Pedestrian Behavior and Safety Perceptions Among University Students at Signalized Crosswalks

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Abstract. A critical component of urban transportation, especially in places with heavy traffic, like university campuses, is pedestrian safety at signalized crosswalks. Crosswalks are places set aside for people to safely cross streets, but their efficacy frequently depends on how well traffic signals are followed, how drivers behave, and how the crosswalk is designed. Common issues include red light running, short durations of signal phases, and pedestrians and vehicles interacting simultaneously, which can lead to risky conflicts, and in turn, dangerous situations. For specific groups, such as university students navigating busy areas like campuses, tailored road safety policies—such as targeted interventions near educational institutions—can significantly reduce risks. By fostering a safer environment, cities can encourage walking as a sustainable and health-conscious mode of transport.

This paper explores university students' pedestrian behavior and perception of safety at signalized crosswalks, emphasizing interactions between pedestrians and vehicles near the campus of Aristotle University of Thessaloniki (AUTh), Greece. The paper evaluates variables affecting pedestrian decisions, including traffic volume, vehicle speed, and signal compliance using data from an in-situ questionnaire-based survey addressed to AUTh university students. The results underline the necessity for improved crosswalk design and enforcement strategies to enhance pedestrian safety. Practical recommendations include optimizing signal timing, increasing crosswalk visibility, and raising public awareness of pedestrian rights and responsibilities. This research provides valuable insights for urban planners and policymakers aiming to create safer and more accessible urban spaces.

Keywords: pedestrian safety · urban mobility · university students · signalized crosswalks

1 Introduction

Pedestrian safety at signalized crosswalks is a major concern, particularly near university campuses where students frequently navigate congested intersections. Signalized crosswalks are designed to facilitate safe pedestrian crossings by synchronizing pedestrian

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O. Gervasi et al. (Eds.): ICCSA 2025 Workshops, LNCS 15892, pp. 81–100, 2026.
https://doi.org/10.1007/978-3-031-97638-4_6

and vehicular movements through traffic light signals. However, the efficacy of these crosswalks is contingent upon numerous factors, including signal compliance by both motorists and pedestrians, driver behavior, and the geometric design of the crosswalks. One of the critical challenges is the prevalence of vehicles violating red light signals, which poses a substantial threat to pedestrian safety. Additionally, insufficient signal phase duration can impede pedestrians from crossing safely, especially in areas or spots with significant pedestrian flows. The concurrent vehicles and pedestrian movements, particularly during peak periods, exacerbate the potential for conflict and hazardous interactions.

University students represent a unique demographic of pedestrians who are routinely required to traverse busy streets multiple times per day as they move between academic buildings and other campus facilities and/or the university campus and their residents. For this demographic, the risk associated with crossing streets can be mitigated through targeted interventions, such as altering the geometric design of crosswalks near campuses and implementing educational or public awareness initiatives to elevate awareness of pedestrian safety. Universities are vibrant environments where many pedestrians, primarily students, faculty, and staff, must coexist with vehicular traffic. Pedestrians, often distracted by their daily routines or electronic devices (smartphones), may not always be vigilant about traffic signals, increasing their vulnerability. Conversely, drivers navigating these areas might exhibit behaviors such as speeding or failing to comply with the traffic lights' signals, further compounding the risk.

In Greece for the year 2022, the total number of fatalities in road accidents was 654, with 70.9% of them being drivers and 17.1% pedestrians (the remaining 11.9% were pedestrian) [1]. Focusing on pedestrians' fatalities, out of 654 total fatalities, 112 (17.1%) were pedestrians. In the age group of 0–24, there were 105 fatalities overall, with only 5 pedestrian fatalities, making up 4.5% of pedestrian fatalities in this age group. For the age group of 25–49, there were 204 total fatalities, 18 of which were pedestrians (16.1%). In the 50–64 age group, there were 141 total fatalities, with 19 pedestrian fatalities, comprising 17.0% of the pedestrian fatalities. The 65+ age group had 192 total fatalities, with pedestrians accounting for 68 fatalities, or 60.7%, indicating a significantly higher risk for pedestrians in this age group compared to others. Lastly, there were 12 fatalities categorized as not specified, with 2 pedestrian fatalities, making up 1.8% of pedestrian fatalities. Within residential areas, passenger cars are involved in 83 fatalities (26.6% of the total residential fatalities). Two-wheel vehicles contribute to a notably high number of fatalities, with 139 deaths (44.6%). Pedestrians also face significant risks in residential areas, accounting for 73 fatalities (23.4% of the residential area fatalities). Analyzing the official recorded data for the year 2022, out of the total 10,487 road traffic accidents, 1561 accidents (14.9%) involved pedestrian entrainment, resulting in 114 pedestrian fatalities, which is 17.4% of the total fatalities, highlighting the significant risk that pedestrians face in road traffic accidents. Comparatively, pedestrian fatalities make up a considerable portion of the fatalities across various collision types. For instance, head-on side collisions, which account for 4245 accidents (40.5%), resulted in 112 fatalities (17.1%). Meanwhile, vehicle collisions with other stable obstacles, such as posts or trees, accounted for 216 accidents (2.1%) and resulted in 55 fatalities (8.4%). The proportion

of pedestrian fatalities in these accidents emphasizes the heightened vulnerability of pedestrians in collisions with moving vehicles and stationary obstacles.

This paper investigates the pedestrian behavior and safety perceptions of university students at signalized crosswalks, with an emphasis on pedestrian-vehicle interactions in the vicinity of Aristotle University of Thessaloniki (AUTh), Greece. Utilizing an in-situ, questionnaire-based survey administered to AUTh students (January 2025), various determinants of pedestrians' decision-making at signalized crosswalks are explored, including traffic volume, vehicular speed, and signal compliance. Furthermore, this research employs a mixed-methods approach to gathering quantitative and qualitative data from a diverse sample of university students. The developed questionnaire is specifically designed to collect data on a wide range of variables, such as pedestrian crossing behaviors, safety perceptions, and specific challenges encountered at signalized crosswalks. Data collection is conducted during peak traffic periods to ensure a representative sample and robust data set.

