An-Najah National University

Faculty of Graduate Studies

SAFETY ANALYSIS OF MICRO-MOBILITY: THE CASE OF NABLUS CITY

By

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This Thesis is Submitted in Partial Fulfillment of the Requirements for the Degree of Master of Roads & Transports Engineering, Faculty of Graduate Studies, An-Najah National University, Nablus - Palestine.

2024

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Dedication

To the souls of the martyrs who have sacrificed their lives for our freedom, to the souls of my grandfather and grandmother who had planted in me the meaning of giving and devotion, to my parents and family who have been my source of inspiration, support, and distinction. To my wife, my companion and my life partner, my inspiration for all my successes. To my dear friends ... my brothers who were created by days and situations.

Acknowledgements

I extend my sincere thanks and great gratitude to everyone who contributed to enriching my thesis, led by Professor Sameer Abu-Eisheh, who was with me throughout the period of my work on my thesis, starting from the main idea until completion of the thesis.

I also extend my sincere thanks to my colleagues throughout my studies, led by my colleague and wife Shefaa, who was and continues to be my source of inspiration to accomplish a lot.

It is my pleasure to thank the Palestinian Police, especially Nablus Traffic Police Department, for all required information and data they provided regarding traffic crashes, in addition to the people who cooperated with me, who are micromobility users in Nablus City, in filling out the questionnaire which was part of my thesis.

Finally, I would like to thank the people who were interviewed, who are representatives of the relevant institutions and who cooperated with me in giving me information related to the topic of the thesis.

I reiterate my thanks to my parents and family who have been following up with me and are a source of support and strength.

Declaration

I, the undersigned, declare that I submitted the thesis entitled:

SAFETY ANALYSIS OF MICRO-MOBILITY: THE CASE OF NABLUS CITY

I declare that the work provided in this thesis, unless otherwise referenced, is the researcher's own work, and has not been submitted elsewhere for any other degree or qualification.

Student's Name: Osaid Majed Hamdan Salman

Signature:

Date: 28. 02. 2024

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Abstract

Background: With the increasing prevalence of micromobility vehicles recently, and the increase in the number of micromobility crashes, along with the absence of a suitable governance and regulatory framework for the use of this new mode of transportation in Palestine, it is crucial to study and analyze traffic safety for micromobility users.

Aims: The main objectives of the study include generating micromobility crash profile and understanding the patterns and causes behind the occurrences of such crashes. Moreover, the study seeks to investigate the micromobility users' behavior. Finally, the study aims to provide recommendations and proposed countermeasures that improve safety for micromobility users.

Methodology: Micromobility crashes data were collected from the Nablus Traffic Police Department for the study period of (2018 to 2022). Based on crash characteristics, analysis was conducted to understand the spatial and temporal aspects. A questionnaire was designed and distributed to a sample of micromobility users and then analyzed to understand the level of awareness concerning traffic safety among a segment of the users of this mode in Nablus City. The behavior of micromobility users was also observed using two cameras installed at a representative intersection. Moreover, analysis of variance using SPSS software was conducted to check if there were significant differences concerning specific characteristics of micromobility users' behavior. Finally, recommendations were provided, including proposing countermeasures to improve safety related to the use of this mode.

Main results: The study investigation of the 138 recorded micromobility crashes in Nablus City during the study period (2018 to 2022) showed that the most frequent crashes occurred in the summer season, in September, on Mondays, and during 17:30 to 18:30. The casualties resulting from micromobility crashes are the highest for the age group of 12 to 18 years. Driving in the opposite direction was the highest reason causing crashes and formed 20.3% of total. Three fatal crashes occurred in Nablus Governorate, but outside Nablus City. The behavior of micromobility users observed and analysis during the three-day period showed that the number of violators reached 392 with a percentage of 74.4%.

Conclusions of the study: A high rate of increase of micromobility crashes is observed, which has reached an average rate of 37% annually in Nablus City during the study period. The major causes of these crashes, as concluded from the traffic police records, are attributed to the wrong behavior of the uses of these vehicles. This was confirmed by the high percentage of micromobility users' violators, as observed during a three-day period at a representative hazardous intersection. No implemented regulations that control the ownership or operation of micromobility vehicles are observed, nor proper enforcement that target the users of these vehicles who commit violations is noticed.

Keywords: Micromobility safety; crash profile; spatial analysis of crashes; micromobility users' behavior; Nablus; Palestine.

Chapter One

Introduction

1.1 Background

Many cities around the world are experiencing traffic congestion, which is motivating them to adopt more sustainable and environmentally friendly transportation systems. One solution that has emerged in recent years is the introduction of micromobility modes, which include e-bikes, e-scooters, e-skateboards, segways, hoverboards, in addition to bike sharing systems. Micromobility is defined by the International Transport Forum (ITF) as the use of vehicles with a mass of no more than 350 kg (771 lb) and a design speed not higher than 45 km/h (micro-vehicles). This definition restricts the vehicle's kinetic energy to 27 kJ, which is a hundred times less than a compact car's highest speed kinetic energy [1].

In urban areas, are starting to accept the micromobility mode as one of the commonly used modes. Portability, ease of use, and cost are among advantages of using such modes. As these small vehicles are so new, current roads infrastructure, as well as traffic regulations, do not yet fully support the operational or legal requirements for these modes. Moreover, these modes pose social and functional concerns [2].

On the other hand, e-scooters have the potential to replace active modes like cycling and walking, which could have a significant effect on the environment and public health. Two major environmental challenges are the extended lifespan of free float e-scooters and the end-of-life of these vehicles, particularly their electric batteries. The sharing of public spaces is another growing issue. The latter relates to sidewalks and road surface that are utilized for e-scooter circulation and parking [3]. Additionally, e-scooters obstructing pedestrian pathways and sidewalks when parked illegally, coupled with safety concerns among pedestrians feeling insecure in the presence of active e-scooters, thus, affect on the level of services of pedestrian facilities [4].

Due to the lack of a suitable governance and regulatory framework, micromobility as a mode of transportation is critical in developing countries, at specific, as noticed in the Palestinian urban areas, where a sharp increase in the use of micromobility is observed over the past couple of years [5]. The difficult task facing a developing country planners and policymakers with regard to micromobility modes is to regulate and implement measures to facilitate the use of these devices on roads on one hand, and to control their movement and ensure the related traffic safety aspects at the other [1].

In order to make regulations of micro vehicles with various characteristics easier, ITF proposes four classifications of micro vehicles depending on their top speed and mass. The report of ITF titled "Safe Micromobility" includes more information on this definition as well as on all sorts of micro-vehicles and their classification [6].

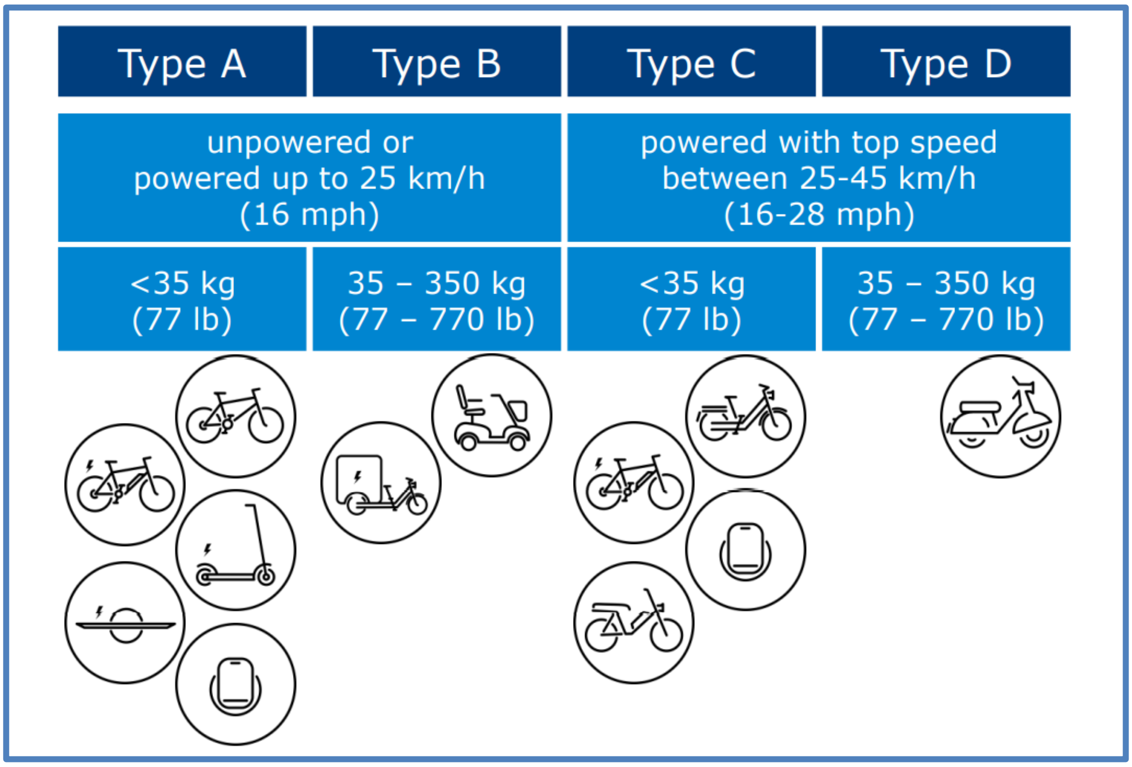
The classification of micro-vehicles according to ITF, illustrated in Figure 1.1, is as follows:

- Micro-vehicles can be classified primarily according to their maximum speed (Figure 1.1). Type A and Type B micro-vehicles include human-powered vehicles such as bicycles as well as vehicles whose power supply cuts off at 25 km/h. Many bicycles, e-bikes, e-scooters, and self-balancing vehicles would fall into this category. The threshold of 25 km/h is known to separate the main categories of e-bikes in Europe. Up to 25 km/h, e-bikes are generally considered and regulated as bicycles. When their design speed is beyond 25 km/h and up to 45 km/h (Type C and Type D), e-bikes are often excluded from bike lanes and subject to further safety regulation.

- Micro-vehicles can be further classified by weight, with a threshold of 35 kg beyond which regulators could impose more safety requirements (Figure 1.1). Vehicle weight does affect kinetic energy and braking systems. Weight can also be seen as a proxy for the capacity to transport additional passengers and goods [2].

Figure 1.1

The Micromobility Definition and Classification According ITF



Reference: (ITF, 2020)

According to the National Association of City Transportation Officials (NACTO), about 136 million trips were generated by shared micro-mobility in the U.S. in 2019, which was 60% up compared with 2018 [7]. Micromobility devices can be well integrated into the overall urban design process of smart and sustainable transportation in the near future [8].

Micromobility devices have been shown to improve the overall sustainability goal in many urban areas around the world with various benefits. The light weight and small size of those devices provide options for short distances as well as "last mile" travels. Micro-mobility devices are popular among riders because they are convenient and efficient; some users of these devices express that they can "ride at a higher speed with less effort," in hilly areas. People also use those devices for recreation and exercise purposes and feel relaxed and have fun while riding.

The spread of micromobility sharing programs reduces the cost of short-distance travel and makes them a cost-effective mode of transportation. Micromobility is also beneficial from a business point of view because the design and development cost of micromobility devices is considerably lower compared to cars [8].

In Palestine, a noticeable increase in the use of micromobility vehicles has been observed recently, especially over the past two years, and as a result the number of micromobility crashes has increased significantly. However, in order to include micromobility safety in Palestine, it is important to study and investigate the challenges related to micromobility, and to address the safety concerns that enhance micromobility safety. Therefore, there is a need to study the control aspects of the roads in terms of safety, assess the extent of their effect on the safety of micromobility, study the micromobility user’s behavior, and assess the regulations and guidelines that ensure the micromobility user's safety.

1.2 Significance of Study

Due to the lack of regulations and studies of micromobility as a new transportation mode spreading in Palestinian urban areas, as well as the noticed increasing number of crashes related to micromobility in the recent years [5], it is important to study the safety, user behavior, and regulatory governance to control the use of these devices.

The use of micromobility is on the rise in Palestine, as can be seen in most the Palestinian urban areas. This mode is becoming more attractive and is rapidly spreading, especially for the youth and those who work for delivery.

