell phones. The second study showed that mobile phone users were to a lesser extent likely to notice any odd activity along their path (a unicycling clown). Thus, mobile phone usage usually cause unintentional blindness even for activities that require few cognitive resources.

Neider et al. (2010) experimented using 36 participants walking on a series of unsignalized intersections on a unautomated treadmill in a simulation test. The study considered that individuals were undistracted while engaging in a hands-free mobile phone conversing or listening to music at the time of crossing. The study concluded that a pedestrian conversing over the phone while crossing the street was to a lesser extent likely to cross the roadway successfully than the pedestrian listening to music. Schwbel et al. (2012) carried out one experiment using an interactive four-dimensional simulation environment to examine the influence of different secondary activities like conversing on the phone, listening to music, and texting on pedestrian safety. Pedestrians were randomly classified to one of the groups: crossing while communicating over the mobile phone, crossing while messaging, crossing while listening to an electronic device, or crossing while being undistracted. The study showed that all groups (3) of pedestrians who were distracted were more often glancing away from the street setting while crossing the road than undistracted pedestrians, and no behavioral variations were found between male and female individuals.

Mwakalonge et al. (2015) studied the statewide application of rules and regulations, campaigning programs, data available, research requirements, and prospectus related to distracted walking problem. They found that some agencies or organizations publicized valuable information that pedestrians should steer clear of distracting activities when walking to improve their safety. They also noticed a positive relationship between distraction and hazardous walking behavior. Pesic et al. (2016) carried out a field-based observation to determine the influence of mobilel phone use on pedestrians' behavior while crossing the street. They considered two groups: the pedestrians who use mobile phones were described as a target group and the individuals who did not use cell phones referred as a time-matched control group. The authors created logistic regression models to predict the unsafe types of behavior. The study concluded that individuals who use cell phones behave less safer than individuals who do not use phones while crossing the road. Moreover, mobile phone speaking had the most significant impact on the risky behavior of individuals compared to listening to music.

Crowley et al. (2019) studied the walking effects at diverse speeds when using a cell phone on several factors among youths. Trials were carried out at both standard and speedy walking. They found that the effects of distracted walking at a fast-walking speed were not substantially higher than with an average walking speed. However, distracted walking has a severe impact on trips and falls among youths with no cognitive loss.

Wachnicka and Kulesza (2020) found that about 10% of unprotected pedestrians use mobile devices and about 5% use headphones at pedestrian crossings in Gdańsk city in Poland. Moreover, injuries related to mobile phone use among pedestrians increased comparative to total pedestrian injuries (J. L. Nasar & Troyer, 2013).

2.2 Examining College Pedestrian Behavior

Stavrinos et al. (2011) used an interactive and immersive method to study the impact of a mobile phone conversation on university students who are walking while distracted. The initial experiment assessed whether pedestrians would exhibit heightened riskier behavior trends while distracted by a real mobile phone conversation compared to while not distracted. Then they examined the impact of participating in a mobile phone conversation, participating in a cognitively tricky spatial task by mobile phone, and participating in a cognitively tricky mental arithmetic task by mobile phone on pedestrian safety. The results from both experiments revealed that the conversation content did not have significant role in distraction among other variables; both ordinary and cognitively complex conversations distracted individuals. In addition, there was no pronounced correlations between susceptibility to distraction and individual difference factors.

Another study examined the type and rate of distractions on campuses, and the impact of distraction observed crossing a busy intersection by Wells et al. (2018). The researchers created two observation strategies; they randomly chose individual pedestrians instead of capturing all pedestrians crossing the street. They coded each block 15-minute observation period. Initially, for five minutes, the coder recorded vehicular traffic. Then, for the next five minutes, the coder registered both safe and unsafe pedestrian behaviors while crossing the primary avenue. The final five minutes were for coders to have a break and move counterclockwise to the next coding spot. The researchers found that more than one-third of 10,543 individuals were distracted while actively crossing a road section, and headsets were common among individuals. They suggested on built environment improvements to decrease pedestrian risk behaviors in active pedestrian zones like college campuses.

2.3 Simulation of Pedestrians Crossing a Street

Traffic simulation is a mathematical modeling of transportation systems. There are a variety of established companies offering softwares with the capability of analyzing traffic flows. VISSIM is one of the traffic simulation software can be used to simulate all modes of traffic and generate analysis reports. The software was developed by the German company PTV and is capable to generate interactions among all modes of traffic. In the VISSIM system's core simulation model, the tracking model uses the “psychophysical driver behavior model” developed by Professor Wiedemann from Karlsruhe University, Germany. Viswalk, part of VISSIM, is a software solution for microscopic pedestrian flow simulation with extensive functions in 3D environments. Viswalk has the capability that allows for simulations with realistic pedestrian behavior and more importantly, the opportunity to simulate realistic complex situations. This is possible without traffic interaction or with traffic interaction (in combination with VISSIM) (PTV Group, 2020).

Boenisch & Kretz (2009) investigated the simulation of pedestrians crossing a street. Their contribution was for both pedestrians crossing a road and vehicles using the roadway system. The study used VISSIM simulation, and by varying demand jam sizes of cars and pedestrians, the travel times of the pedestrians can be estimated and compared. The research considered a study of VISSIM’s conflict area functionality since there is no empirical details for standardization issues. The study found that there was a non-monotonic reliance of pedestrians’ travel time on pedestrian demand above a vehicle demand threshold.

Lee & Lam (2008) developed a novel pedestrian simulation model to estimate the least required pedestrian crossing time for a signalized pedestrian crosswalk in Hong Kong. The novel pedestrian simulation model can estimate the differences in walking speed for pedestrians, specifically on the impacts of pedestrian streams that are bi-directional, to estimate the least required time of pedestrian to cross the intersection. The study used recorded videos that were taken from the observational assessments at the pre-defined crosswalk in active areas to generate data needed for model standardization. The study found that the pedestrian-design walking speed for current crosswalks that are signalized should be altered to take into the account the effects of the pedestrian streams that are bi-directional.

Wang et al.(2013) had a study on the simulation of individual walking and vehicles when crossing the intersection with no traffic signal by using microscopic traffic simulation software of VISSIM. The results found that the VISSIM simulation can properly replicate the real-time traffic data, and the errors were only about 5%. Another study was conducted by Tapiro et al. (2016) in a semi-immersive virtual setting to compare children and adult pedestrian crossing behavior. Children were expected to press a button when they thought it was safe to cross. Results indicated that mobile phone conversations influenced crossing behaviors involving all age groups.

Sobhani & Farooq (2018) employed new head-mounted virtual immersive/interactive reality environment (VIRE) to evaluate individuals' behavior in pre-defined pedestrian road crossing settings that are: undistracted, distracted with a mobile phone, and distracted with a mobile phone with a virtually executed measure of safety on the road. In the distraction scenarios, pedestrians were involved in a game of maze-solving on a virtual mobile phone whilst checking time for a safe crossing opening. The authors utilized color-changing LED lights and smart flashing on the pedestrian crosswalk to simulate safety countermeasures to alert the distracted individual who starts crossing. In addition, alternate safety measures, speed data, and distraction features like the direction and alignment of the individuals were gathered and assessed by utilizing a Multinomial Logit (MNL) model. The model indicates that safety remedy that employed the smart LED light enhances the safety of distracted individuals and a successful pedestrian crossing rate.