The findings from this research highlight the necessity for enhancements in crosswalk design and the implementation of robust enforcement strategies to improve pedestrian safety. Practical recommendations derived from this research include optimizing signal timings to ensure adequate pedestrian crossing time, enhancing crosswalk visibility through improved lighting and signage, and conducting public awareness campaigns to educate both drivers and pedestrians about signal adherence and pedestrian rights. The insights garnered from this study aim to furnish urban planners and policymakers with empirical evidence necessary to devise and implement measures that foster safer and more accessible urban environments. By prioritizing pedestrian safety, cities can safeguard their inhabitants and champion healthier, more sustainable modes of transportation. Section 2 concerns the Literature Review, Sect. 3 describes the Methodology applied, Sect. 4 presents the Results and Sect. 5 the main findings and conclusions (Discussion and conclusions).

2 Literature Review

The literature review is based on evidence drawn from the SCOPUS database, using the following query "*TITLE-ABS-KEY (pedestrian and safety and signalized and crosswalks) AND PUBYEAR > 2009 AND PUBYEAR < 2026*". In total, 258 articles were retrieved, considering the period from 2010 to 2025, without any other restraints with an increasing trend in the number of documents, peaking in the year 2023 with 26 documents. It dips slightly in 2024 to 20 documents. The highest activity period was between 2020 and 2023. Focusing on the distribution of documents by country/region, China leads with 99 documents, followed by the United States with 51 documents. India ranks third with 31 documents. With regard to the subject area of documents, "*Engineering*" has the highest number of documents at 197, followed by "*Social Sciences*" with 140 documents, "*Computer Science*" has 53 documents, "*Medicine*" has 38, "*Mathematics*" has 27 and "*Psychology*" accounts for 24 documents as the leading subjects. Out of the 258 articles, 185 of them contain the keyword "*pedestrian*" (71.7%), 84 contain the keyword "*safety*" (32.5%), 70 contain the keyword "*signalized*" (27.1%), 63 contain the keyword "*crosswalk*" (23.2%), 39 contain the keywords "*pedestrian safety*" (15.1%) combined and 7 contain the keywords "*signalized crosswalks*" (2.7%) combined.

According to Sherif et al. (2025) [2], who based their research on a sample of 5000 pedestrians at several locations in Central Florida, distracted pedestrians did not significantly impact the intersections' traffic operations. However, the authors highlighted the fact that although distractions among pedestrians increased their crossing time by nearly 4%, this extra time caused by their distractions was almost equal to or less than drivers' startup lost time of 2 s. Gyo et al. (2024) [3] introduced a two-stage pedestrian crossing model using Physics-Informed Neural Networks (PINNs), which incorporates fluid dynamics equations to analyze pedestrian movement characteristics such as speed, density, and acceleration. Abaza et al. (2018) [4] examined six intersections known for high pedestrian crash rates in Anchorage, Alaska to measure crossing compliance. Findings revealed that: (a) un-signalized crosswalks had more violations compared to signalized ones, highlighting the need for safety measures, (b) violations were frequent during evening peak hours, but also notable in the late evening, (c) bus stops located far from intersections contributed to lower crossing compliance and higher pedestrian fatalities and (d) pedestrian volume had a stronger association with crossing compliance than vehicular traffic volume. The authors identified that higher traffic volume generally increased compliance, but spatial and overall compliance decreased with pedestrian volumes exceeding 100–120 pedestrians per hour. Additionally, pedestrians, especially at signalized crosswalks, tended to group together, which impaired safety.

Makarova et al. (2016) [5] analyzed road traffic accidents at non-signalized pedestrian crosswalks. The authors conducted a field study to assess traffic and pedestrian flow parameters and develop simulation models for different street and road network conditions and proposed various solutions to enhance pedestrian safety at non-signalized crosswalks. Alhajyaseen & Nakamura (2010) [6] through their research found that the maximum reduction in the capacity of signalized crosswalks occurs at roughly equal pedestrian flow from both sides of the crosswalk. Ackahh et al. (2024) [7] examined the rate of pedestrian violations at signalized crosswalks and the associated risk factors. Data were collected through roadside observational surveys at ten (10) selected crosswalks within the Accra Metropolis, Ghana. The risk factors for red-light violations were identified using a mixed-effect logistic regression model, while the descriptive statistics indicated that the red-light violation rate in Accra was approximately 62%. Most violations (63.5%) occurred in the evening and on weekends (73.6%), while over 98% of pedestrians showed safety awareness by observing oncoming traffic before and during crossing. The mixed-effect logistic regression model identified six significant independent variables influencing the risk of red-light violations and specifically: age, signal cycle length, number of pedestrians crossing at a time, day of the week, and pedestrian light observation. Aghabayk et al. (2021) [8] investigated factors influencing pedestrian crossing behaviors at signalized and unsignalized intersections in Tehran, Iran. Analyzing data from 552 pedestrians, the authors examined the impact of gender, age, group-crossing, technological device use, and carrying items on behaviors like crossing speed and situational awareness, and concluded that (a) males and older pedestrians exhibit different behaviors at signalized versus unsignalized intersections, (b) pedestrians crossing alone are more cautious and quicker than those in groups and (c) the use of technological devices negatively impacts safe crossing behaviors, with phone users being the least cautious. Liu et al. (2022) [9] studied pedestrian temporal violation behavior at signalized