The growth in car ownership and in the demand for transportation, as well as the resulting traffic congestion, has raised the need for compact, flexible, and more sustainable alternatives of transportation. Recent developments in the micromobility industry show that these devices might contribute to reduce travel time and provide faster access than other vehicles, especially in congested areas [8]. The number of licensed vehicles per class is increasing rapidly annually [9]. Mobility using micromobility modes could contribute to creating additional conflicts in traffic movement; increasing the number and severity of crashes between them. This highlights the increasing need for a regulatory framework for micromobility. It is to be indicated that there are no published statistics on the number of micromobility modes in Palestine.

In the Palestinian Traffic Law No. 5 of 2000, there is no clear definition for all types of vehicles that are classified as micromobility vehicles yet, and there are no approved provisions regulating the movement of this type of vehicle.

The analysis of micromobility crashes can be challenging because of the lack of regulations on one hand, and studies that were conducted in Palestine on traffic safety aspects of micromobility. The study was motivated by the increase in the number of micromobility crashes (especially e-bike crashes) in the recent years as noticed in Palestine.

1.3 Objectives of Study

The objectives of the research include the following:

1) Generate micromobility crash profiles after collecting micromobility crashes data especially in Nablus City.
2) Understand the pattern, causes, and outcome of micromobility related traffic crashes.
3) Identify locations with high frequency of micromobility involved crashes during the analysis period in Nablus City.
4) Investigate and understand the users' behavior of various aspects of micromobility and their compliance with traffic safety at the selected intersection in Nablus City.
5) Provide recommendations, policies, and propose countermeasures that may decrease the number and severity of micromobility mode crashes and regulate the use of this mode.

1.4 Study Area

Nablus City is selected as a case study in order to conduct a study on micromobility safety. Relevant data on detailed traffic crashes are available from Traffic Police records, which can be supplemented by other data on the behavior of micromobility users. Nablus City is one of the most populous Palestinian cities. Nablus City is considered as the center of the northern West Bank, with an estimated population of approximately 174,387 in mid-year 2023 according to PCBS statistics [10].

In Nablus City, there is considerable increase in the number of vehicles annually, which further exacerbates traffic congestion, and therefore causes delays in trips. This has motivated the increasing need to use new transportation modes to avoid the traffic congestion. In addition to facilitate access to the city center, one of the options that has been observed, is related to the use of micromobility mode which might provide a solution to the delay and traffic congestion challenges.

1.5 Methodology of Study

1.5.1 Introduction

The methodology used to investigate micromobility safety is presented in this section. It includes collecting data, conducting interviews, questionnaire design and distribution, generation of crash profiles, and conducting spatial and statistical analysis of crashes. The methodology includes benefiting from the outcome of the study to propose countermeasures that could enhance micromobility safety.

The methodological approach followed in this study is presented hereafter.

1.5.2 Literature Review

Desk study and internet search were carried out by reviewing previous publications, studies, and literature on the subject of micromobility in both developed and developing countries.

1.5.3 Study area

As mentioned before, Nablus City was selected as the study area; it is one of the largest Palestinian cities in which the movement of micromobility vehicles is active, and it is considered the center of the northern West Bank

1.5.4 Data Collection

Data were collected mainly through three ways. The first was the collection of micromobility crash data in Nablus City from Nablus Traffic Police Department for the five-year study period (2018-2022). Secondly, data were also obtained by installing monitoring cameras at one of the hazardous intersections in order to observe the behavior of the micromobility users. In addition, data collection involved gathering the feedback of a specially designed questionnaires from a sample of micromobility users in Nablus City.

The detailed crash data obtained from Nablus Traffic Police Department would help to analyze the micromobility safety aspects in the study area. These data include the location of each crash, time, year, month, day, hour, type of injury, the severity, and the reason for the crash.

The collected data about micromobility users' behavior at the selected intersection using monitoring cameras, installed especially for the purpose of the study. The study period of investigating the behavior of micromobility users was selected to cover three consecutive days (Friday, Saturday, and Sunday).

Regarding Friday, it was chosen as it is a weekend day and therefore traffic volume is usually light, and therefore the behavior of micromobility users was observed in low traffic volume conditions. In Saturday, the commercial activity and food delivery are relatively more active than on other days of the week, and therefore, the behavior of micromobility users was monitored in a high traffic volume condition. Sunday was also selected to represent a normal weekday, micromobility users' behavior was studied on this day when institutions and business activities are in operation.

During the micromobility users' behavior study period, for every micromobility vehicle that crossed the intersection, several aspects were observed. General aspects were observed and recorded including hour, day, wearing helmet or not, presence of rear passenger, and the direction of micromobility. In terms of behavioral aspects, violations of micromobility were recorded, including red light crossing, wrong/illegal overtaking, driving in the opposite direction, and making a wrong U-turn.

Data were gathered from micromobility users through a questionnaire that was distributed to a randomly selected sample. It addressed several issues to identify the level of awareness of traffic safety in the city of Nablus, in addition to the traffic challenges they face. The questionnaire included several questions such as gender, age, educational level, trip purpose, and trip route. Other specific questions include the number of crashes the micromobility driver was involved in during the past year and the severity of crashes (if any), the frequency of using a micromobility vehicle, weather conditions to use a micromobility, safety equipment or tools used by micromobility users while driving, adherence to traffic laws while driving, the family ownership of a private vehicle of the household, violations committed by micromobility users, and motives and reasons for using micromobility vehicles if the family owns a private vehicle.

1.5.5 Interviews

This section explains the interviews conducted with representatives of institutions and ministries related to safety aspects for micromobility in order to understand the reality of micromobility mode, especially the safety aspects, the laws and regulations governing this mode of transportations, and the difficulties the micromobility users face, in addition to any recommendations that would contribute to improving traffic safety for users.

These included the Ministry of Transportation (MOT) representative, Head of the Traffic Engineering and Safety Sector who was interviewed to understand what the role of MOT regarding micromobility as a new transportation mode, as well as the policies, strategies and regulations in dealing with this new mode of transportation, specifically in light of the recent occurrence of micromobility crashes. The Palestinian National Institute of Public Health (PNIPH) representative was interviewed via a phone call to determine whether injuries in micromobility crashes are being dealt with, and to learn about the available indicators that help to improve traffic safety for micromobility users.

A Global United Insurance representative was interviewed to know about the mechanism of dealing with micromobility crashes in the absence of insurance for them, and the followed procedures from a legal standpoint and compensation on the one hand, and from a therapeutic standpoint on the other hand.

A representative of Nablus Traffic Police Department was interviewed in order to know their opinion on the micromobility user's behavior, what kind of violations that the micromobility users do more often, and fines imposed on the traffic law violators.

Finally, the owner of Jamil Amer Shop, who sells and repairs electric bicycles and scooters, was interviewed to understand the types of electric bikes and scooters, speed range for each type, and what faults they fix most frequently?

1.5.6 Analysis

This section includes conducting analyses of the collected data that were obtained from Nablus Traffic Police Department, in addition to the data was extracted from a gathered questionnaire, and from the cameras were installed at the selected intersection. This involved developing the study and investigating the profile of micromobility crashes in Nablus City based on the number of micromobility crashes, the casualties, and the reasons of crashes. Temporal analysis of crash data was conducted to examine the time or day, day of week, and month of year, as well as annual analysis for the five-year period as indicated.

Spatial analysis was conducted using GIS to highlight the hazardous locations based on zonal distribution of micromobility crashes. This contributes to selecting the location in order to study and observe the behavior of micromobility users using the monitoring cameras at that location.

Analysis on collected data from the monitoring cameras was conducted to investigate the distribution of micromobility for each day. Moreover, this was used to figure out what violations that micromobility users do when crossing the intersection. ANOVA test was used to determine if there were significant differences between different violations done by micromobility users with the time of micromobility user's violations between days or within the same day.

1.5.7 Identification of Countermeasures and Recommendations

Based on the results of the analysis and what was included through the analysis of micromobility crash data, as well as the behaviors of micromobility users through the surveillance cameras and the questionnaires outcome, identifications of countermeasures, and recommendations will be proposed to the relevant institutions that might improve the reality of traffic safety for micromobility users.

1.6 Thesis Structures

This thesis is composed of four chapters. Chapter One includes the background, overview of micromobility safety, significance of study, objectives of study, the study area, and the methodology followed. Chapter Two presents a review of similar studies in developed and developing countries related to micromobility safety, including their involvement in crashes, the outcome of crashes, and the behavior of micromobility users prior to crash. Chapter Three explores data collection from Nablus Traffic Police Department and that extracted from the monitoring cameras installed at the selected intersection, in addition to the data gathered from a questionnaire. In additions, this chapter presents the outcome of the analysis of the collected data. Finally, Chapter Four summarizes the conclusions of the thesis, and presents recommendations to improve micromobility safety.

Chapter Two

Literature Review

2.1 Chapter Overview

This chapter presents a review of some previous studies and research conducted about regulations, safety, and policies for micromobility in developed and developing countries. It is to be stated that there are no studies that have been found dealing with the subject in Palestine. Only one study is found dealing with motorcycles safety in Palestine, which was conducted by Abdul Hadi in 2023 on Nablus City [11]. However, it is to be noted that motorcycles are not classified as micromobility vehicles in many countries around the world.

According World Health Organization (WHO) report, approximately 30% of fatalities resulting from road crashes involve powered two- and three-wheeled vehicles, including motorcycles, mopeds, scooters, and electric bikes (e-bikes), and the numbers are rising [12].

2.2 Studies in Developed Countries

In the USA, a number of studies for micromobility safety were published. One of these addressed the primary concern related to using micromobility on the road, where riders travel near moving motor vehicles, meaning relatively unprotected Personal Micromobility Devices (PMD) riders' risk significant injuries in the event of a collision. A database tracking e-scooter-related fatalities is kept up to date by the Collaborative Sciences Center for Road Safety (CSCRS), a US DOT National University Transportation Center. Of the 90 reported e-scooter rider fatalities as of December 2021, 64 happened on roadways, and 57 of those 64 fatalities involved automobiles. Perhaps unsurprisingly, e-scooter riders generally appear to prefer riding in locations not shared by motor vehicles, such as sidewalks and bike lanes. The same is likely true for riders of other PMDs as well [13].

The US National Electronic Injury Surveillance System (NEISS) was employed to collect data on transportation-related injuries, covering electric bikes, electric scooters, and pedal bicycles from 2000 to 2017 [11]. Specific product codes were used to categorize various vehicles, excluding injuries from unpowered skateboards, standup scooters, personal transporters, motorbikes, mopeds, electric bicycles, and other powered vehicles with three or more wheels. The study revealed a total of 130,797 injuries related to powered scooters (5.3 per 10,000 emergency department injuries), and 3,075 e-bike injuries (0.13 per 10,000). The age distribution indicated a mean age of 29.4 years for powered scooters, 31.9 years for e-bikes, and 25.2 years for bicycles. Gender distribution showed 60.0% male for powered scooters, 83.3% male for e-bikes (significantly more than powered scooters), and 72.4% male for pedal bicycles. Pediatric injuries were notable in the 10–14 age group for powered scooters. Statistically significant gender differences were observed between e-bike and powered scooter injuries [14]. These findings offer valuable insights into injury patterns and demographics, emphasizing distinctions in age, gender, and injury rates among the studied transportation modes.

A retrospective cross-sectional study was conducted from January 2009 to December 2019 to quantify injuries associated with electric scooters, specifically focusing on head and neck injuries [15]. The study analyzed 2,823 cases of electric scooter-related injuries in patients presenting to US emergency departments. Patient data were collected from the National Electronic Injury Surveillance System (NEISS) database, which follows standardized data collection procedures among participating institutions. The data were stratified by department size and ordered geographically, enabling the calculation of national weighted estimates. Importantly, all data were re-identified and publicly available, exempting the study from institutional review board approval. The research aimed to enhance the understanding of safety aspects related to e-scooter use, contributing valuable insights for promoting safe usage practices.

The study analyzed electric scooter injuries, estimated at a total of 103,943 cases during the ten-year study period. Incidence rates increased, reaching 8.63 cases per 100,000 person-years in 2019. Head and neck injuries comprised 28.5% of total cases, with a shift in the most affected age group from ≤17 years before 2018 to 18- to 44-year-olds in 2018–2019. Notably, head and neck injuries decreased from 2009 to 2017, but rose significantly post-2017 by 1.22 cases per 100,000 person-years. The study highlights evolving trends in electric scooter-related injuries, emphasizing increased incidence rates and changing age distributions for specific injury types.