CHAPTER 3

Methodology

Following the comprehensive literature review, this study documented several measures to curb distracted walking. Further, the research evaluated their efficiency in lessening the incidences of distracted walking. The researchers then used a before and after approach to evaluate the effectiveness of the measures proposed to curb distracted walking at pedestrian walkways/pathways and pedestrian crossing at an urban intersection. The measures included a message posted on a sign and pavement painting on walkways/pathways and pedestrian crossing at signalized and non-signalized urban intersections. The research team conducted several experiments in VISSIM microscopic simulation for before and after observations for each message on a sign or pavement markings. The study analyzed the before and after observations and identified how effective the measures were in reducing distracted walking.

Figure 1 shows the graphical layout of the stages of the research approach of this study. The next sections will explain the research methodology.

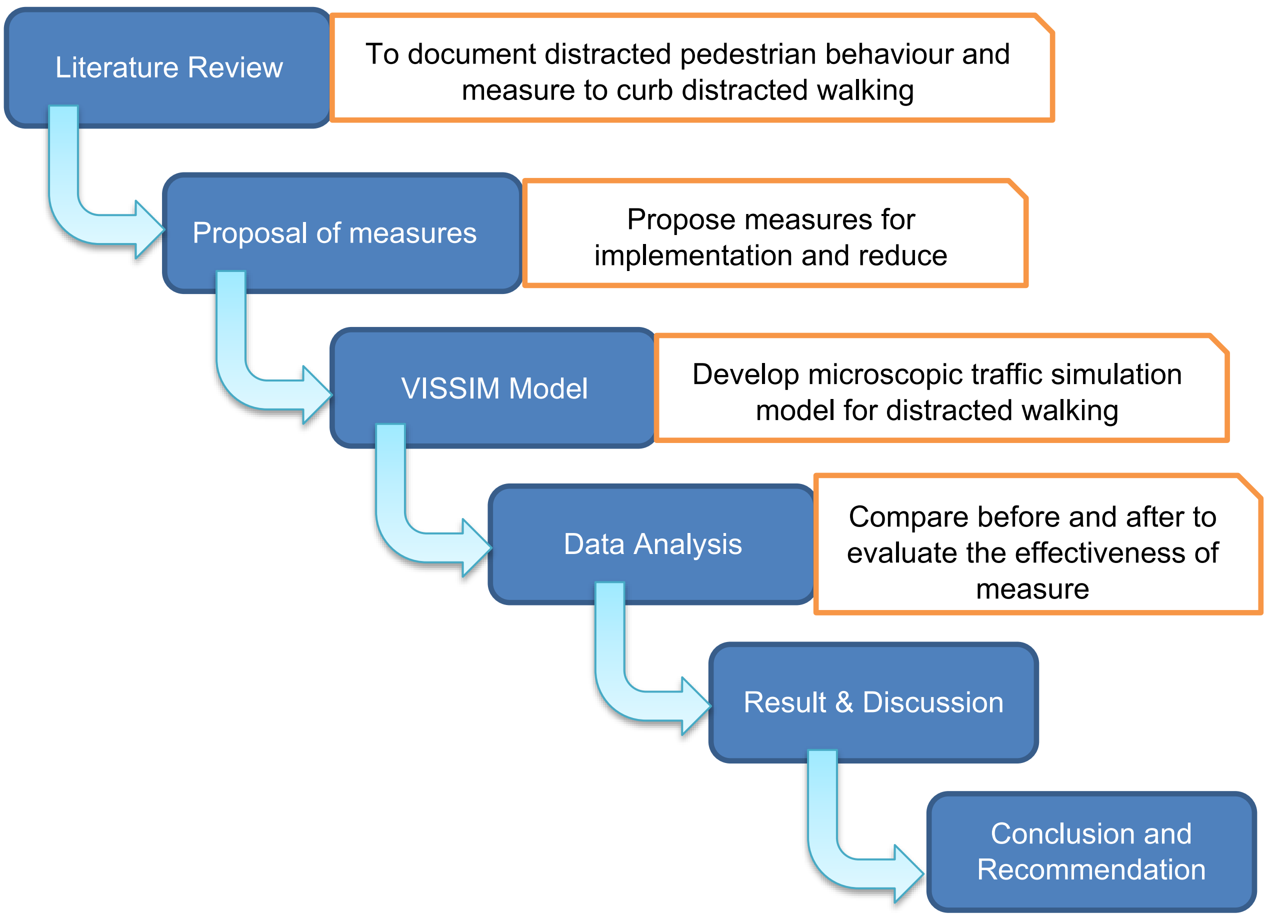

Figure 1 The Research Approach of this Study

3.1 Proposal of Measures

As stated in the objective, the focal point of this project is to see the impact of safety pedestrian signs on distracted pedestrians. The signs were searched through the world wide web and reconfigured in Adobe Photoshop CS5 to create the safety signs. In Photoshop, we have written one or more words, then created a visualization based on the different built-in features of photoshop. Our target was to make the sign attractive and noticeable from a great distance. Finally, portable network graphics (PNG) format was used while rendering the created signs from Photoshop. For that, a survey was taken at South Carolina State University and Benedict College with 160 participants to see the best safety sign out of four signs to implant on sidewalks. In addition, a memo was written to the city of Orangeburg to inform the administration of the project. Figure 2 shows the safety signs that were deployed to collect field data. The survey form is attached in Appendix A.

Safety Sign A

Safety Sign B

Safety Sign C

Safety Sign D

Figure 2 Prepared Safety Signs to Collect Field Data

3.2 VISSIM VisWalk Intersection Modeling

This study developed a "T" intersection model using VISSIM microscopic traffic simulation software. The intersection was located near a large university area where pedestrians crossing a boulevard with a lane for each direction of flow are simulated in VISSIM. This intersection handles hefty pedestrian volume during the day from students (primarily), faculty members, staff members, and guests to the university. The crosswalk was divided into Northbound (NB) pedestrians, who come across the Westbound vehicle stream first, and Southbound (SB) pedestrians, who come across the Eastbound vehicle stream first. There are three East-bound traffic lanes and two lanes for West-bound traffic. Figure 3 represents the T intersection coded in VISSIM VisWalk for+ this study. Here, the travel time of the pedestrian and the walking speed was measured in the NS direction.