crosswalks using video data from three (3) locations in China. The authors identified six (6) significant factors influencing violations: gender, phone distraction, location type, pedestrian volume, day of the week, and time of day. The authors found that longer waiting times increase violations, males and phone-distracted pedestrians are more likely to violate, and violations are more frequent at road segment crosswalks, during weekdays, and in the morning. Iryo-Asano et al. (2015) [10] analyzed pedestrian-vehicle conflicts at signalized intersections in Japan, focusing on pedestrian behavior during the pedestrian flashing green (PFG) interval. They developed models concerning the probabilistic behavior of pedestrians, including their decision to stop crossing and speed distribution. The authors found that longer crosswalks increase stop probabilities and pedestrian speeds differ between the first and second halves of crosswalks. Wang et al. (2024) [11] introduced through their research the "yielding dilemma zone" model to address driver decision-making challenges at non-signalized crosswalks in Xi'an, China. Analyzing 1687 instances of driver yielding behavior using Support Vector Machine (SVM), Artificial Neural Network (ANN), and Binary Logistic Regression (BLR) models, the authors identified significant factors influencing driver-pedestrian interactions, such as pedestrian speed, vehicle type, and traffic conditions. The research findings highlighted higher collision probabilities within dilemma zones and suggest using SVM for warning signs and ANN and BLR for real-time assistance systems, aiming to enhance pedestrian safety and traffic management. Alhajyaseen & Iryo-Asano (2017) [12] examined pedestrian-vehicle conflicts at signalized intersections, focusing on sudden pedestrian speed changes that drivers cannot predict. Analyzing video data from five (5) crosswalks in Nagoya City, Japan, the authors identified significant factors influencing these speed changes, such as entering speed, required speed to finish crossing, and crosswalk length, highlighting the importance of these sudden changes in conflict analysis and offer insights into improving pedestrian safety. Iasmin et al. (2016) [13] investigated pedestrian safety at signalized intersections, focusing on accidents involving left-turning vehicles and pedestrians. The authors evaluated the safety impact of crosswalks made from different materials, finding that brick pavement increases safety by encouraging drivers to yield to pedestrians. Montecchini and Paganelli (2015) [14] examined the complexities of signalized crosswalks in urban areas, focusing on safety, cycle length, and delay, highlighting pedestrians' tendency to seek the shortest path, sometimes unsafely, and drivers' disregard for pedestrian signage, using as a field study the city of Bologna, Italy. Li et al. (2022) [15] evaluated the impact of law enforcement cameras on pedestrian-vehicle conflicts at non-signalized crosswalks, finding that cameras reduce both actual and perceived risks for pedestrians, decrease driver aggressiveness, and lower conflict severity. Kutela (2022) [16] evaluated the impact of crosswalk-related and non-crosswalk features on drivers' spatial yielding compliance at signalized midblock crosswalks in Las Vegas. The author concluded that state law signs, "PED XING" signs, and rectangular rapid flashing beacons (RRFBs) improve compliance, while yield lines over 40 feet from the crosswalk, one-stage crossings, and high traffic volumes reduce compliance. Ni et al. (2017) [17] examined pedestrian safety perceptions at signalized intersections in Shanghai, China, surveying 1286 pedestrians. The authors categorized behaviors into Green walkers, Late walkers, and Red walkers based on signal indications, finding that refuge

islands and conflict involvement significantly impact safety perceptions, with all pedestrian types favoring refuge islands. Patra et al. (2020) [18] analyzed pedestrian behavior and choices between at-grade signalized crosswalks and foot overbridges in Mumbai, India, finding that the total crossing time ratio significantly influences the choice, with a higher probability of using foot overbridges as the ratio decreases. Islam et al. (2022) [19] estimated models of frequency and injury severity in pedestrian crashes at signalized intersections and examines the "safety in numbers" effect in the United States. The authors using pedestrian crossing volumes from push-button traffic signal data, identified characteristics of signals with higher crash rates and factors influencing crash severity, showing that higher pedestrian volumes reduce crash rates. Gruden et al. (2022) [20] examined how intersection typology and smartphone use affect pedestrian behavior and safety at signalized crosswalks. The authors by using eye-tracking technology, analyzed attention, crossing performance, and reaction times, confirming that intersection type and smartphone use significantly impact pedestrian gaze behavior and crossing performance. Wachnicka and Kulesza (2020) [21] investigated pedestrian and cyclist behavior at signalized crossings in Gdansk, Poland, focusing on the use of electronic devices. The authors found that 10% of users use phones and 5% use headphones, with most being young people. Dangerous behaviors, such as crossing at red lights, were observed regardless of device use, highlighting that traffic disruptions caused by phone users but cannot conclusively link device use to increased accident risk due to a lack of specific accident statistics. Wang et al. (2021) [22] evaluated the effectiveness of exclusive pedestrian phases (EPP) at intersections, considering pedestrian-vehicle interactions. The authors by using video data and simulations, found that pedestrian-vehicle interactions significantly impact total delay, concluding that higher pedestrian flow and vehicle yielding rates reduce delay increments after implementing EPP. Ryan et al. (2019) [23] evaluated the effectiveness of flashing yellow arrows for right-turn applications at signalized intersections to improve pedestrian safety, through static and simulator evaluations, finding that drivers understand and respond safely to flashing yellow arrows, suggesting their potential to reduce vehicle-pedestrian conflicts at intersections. Basbas et al. (2018) [24] examined students' behavior and perceptions at five signalized pedestrian crossings near Aristotle University of Thessaloniki, Greece. The authors by using 500 questionnaires, pedestrian flow counts, and traffic data, employed descriptive and inferential statistics to analyze behavior and perceptions. Zhou et al. (2024) [25] propose a deep learning-based method for predicting pedestrian trajectories and assessing risk for Autonomous Vehicles (AVs), using LiDAR data and signal information. The Long Short-Term Memory (LSTM) network predicts future trajectories and risk factors, achieving high accuracy. Cai et al. (2024) [26] proposed using machine learning (ML) to enhance pedestrian crossing predictions in intelligent transportation systems. Chen et al. (2023) [27] predicted pedestrian crossing decisions at intersections in Changsha, China, with different transition signals and crossing facilities, finding that while crossing facilities reduce risks, pedestrians remain at high risk. The authors by using logistic regression models indicated that factors influencing crossing decisions vary by intersection type, with no single factor having a uniform impact. Perra et al. (2022) [28] examined the factors affecting the crossing duration of pedestrians distracted by mobile phones at signalized and unsignalized crossings in Thessaloniki, Greece, finding that crossing duration at

unsignalized crossings is influenced by potential vehicle conflicts and additional distractions, while at signalized crossings, it is affected by the pedestrian's age and position before crossing. Zhang et al. (2022) [29] examined the impact of autonomous vehicles (AVs) on the capacity of left-turn lanes at signalized intersections in Japan, considering AV penetration rates, pedestrian flow rates, and crosswalk length finding that strict compliance with traffic laws by AVs significantly reduces left-turn lane capacity, particularly at longer crosswalks. Khademi et al. (2024) [30] used Virtual Reality (VR) technology to evaluate visual and auditory warnings for pedestrians at signalized intersections. The authors tested four (4) signal types, found that visual signals reduce violations, especially at night and among males, while auditory signals improve attention to traffic. Lao and Furth (2024) [31] examined the use of pedestrian-left turn overlaps at signalized intersections to reduce pedestrian delay. By allowing half-crossings during both the left turn and parallel vehicle phases, pedestrian delay can be significantly reduced with minimal impact on vehicle delay. Baldassa et al. (2024) [32] using a Virtual Reality (VR) experiment investigated factors influencing young people's likelihood of violating traffic laws and their crossing speeds, finding that students who walk to school and those in larger cities are less likely to violate laws, while those with frequent real-life misconduct are more likely to disregard red lights. Table 1 summarizes the studies included in the literature review as per their conceptual focus.

