Increasing pedestrian safety

2. 0 Literature Review

2. 1 Introduction

Intersection is the most critical place for pedestrian as they come directly into contact with the ongoing traffic. Both signalized and un-signalized intersection pose a safety concern and different measures have been taken to safely and effectively accommodate pedestrian and traffic in the intersections. To accommodate pedestrians, two common types of pedestrian phasing have been used at signalized intersections -concurrent phasing and exclusive phasing (or scramble phasing). Concurrent pedestrian phasing is the most common and used all over the world, but there are so many places where exclusive pedestrian phasing has also been used.

A concurrent phasing allows pedestrian to cross parallelly with the motor vehicle traffic on any approach having green indication. Both pedestrians and vehicles share the same green phase of traffic signal which allows longer flow of traffic and pedestrians. The interaction of traffic come with the pedestrian due to right turning and left turning movements across the pedestrian crosswalk. There may be another interaction from the vehicles of right turns on red from the approach perpendicular to the crosswalk. Alternatively, an exclusive pedestrian phase is only for pedestrian crossing which stops all the vehicular movement and pedestrian can cross any direction including diagonally. This increases the overall cycle length of the signal, but ensures no interaction of pedestrian with the traffic.

2. 2 Academic Research

To address pedestrian safety huge amount of research has been done, but there is still much work to do and there is still scope to look from a different new perspective and analyze the safety measures. There are various factors responsible for pedestrian safety at an intersection and different studies have been done to analyze those factors and measure the importance. But, surprisingly, there have been relatively few studies performed comparing concurrent and exclusive pedestrian phase form the viewpoint of the safety benefits, number of illegal crossings, crash number and change in LOS of the intersections.

After the implementation of an exclusive pedestrian phase, it is very essential to understand how users are accepting this. Any facility can be a failure if the people cannot use the way it should be used. Positive and accepting perspective is crucial for the success of an exclusive pedestrian phase as non-compliance will lead to illegal crossing which will undue the ultimate goal of exclusive pedestrian signal. McKernan et al. (2016) investigated pedestrian compliance of concurrent and exclusive pedestrian crossing at 42 signalized intersections to find whether there are differences between pedestrian compliance with exclusive pedestrian phasing and concurrent pedestrian phasing. They used binary regression model to estimate pedestrian compliance and they considered pedestrian phasing type, intersection characteristics such as vehicular and pedestrian volume, crossing distance and speed limit. They found significantly higher pedestrian compliance with concurrent pedestrian phasing then exclusive pedestrian phasing. But the difference was not significant when they considered exclusive pedestrian phase intersections as if it had concurrent phasing and

they concluded that pedestrian treat exclusive pedestrian phase as a concurrent pedestrian phase. (McKernan, 2016). Few other researchers observed and collected data regarding pedestrian compliance with exclusive pedestrian phase. According to Lina Kattan, public showed a positive attitude toward exclusive pedestrian phase and they understood the change in the way the intersection used to work and accepted it. (Lina Kattan 2009).

To get the benefits of an exclusive pedestrian phasing, it is necessary to understand pedestrian crossing behavior in such an unconventional facility. Few studies investigated the changes in pedestrian crossing behavior following the implementation of an exclusive pedestrian phase. Hediyeh et al. (2015) investigate the changed behavior using spatiotemporal gait parameters (step length and step frequency). They found both average step length and walking speed were significantly higher for diagonally crossing pedestrians compared with pedestrians crossing on the conventional crosswalks. They found pedestrians to have the tendency to increase their step length more than their step frequency to increase walking speed. They also found that, compared with men, women generally increase their walking speed by increasing their step frequency more than step length. However, when in non-compliance with signal indications, women increase their walking speed by increasing their step length more than step frequency. (H. Hediyeh, 2015). Medina et al. also emphasized on better understanding of pedestrian behavior at locations with exclusive pedestrian phases. To do that they collected field data from a college campus at busy intersection and analyzed the individual and group crossing data. From the analysis, they found 15th percentile speeds for the diagonal and the parallel crossings were

respectively 4. 37ft/s and 4. 49 ft./s which are higher than the 3. 5 ft./s as recommended by the MUTCD. They also found, 15th percentile speeds of pedestrians traveling individually and those in free flow were significantly higher than those traveling in groups and in non-free-flowing conditions. In addition, they observed fewer pedestrian to cross diagonally than parallelly. (J. C. Medina, 2014). Hediyeh et al. (2014) has also investigated changes in pedestrian speed behavior following the implementation of an exclusive pedestrian phase. They studied pedestrian speed variations with respect to design changes to intersection crossings. The results showed that the average crossing speed is higher after the implementation of the exclusive pedestrian phase. They found higher average crossing speed for diagonal crossing than side crosswalk crossing. They also observed pedestrians to have higher speed through the first half of the crosswalk. (Houman Hediyeh, 2014)