According NEISS database, about of 70,719 patients between 2014 and 2020 were injured after usage of e-scooters, bicycles, or all-terrain vehicles [16].

In 2018, the city of Austin, Texas, finished a three-month dockless electric scooter-related injuries research, which noticed that for every 100,000 scooter trips made during the study period, 20 people were injured. A severe injury affected around half of the injured people, with fractures accounting for 84% of those injuries [8]. The e-scooter-related injury crashes were examined using data for the period from September to November, 2018 from Austin-Travis County Emergency Medical Services (ATCEMS) incident reports and Emergency Department (ED) syndromic surveillance chief complaint data from nine local hospitals. The classification system for scooter injury crashes included confirmed cases (injury related to a rentable dockless electric scooter), probable cases (injury related to an electric scooter, unspecified as rentable or dockless), suspect cases (insufficient information to determine scooter rental status), and not a case (injury unrelated to rentable dockless electric scooters or occurring outside the study period or City of Austin).

The study conducted descriptive statistics on potential e-scooter-related injuries in Austin, Texas, from geocoded crash locations, focusing on confirmed and probable cases according to the National Transportation Safety Board's (NTSB) definition of severe injury. Severe injury criteria included hospitalization for more than 48 hours, certain types of fractures, severe hemorrhages, nerve/muscle/tendon damage, involvement of internal organs, and specific burns. A total of 271 individuals with potential e-scooter-related injuries were identified, with outcomes classified into confirmed (160), probable (32), and suspect (46), while the rest (32) are not considered as injury cases. Of the 271 injured riders, 48% had head injuries, 70% sustained upper limb injuries, 55% lower limb injuries, and 18% chest/abdominal injuries. Common injury locations included arms (43%), knees (42%), face (40%), and hands (37%). The study provides valuable insights into the demographics, types of injuries, and factors associated with e-scooter crashes, emphasizing the prevalence of head and upper limb injuries.

In Canada, a variety of micromobility devices have emerged on Canadian roads in the past decade. Observed PMDs mainly include segways, e-bikes, and e-skateboards or hoverboards. The most recognizable form of micromobility available in many jurisdictions across Canada, however, is the e-scooter, which has become a regular sight on roads and sidewalks in the past few years. Although e-scooters, like bicycles, can be purchased and owned by individuals, the sudden ubiquity of e-scooters in some cities is generally attributed to the commencement of dockless e-scooter rideshare services operated by private companies. These services, which distribute and maintain large fleets of e-scooters in the cities where they are permitted to operate, generally began operating in 2017. Prior to the COVID-19 pandemic, the global market for e-scooters would be worth approximately 40 to 50 billion dollars by the year 2025 according to a study carried out by the Boston Consulting Group [17].

Many Canadian communities have permitted the use of these services through pilot projects designed to collect data for use in transportation and infrastructure development, in compliance with the rules. More residents of some cities now rather frequently use e-scooters. By 2019, it was anticipated that 10% of Calgary City residents would have used a dockless e-scooter sharing service [18].

The Road Safety Monitor, an annual survey by the Traffic Injury Research Foundation, assesses Canadians' knowledge, attitudes, and behaviors regarding road safety. In the 2021 survey, questions focused on regulations violations, technological distractions, and unsafe behaviors related to Personal Mobility Devices (PMDs). This included actions like performing stunts on public roads, disobeying traffic signs, riding on sidewalks, using headphones or cell phones while traveling, weaving through traffic, riding at night without visibility measures, and riding without a helmet. The survey highlighted varying local laws regarding PMD usage, such as restrictions on sidewalks, which can lead to rule violations. Studies reveal widespread ignorance or lack of awareness of these laws among e-scooter users [18].

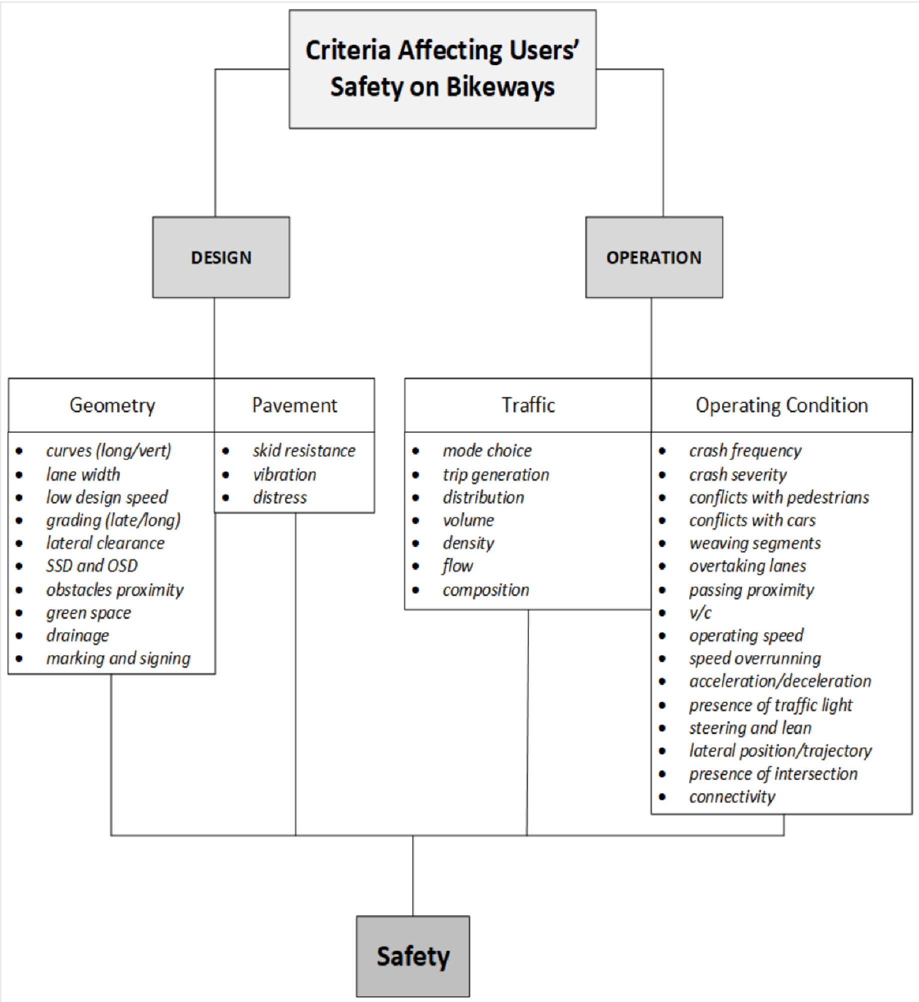
Major cities in Europe have seen a significant increase in micromobility infrastructure, including cycling infrastructure, with 42 European Metropolitan cities implementing about 1422 km of cycling infrastructure in a year. However, the design principles for bikeways primarily rely on conventional road design for bicycles and lack consistency in accommodating emerging powered micromobility devices like e-scooters [19].

To explore safe bikeway infrastructure design and to enhance micromobility safety, the study identified three overlooked topics (marking and signing, grading, and mode choice) and nine understudied areas (vibration, distress, skidding, alignment features, clearance, lateral control, connectivity, traffic composition, and intersection presence) that significantly impact micromobility safety. The study highlighted the criteria that affect micromobility safety. Micromobility safety provided valuable insights into the impact of infrastructure design, pavement conditions, traffic patterns, and operating conditions on user safety. These findings can help to inform on the development of safer micromobility networks and improve the design and maintenance of infrastructure to ensure the well-being of micromobility users. However, there is a need for more comprehensive and reliable crash data to further enhance our understanding of micromobility safety and develop effective safety measures.

Assuming the homogeneity of fundamental aspects of infrastructures, the criteria affecting users' safety on bikeways were adapted from AASHTO Green Book 2011. Figure 2.1 shows the classification of criteria affecting safe infrastructure for bikeways, which enhance micromobility users' safety [20].

Figure 2.1

The Classification of Criteria Affecting Safe Infrastructure for Bikeways



Source: Sabbaghian H, Castelló D, García A, 2023

According the guide of Personal Electric Vehicle (PEV) and electric bike laws in Europe, legislation within the EU are fairly uniform in handling PEV within most countries in Europe. The EU directive 2002/24/EC exempts certain bicycle/electric bike models from type approval [20]. This is provided they are equipped with pedal assistance and an auxiliary electric motor, maintaining a continuous rated power of 0.25 kW/250W. This output is to progressively decline and eventually cut off once the vehicle reaches 25 km/h, or if the cyclist stops pedaling.

In Belgium, PEV law and technical regulations passed during 2016–2017 allow the public to ride three types of e-bikes of varying power:

- 250-watt models: e-bikes limited to 25 km/h, suitable for all ages with no helmet requirement.
- 1000-watt models: limited to 25 km/h but now classified as "motorized bikes,", rider age of 16 required alongside a conformity certificate. This e-bike, like the 250W models, does not require a helmet to ride legally.
- 4000-watt models: now classified as "speed pedelecs (pedal electric cycle)" are powerful models classified as mopeds, requiring riders to abide by moped regulations.

E-bikes are promoted as a sustainable mobility solution for older adults (≥65 years). In Flanders, Belgium, a survey of 357 older e-bike users in 2018 found that the key benefit was the ability to cover longer distances (35.0%). Men often cited battery issues without perceiving any significant drawback, while women more frequently expressed fear of falling or injuries. E-bikes served various purposes, with men using them for solo recreation and women for social reasons. Approximately 27.5% reported experiencing an e-bike crash, often attributed to uneven or slippery surfaces (26.5%) [21].

In Flanders in 2021, there were 533 police-registered e-scooter-related injury crashes, more than double the previous year's 206. To address the increasing injuries and prevent e-scooters from dominating public spaces, new rules classify them as essentially motorized vehicles. These regulations largely prohibit anyone under 16 from using e-scooters, enforce restrictions on pavement use, and disallow a second passenger, aiming to reduce both the frequency and severity of e-scooter crashes [22].

In Germany, small electric vehicles like hoverboards, unicycles, e-scooters, and e-bikes are allowed on public roads under certain regulations. As of June 15th, 2019, electric scooters and other personal and small electric vehicles (PEVs and SEVs) are legal, but riders and vehicles must adhere to specific rules. These include a weight limit of 55 kg, a handlebar in the design, two functioning brakes, speeds ranging from 6 to 20 km/h, and required features like front lighting, side reflectors, and a bell or warning signal. Despite the legality, the number of injuries from e-scooter crashes in Berlin significantly increased in 2021, with 572 injuries recorded in the first 11 months compared to 235 in 2020 [23].

In Denmark, it was found that as e-bikes become more widespread. The number of crashes in which they are involved was also growing. A survey of 685 e-bike users examined the factors, which contribute to perceived e-bike safety and involvement in safety critical incidents. Using regression analysis, it was demonstrated that riding style and e-bike attitude played a crucial role in both perceived safety and involvement in safety critical incidents. The most frequent explanation offered for these situations was that other road users had underestimated the speed of the e-bike, followed by rider problems regulating e-bike speed. Proposed preventive measures involve awareness campaigns, improving e-bike visibility, and emphasizing the importance of familiarization with e-bikes before navigating challenging traffic situations [24].

The Israeli Government's Ministry of Transportation announced in 2019 the launch of a new category of driver's license: a license for electric bicycles. The move was part of a broader plan to address the growing problem of young people using electric bicycles as their primary mode of transportation. This new mode of transportation has become a traffic nuisance and the cause of an increasing number of crashes in the main urban centers.

The new driving license category A3 has been valid since January 2019 for electric bike riders only. Unlike other license categories that can only be granted at the age of 17, the new license for electric bike users has been available since the age of 15.5. The written exam for the new license had been made available at specified driving test centers in the country. It consists of 30 questions about traffic laws, bicycle safety, and pedestrian rights [25].

New rules for electric bikes impose heavier fines on offenders. Everyone who rides a bike without a helmet has to pay a fine of 1,000 NIS. These measures were put in place after a teen was killed by a drunk driver in Yafa while riding his e-bike, an incident that drew attention to growing safety concerns about electric bikes [25].

On July 14, 2014, the Knesset approved more regulations that define the rules for the use of electric bicycles. These regulations entered into force on September 1, 2014. On May 1, 2016, new regulations began to be implemented that set the age for riding electric bicycles to at least 16 years instead of 14 [26].