Table 1. Literature review clustering

Category	Authors (Year) [Reference]
Distracted Pedestrians	Sherif et al. (2025) [2], Gyo et al. (2024) [3], Perra et al. (2022) [28]
Pedestrian Safety Behavior and Compliance	Abaza et al. (2018) [4], Makarova et al. (2016), [5], Alhajyaseen & Iryo-Asano (2017) [12], Ackahh et al. (2024) [7], Aghabayk et al. (2021) [8], Ni et al. (2017) [17], Li et al. (2022) [15], Patra et al. (2020) [18], Islam et al. (2022) [19], Wachnicka and Kulesza (2020) [21]
Intersection Design	Makarova et al. (2016) [5], Alhajyaseen and Nakamura (2010) [6], Kutela (2022) [16], Wang et al. (2021) [22], Zhang et al. (2022) [29], Montecchini and Paganelli (2015) [14]
Technology in Crossings	Gyo et al. (2024), [3], Wang et al. (2024) [11], Zhou et al. (2024) [25], Zhang et al. (2022) [29], Gruden et al. (2022) [20], Cai et al. (2024) [26], Chen et al. (2023) [27], Khademi et al. (2024) [30], Baldassa et al. (2024) [32], Ryan et al. (2019) [23], Lao & Furth (2024) [31]

3 Methodology

The in situ as well as the questionnaire-based surveys were implemented at the at-grade intersection of Egnatia and 3rd Septemvriou streets in the Municipality of Thessaloniki, Greece. Egnatia street is one of the most significant streets in the city of Thessaloniki, running the urban landscape from one side of the city to the other in the direction of South East to North West. The street serves the traffic through two (2) lanes per direction as well as a bus lane located at the right side as vehicles move. The street is divided along its entire length with a median island of varying width per section. At each intersection with a major street, traffic is controlled by traffic lights. Right-turning movements are typically permitted while left-turning movements are allowed per case. Where permitted, the left turning movements are facilitated through a dedicated left turning lane and traffic lights. At the specific at-grade intersection, vehicles can perform a left turning movement using a dedicated lane for this purpose, as presented in Fig. 1.

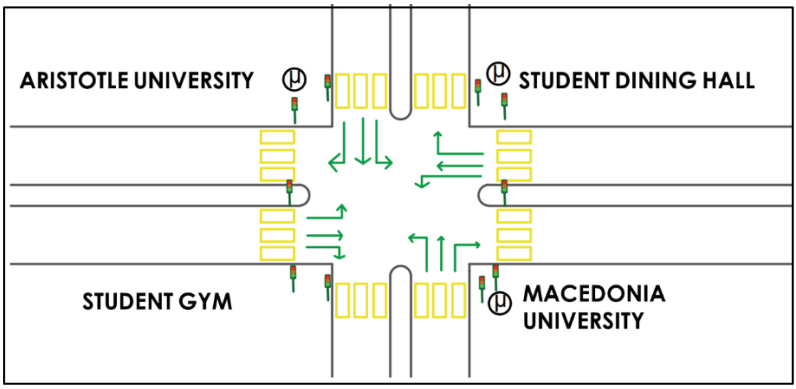

Fig. 1. At grade intersection of Egnatia and 3rd Septemvriou streets–Study area [33]

3rd Septemvriou street runs the landscape vertically to Egnatia street, in the North-South direction. Both sections of the street serve traffic through two (2) lanes per direction. The street is divided with a median island running along with varying width. Traffic is controlled with traffic lights and vehicles at each section are allowed to either move forward or perform left or right turning movements. Pedestrians are served through crosswalks at each section of both intersecting streets as well as pedestrian lights. It should be mentioned that the permitted left-turning movements are controlled with yellow flashing lights (arrows), which according to the Greek Highway Code, vehicle drivers are all obligated to drive with caution providing priority to pedestrians and other vehicles crossing their paths [34]. In this intersection, two (2) members of the research team conducted the questionnaire-based survey addressed exclusively to AUTh students. The questionnaire developed for this purpose begins with socio-demographic questions, including gender, age group, profession, education level, and household income.

It then addresses travel habits, focusing on whether participants own or regularly use private vehicles and their frequency of using pedestrian crosswalks. The questionnaire

focuses on pedestrian behavior at crosswalks, asking whether participants usually cross at designated areas and whether they adhere to traffic signals, such as crossing on a green light or taking risks at a red light. It also explores safety perceptions by assessing how secure individuals feel when crossing and whether changes, such as replacing the existing, conventional traffic light with an enhanced system, would improve their perception of safety. The questionnaire evaluates various factors that influence the decision to cross, such as vehicle speed, traffic density, urgency to reach the destination, the presence of other pedestrians, and the signaling system. The participants were asked to rank these factors by importance, providing insights into the most critical elements affecting pedestrian behavior.

Additionally, the survey investigated the perceived risks associated with crossing, such as short signal durations, drivers violating traffic signals, and the simultaneous presence of vehicles and pedestrians. In addition, several types of participant distractions were addressed, such as using a phone, listening to music, or engaging in conversations, and how these behaviors affect their safety and frequency of risk-taking decisions.

The final sections focus on evaluating potential safety improvements, such as better lighting, clearer signage, lower speed limits, and the use of cameras to enforce compliance, concluding by asking participants to prioritize these measures and identify the most significant hazards they face while crossing. Overall, the questionnaire consists of six (6) questions related to demographic information and 14 questions related to the perceived risks associated with crossing.

4 Results

During the questionnaire-based survey, 304 questionnaires were filled in total. The gender distribution among respondents shows a balanced representation, with 159 men and 145 women participating in the survey (Fig. 2). The age distribution reveals that the majority of respondents are under the age of 24, with 282 individuals falling into this category, while only 22 respondents fall within the 25–39 age range (Fig. 3).