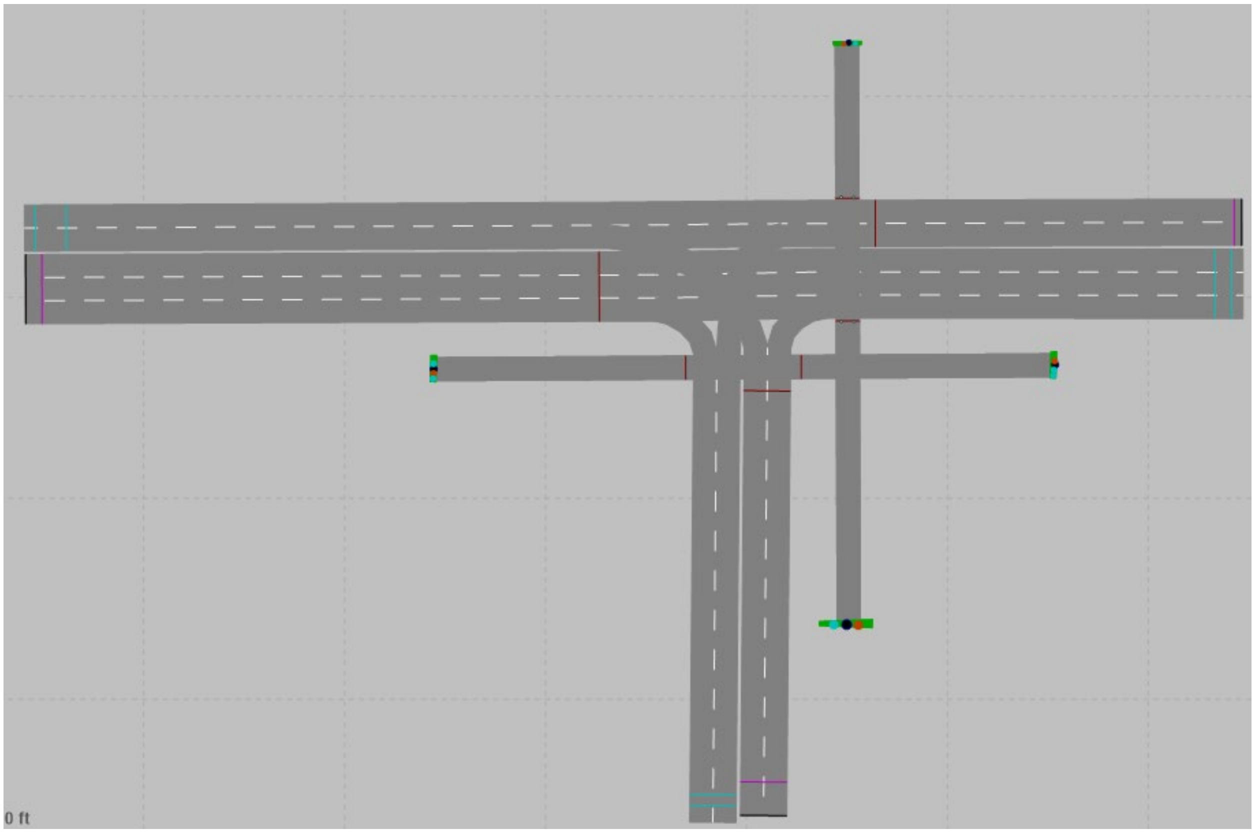

Figure 3 The T-intersection Coded in VISSIM VisWalk

3.3 VISSIM VisWalk Walking Behavior Parameter Modification

Study data includes the data of the crossroad setting and traffic condition of the crossroad. The crossroad setting data consists of the lane, the number of vehicles, the setting way of the lane, the median, lane width, crosswalk width and length, and markers on the road. The traffic condition data of the crossroad consist of:

- The pedestrians and vehicles composition.
- Pedestrians and vehicles' parameters, such as speed and acceleration at the intersection, acceleration when vehicles start, and average walking time to cross the crosswalk (least required duration of pedestrian to cross).
- Pedestrian flow and motor traffic flow parameters, such as static density and queuing feature of pedestrians, and traffic stream characteristics.
- Clearance time when a pedestrian pass or refuse the vehicle flow and extreme waiting time.

The modified walking behavior parameters are as follows: a summary is shown in Table 1. Table 1 has been developed as per the instructions provided in the VISSIM Manual (PTV AG, 2020).

Tau (τ): Tau denotes the relaxation time or inertia associated with the response time (PTV AG, 2020). Increasing the tau value decreases the acceleration and density and increases the radius of the walking path.

Lambda_mean (λ_mean): Lambda governs the impact of a pedestrian on the forward pedestrian psychologically and socially (PTV AG, 2020). Increasing lambda makes the counterflow and bottleneck flow more efficient and pushes more pedestrians into congested conditions.

A_soc_isotropic, B_soc_isotropic, A_soc_mean, and B_soc_mean: These parameters regulate the strength and the typical range of the social force between two pedestrians (PTV AG, 2020). Increasing these values increase the headways among pedestrians.

VD: VD controls the distance between two pedestrians moving in the opposite direction. Increasing VD makes opposing pedestrians evade more (PTV AG, 2020).

Noise: The higher the parameter value, the higher the random force will be added to a pedestrian if the pedestrian persists below their chosen speed for a specific time (PTV AG, 2020). If the noise value is higher than 0.8, one pedestrian will back up after a while, and another pedestrian will go through. Thus, increasing noise value prevents deadlock.

React_to_n: This parameter denotes the number of the closest pedestrian considered when calculating a pedestrian's total force (PTV AG, 2020). Decreasing the value of n makes the pedestrians jitter and increases density.

Queue_order and queue_straightness: These specify the shape of queues and their range is 0.0 - 1.0 (PTV AG, 2020). The greater the values, the more straight the queue will appear.

Side_preference: It governs whether opposing pedestrian streams prefer using the right or left side when passing on each other (PTV AG, 2020). There are three preferences—0 means no preference, –1 means right side, and 1 means left side. The default value of this parameter is 0.

Table 1: VisWalk Walking Behavior Parameters and Corresponding Values

Viswalk Parameters	Default	Minimum	Maximum	Impact on increasing
Tau (τ)	0.4	0.05	0.8	Decreases the acceleration and density of the walking path
Lambda_mean (λ_mean):	0.176	0	1	It makes the counterflow and bottleneck flow more efficient and pushes more pedestrians into congested conditions.
A_soc_isotropic,	2.72	1.36	5.44	Increase the headways among pedestrians
B_soc_isotropic,	0.2	0.1	0.4	Increase the headways among pedestrians
A_soc_mean	0.4	0.2	0.8	Increase the headways among pedestrians
B_soc_mean	2.8	1.4	5.6	Increase the headways among pedestrians
VD (seconds)	3	0	30	
Noise	1.2	0	2.4	Prevent deadlock
React_to_n	8	2	32	Decrease density
Side_preference	None	-1 (right)	1 (left)	It makes opposing pedestrians evade more
Queue_order	8			The queue will be straighter
degree of orderliness	0.4	0	1	
queue_straightness	0.4	0	1	The queue will be straighter

CHAPTER 4

Data Analysis

4.1 Pedestrian Safety Sign Survey Data Analysis

Figure 4 shows the result of the average ranking for safety signs A, B, C, and D, where people were asked to rank these four signs among 1 (excellent), 2 (good), 3 (fair), and 4 (poor) to determine the effectiveness of Safety Signs for pedestrians in reducing distraction while walking. It has been observed from the figure that safety sign A was more preferable to the other signs, followed by sign D. However, signs B and C almost got a similar ranking. A statistical test was performed to check whether the differences were significant.