The regulations include the following:

- An electric bike can only be ridden by people ages 16 and over.
- Until the age of 18, a helmet must be worn in all cases.
- Riding is only permitted on bike paths. If there is no dedicated bike path, ride on the road with caution and in compliance with traffic laws.
- In any case, riding on the sidewalk is prohibited.
- Electric bikes are bikes with a motor with a maximum power of 250 watts, so that the motor stops working when the bike's speed exceeds 25 km/hr, according to European standards.
- The e-bike must be equipped with safety accessories that include a horn or bell, a front light with white light, a rear light with red light, a light reflector on the back, and a yellow light reflector on the pedals.
- The e-bike must bear an official marking with the words "assisted bike".

From 2016 to 2021, approximately 12 deaths were recorded as a result of injuries to children while riding bicycles and electric bikes in Israel. Nine of them were children who rode electric bikes; two were other micromobility vehicles; and one was a boy riding a bicycle. The category of boys came from the 15-year old, which ranked first, as their share was 7 victims. Btarim Children's Safety Foundation confirmed that among the causes of crashes such as those that happen to electric bicycle riders is the lack of experience, skill, and appropriate training for driving them, in addition to the dangers of excessive speed when driving, which is practiced by some boys and endangers their lives [27].

The statistics for the year 2016 from the "Gartner" Institute indicated that 549 electrical bike users were injured in the years 2015–2016 in electric bicycle crashes in Israel, and that the majority of injuries were fractures in the limbs and then serious head injuries. The statistics also indicate that most of the patients who underwent treatment in hospitals did not adhere to putting a protective helmet on their heads as stipulated by law. The percentage of injured people from the Arab community was less compared to the injured from the Jewish community, and that 10% of the injured Jews put the helmet on while only 4% of Arabs put a protective helmet on their heads [28].

2.3 Studies in Developing Countries

In China, the number of e-bikes on China's road increased from a few in 1998 to 300 million in 2023 compared with 160 million in 2012. These ecofriendly vehicles, which also reduce traffic congestion and protect the environment, have caused a significant rise in traffic crashes and injuries. The use of e-bikes is rising quickly in China and so the frequency of e-bike-related traffic crashes. The number of nonfatal injuries from e-bikes exceeded those from bicycles [29].

Road traffic crashes are related to risky cycling behaviors, and e-bike riders who practice unsafe behaviors are more likely to be involved in road traffic crashes. According to studies on the effects of aggressive driving, the rate of fatalities among aggressive drivers was about 10%, compared to the rate of fatalities among nonaggressive drivers, which was about 4%. About 90% of fatal crashes in China's three-year report (2010–2012) on traffic crash data were attributed to dangerous riding behaviors. Speeding was linked to serious injuries among e-bike riders. One dangerous riding behavior that usually leads to crashes involving e-bikes is riding in the lanes for motor vehicles. According to a survey of 31,000 crashes from 2008 to 2014, over 60% of crashes were on urban roads, and about 40% occurred in motor vehicle lanes [30].

A Chinese observational study of 451 two-wheeled vehicles indicated that e-bike riders crossed red lights more frequently (62%) than non-powered bicycle riders (50%) did. In a similar vein, comparison research conducted found that the most dangerous behaviors of e-bike riders were violating traffic laws and running red lights. E-bike crashes in China have created a significant hardship and caused significant social suffering, most prior research on the risk factors for e-bike-related traffic crashes has a descriptive methodology, while analytical studies are uncommon [30].

The study identified residents in China who chose e-bikes for transportation and experienced traffic crashes in the past year as cases, matching them with controls who had not been in a crash. The data collected from July to September 2015 revealed risk factors for e-bike-related traffic crashes. Running red lights, riding while drinking, carrying adults, turning without signaling, riding in the motor vehicle lane, prior crash history, and using a scooter-style e-bike were identified as potential risk factors. The findings emphasize the need for increased behavioral intervention and education to decrease risky riding behaviors and reduce e-bike-related traffic crashes [30].

In another study that aimed to describe the riding behaviors of e-bike riders in China, it was found that 26.6% of the 18150 E-bike riders observed violated traffic laws, including running red lights, riding in the opposite direction and riding in motor vehicle lanes [31].

In Ghana, a study explored the potential use of electric mopeds (e-mopeds) and electric cargo bikes (e-cargo bikes) in Ghana, focusing on the transition process and social acceptance [32]. The findings suggest that light electric vehicles could provide a sustainable mobility solution for both urban and rural transport needs in Ghana. The investigation influences decisions on adapting existing e-vehicles to local transportation needs, market entry strategies to enhance social acceptance, and the design of sharing systems for mass usage at reduced costs. The study employs a technique categorizing acceptance subjects as either opponent of the sharing system or potential users, defining the e-vehicle sharing system as the object, and considering contextual factors such as societal and cultural tendencies. The aim is to understand Ghanaians' overall perceptions of mobility and electric mobility devices, examining specific social groupings and demographics to inform broader acceptance studies.

The study investigated the factors influencing the use of conventional motorbikes in different regions and demographic groups in Ghana to understand potential variables affecting the adoption of micromobility vehicles and sharing systems like e-mopeds and e-cargo bikes. The primary focus was on potential users, serving as the foundation for micromobility development in Ghana.

A survey with 1,604 participants, primarily focusing on potential users, was conducted to assess acceptance of certain subjects in Ghana. Gender distribution showed 24% female, 75% male, and 1% choosing not to answer. Out of 1,590 participants indicating age and area of residence. Nearly half (46.6%) of the 1,128 participants expressing their views indicated that owning a motorbike brings a sense of pride. Analyzing the age distribution, a subtle trend emerged, suggesting that younger age groups tend to derive a higher sense of pride from owning a motorbike than older age groups. Furthermore, when considering geographic location, the study found that a sense of pride and ownership was notably higher in rural settings, including the countryside and small towns, compared to urban settings and college campuses. The results indicate that acceptability is predominantly influenced by factors such as safety and acquisition costs.

In the United Arab Emirates (UAE), Executive Council Resolution No. 13 of 2022 regulated the use of bicycles in the Emirate of Dubai. The resolutions definitions include:

- Electric bicycle: A vehicle with two or more wheels, equipped with an electric motor, that is powered by the electric motor or by the cyclist's propulsion.
- Electric Scooter: A vehicle with two or more wheels, equipped with an electric motor, propelled by the power of the motor or by the power of the cyclist, driven in a standing manner, and without a seat.
- Route: The route is determined by the authority on the road for bicycles, according to the nature of the road, its uses, and the type of bicycle.

In 2021, two deaths were recorded, and 19 riders were injured in e-scooter crashes in UAE, while in 2022, two deaths were recorded, and 10 injuries, noting that the majority of crashes were collisions with vehicles [33].

In the UAE, a person under 16 years will be subject to a traffic violation if rides an e-bike, e-scooter, or any other type of bicycle specified by the authority, or if they drive an electric scooter without obtaining a driving permit. According article no. 5, the technical requirements that must be met by the bike. In addition to the technical standards approved by the competent federal authorities, the bicycle, when driving it on the path or areas specified by the authority, must meet specific technical requirements, including those related to lamps, handlebar, brakes, etc. According article no. 6, the cyclist's obligations were specified to include observing traffic legislation, riding the bicycle in lanes specified by the authority, obtaining a driving permit, etc. [33].

In Vietnam, the use of e-bikes has been significantly increasing recently. There were around 5 million e-bikes and e-scooters used in 2019; more recently, the number of e-bikes sold in Vietnam has increased at a rapid annual growth rate. E-bikes has apparently become an important transport means in the country. Unlike other countries where e-bikes are often used by people of all ages, to date, the usage of e-bikes in Vietnam has been limited to mainly students, especially high-school students.

A study was conducted at several high schools in Hanoi City, Hung Yen province and Vinh Phuc province from December 2020 to January 2021 to investigate the elements that affect attitudes toward traffic safety and dangerous driving behaviors by using structural equation modeling. It found that 52% of high school students in the city, chose an e-bike as their primary mode of transportation for daily trips [34]. The study's sample of 594 high school students who ride e-bikes was able to demonstrate a significant correlation between traffic safety attitudes and behaviors as well as a significant impact of traffic risk perception and safety knowledge on those attitudes. The respondents consisted of 40.6% males ($n = 241$) and 59.4% females ($n = 353$), with ages ranging from 15 to 19 years.

The study identified significant associations between attitudes toward traffic safety and risky behaviors among e-bike riders. Positive attitudes were linked to fewer risky driving behaviors ($\beta = 0.24$, $p < .01$). Traffic risk perception strongly influenced safety attitudes ($\beta = -0.45$, $p < .001$), with higher perceived risks correlating with safer attitudes. Better safety knowledge was also related to safer attitudes ($\beta = -0.07$, $p < .05$). Descriptive norm was a significant factor in risky driving behaviors ($\beta = -0.11$, $p < .05$), indicating that those perceiving widespread violations of traffic rules were more likely to engage in risky behaviors. Perceived family commitments to traffic safety and perceived privilege of high school e-bike riders were significant variables for both safety attitudes ($\beta = -0.16$, $p < .05$ and $\beta = 0.31$, $p < .001$, respectively) and risky behaviors ($\beta = -0.17$, $p < .01$ and $\beta = 0.14$, $p < .05$, respectively). Higher family commitment and lower perceived privilege correlated with safer behaviors. Gender, riding experience, and daily riding time were also associated with attitudes and behaviors, with females and less experienced riders demonstrating safer tendencies. The model explained 34% of the variance in risky behaviors and 46% in traffic safety attitudes.

The study found that higher levels of perceived family commitment to traffic safety or lower levels of perceived privilege of e-bike riders who are high school students were significantly associated with both safer traffic safety attitudes and less risky behavior [34].

In India, two-wheelers make up more than 79% of all vehicles on Indian roads. The authorities found that the e-bike needs to be given more attention due to the increase in the penetration of electric vehicles [35]. In the context of Indian cities aiming to reduce carbon emissions in transportation, electric two-wheelers (E2W) hold potential. To position E2Ws as an appealing alternative to traditional two-wheelers, understanding the decision-making process of prospective users is crucial.

A study conducted in 2022 proposed a comprehensive methodology to assess the decision preferences of potential users toward electric two-wheelers and associated attributes in the Indian setting [36]. Therefore, the study focused on attributes like Operating Cost (OC) savings, top speed, range, charging duration, acceleration, and purchase cost. A Stated Preference (SP) survey was designed and conducted among potential E2W users in Hyderabad, India.

The study involved the development of multinomial logit (MNL) and random parameter logit (RPL) models, through which the willingness-to-pay (WTP) for each identified attribute was determined. Furthermore, the impact of socio-economic characteristics on the decision-making process of potential users was examined.

The findings indicated that the top speed had the greatest impact on an individual's choice, followed by acceleration and charging duration. Additionally, factors such as age, income, and journey time significantly influenced how individuals perceived electric two-wheelers (E2W) and their associated attributes in the Indian context.

2.4 Summary

Review of literature, whether in developed or developing countries, shows that there is a continuous increase in the use of micromobility mode around the world. It shows that the probability of micromobility crashes increases and there would be increases in the number of injuries. This leads to highlighting the importance of having policies as well as regulations that control the process of using this mode of transportation in order to achieve safety for its users. In addition, there is need for proper infrastructure design guidelines including pavement conditions, traffic patterns, and operating conditions on user safety to address the safety concerns as well as the geometric street elements that are needed to support this mode of transportation.

In numerous cities in developed countries, such as major cities in Europe, there have been a significant increase in micromobility infrastructure, including cycling infrastructure. This may assist in reducing traffic density, and thus reducing traffic congestion and achieving sustainability, especially in urban areas.

As for developing countries, a number of these countries had prepared regulations and laws that regulate the use of micromobility vehicles, such as the UAE. Needs were defined for further design of the infrastructure to accommodate this mode of transportation and make it more effective and safer for its users.

There are no studies on micromobility in Palestine. No regulations and laws have been issued regulating the use of micromobility vehicles, despite the increasing use of these vehicles and the occurrence of many crashes which caused some deaths. It is important to study micromobility safety, user behavior, and regulatory governance to control the use of micromobility as a new transportation mode and to ensure the related safety aspects, especially on the light of the lack or absence of strict regulatory governance for these devices.