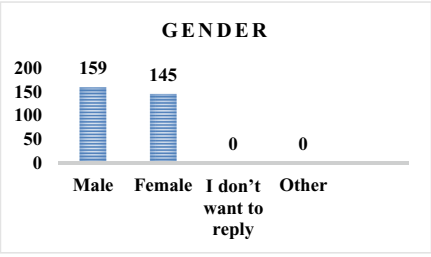

Fig. 2. Gender distribution

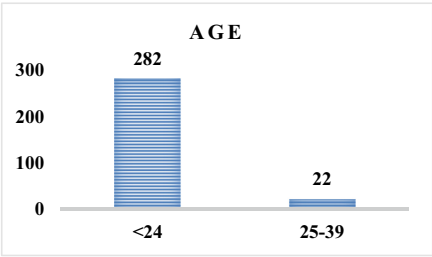

Fig. 3. Age distribution

Examining the occupation distribution, it was found that a significant portion of respondents are unemployed (176), followed by those in other occupations (62) and employed individuals (59). This high unemployment rate was expected as the survey was addressed to the AUTh students (Fig. 4). The majority of respondents are undergraduate

students (Bachelor's) (299), with only a few Master's Degree students/PhD candidates (5). This demographic profile suggests that the survey primarily reflects the perspectives of young, educated individuals who are still in the process of completing their tertiary education (Fig. 5).

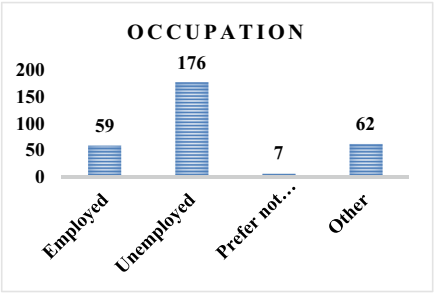

Fig. 4. Occupation distribution

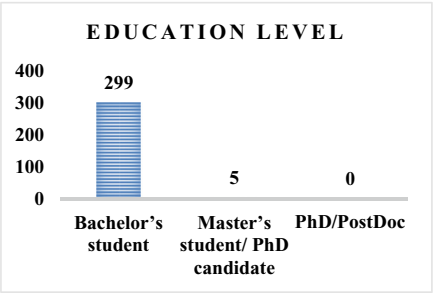

Fig. 5. Education Level distribution

The monthly income distribution among respondents is varied. Most respondents earn between 1601–2400 euros (102), while a significant number prefer not to disclose their income (54). Other income brackets include 0–800 (26 respondents), 801–1600 (79 respondents), and >2400 (43 respondents). This variation in income levels indicates a diverse economic background among the respondents, which could influence their perceptions and behaviors related to pedestrian safety (Fig. 6).

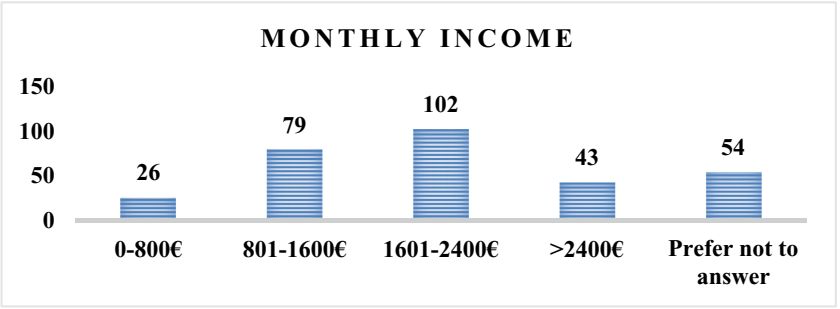

Fig. 6. Monthly Income distribution

Car ownership data shows that most respondents have a car in their family (284), while a few do not (20) (Fig. 7). However, when it comes to using a car for commuting, the responses are evenly split, with 154 respondents using a car and 154 not using one. This suggests that while car ownership is common, it does not necessarily translate to regular car usage for commuting purposes (Fig. 8).

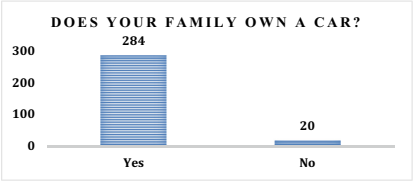

Fig. 7. Private car ownership

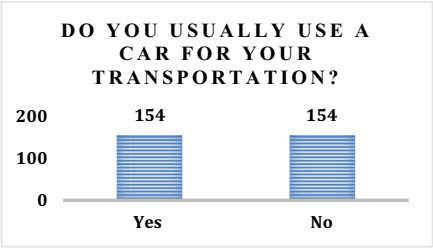

Fig. 8. Private car usage

The survey also explores respondents' behaviors and perceptions related to crosswalk usage. Most respondents use crosswalks (244), while some do not (60) (Fig. 9). When crossing the road, most respondents do so when the pedestrian light is green (141) or at any time (103), with none crossing when the light is red (Fig. 10). This indicates a general adherence to traffic signals among the respondents. However, when crossing at a red light, respondents' feelings of safety vary, with most respondents feeling moderately safe (29) or safe (15) (Fig. 11).



Fig. 9. Way of street crossing

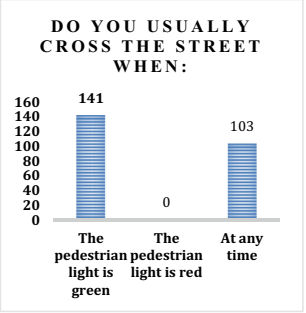

Fig. 10. Traffic light indication while street crossing

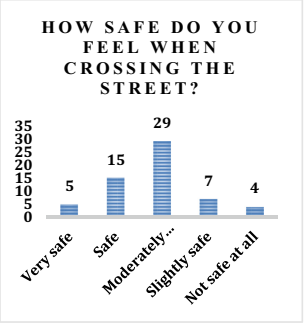

Fig. 11. Perceived level of safety while street crossing

Regarding the potential replacement of traffic lights, most respondents believe that replacing the existing traffic light at the intersection with the one shown in the survey (with a time counter for the pedestrians to pass) would enhance their safety (207). This suggests a perceived need for improved traffic control measures to ensure pedestrian safety (Fig. 12).