Marsh et al. conducted a survey and an analysis of existing pedestrian and vehicle movements to find the change in patterns that would result from the inclusion of an exclusive pedestrian phase in the existing signalized intersections. He considered convenience, comfort and safety as three main requirements for pedestrian crossing and the improvement of these criteria due to the change of crossing facility. The investigation showed that the three criteria are not enhanced by the change to exclusive pedestrian control. He also found vehicular traffic is to be disadvantaged with an increase in delays, stops and longer queues at traffic signals. Again, he found an increase in pedestrian delay by varying degrees, though it reduces the distance pedestrians must travel. Using a computerized simulation, he found

that exclusive pedestrian phasing would have resulted in a 5% to 7% reduction in distance traveled by pedestrians at several intersections in New Zealand. (Marsh, 1982)

The main purpose of implementing an exclusive pedestrian phase is to reduce the interaction of pedestrian with the traffic. Though it is designed to meet the purpose but the filed condition is not always favorable. Various reasons may be responsible for this including illegal pedestrian crossing, red light running etc. The interaction may not always lead to a safety hazard but definitely this is crucial for the success of exclusive pedestrian phase. Zhanga et al. (2015) compared exclusive and concurrent pedestrian phasing from the perspective of severity of interaction with motor vehicles where they observed and classified pedestrian crossing and severity of interaction. From their research, they found that, pedestrian experience lower interaction severity with motor vehicles with exclusive pedestrian phase compared to crossing on the green light with concurrent pedestrian phase. They also found lower crash number in case of exclusive pedestrian phase but crash severity was high than crashes of concurrent pedestrian phase. (Yaohua Zhanga, 2015)

Reducing interaction is supposed to lead in reduction of pedestrian crash number. As pedestrian phase is implemented only to accommodate pedestrian safely it was thought to reduce pedestrian crash number significantly. Different study shows different results regarding the reduction of crash frequency. Zegeer et al. (1982) studied 1296 traffic signalized intersection to determine significance of pedestrian signal indications and signal timing strategies to pedestrian accidents. From their analysis using

different statistical tests, they found no significant difference in pedestrian accidents between intersections that had concurrent walk pedestrian signals compared with intersections that had no pedestrian signal indications. For exclusive pedestrian crossing, they found lower number of pedestrian crashes with moderate to high pedestrian volume. (Charles V. Zegeer, 1982). Again, Garder et al. (1989) tested the safety benefit of exclusive pedestrian crossing at three sites and found to be beneficial in small town but not in city. He found that exclusive pedestrian signal may not be effective in city due to high number of red walker in the city traffic signal intersection. He suggested that shorter waiting time will decreases the number of red walking. (Garder, 1989). As the sample size was not very large, detailed study is required to say where exclusive pedestrian phase is beneficial, in the city or in the small town. Zaidel et al. (1987) also tested the relationship between pedestrian crossing types and average number of accidents including both pedestrian and vehicle accidents. From their analyzed 5-year data from 320 signalized intersections they concluded that, pedestrian crossing type has no effect on vehicular accident and very less effect on pedestrian accident. They identified vehicle volume, pedestrian activity, and intersection complexity as the reasons behind pedestrian and vehicular accidents. But they indicated that, exclusive and concurrent pedestrian phases may provide different degrees of pedestrian protection for different combination of vehicle and pedestrian volume. (D. M. Zaidel, 1987). Fleig and Duffy found no significant reduction in the proportion of unsafe acts or pedestrian accidents after the installation of exclusive pedestrian signals at 11 locations. Their accident data were limited to 27 accidents in the before period and 25 accidents in the after period, with each of these periods only

one year in duration. The authors of the study concluded that pedestrian signals are not effective in reducing pedestrian accidents (P. Fleig, 1967). But the limited data used raise questions about the statistical validity of this conclusion. Chen et al. evaluated relative effectiveness of four signal related pedestrian countermeasures in New York City and found exclusive pedestrian phase as the second most effective countermeasure to reduce pedestrian crashes but they described it to insignificantly increase vehicle crashes. (Li Chen, 2012). The few published evaluations of scramble signals have generally found that in cases in which vehicle volumes are high, scramble phasing has reduced crashes and traffic conflicts. Moreover, in cases with high pedestrian volume conflicting with turning vehicles, scramble phasing has been shown to be especially effective.