Chapter Three

Data Collection and Analysis

3.1 Chapter Overview

In this chapter, interviews outcome, questionnaire outputs, as well as data collection and analysis outcome are presented. Micromobility crash data were collected from Nablus Traffic Police Department to develop micromobility crash profiles. Data were also obtained after gathering the questionnaire from micromobility users to study the behavior and violations for questionnaire respondents on one hand, and to understand the level of awareness of traffic safety among a segment of drivers of micromobility vehicles in the city of Nablus, in addition to understanding the traffic challenges they face on the other hand. Field observations data were also collected to detect the behavior of micromobility users at one of the hazardous locations in the city using cameras, and to assess their adherence to traffic regulations. Interviews were also conducted to gain insight related to micromobility in Palestine.

Relevant statistical tools and tests were applied on the collected data. Descriptive statistics were conducted by SPSS, as well as testing hypotheses using ANOVA test to examine if there are any statistical differences in the behavior of the micromobility users' violations.

3.2 Interviews

The following is a summary of the results of the interviews with several agencies on the reality of micromobility transportation mode in Nablus City. More on the specific names of the interviewees and their institutions, as well as the dates of the interviews is found in Table A1 in Appendix A.

- **Ministry of Transportation (MOT)**

  According to the MOT representative, the ministry did not specify whether the micromobility was classified as a vehicle or not, and there are no studies or statistics about the numbers of micromobility crashes, not even in the mechanism of importing micromobility vehicles.

  According to Item No. 5 in the Palestinian Traffic Law issued in 2000, the bicycle had been mentioned, but other micromobility vehicles such as electric bikes, scooters, and so on, were not addressed. Bicycles are supposed by the Traffic Law (Item No. 5) to be registered with the local authorities and take a number, but the local authorities did not play this role at all.

The draft traffic law (currently under the approved process) did not give clear definition for micromobility vehicles nor any regulations related to its use, noting that there is a definition of a bicycle and a motorized bicycle.

As for the number of micromobility vehicles, it is difficult to determine or even to estimate, as it cannot be counted, since there is no registration for it by any agency or authority, in addition to the presence of a large number of used vehicles, which are brought from Israel.

The MOT did not study the possibility of issuing a driver's license for users of micromobility vehicles, since this type appeared to be used recently, but the interviewed official indicated that the World Bank was recently requested to assist in regulating the use of micromobility as a new mode of transportation in Palestine.

Recently, the formation of the Road Traffic Safety Committee by the Palestinian Council of Ministers was assigned the task to manage traffic safety and as a coordinating body between the relevant authorities after the dissolution of the Supreme Traffic Council. The committee started work from the beginning of September 2023. It includes Ministry of Transportation, Traffic Police, Ministry of Local Government, Ministry of Public Works and Housing, Ministry of Finance (to raise funds for traffic safety) and the Civil Affairs Authority (as the authority coordinates with Israeli occupation authorities, in light of the existence of many linking roads on which the occupation authorities impose their powers). It is to be stated that the Ministry of Health requested to be a member of this committee, but this has not been approved yet.

The MOT recommended the following:

- Demanding the issuance of an executive regulation organizing the use of micromobility vehicle.
- Local authorities should start registering micromobility vehicles and issue licenses for each vehicle.

– **Nablus Traffic Police Department**

According to what the traffic officer explained, a bicycle is considered as a vehicle according to the Palestinian Traffic Law Item No. 5 in 2000, and the definition of a vehicle; every instrument or facility of transportation or traction prepared for walking or pulling on wheels or chains and driven by mechanical or physical force.

The interviewed officer indicated that over the past two years, it has been observed that the use and spread of electric bicycles and electric scooters has been increasing in Nablus City, and that the number of electric bicycle and electric scooters crashes have increased. As a result of this increase, the Traffic Police Department recommended that the micromobility vehicle should have a license issued by local authorities provided that the driver is 18 years or older with vehicle insurance to maintain the safety of micromobility users and the pedestrians.

According to the experience of the traffic police officer, the most frequent violations committed by drivers of micromobility vehicles were as follows:

- Driving in the opposite direction.
- Not driving in the right lane.
- Improperly changing lane.
- Non-compliance with traffic signals and traffic laws.
- Failure to take safety measures for citizens.

The traffic police officer clarified that a fine could be issued to the user of the micromobility if he/she was caught violating one of the laws, since from a legal point of view, it is permissible to violate the road passer if he/she commits a traffic violation such as crossing a red light at an intersection. However, he indicated that no such fines are have been issued.

In the event of a crash between a private or commercial vehicle, or any other type of vehicles, with the micromobility vehicle, and in the event that the responsibility lies on micromobility vehicle’s driver, he/she will be criminally prosecuted by the police if the driver is 18 years or older. However, if the driver is less than 18 years old, he/she is transferred to the Family Protection Department in the police, then he/she is transferred to the Family Protection Prosecution, and he/she is also subject to a criminal trial.

At the end of the interview, the traffic officer recommended the following:

- Demand the enactment of a law that obliges drivers of micromobility vehicles, particularly electric bicycles, bicycles, and electric scooters, to obtain a driver's license, provided that the driver's age is 18 years or older.
- Seize each micromobility vehicle that violates traffic laws, and harsher fines for traffic offenders.
- Design lanes and paths for micromobility vehicles to reduce the conflict points with other vehicles.
- Conform the micromobility to international technical specifications to ensure the safety of their users.

– **Palestinian National Institute of Public Health (PNIPH)**

PNIPH is a governmental institute affiliated to the Council of Ministers. According to the interview via phone call with the Director of PNIPH, he said that the institute is supposed to be fed with data by the partners, namely the Ministry of Health and the Traffic Police Department, and accordingly, the PNIPH comes up with indicators. However, as a result of not obtaining any data related to micromobility crashes or users' injuries, there are no indicators related to this.

– **Insurance Agencies**

The Director of the Global United Insurance (GUI) - Bidya Branch was interviewed, who explained that there is no insurance for micromobility vehicles until now despite the spread of this mode of transportation and it has been subjected to many traffic crashes recently.

Regarding the mechanism for dealing with micromobility crashes, in the event of a crash between a micromobility vehicle and another vehicle, and based on the traffic police report in the event that the responsibility lies on micromobility vehicle user, and in case of a therapeutic case, the micromobility user is covered by the other vehicle insurance. In case of damage to the other vehicle, it is the right of the other vehicle owner to claim compensation from the micromobility user. The Director of GUI recommended that there should be a law regulating the use of micromobility vehicles to increase traffic safety for their users.

– **Stores for selling and maintaining micromobility vehicles**

During an interview with the owner of a shop selling and maintaining electric bicycles and electric scooters in Nablus, he estimated that the number of micromobility vehicles is in the range of 1000 to 1500 in Nablus City.

From the year 2018, Jamil Amer Store started dealing with the purchase of electric bikes and electric scooters in Nablus City. The store owner indicated that micromobility became significantly increasing at the beginning of the year 2021, knowing that there are new imported electric bicycles and electric scooters, all are obtained from Israel.

The most common of electric bikes are those falling under (class-20 electric bikes). There are three types of those as follows:

- A wide wheel
- Medium wheel.
- Thin wheel.

Each of these types has four categories based on power voltage: 36 volts, 48 volts, 60 volts, and 72 volts. The most common is the 48 volts. As for scooters, they are of two types, short size and long size. Each of these types has three categories; 36 volts, 48 volts, and 60 volts. The most common is also the 48 volts.

Regarding speed, the shop owner explained that the speed of the electric bike ranges from 25 to 110 km/h, but for electric scooter ranges from 25 to 60 km/h depending on the power category and the class of the micromobility vehicle. Moreover, he indicated that most of the sales are for work and delivery purposes, and for daily needs (shopping). Maintenance performed on micromobility vehicles (e-bikes and e-scooters) is mainly repairing the electric panels, which are the result of excessive use, either as a heavy weight or a road with steep road for a long distance or tire failure.

3.3 Questionnaire

3.3.1 Questionnaire Overview

A questionnaire was designed and used to obtain information from the micromobility users in Nablus City during eight days within four periods, starting from 23/09/2023 and ending on 4/10/2023. These days covered most days of the week from Saturday to Thursday.

The total number of licensed vehicles in Nablus Governorate in 2022 was 52,675 [9]. The estimated mid-year population of Nablus Governorate in 2022 is 423,572, including 171,150 in Nablus City (i.e., the ratio of the city's population to the governorate's population is approximately 40.4%) [10]. Therefore, it can be estimated that the number of licensed vehicles in Nablus City is similarly 40.4% of what was registered in the governorate as a whole, resulting at about 21,280 vehicles.

To determine the target sample size (n), this study used the Cochran's formula [37] as shown below:

$$\text{Target sample size} = \frac{\frac{Z^2 \times p \times (1-p)}{E^2}}{1+\frac{Z^2 \times p \times (1-p)}{E^2 \times N}} \qquad (1)$$

where E is the margin of error chosen as 4%, the reliability level selected at 95%, and therefore Z-score corresponding to the desired confidence level = 1.96.

Assuming that the number of micromobility vehicles is 1,500, then the total estimated number of vehicles in Nablus City, after adding the assumed number of micromobility vehicles becomes 22,780, hence p equals 0.07.

With the population size (N) considered as 22,780 vehicles, and all the other parameters as stated before, the target sample size is then calculated using Eq. (1) to be 155. The total number of gathered questionnaire responses was 158 micromobility users, which is higher than the calculated target sample size of 155.

The questionnaire was designed to address several questions, including general questions related to user's social characteristics (gender, age, educational level), and trip-specific information (trip purpose, and trip route, etc.). This in addition to questions related to the behaviors of micromobility users, the violations they commit, and the motivations for using micromobility vehicles in order to study and understand the level of awareness of traffic safety among a segment of users of micromobility vehicles in the city of Nablus, and to understand the traffic issues they face. The questionnaire is directed to people who use micromobility vehicles whether as a mode of transportation for shopping, work, sports and leisure, delivery purposes, or for any other trips in a way. The questionnaire form is shown in Appendix B.

3.3.2 Questionnaire analysis

In this subsection, the gathered questionnaire data from the users of micromobility within study area are presented and then analyzed based on user characteristics. It is to be observed through questionnaires collected within the study period, as previously indicated, that all users of micromobility vehicles were 100% male, and this may be due to the nature of the prevailing culture and social aspects in Palestine. The distribution of the total number of respondents by age groups is shown in Figure C.1 in Appendix C. The distribution of the total number of respondents by educational level is shown in Figure C.2 in Appendix C.

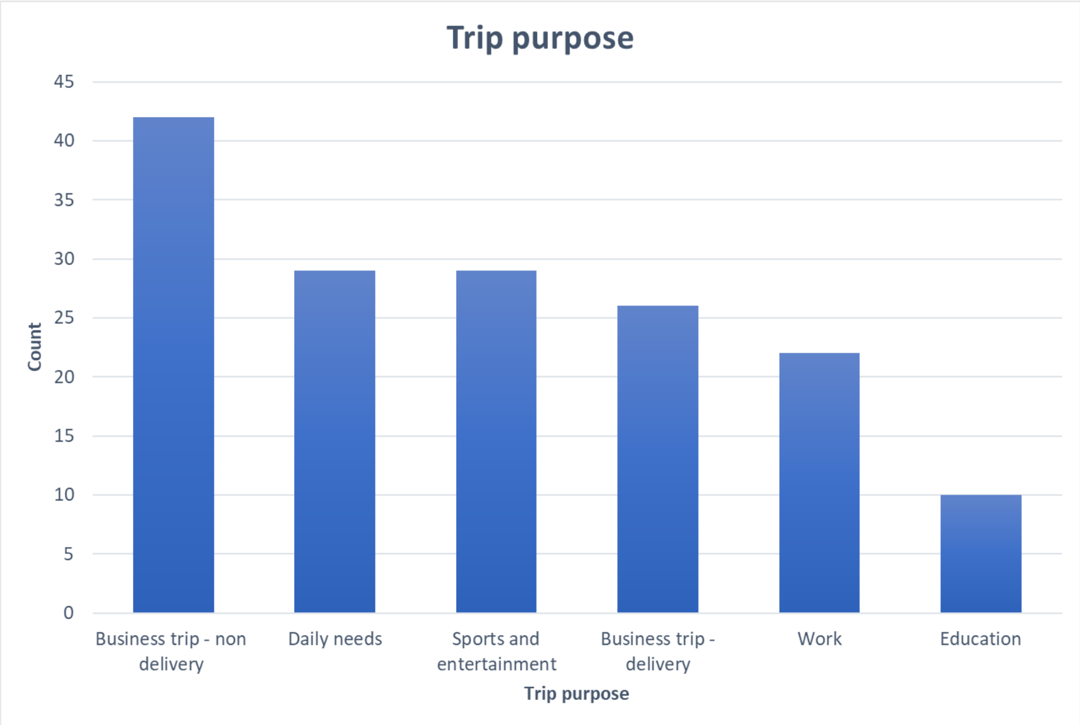
From Figure C.1 in Appendix C, it can be noted that the micromobility users were aged from 6 to 56 years, where the age group from 12 to 18 years is the most frequent, forming 45.6% of total. This may be attributed to this category's uses of micromobility for multiple purposes such as sports, entertainment, daily needs, and/or education.