Several factors influence respondents' decisions to cross the road. The most important factors include the length of the crosswalk (145) and the presence of other pedestrians (135). Other factors such as the number of passing vehicles (89), the speed of passing vehicles (104), and the indication of the traffic light (76) also play a role in their decision-making process (Fig. 13).

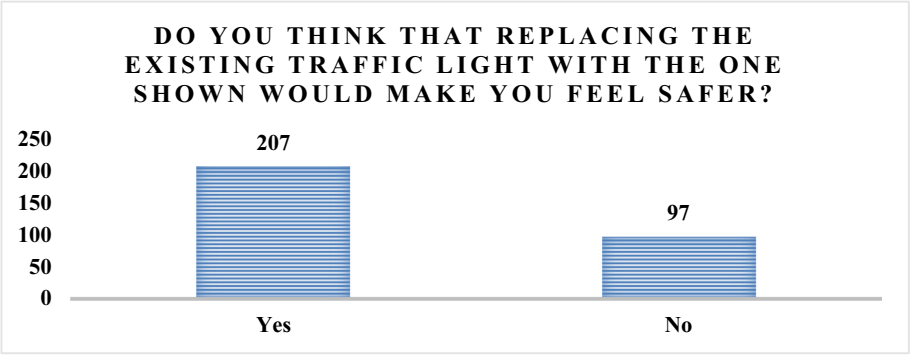

Fig. 12. Replacing existing traffic light at the intersection with one indicating the pedestrians' remaining time green light time

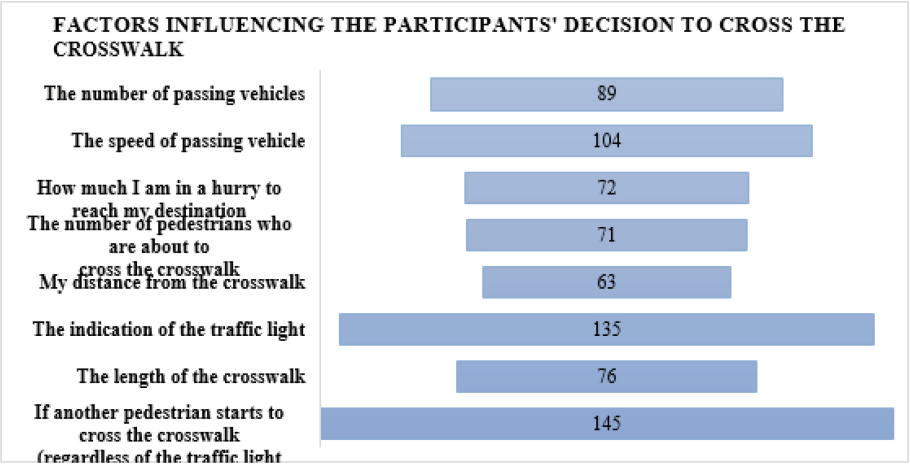

Fig. 13. Factors influencing the participants' decision to cross the crosswalk

Almost all respondents are aware that drivers are obligated to yield at crosswalks (299), indicating a high level of knowledge about traffic laws (Fig. 14). However, several factors cause insecurity when using crosswalks. The most significant concerns include drivers running the yellow light (104) and the simultaneous passage of vehicles and pedestrians (86). Other concerns include the short duration of the green phase light (65) and vehicles in the first row that are about to start (70) (Fig. 15).

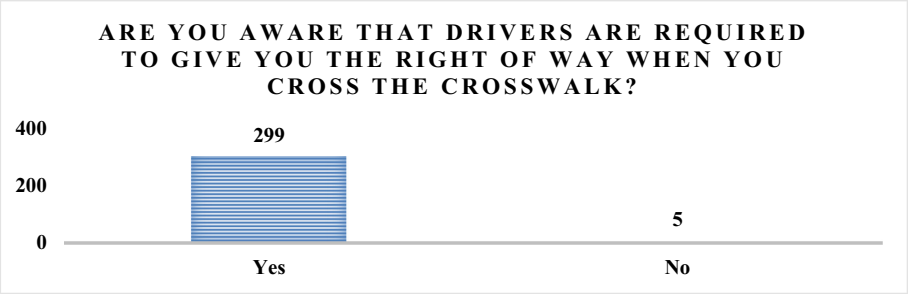

Fig. 14. Participants' awareness on crossing a crosswalk priority

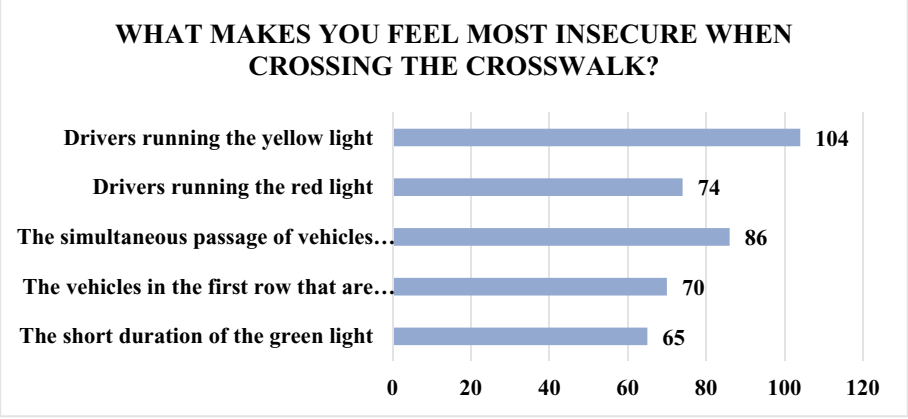

Fig. 15. Factors affecting participants' level of insecurity

Vigilance is a common practice among respondents, with almost all checking for oncoming vehicles when crossing (298) (Fig. 16). The frequency of using pedestrian crossings daily varies, with most respondents using them more than five times daily (154). This high frequency underscores the importance of ensuring pedestrian safety at crosswalks (Fig. 17).

To improve crosswalk safety, respondents were asked about their perception of several measures. The most important measures, as perceived by the respondents, include improved horizontal markings (86) and cameras (104). Other suggestions include improved lighting (65), improved vertical signage (70), and reduced speed limits (74) (Fig. 18). The main reasons for feeling unsafe at crosswalks are the lack of driver attention (210) and insufficient waiting areas for pedestrians (197). Other reasons include insufficient green light time for pedestrians (123) and insufficient signage (114). These findings highlight the need for better infrastructure and driver awareness to enhance pedestrian safety (Fig. 19).