Test that all means are the same	
Hotelling T2	23.14
Hotelling F (3, 157)	7.62
Prob > F	0.0001

As shown above, the differences between signs rankings are statistically significant at a 5% significance level.

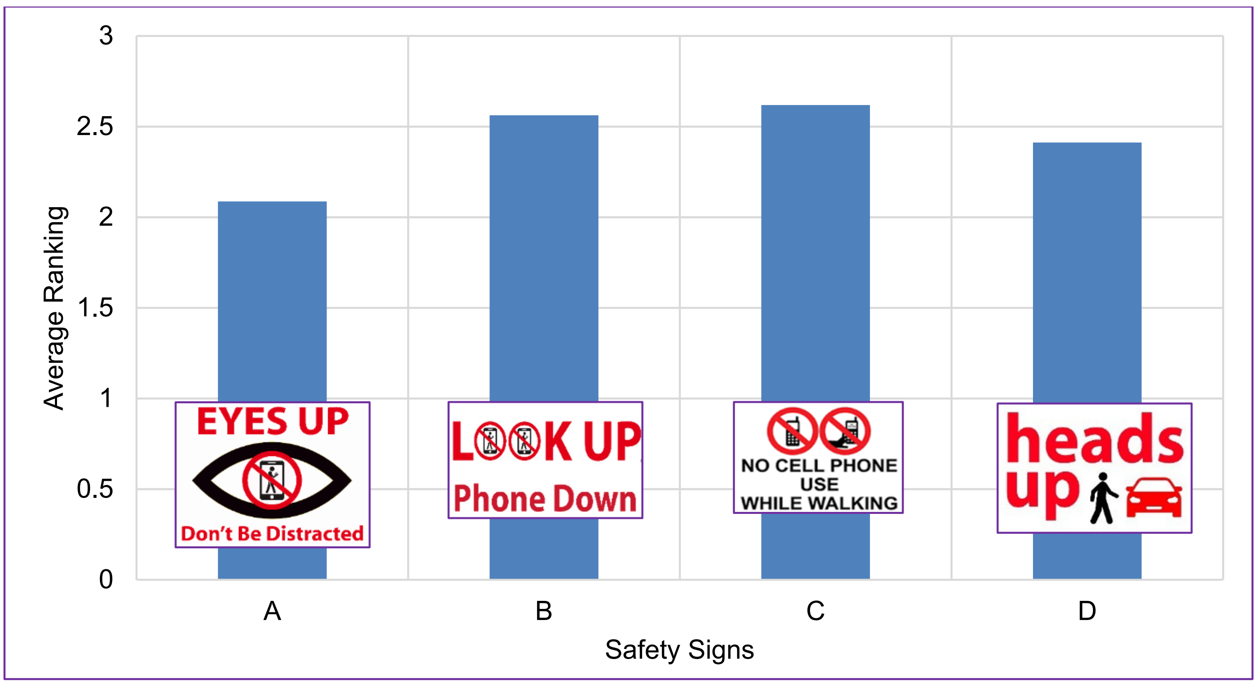

Figure 4 Ranking of Safety Signs [Lower is better]

Figure 5 indicates the overall scenario of survey data for safety sign A. More than 58 people rate safety sign A as 1, which suggests that this sign is excellent. Therefore, it is assumed that they think this sign effectively reduces distractions in walking. In addition, 52 people responded to this sign as good and 28 as fair. However, only 22 people rate as poor of this safety sign as they think that sign will not be adequate to reduce the distraction in walking.

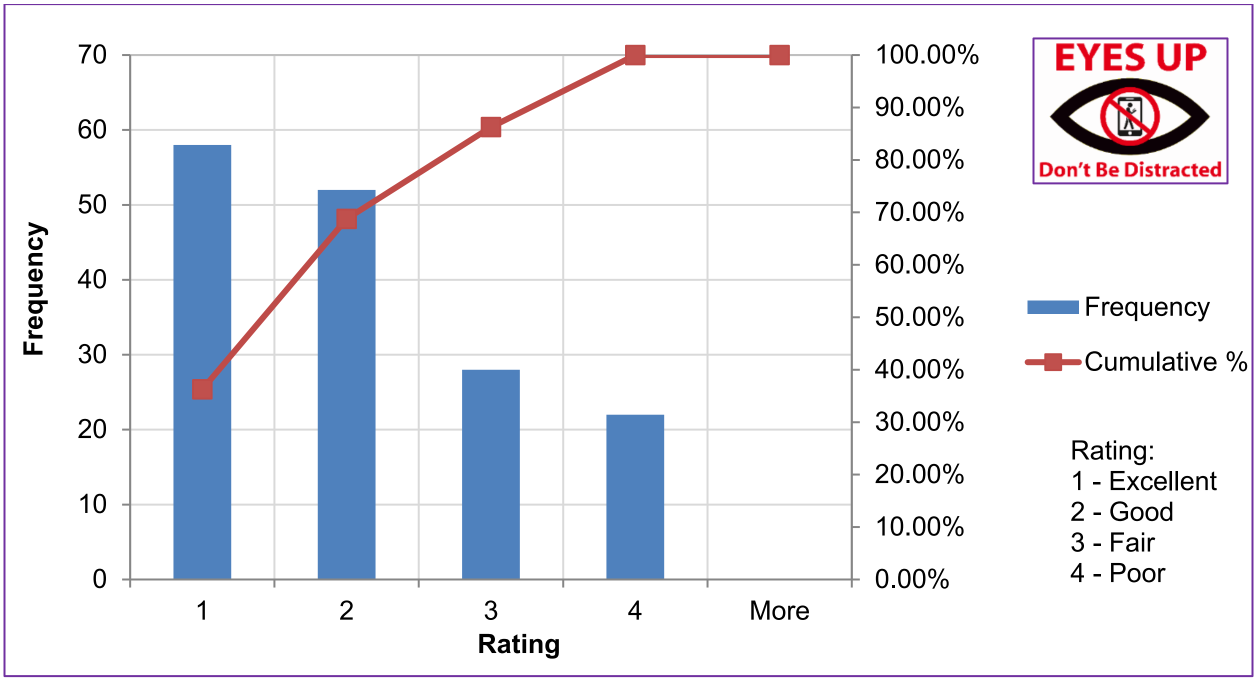

Figure 5 Rating of Safety Sign A

Figure 6 illustrates the number of pedestrian ratings for the traffic safety sign B. It can be seen that about only 19 pedestrians rate sign B as 1, 57 pedestrians rate it as 2, and 59 pedestrians rank the safety sign B as 3. On the other hand, 25 pedestrians might think that this sign is ineffective in reducing distractions or ensuring safety. Therefore, they ranked this sign as inferior.