From the perspective of micromobility users, as noted in the questionnaire, to move from an origin to a destination, the respondent had assessed travel time for three different alternative modes of transportation; private car or taxi, walking, and micromobility vehicle in a case of traffic congestion within study area. The questionnaire showed that using a private vehicle or taxi instead of walking saves a travel time. However, the questionnaire showed that regarding the use of micromobility as an alternative to private car or taxi, about 30% of users said that the travel time increases compared to private car or taxi. About 28% of users explained that the travel time for both modes (private car or taxi and micromobility) are the same without any significant difference, while by about 42% indicated that using a micromobility vehicle reduces the travel time.

The distribution of the total number of respondents by trip purpose is shown in Figure 3.1. The distribution of the origin-destination activity by the respondents is shown in Figure C.3 in Appendix C.

Figure 3.1

Distribution of Total Number of Respondents to the Questionnaire in Nablus City by Trip Purpose



It can be noted that the highest trips are business trips-non delivery, followed by daily needs (shopping), and sports and entertainment. This can be explained by the main function of using this mode of transportation as it is easy to access the city center, especially in the case of traffic congestion thus encouraging its use for such purposes. As a result, the most frequent trip routes were the work-to-work activity and business-delivery to business-delivery activity, as shown in Figure C.3 in Appendix C.

The questionnaire addressed the frequency of use of a micromobility (daily, weekly, or monthly), the time period, in addition to the weather conditions that the users can drive a micromobility. Figure C.4 in Appendix C illustrates the frequency of use of these vehicles.

From Figure C.4 in Appendix C, it can be noted that the micromobility riders use them daily with 83.5%, while 15.2% use them weekly. The number of times a micromobility rider uses the micromobility daily once or twice formed 36.7% from all respondents, noting that those who used micromobility more than twice daily use it for business (delivery or non-delivery) purposes such as the riders use them fifteen times daily for delivery purposes. As for users on a weekly basis, whether once or several times, most of those who use micromobility weekly were for daily needs purposes. Moreover, as Figures C.5 and C.6 show, micromobility drivers user it during morning and afternoon periods with a percentage of 47.5% from all respondents, while there is a percentage of 17.7% who use it at all times as shown in Figure C.5, and this is specifically used for business purposes.

The distribution of micromobility users related to weather conditions is shown in Figure C.6 in Appendix C. It can be shown that 43.7% of micromobility users drive in hot, moderate, and lightly rainy weather. The related trips are believed to be associated with work trips and business (delivery and non-delivery) purposes.

After that, the questionnaire addressed the use of safety equipment or tools used while driving, as shown in Figure C.7 in Appendix C. Analysis shows that 85% of micromobility users do not use any safety tools, 7% use driving glasses, and only 2% wear helmets.

As for the self-reported violations, according to the questionnaire, the more frequent violation was “not wearing a helmet” with a count of 118 (74.7%). The distribution of self-reported violations by micromobility users' is shown in Figure C.8 in Appendix C.

In terms of the self-reported crashes the micromobility driver was involved in during the past year, as shown in Figure C.9 in Appendix C, most of users have not been involved in any crashes and 19.6% of users were involved in one crash only with slight injuries.

Finally, the questionnaire showed that the motives and reasons for using micromobility vehicles (as shown in Figure C.10 in Appendix C), if the family owns a private vehicle, was to avoid traffic congestion, with a percent of 30.8%, accessibility (especially to city center) with a percent of 22.1%, and for sports and entertainment with a percent of 19.0%. Other motives, including reducing travel time or the nature of the work, formed 28.1% of total.

3.4 Micromobility Crash Profile

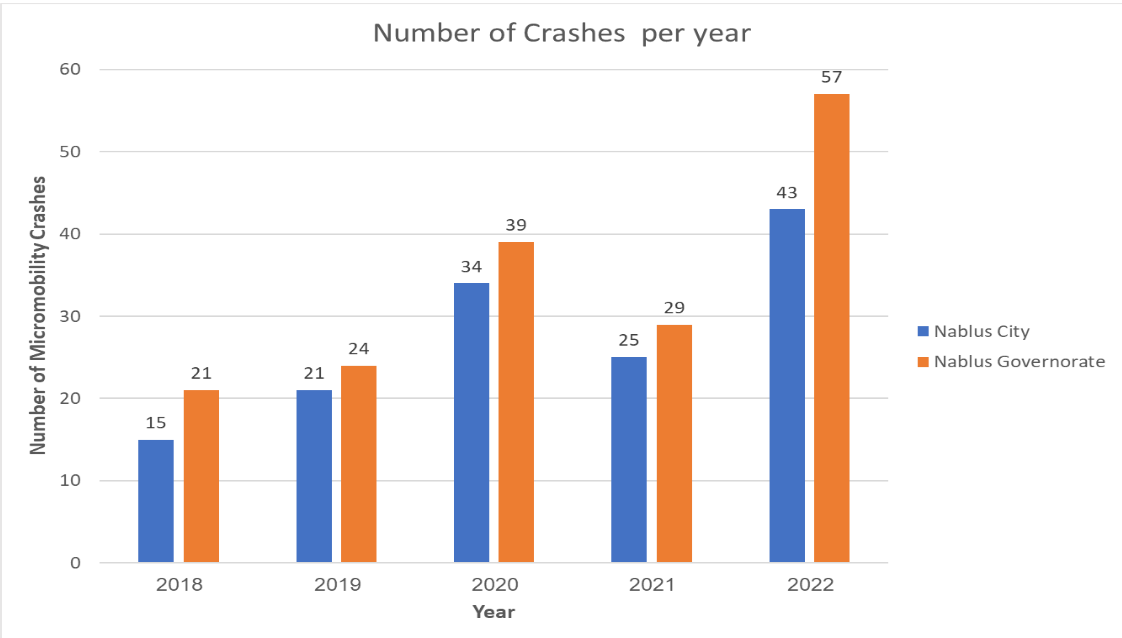
The number of casualties in road traffic crashes is increasing annually as noticed in PCBS published statistics. However, it is also to be indicated that there are no published statistics by PCBS on the crashes in which the micromobility mode is involved. Therefore, data were collected from Nablus Traffic Police Department and analyzed as presented hereafter.

This section presents the collected data related to micromobility crashes and the analysis process temporally and spatially based on the characteristics of the involved users and crashes specifics (including gender, age of driver, location of crash, time of crash, day, month, year, reason of crash, degree of injury, and vehicle crash involvement).

The total number of recorded micromobility crashes was 170 in Nablus Governorate, and 138 of them were in Nablus City during the study period (2018 to 2022) [38-42]. The annual distribution of micromobility crashes in the governorate and the city is shown in Figure 3.2, while the distribution of total crashes by type of micromobility vehicles is shown in Figure D.6 in Appendix D. On the other hand, the distribution of the total number of casualties by age groups is shown in Figure D.1 in Appendix D.

Figure 3.2

Distribution of Total Micromobility Crashes in Nablus City and Nablus Governorate by Year During the Study Period (2018 – 2022)



From Figure 3.2, it can be noted that most of the registered micromobility crashes occurred within Nablus City, with a percentage 81.2% of total.

The number of micromobility crashes in Nablus City is increasing annually. The average annual rate of increase in the number of crashes for this mode during the five-year study period was 37%. This confirms the increase in the use of this mode of transportation in Nablus City. The number of crashes in the year 2021 dropped by 26% compared to that in the year 2020, despite the limited movement of vehicles in the year 2020 as a result of the COVID-19 pandemic. According to Nablus Traffic Police Department, this may be due to the relatively increasing use of micromobility during the COVID-19 pandemic as a result of restrictions on the movement of any vehicle except in emergency cases, which forced many people to use micromobility as a mode of transportation, which showed an increase in the number of crashes involving micromobility.

It is to be noted that it was not possible to represent crashes in terms of rates per 100 or 1000 micromobility vehicles, due to the lack of statistics on the number of micromobility vehicles for each year during the study period (2018-2022) .

The highest number of crashes per type of micromobility vehicle in Nablus City was the e-bikes crashes with a percentage 57.2%, followed by bicycles forming 39.9% of the total micromobility crashes during the study period as shown in Figure 3.2b.

However, the casualties resulting from micromobility crashes in Nablus City were the highest for the age group (12 to 18 year), forming 31.9% of total, which are more used for these small devices. This explains why young people are the most at risk of crashes as a result of carelessness and high speed, and this is consistent with the questionnaire gathered from micromobility users, which showed that the persons within age group (12 to 18 year) were the most using micromobility.

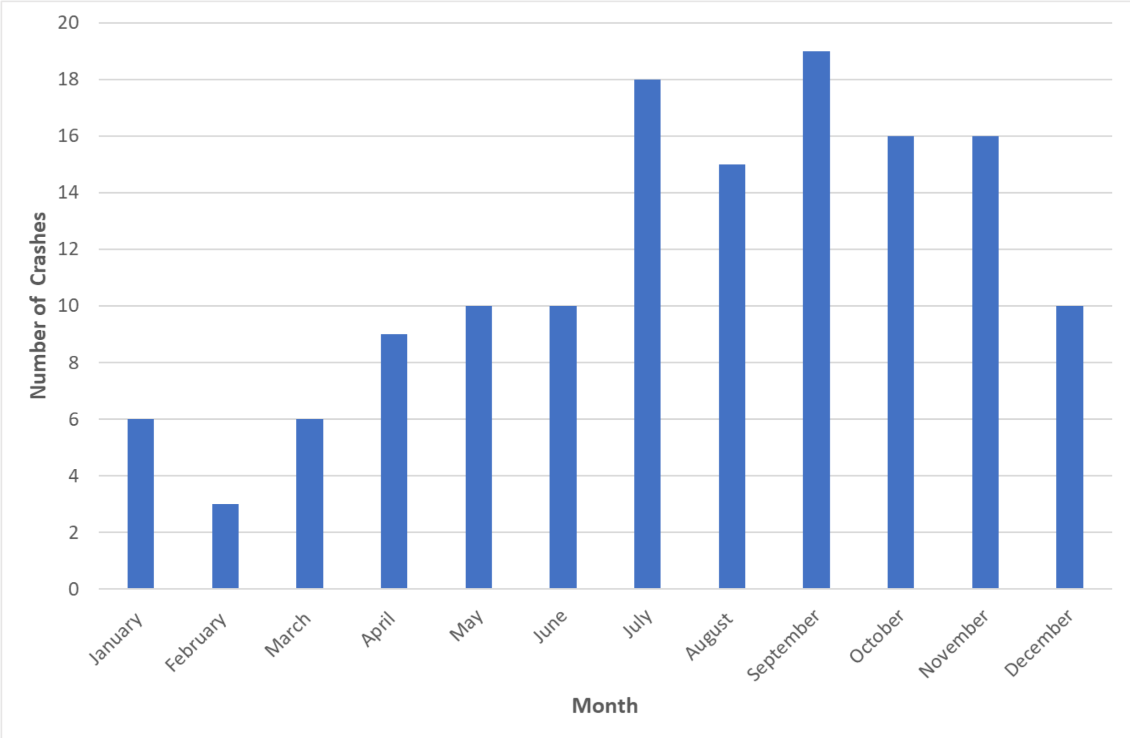
The quarterly distribution of the micromobility crashes is shown in Figure D.2 in Appendix D. It can be seen that the quarterly distribution of crashes during the study period showed the highest frequency of crashes are in the third quarter of the year, the summer season, which can be explained by the active movement of micromobility in the summer as a result of school holidays.

The summer season shows higher numbers of crashes followed by autumn, then spring and finally winter seasons for the whole study period, as shown in Figure D.2 in Appendix D. This might be attributed to the relatively favorable weather and the increasing use of micromobility during this season, especially for fun by the youth.