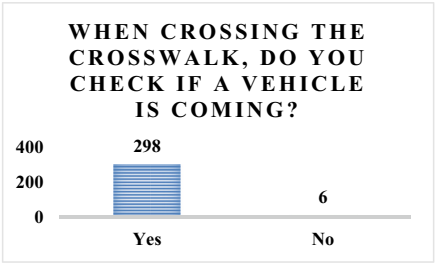

Fig. 16. Participants' vigilance for passing through vehicles

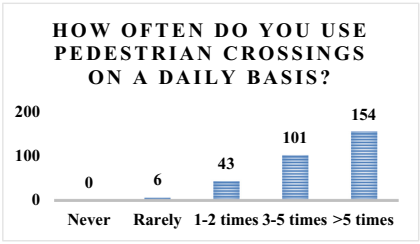

Fig. 17. Participants' daily cross walking frequency

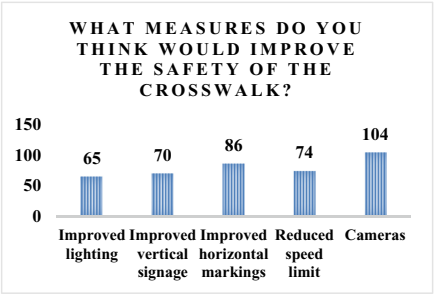

Fig. 18. Participants' chosen measures to improve cross walk's level of safety

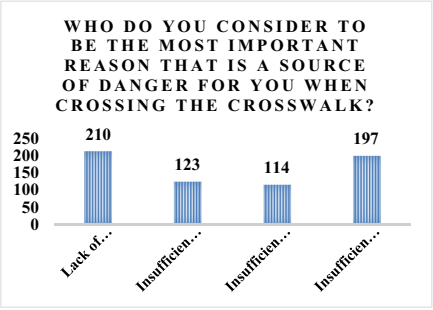

Fig. 19. Participants' perceived reasons of danger while cross walking

The participants' responses vary regarding the influence of haste or lack of time. A small number of respondents (15) are never influenced by haste, while a larger group (44) is rarely influenced. Most respondents fall into the sometimes (114) and often (113) categories, indicating that time pressure is a common factor for many when crossing the street. A smaller group (18) is always influenced by haste, suggesting that for some, time constraints are a constant concern (Fig. 20).

Regarding safety while crossing the crosswalk, the data shows different levels of perceived safety depending on the activity. When talking over the phone, a small number of respondents (17) always feel safe, while a larger group (62) often feels safe. The majority feel safe sometimes (148), indicating that talking over the phone can be a distraction but not always perceived as highly hazardous. A significant number of respondents feel rarely (60) or never (17) safe, highlighting the potential risks associated with this behavior. When using the phone for other purposes, such as texting or watching videos, the perceived safety declines. Only 16 respondents always feel safe, and 58 often feel safe. The majority feel safe sometimes (79), while a significant number feel rarely (103) or never (48) safe. This suggests that using the phone for activities that require more attention can significantly influence the perception of safety. Talking with friends while crossing seems to be less of a concern, with 28 respondents always feeling safe and

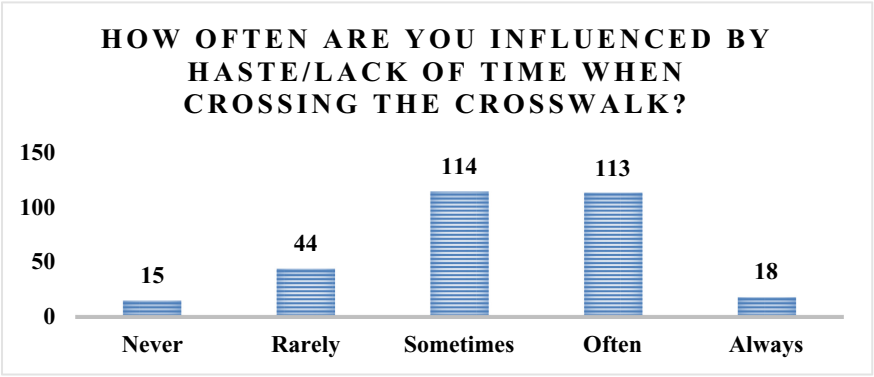

Fig. 20. Participants' haste lack of time frequency affection on cross walking

136 often feeling safe. The majority feel safe sometimes (89), while fewer feel rarely (45) or never (6) safe. This indicates that social interactions, while still a distraction, are perceived as less risky compared to phone use. Listening to music with headphones presents a mixed picture. A notable number of respondents (70) always feel safe, and 74 often feel safe. However, the majority feel safe sometimes (63), while a significant number rarely (64) or never (33) safe. This suggests that while some feel confident in their ability to stay aware of their surroundings, others recognize the potential risks of reduced auditory awareness (Fig. 21).

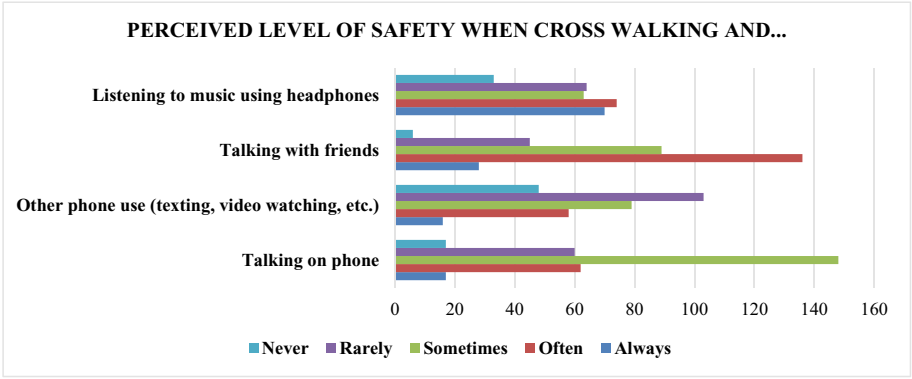

Fig. 21. Participants' level of safety when cross walking related to specific actions