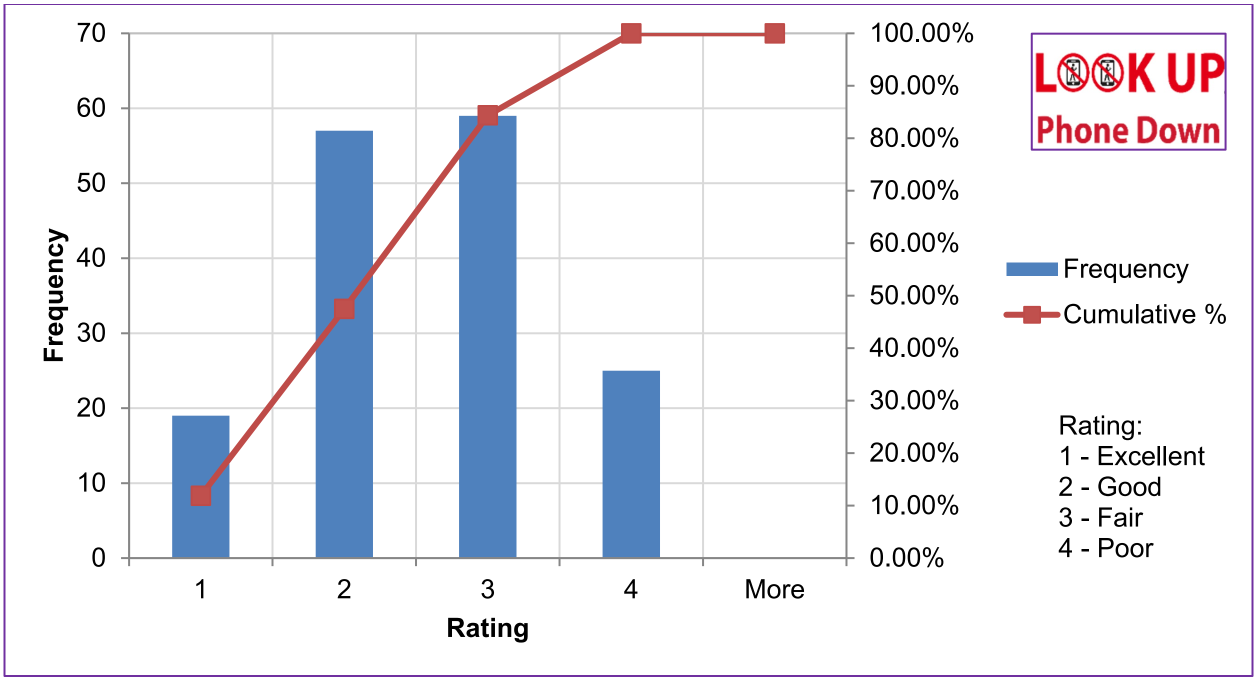

Figure 6 Rating of Safety Sign B

Figure 7 shows the number of people who viewed safety signs C as 1 (excellent), 2 (good), 3 (fair), and 4 (poor) to curb inattention in walking. Nearly 38 pedestrians think the sign is excellent, and 33 ranked it as good. However, 41 people rated this sign as fair, and 48 pedestrians figured it would not be practical or attractive to reduce distraction as they ranked this sign as inferior and gave a rating of 4.

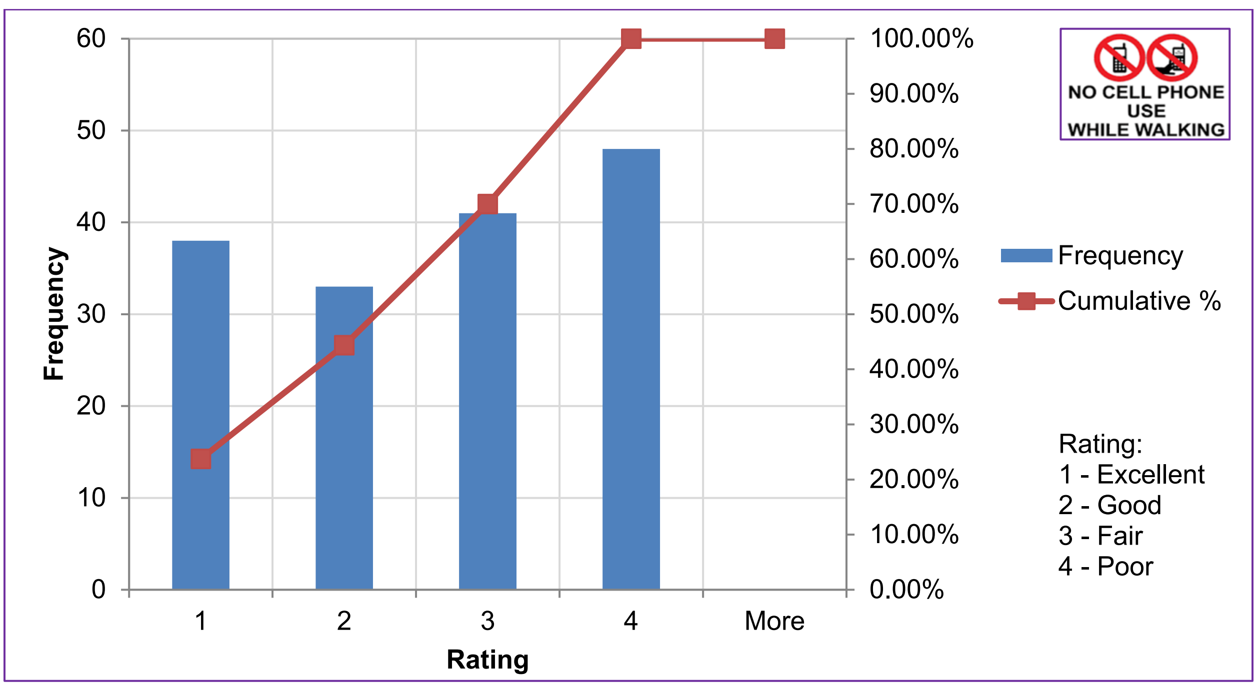

Figure 7 Rating of Safety Sign C

Figure 8 shows the survey results in which people were asked about their preferred signs among four signs. The figure shows that 57 pedestrians rate safety sign D as excellent as they might feel that the sign is attractive or can fulfill the purpose, 27 pedestrians as good, and three pedestrians as fair. On the other hand, about 47 pedestrians ranked sign B as inferior as they might assume that this sign will not curb inattention while walking.