The monthly distribution of the micromobility crashes is shown in Figure 3.3. From the figure, the summer months from July to September have the highest number of crashes with 52 crashes, where the peak is in September with 19 crashes.

Figure 3.3

Distribution of Total Micromobility Crashes in Nablus City by Month of the Year During the Study Period (2018 –2022)



As for the daily distribution of crashes, as shown in Figure D.7 in Appendix D, Monday is the day with the highest number of crashes and this may be random as it is a working day, and vehicle movement is supposed to be active as the same for the other days of week, whether micromobility vehicles or other vehicles. This is consistent with the data extracted from questionnaires, which showed that the highest percentage of use of micromobility is for business-non delivery trips. Friday witnessed the second highest number of crashes after Monday, with slight difference, which can be interpreted as being a weekend, and thus there is active use of micromobility for sports and entertainment by young riders, in addition to use for food delivery purposes.

The hourly distribution of the micromobility crashes is shown in Figure D.8 in Appendix D. The distribution of the total micromobility crashes by the period of occurrence (morning, afternoon, and evening) within the day is shown in Figure D.3 in Appendix D.

Late afternoon has the highest number of micromobility crashes, where a peak in noticed from 17:30 to 18:30 with a value of 17 crashes, followed by a peak in the morning from 9:30 to 10:30 with a value of 10 crashes. Both peaks occur just after the common morning and afternoon peak hours, which can be explained by the frequent delivery trips made by micromobility vehicles for mainly the purpose of delivery of food, which is consistent with the habits related to eating times. The distribution of crashes for each of the morning, afternoon and evening periods, as shown in Figure D.3 in Appendix D, which also shows that the afternoon period has the highest percentage of crashes for this mode, where this is due to its use for delivery purposes as well.

The distribution of the micromobility crashes by reason of crash is shown in Figure B4 in Appendix B. It can be noted that “driving in the opposite direction” is the highest cause forming 20.3% from total, followed by “improperly changing lane” with a percentage 17.4%. “Not securing the turning left” formed 8.0%, while “failure to take safety measures for citizens” and “not giving priority” come next with a percentage 6.5% for each. Therefore, these five reasons for crashes formed approximately 58.7% of the total number of micromobility crashes during the study period.

The distribution of the micromobility crashes by type of vehicle involved in the crash is shown in Figure D.5 in Appendix D. When a crash occurs between a micromobility vehicle and any other vehicle, private vehicles formed 85.5%, followed by shared-taxis with a percentage 8.0%, then followed by motorcycles and trucks with a percentage of 2.9% each, while vans have a percentage 0.7%.

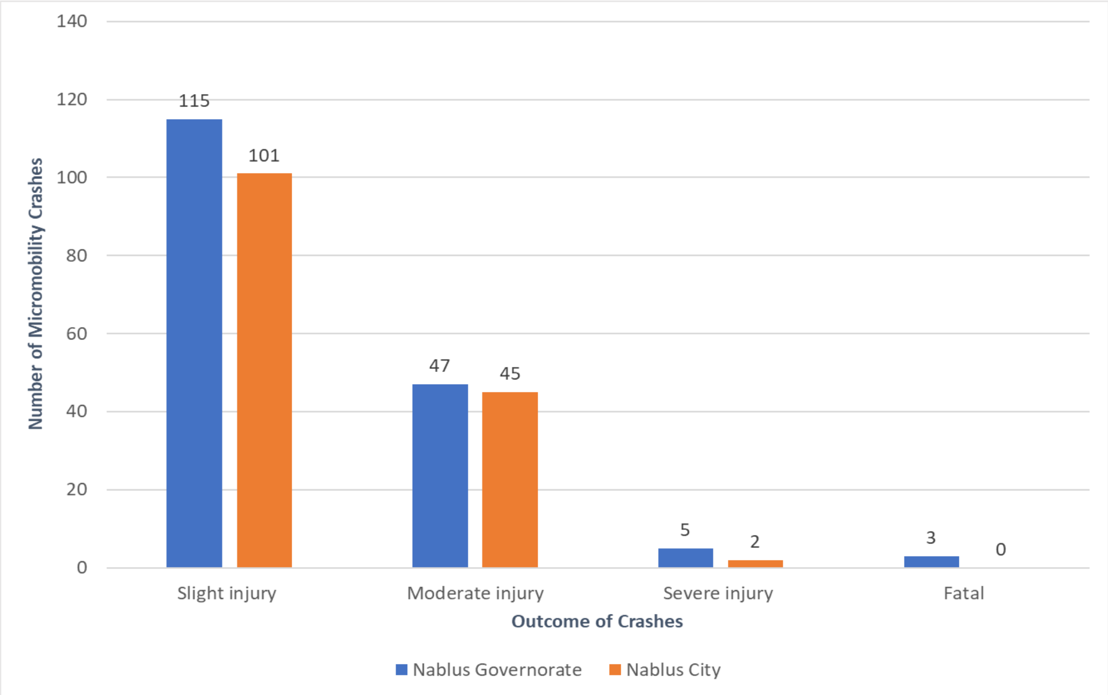
The distribution of total micromobility crashes by severity of injury in Nablus City is shown in Figure 3.4. The number of injuries resulting from micromobility crashes in Nablus Governorate was 170 injuries, including 148 injuries. In Nablus Governorate, and during the five-year study period, 67.7% of micromobility crashes injuries were classified as slight injuries, 27.7% as moderate injuries, 3.0% as severe injuries, and 1.8% were fatalities. As for Nablus City, and during the same study period, 68.24% of micromobility crashes injuries were classified as slight injuries, 30.41% as moderate injuries, and 1.35%

as severe injuries, without fatalities within study area, as shown in Figure 3.4.

These results can be explained that most of the injuries resulting from micromobility crashes within the city were slight to moderate, with a very small percentage of severe injuries and no fatalities. This is due to the relatively low speed within the city and the presence of traffic congestion that limits speed, especially within the city center or around it. As for fatal micromobility crashes, the Traffic Police Department recorded three fatal micromobility crashes in Nablus Governorate outside Nablus City during the study period. This was due to driving at speeds not suitable with road conditions, in addition to failure to take safety measures for citizens [35-39].

Figure 3.4

Distribution of Total Micromobility Crashes by Severity in Nablus City by Type of Injury During the Study Period (2018 –2022)



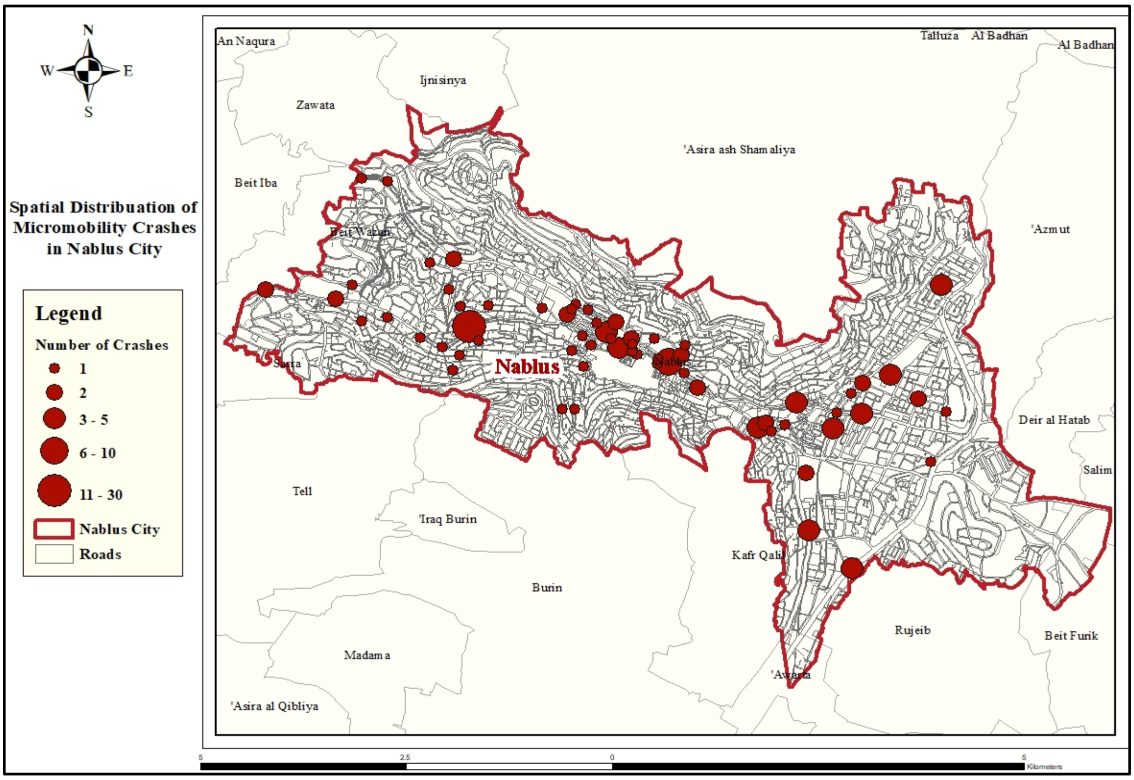
It is to be noted that property damage was not recorded in Traffic Police Department records. This is due to the fact that the physical damage that a micromobility vehicle may cause is negligible when it does not constitute any injury to the micromobility vehicle driver.

3.5 Spatial Distribution of Micromobility Crashes

Crash locations as collected from the crash data obtained from Traffic Police were marked on a map, as illustrated in Figure 3.5, which shows the spatial distribution of all the micromobility crashes in the city. Such information are then used for spatial analysis. The figure shows that the center of the city, in addition to Rafidia and Balata areas, have the highest number of micromobility crashes.

Figure 3.5

Spatial Distribution of Total Micromobility Crashes in Nablus City During the Study Period (2018–2022)



3.5.1 Zonal Distribution of Micromobility Crashes

Figure D.9 in Appendix D presents the zonal distribution of total micromobility crashes, which shows that Zone 9 (Rafidia) to have the highest number of crashes (33), followed by Zone 2 and Zone 38 (CBD) and Balata neighborhood, with a number of 11 crashes for each. These high rates in these areas may be due to the large number of vehicles, including micromobility vehicles, being the most active areas in the city. In the area with the highest rate, Rafidia, the presence of a number of intersections in the area generates conflict points, including with micromobility vehicles, thus increases the probability of the occurrence of crashes. This in addition to the nature of Rafidia that generates higher use of micromobility usage for several purposes, especially for delivery purposes due to the spread of the restaurants there.

3.5.2 Distribution of Micromobility Crashes per km^2

Based on area analysis (i.e., crashes per km^2), it can be noted that Rafidia has a relatively high number of crashes, as shown in Figure D.10 in Appendix D. Zone 9 (Rafidia) has the highest rate of 62 crashes per km^2 (Zone 9 area is about 0.531 km^2 (noting it had the highest number of micromobility crashes within the zone of 33), followed by Zone 2 (Al-Horiah neighborhood and Zone 5 (the CBD), with a rate of 45 and 44 crashes per km^2, respectively.

It is to be noted that the exact location of some crashes was not recorded by the Traffic Police except as a general location such as indicating the location to be Rafidia area without mentioning the exact location.

There were only 35 crashes out of the total of 138, with a percentage 25.4%, with precise locations. Moreover, crash locations were reported considering street names for 73 of the crashes with a percentage 52.9% from the total. It is noted that 30 micromobility crashes, forming 21.7% from the total, occurred in Rafidia area. Therefore, this area, with its main street, is considered to have the most hazardous street. This is due to the active movement on Rafidia Street, and the presence of many shops, restaurants, and institutions on this street.

3.6 Behavior Observation Micromobility Users and Analysis

To study the behavior of micromobility users, a representative intersection was selected (Al-Badawi intersection) at the middle of Rafidia area to observe the behavior micromobility users during a three-day study period, from Friday 29/7/2022 to Sunday 31/7/2022. Two cameras were installed at Al-Badawi intersection, where the number passing micromobility vehicles was detected, and the behavior of their uses were captured.

3.6.1 Overall Behavioral Analysis

It was observed that 527 micromobility vehicles crossed the selected intersection during the three-day study period with the following distribution: 83.6% e-bikes, 12.9% bicycles, and 3.5% e-scooters. The distribution of micromobility for the three days is shown in Figure E.1 in Appendix E.