Abrams et al. conducted a research to compare safety of pedestrians and delay of both pedestrian and vehicles for four different types of phasing facility of an intersection. The results of the study indicated that the combined pedestrian-vehicle interval will almost always minimize overall pedestrian and vehicle delay. The only exception occurs for the case in which a pedestrian-vehicle conflict causes long queues of vehicles to form in a right-turning lane (or left-turning lane on a one-way street). They suggested that, exclusive pedestrian phasing is capable of increasing pedestrian safety by completely separating pedestrian and vehicular movements; however, this benefit is canceled if pedestrian compliance is low. They emphasized that, if violations are frequent, the use of exclusive pedestrian phasing may be a safety hazard. (C. M. Abrams, 1977)

Very few researchers tried to model exclusive pedestrian phase and evaluate the delay. Nash et al. carried out a modelling work to assess the efficiency of exclusive pedestrian phases at traffic signals. They examined one cross intersection and one T-intersection in the Melbourne CBD and used SIDRA software package to model the existing two-phase operation and the three-phase exclusive pedestrian crossing arrangement. They found a slight increase in pedestrian delay and significant increase in vehicular delay. (D. Nash, 2010)

The main reason behind insignificant reduction of pedestrian crash number is number of illegal crossing. Since, traffic is stopped on all directions, exclusive pedestrian phasing results in longer delays for motor vehicles and pedestrians. The illegal crossing is intrigued by this long waiting time which can make pedestrian frustrated. In such case, pedestrians often do not wait for the pedestrian phase, potentially resulting in unexpected interactions between pedestrians and motor vehicles. The requested pedestrian phase may then go unused, but the drives have to wait for the phase to run its course. It also impacts them negatively and red light running may increase. Pedestrian phase is an additional phase. Few studies showed that crash frequency in a signalized intersection may change due to increase of the number of signal phases. Agbelie et al. investigated crash data of seven years from 381 intersections and concluded that, a unit increase in the number of signal phases would increase crash frequency by 0. 4. (Bismark R. D. K. Agbelie, 2014)

Some researcher has got opportunity to conduct study right after the implantation of an exclusive pedestrian signal like Kattan et al. (2009), who

conducted a study to evaluate the pedestrian safety of an exclusive pedestrian phase at an intersection of Canada. They collected pedestrian conflicts on that intersection for six weeks and developed poison regression model to model the number of conflicts and violations. Their findings showed decreased pedestrian-vehicle conflicts but increased pedestrian signal violations. They found 13% of the violation was safe as it was concurrent with the vehicle movement and 2% crossings were unsafe. (Lina Kattan, 2009). They continued the study to determine the longer-term effect of this operation on pedestrian safety. To do that, they collected data again one year after the implementation of exclusive pedestrian signal and developed four poison regression model to model the number of conflicts and violations. They found some changes in the results from the previous study conducted at the same location. Their results showed that the number of pedestrian-vehicle conflicts and pedestrian violations decreased significantly on weekdays but both pedestrian violations and conflicts increased significantly on weekends after implementation of the scramble operation. (Manoj Shah, 2010). Bechtel et al. (2004) conducted a similar study in the city of Oakland, California to determine the safety impacts of an exclusive pedestrian signal. They found statistically significant decrease in the number of conflicts between pedestrian and vehicle but significant increase in the number of illegal crossing. They concluded that exclusive pedestrian phase improved pedestrian safety despite the increased number of illegal crossing as those illegal crossings are concurrent to traffic flow which makes the crossing somehow safe. (Allyson K. Bechtel K. E., 2003). Several other researchers tried to measure the pedestrian- vehicle conflict level for exclusive pedestrian signal. Yang et al. (2005) found that exclusive pedestrian phases

are effective measures to reduce conflicts between pedestrians and motor vehicles at signalized intersections. (X. Yang, 2005).

The main issue with implementing exclusive pedestrian phase is not having specific guidelines. For traffic signal or number of phasing there are developed guidelines to follow. But no specific guidelines for implementing exclusive pedestrian phase was found in MUTCD or similar sources. Few researchers suggested few cases when to install an exclusive pedestrian phase. According to Li Chan, exclusive pedestrian phase should be installed at intersections with many pedestrians and a modest amount of traffic. But no range was developed to follow or work on. Again, in downtown area where pedestrian accumulation is rapid, an exclusive pedestrian phase may be beneficial.

Compared crash data has not covered long range of time. Previous few studies compared crash data for one to three years before and after the implementation. More detailed analysis is needed to come to the conclusion if the pedestrian safety has been improved or not.

Implementation of a type of pedestrian signal is also related to the characteristics of the location and the problem that the intersection is facing. For example, increasing cycle length may not be effective in a university area, but may be needed in an area with high number of elderly people.

The above-mentioned studies focused on the compliance issue, before and after crash analysis to some extent, and safety benefit, none of the studied examined the change of LOS in the intersection for different types of

pedestrian facility. Again, pedestrian vehicle interaction and conflict count may be used to predict crashes.

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