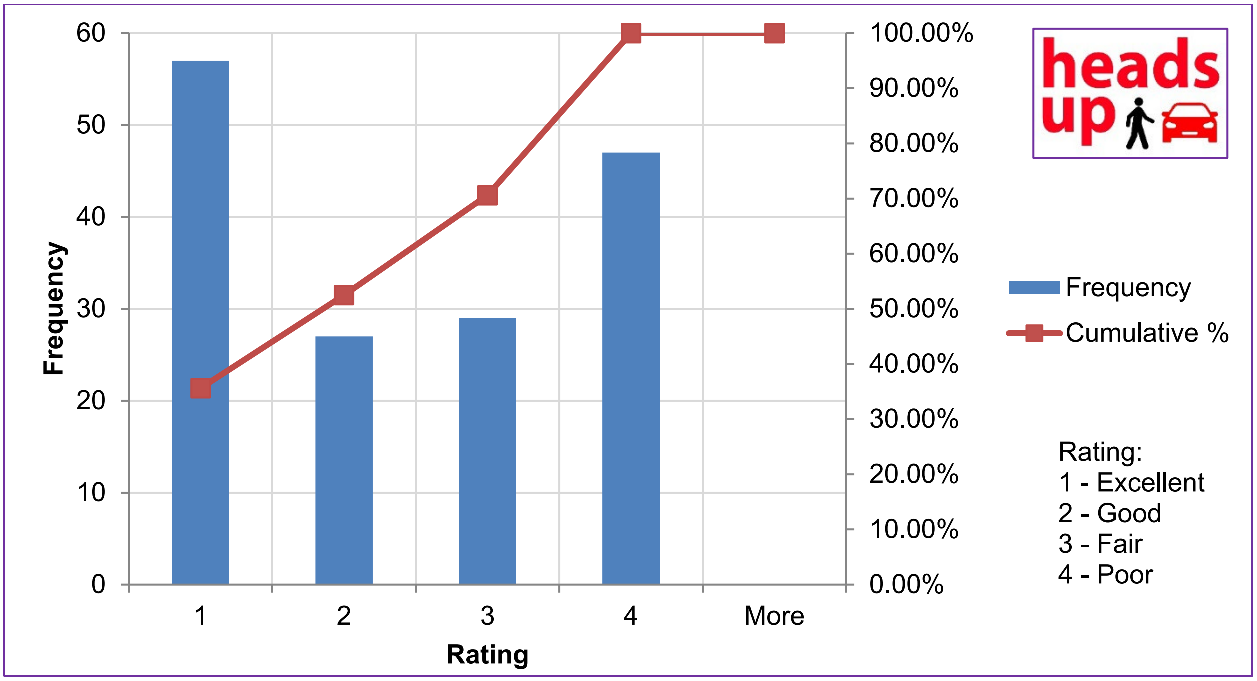

Figure 8 Rating of Safety Sign D

4.2 Developing Distracted Pedestrians in Simulation

According to the PTV VISSIM software manual and a previous study, it was found that the value of tau (τ) can regulate the walking speed and pedestrian's travel time significantly (PTV AG, 2020). Several simulation runs were conducted with different tau values (τ) to examine its impact on walking speed and travel time to define regular pedestrians and distracted pedestrians. A previous study observed that the distracted pedestrian might have lower walking speed as s/he is engaged in other distracting activities (Sobhani & Farooq, 2018). A summary of the scenarios (10 simulation runs per scenario) with different tau values (τ) is shown in Table 2. It was observed that the default value of τ is 0.4 in the VisWalk. Reducing the τ value from the default increases the average walking speed and reduces the average travel time. Opposite scenarios were observed with increasing the τ value.

Table 2: Variation of Walking Speed and Pedestrian Travel Time with Different τ values

Scenario	Tau (τ)	Average Speed (ft/s)	SD of Speed (ft/s)	Average Travel Time (s)	SD of Travel Time (s)	No. of Pedestrians	Tau Comments
1	0.05	3.568	0.832	18.555	4.459	544	Minimum
2	0.2	2.872	1.209	29.275	19.316	544	
3	0.4	2.861	1.154	29.022	18.869	535	Default
4	0.6	2.744	1.121	30.400	19.325	535	Maximum
5	0.8	2.678	1.115	31.428	19.535	534	

A detailed explanation of the impact of the τ value on the walking speed and pedestrian travel time is shown in Figures 9-12.

From Figure 9, it was observed that the walking speed decreased with the increase of the τ value. A sharp reduction in walking speed was observed for increasing the τ value from 0.05 to 0.2. However, the reduction of walking speed was steading for further increase of τ value from 0.2 to 0.8.

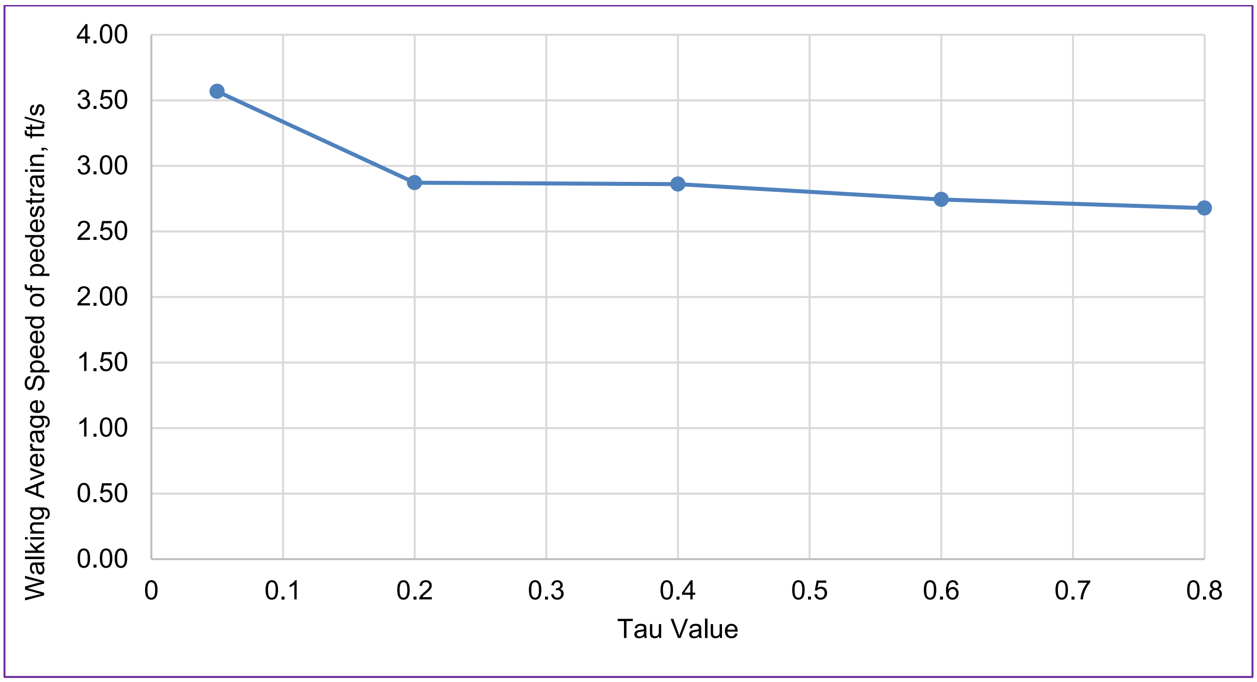

Figure 9 Impact of Tau (τ) Value on Pedestrian's Average Walking Speed

Figure 10 shows the variation of the standard deviation of the walking speed with the change of τ value. It was observed that the standard deviation of walking speed was lower with the smaller τ value. However, the standard deviation was increased with the increase of τ value, reached a peak for τ value of 0.2, and later decreased. This phenomenon denotes that the higher τ value creates a higher fluctuation of walking speeds among the pedestrians.

