International Co-operation on Theories and
Concepts in Traffic Safety

Assessing Pedestrian Waiting Behavior under Time Pressure at Traffic Signals: A Survival Model Study

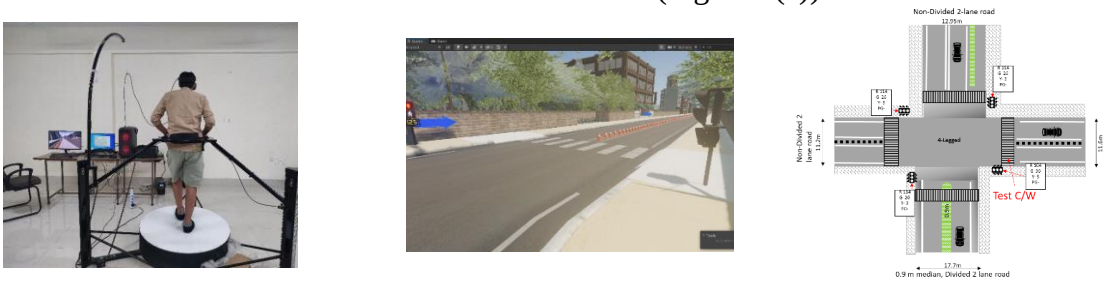
[1]*Apurwa Dhoke, [1]Pushpa Choudhary
*Lead presenter
[1]Indian Institute of Technology Roorkee, India

Introduction

Understanding the factors affecting the pedestrian's decision to wait at the signalized intersection is crucial for enhancing pedestrian safety. An important parameter like time pressure is influenced by other relevant factors like signal timing, individual characteristics, and these variables affect the pedestrian's behavior. While several studies have examined the impact of time pressure on pedestrian behavior on mid-blocks, overlooking the interactions that occur at signalized intersections. Thus, there is a need for comprehensive research that considers the influence of different levels of time pressure and other influencing parameters at signalized intersections. Therefore, the current study aims to understand how time pressure interacts with various factors to influence pedestrians' waiting decisions.

Research Methodology

The study conducted an onsite investigation of pedestrian behavior at a signalized intersection in Delhi, India. Detailed data on intersection features and vehicle attributes like headway, volume, etc., were collected. Further, a virtual scenario representing a real-world intersection is replicated, using UNITY 3D. To understand pedestrian behavior in Virtual Reality (VR), a pedestrian simulator was utilized (Figure 1(a)). It comprised a VR headset that displays the virtual environment (Figure 1(b)) and a Powered Motion Platform (PMP) which allows pedestrians to walk and interact in the virtual world (Figure 1(a)).



(a) **(b)** **(c)**

Figure 1: (a) Pedestrian simulator setup (b) Participant's view of the scenario (c) Layout of the intersection scenario

The scenario consisted of a 4-legged 2-lane divided signalized intersection resembling an urban environment (Figure 1(c)). At the intersection, pedestrians faced a 112s red and a 31s green to cross the road. For the experiments, the scenario was divided into End of the Green (EG), Middle of the Red (MR), and End of the Red (ER). Around 60 individuals participated in the study, 20 in each scenario. The participants walked on the virtual road from A to B on the test crosswalk (Figure 1(c)). For each scenario, the simulator experiments were conducted in three conditions: no time pressure (NTP), low time pressure (LTP), and high time pressure (HTP). As a result, 60 participants resulted in 180 observations, yielding head turns, waiting time and

signal non-compliance. Further, pedestrians' demographic (gender, age, and education) and usual walking features (signal and crosswalk crossing habits, reasons for signal and crosswalk non-compliance, and crash history) were collected through a questionnaire.

Results

The present study evaluates the influence of time pressure and other factors on waiting duration at signalised intersections using a survival model for time-to-event data. The event of interest is the termination of waiting duration, with uncensored events representing pedestrians who terminate waiting during a red light (risk-taking) and censored events representing those who terminate at a green light (risk-free). The study employs an Accelerated Failure Time (AFT) parametric survival model to interpret the impact of covariates on waiting duration. To account for unobserved heterogeneity due to multiple observations from one subject, AFT survival analysis with frailty effects was used. Among Exponential, Weibull and Log Logistic AFT with Gamma and Inverse Gaussian frailty, the Weibull AFT with Gamma frailty provided best fit.

Among the various covariates, scenarios (EG, MR and ER), conditions (NTP, LTP, HTP), age, education, signal crossing habits, reasons for signal and crosswalk non-compliance and crash history significantly affected the waiting duration. It was found that during MR and ER, waiting duration increased significantly than that in the EG. Further, during LTP and HTP, the waiting duration is reduced by 93% and 94%, respectively. The Exp(coef) of 0.625 implies that for each additional year of age, the waiting time decreases by approximately 37.49%. In terms of education, for pedestrians with higher education (Ph.D. or above), the waiting time increased 26.38 times as compared to undergraduates. Participants who reported (in a questionnaire) that they usually wait for the green light but begin crossing in red, have 12% reduced waiting time in VR. For the reported reasons for signal non-compliance, individuals who reported that they were in a hurry, and they didn't see any traffic had 92% and 99% less waiting time. Further, those pedestrians who met with crash in last 5 years have resulted in a decrease in waiting time.

Discussion and Conclusion

The current study valuable insights into various factors influencing the pedestrian waiting duration by using a Weibull AFT with Gamma frailty. The findings indicate that time pressure reduces waiting time, irrespective of their levels, highlighting the critical impact of urgency on behaviour. Age was inversely related to waiting time suggesting that younger ones are more likely to wait. However, the current study includes pedestrians aged between 18 to 32 years only. Education also exhibited a significant role, potentially indicating greater risk aversion among more educated pedestrians. Self-reported usual walking characteristics like habitual behaviour and reasons for non-compliance further influenced the waiting duration.

These findings emphasize the need for effective pedestrian interventions, considering the covariates such as time pressure, age, and personal characteristics. Understanding these parameters can improve the design of infrastructure and help in building more efficient traffic signals to improve pedestrian safety by increasing pedestrian compliance. Future research can continue to explore the dynamics of pedestrians in varied environments with a wider population range to validate and expand the results.