In terms of actual behavior, the data shows how often respondents engage in these activities while crossing the crosswalk. Talking over the phone is a common behavior, with only 5 respondents never doing it, 80 rarely, 131 sometimes, 82 often, and 6 always. This indicates that phone conversations are a frequent activity for many pedestrians. Using the phone for other purposes is less common but still significant. Thirty-two respondents never engage in this behavior, 109 rarely, 90 sometimes, 65 often, and 8 always. This suggests that while less frequent than talking, other phone uses (texting,

video watching, etc.) are still a notable distraction. Talking with friends is a very common behavior, with only 1 respondent never doing it, 22 rarely, 67 sometimes, 188 often, and 26 always. This indicates that social interactions are an integral part of many pedestrians' routines. Listening to music with headphones is also common, with 33 respondents never doing it, 41 rarely, 38 sometimes, 102 often, and 90 always. This suggests that many pedestrians regularly listen to music while crossing, which could impact their situational awareness and safety (Fig. 22).

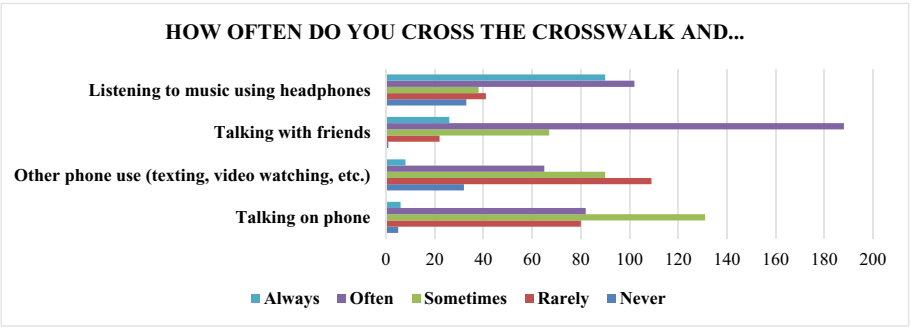

Fig. 22. Participants' frequency of cross walking related to specific actions

5 Discussion and Conclusions

The data collected from the 304 questionnaires offer valuable insights into pedestrian behavior and safety perceptions among university students at signalized crosswalks. Most respondents indicated that they consistently use designated crosswalks, demonstrating an overall awareness of traffic regulations. However, a notable proportion admitted to crossing outside designated areas, often driven by convenience or perceived time constraints. Furthermore, while 141 respondents stated they wait for the pedestrian light to turn green before crossing, 103 indicated they cross at any time they deem safe, revealing a significant degree of risk-taking behavior. This aligns with previous studies that highlight pedestrian non-compliance as a persistent issue in urban environments [35, 36].

Another critical aspect is the influence of external factors on pedestrian decisions. The two most important determinants for crossing behavior were the length of the crosswalk (145 respondents) and the presence of other pedestrians (135 respondents). This suggests that pedestrian movement in groups plays a crucial role in influencing crossing behavior, aligning with the concept of 'herd mentality' in traffic psychology. Additionally, vehicle speed (104 respondents) and traffic volume (89 respondents) were identified as factors affecting crossing decisions, reinforcing the idea that risk assessment plays a vital role in pedestrian behavior.

It must be noted that a discrepancy between pedestrian behavior and perceived safety is identified. While most respondents are aware that drivers must yield at crosswalks,

a significant number still express concerns over safety. The primary sources of safety concerns at crosswalks include drivers running the yellow light and the simultaneous presence of vehicles and pedestrians. This finding underscores the need for stricter enforcement of traffic regulations and improved driver compliance with pedestrian priority rules. The results also suggest that pedestrian distractions play a considerable role in safety perceptions. Many respondents admitted to engaging in distracting activities while crossing, such as talking over the phone, listening to music with headphones, or talking with friends. Notably, listening to music with headphones was identified as a particularly risky behavior, as it reduces auditory awareness and reaction times. These findings are consistent with existing literature that links pedestrian inattention to increased accident risk at crosswalks.

To address pedestrian safety concerns, respondents were asked to prioritize potential safety improvements. The most highly rated measures included enhanced horizontal markings, installation of cameras for enforcement, improved lighting, and reduced speed limits. A particularly noteworthy finding is the strong support for replacing the existing pedestrian traffic light with one that displays the remaining time for the pedestrians' green light. Such modifications could increase pedestrian compliance and reduce the likelihood of last-minute crossings that heighten accident risk. Moreover, the lack of sufficient waiting areas for pedestrians and the short duration of green lights were identified as major concerns, highlighting the need for optimized signal timing to accommodate pedestrian traffic.

The influence of haste on crossing behavior was another important aspect examined in this research. A significant portion of respondents indicated that they are sometimes or often (almost equally) affected by time constraints when making crossing decisions. This suggests that perceived urgency can lead to riskier pedestrian behaviors, such as crossing during a red light or rushing across an intersection with limited time remaining. This finding emphasizes the importance of ensuring adequate crossing times at signalized intersections to accommodate pedestrian movement without encouraging risky behavior.

The findings suggest that targeted interventions, such as improved crosswalk visibility, optimized signal timings, and stricter law enforcement, could significantly enhance pedestrian safety at signalized intersections. Additionally, implementing pedestrian countdown signals and expanding pedestrian waiting areas could further improve safety outcomes. This research also underscores the importance of educational campaigns aimed at reducing pedestrian distractions and raising awareness of safe crossing practices. By integrating behavioral insights with infrastructure improvements, urban planners and policymakers can create safer, more pedestrian-friendly environments, ultimately fostering a culture of compliance and reducing accident risks at signalized crosswalks.

Future research should explore the effectiveness of specific interventions, such as real-time enforcement measures and intelligent traffic management systems, in improving pedestrian safety. Additionally, potential limitations of the current research should be acknowledged, including sample size constraints and the geographical focus on a single urban area and cross walk. Addressing these limitations in future studies could enhance the generalizability and reliability of the findings. Additionally, expanding the study to other urban areas with different traffic conditions and demographic profiles would

provide a broader understanding of pedestrian behavior and risk factors, facilitating the development of comprehensive safety strategies. However, these limitations may not fully represent broader pedestrian behaviors and safety concerns in other regions.

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