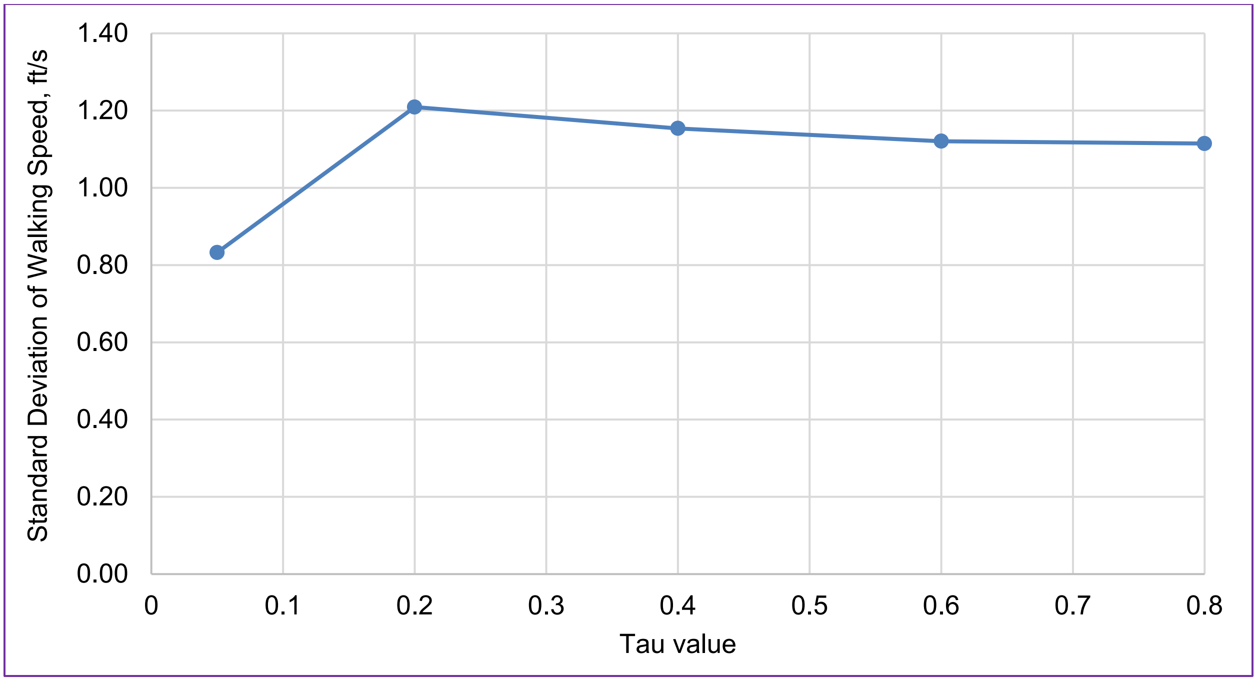

Figure 10 Impact of Tau (τ) Value on the Standard Deviation of Walking Speed

The impact of the τ value on the average travel time of the pedestrian is shown in Figure 11. It was observed that the travel time increases with the increase of τ value. A sharp rise in the travel time of pedestrians was observed due to the increase in τ value from 0.05 to 0.2. This relation denotes that pedestrians may walk more in a scattered manner with a higher τ value.

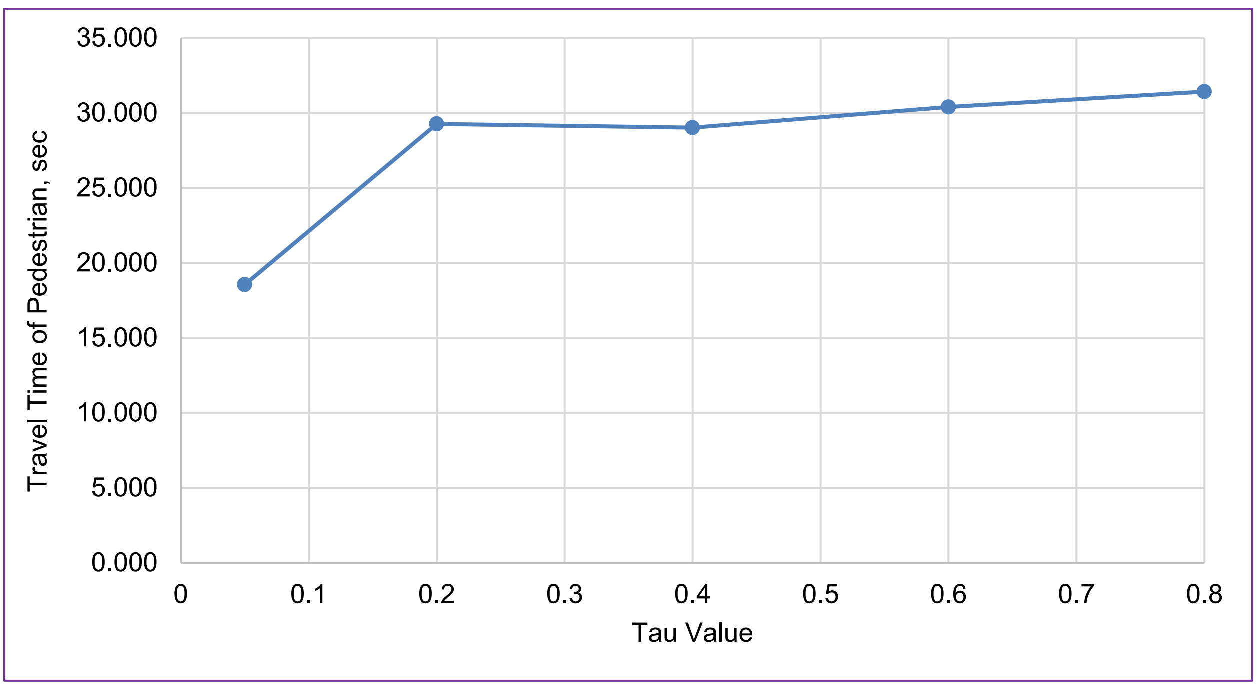

Figure 11 Impact of Tau (τ) Value on Pedestrian's Average Travel Time

The impact of the τ value on the standard deviation of travel time is shown in Figure 12. It was observed that there was a big jump in the standard deviation due to the increase of the τ value from 0.05 to 0.2. Later, the standard deviation of the travel time was almost constant regardless of the increase in the τ value.

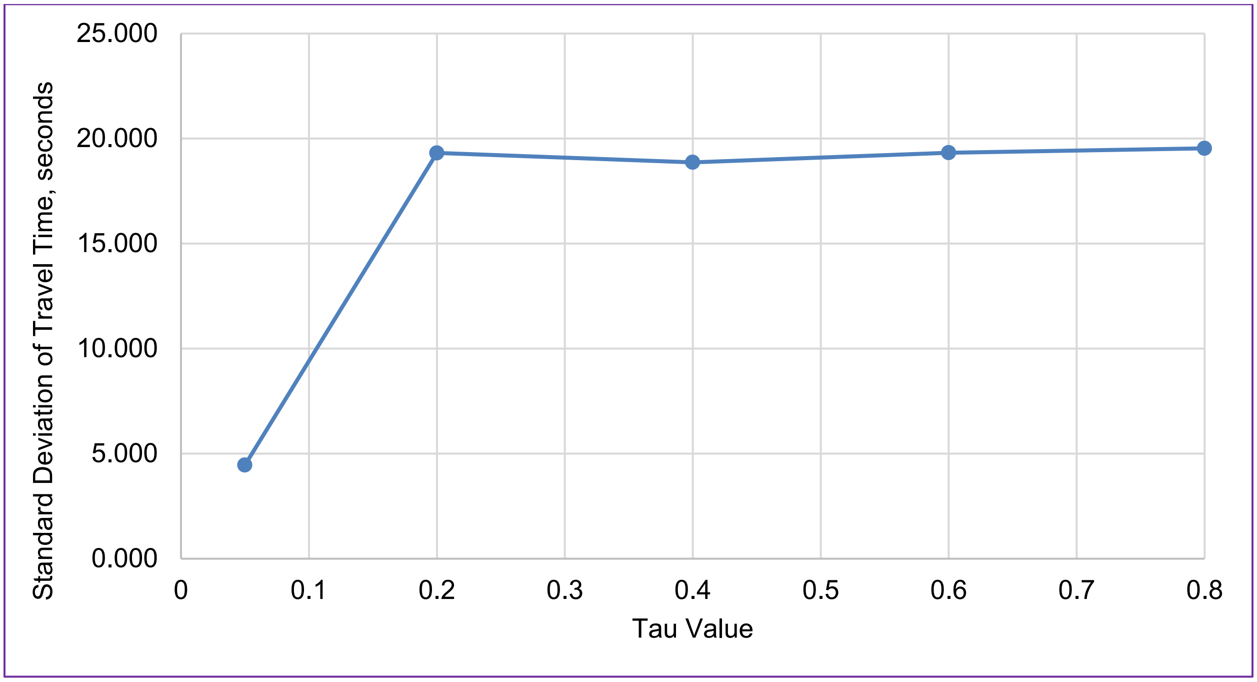

Figure 12 Impact of Tau (τ) Value on the Standard Deviation of Travel Time

Moreover, a τ value of 0.11 resulted in an average speed of 3.29 ft/sec, i.e., 1 m/s, which was considered non-distracted in a previous study (Sobhani & Farooq, 2018). Besides, the τ value of 0.2 yielded an average speed of 2.87 ft/sec, i.e., 0.9 m/s, which was considered distracted in a previous study (Sobhani & Farooq, 2018). That study also mentioned that the distracted pedestrian waited on average 21.2 s (st. dev. = 10.9 s) before initial crossing.

4.3 Simulation Model Calibration and Validation Shortcoming

This study initially aims to conduct a field study to collect real-world data to calibrate and validate the model. Unfortunately, due to the COVID-19 pandemic, the research team could not collect field data. Therefore, the calibration and validation of the simulation model were not performed.

CHAPTER 5

Conclusions and Recommendations

5.1 Conclusions

In this study, four pedestrian safety signs were designed, and user acceptance was measured. The followings are the major conclusions of this study:

- After designing four pedestrian safety signs, a survey was undertaken to determine the perception of pedestrians about the effectiveness of these four safety signs on the reduction of distraction while walking. Survey results show that the highest number of pedestrians ranked safety sign A as excellent.

- VISSIM microscopic simulation software was used to develop a T-signalized intersection to see distracted and non-distracted pedestrian behavior in terms of average speed and the crossing time of walkways.

- The simulation analysis shows that the walking speed of the pedestrian increases and the travel time decreases with the increase in τ value, a parameter of walking behavior in VISSIM VisWalk. However, a substantial impact on the travel time and walking speed were observed for increasing the τ value from 0.05 to 0.2. The further impact with an increased τ value was not significant enough.

- The simulation results show that the average speed of distracted pedestrian is 2.87 ft/sec or 0.9 m/s and for non-distracted is 3.29 ft/sec or 1 m/s, which support a previous study (Sobhani & Farooq, 2018).

5.2 Recommendations and Future Scopes

The following actions are recommended from this study,

- This research can be expanded by doing a field experiment using safety signs, which were ranked as excellent among pedestrians during the survey.
- This study only considered signalized intersections. Future research can be conducted on unsignalized intersections to determine the impact of distraction on that type of segment.
- Only a small number of pedestrians participated in the survey of this study. In future research, the pedestrian sample size of the study can be expanded.

5.3 Research Shortcomings

This research was able to do a field survey on the perception of a pedestrian on the safety signs. However, the study could not conduct a field experiment because of the COVID-19 pandemic. The research team was prepared to perform this experiment and had already developed a memo (Appendix B) to seek permission from the Orangeburg, SC county authority for the experiment. However, due to the continuing spread of the COVID-19 virus, the field experiment was abandoned.

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APPENDIX

Appendix A – Survey form

Pedestrian Sign Experiment

Dear Respondent,
The Students of the Transportation Program in the Department of Civil and Mechanical Engineering Technology at **South Carolina State University, funded by Tier I University Transportation Center for Connected Multimodal Mobility (C^2M^2),** are administering a study to determine the effectiveness of Safety Signs for pedestrians in reducing distraction while walking. According to USA Today, the number of **injured distracted walkers** has **quadrupled in the past seven years** into 2012. Considering this information, the plight of distracted walkers is a critical problem. There must be action taken to reduce the number of distracted walkers.

The survey will take no more than 2 minutes to complete. Your responses are **confidential**. No names or other identifying information will be used in data analysis. Your responses are very important in this research study to examine the problem of distracted walking.

1. Please rank the following safety signs from 1-4 (1= catches your attention and proficient sign) (4= unappealing)

   Rating:
   1 - Excellent
   2 - Good
   3 - Fair
   4 – Poor

☐ 

Safety Sign A

☐ 

Safety Sign B

☐ 

Safety Sign C

☐ 

Safety Sign D

Thank you very much for your time and cooperation.

Comments: If you have any comments or any other information you would like to share with us, please write these in the space provided below:

Appendix B – Memo to the City of Orangeburg

Master of Science in Transportation Program, SCSU - Distracted Pedestrian Experiment

To: City of Orangeburg

From: Dr. Judith Mwakalonge, Associate Professor, SCSU

CC: Md Mahmud Hasan Mamun, Isa Musa, Gurcan Comert, Samia Akter

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Dear City of Orangeburg,

As a research team from South Carolina State University and Benedict College, we are conducting an experiment for distracting pedestrians in downtown Orangeburg funded by the U.S. DOT Tier I University Research Center of Connected Multimodal Mobility housed at Clemson University.

We have noticed that there have been close incidents regarding pedestrians not being aware of their surroundings downtown. For example, pedestrians walk across the street without realizing a vehicle crossing because of the distractions of their electric devices. As a team, we created safety signs for distracting pedestrians and would like to use some of these signs shown on the page below in downtown Orangeburg as a precaution not only for pedestrians' safety but also for drivers. In addition, we would like to conduct a before-after study to test the signs' effectiveness. The preferred order of signs is given below based on our preliminary survey results on college campuses.

We would be happy to supply more information if needed and receive your approval for this research.

Thank you for your time.

Attachments: Pedestrian Safety Signs

Safety Sign A

Safety Sign B

Safety Sign C

Safety Sign D