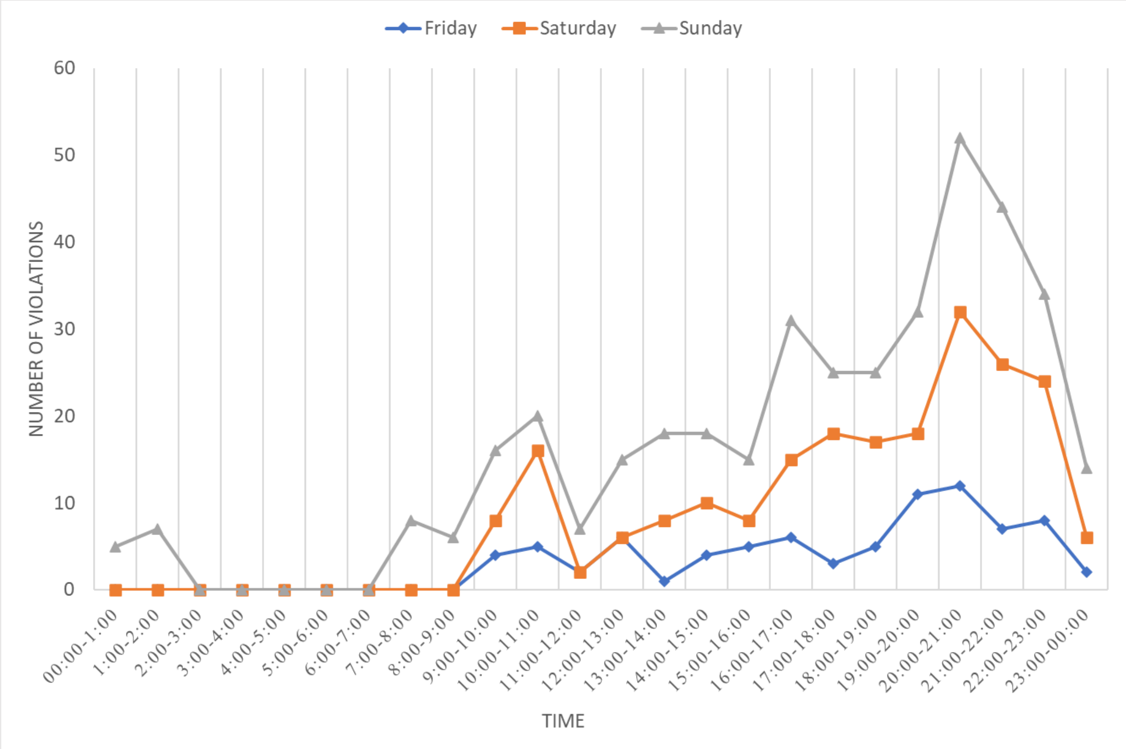
The number of micromobility vehicles was the highest daily volume on Saturday, which reached 215 vehicles, while on Friday it was the lowest, with 100 vehicles. As for Sunday, it was close to on Saturday, where the number of micromobility vehicles that crossed the intersection reached 212. It is to be noted that the number of micromobility vehicles on Friday was less than on Saturday and Sunday, as it is a weekend day. On the other hand, on Saturday and Sunday, traffic movement is active in the city of Nablus, as it receives visitors from various governorates and from beyond the green line. In addition, Sunday is a working day and all shops and institutions are open.

The micromobility users' behavioral violations in the study period is shown in Figure 3.6, as obtained from the recorded videos. The behavior of micromobility users was carefully observed. The hourly distribution of micromobility vehicle in the study period is shown in Figure E.2 in Appendix E.

Table 3.1 summarizes the hourly distribution of total micromobility vehicles for three days during the study period and the percentage of violators for each day during the study period. It can be noted that there is a relationship between the number of micromobility vehicles and the numbers of violators and the violations they commit, as shown in Figure 3.6, E.2 and Table 3.1. As the number of micromobility vehicles increases, the number of violators also increases. Moreover, the number of violators reached 81 on Friday, representing 81% of total. On Saturday, the number of violators reached 133, representing 61.9%, while on Sunday, the number of violators reached 178, representing 83.9% of total. It can be concluded that the percentage of the number of violators is very high, as it reached 74.4% for the three-day study period, meaning that a large percentage of micromobility users commit traffic violations. Moreover, the following can be concluded:

Figure 3.6

Hourly Distribution of Micromobility Users Violations During the Study Period



- The number of micromobility vehicle increases in afternoon and evening for all days.
- On Sunday, micromobility vehicles s are observed to start movement earlier than on Friday and Saturday, as it is a normal working day and employees use them to work, and students use them for the education trip purpose.
- Mid-day violations fluctuate up and down in the three days (Friday, Saturday, and Sunday).
- The highest number of micromobility vehicles and the violators over the three days was between 20:00-21:00 with a largest number of micromobility vehicles reached 31 with 20 violators.

From the video records, micromobility users' behavior was carefully observed over the three days during study period. These include the absence of wearing helmets, presence of rear passengers, wrong/illegal overtaking, driving in the opposite direction, wrong U-turn, maneuvering, and crossing red light. Table 3.2 summarizes the collected data during the study period and different acts that micromobility users do when crossing the intersection.

Table 3.1

Hourly Distribution of Total Micromobility Vehicle and Number of Micromobility Users Committed Risky Behaveiors During the Study Period

Hour	Friday			Saturday			Sunday			All Days*		
	# of Micromobility Vehicles	# of Risky Behaviors	% of Risky Behaviors	# of Micromobility Vehicles	# of Risky Behaviors	% of Risky Behaviors	# of Micromobility Vehicles	# of Risky Behaviors	% of Risky Behaviors	# of Micromobility Vehicles	# of Risky Behaviors	% of Risky Behaviors
09:00-10:00	5	4	80.0%	5	4	80.0%	9	8	88.9%	19	8	84.2%
10:00-11:00	5	5	100.0%	13	11	84.6%	5	4	80.0%	23	20	87.0%
11:00-12:00	2	2	100.0%	0	0	0.0%	7	5	71.4%	9	7	77.8%
12:00-13:00	7	6	85.7%	0	0	0.0%	11	9	81.8%	18	15	83.3%
13:00-14:00	4	1	25.0%	10	7	70.0%	11	10	90.9%	25	19	72.0%
14:00-15:00	5	4	80.0%	7	6	85.7%	9	8	88.9%	21	17	85.7%
15:00-16:00	5	5	100.0%	9	3	33.3%	7	7	100.0%	21	15	71.4%
16:00-17:00	7	6	85.7%	13	9	69.2%	17	16	94.1%	37	31	83.8%
17:00-18:00	5	3	60.0%	18	15	83.3%	9	7	77.8%	32	25	78.1%
18:00-19:00	7	5	71.4%	17	12	70.6%	9	8	88.9%	33	25	75.8%
19:00-20:00	12	11	91.7%	20	7	35.0%	16	14	87.5%	48	32	66.7%
20:00-21:00	12	12	100.0%	31	20	64.5%	25	20	80.0%	68	53	76.5%
21:00-22:00	10	7	70.0%	29	19	65.5%	23	18	78.3%	62	33	71.0%
22:00-23:00	11	8	72.7%	33	16	48.5%	13	10	76.9%	57	37	59.6%
23:00-00:00	2	2	100.0%	10	4	40.0%	10	8	80.0%	22	14	63.6%
Total	100	81	81.0%	215	133	61.9%	212	178	83.9%	527	392	74.4%

* All days during the study period (Friday, Saturday, and Sunday)

Table 3.2

Behavior Characteristics of Micromobility Users During the Study Period

Item	Friday		Saturday		Sunday		All Days*	
	Number	% of total	Number	% of total	Number	% of total	Number	% of total
Micromobility users that did not commit risky behavior actions	19	19.0%	82	38.1%	35	16.0%	135	25.6%
Violators	81	81.0%	133	61.9%	178	84.0%	392	74.4%
Total	100	-	215	-	212	-	527	-
Presence of Rear Passenger with Wrong/Illegal Overtaking	1	0.7%	0	0.0%	4	1.1%	5	0.8%
Presence of Rear Passenger with Crossing Red Light	3	2.2%	0	0.0%	3	0.9%	6	1.0%
Presence of Rear Passenger with Driving in opposite direction	1	0.7%	0	0.0%	1	0.3%	2	0.3%
Presence of Rear Passenger with Wrong U-turn	0	0.0%	0	0.0%	1	0.3%	1	0.2%
Wrong/Illegal Overtaking Only	40	29.0%	28	21.1%	105	29.8%	173	27.8%
Crossing red light only	47	34.0%	35	26.3%	110	31.3%	192	30.8%
Wrong Maneuvering only	7	5.2%	18	13.5%	7	2.0%	32	5.1%
Wrong U-turn only	0	0.0%	26	19.5%	7	2.0%	33	5.3%
Driving in opposite direction only	15	10.9%	26	19.5%	51	14.5%	92	14.8%
Wrong/Illegal Overtaking with crossing red light	18	13.0%	0	0.0%	55	15.6%	73	11.7%
Crossing red light with maneuvering	6	4.3%	0	0.0%	4	1.1%	10	1.6%
Crossing red light with wrong U-turn	0	0.0%	0	0.0%	4	1.1%	4	0.6%
Total Risky Behavior Actions	138	-	133	-	352	-	623	-

* All days during the study period (Friday, Saturday, and Sunday)

Table 3.3

Micromobility Users Wearing Helmet Characteristics During the Study Period

Item	Friday		Saturday		Sunday		All Days*	
	Number	% of total	Number	% of total	Number	% of total	Number	% of total
With helmet	0	0.0%	2	0.9%	0	0.0%	2	0.4%
Without helmet	100	100.0%	213	99.1%	212	100.0%	525	99.6%
Total	100	-	215	-	212	-	527	-
With helmet + No risky behavior actions	0	0.0%	1	0.5%	0	0.0%	1	0.2%
With helmet + Risky behavior actions	0	0.0%	1	0.5%	0	0.0%	1	0.2%
Without helmet + No risky behavior actions	19	19.0%	81	37.7%	34	16.0%	134	25.4%
Without helmet + Risky behavior actions	81	81.0%	132	61.3%	178	84.0%	391	74.2%
Total	100	-	215	-	212	-	527	-

* All days during the study period (Friday, Saturday, and Sunday)

Table 3.4

Micromobility Users Rear Passengers Characteristics during the Study Period

Item	Friday		Saturday		Sunday		All Days*	
	Number	% of total	Number	% of total	Number	% of total	Number	% of total
Rear Passenger	8	8.0%	1	0.5%	10	4.7%	19	3.6%
Rear Passenger with Helmet	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Rear Passenger without Helmet	8	100.0%	1	100.0%	10	100.0%	19	100.0%
Total	8	-	1	-	10	-	19	-
Rear Passenger + Micromobility users that did not commit risky behavior actions	3	37.5%	1	100.0%	3	30.0%	7	36.8%
Rear Passenger + Risky behavior actions	5	62.5%	0	0.0%	7	70.0%	12	63.2%
Total	8	-	1	-	10	-	19	-

* All days during the study period (Friday, Saturday, and Sunday)

Table 3.3 summarizes different characteristics and acts that micromobility users do related to wearing a helmet. Table 3.4 summarizes different characteristics and acts that micromobility users do while having a rear passenger.

From Tables 3.2, 3.3, and 3.4, the following can be concluded:

- The number of micromobility users that committed risky behavior actions during the three days of the study period reached 392, and formed a percentage of 74.4% of total micromobility users who had crossed the intersection, while the number of micromobility users that did not commit risky behavior actions reached 135, with a percentage 25.6%.
- The most frequent risky behavior actions were crossing a red light at the intersection, followed by wrong/illegal overtaking, and then driving in the opposite direction, forming 30.8%, 27.8%, and 11.7%, respectively.
- The vast majority of the micromobility users who crossed the intersection did not wear a helmet, as Table 3.3 shows, while there were only two micromobility vehicle users out of a total of 527 who wore a helmet during the study period forming less than 1.0%. Moreover, the number of those who do not wear a helmet and were violators were 391, with a percentage of 74.2%, and those who did not wear a helmet and did not commit risky behavior actions were 134 with a percentage 25.6%.
- The number of rear passengers riding micromobility vehicles was 19, forming 3.6% of the total micromobility vehicles, and most of the related micromobility users were violators.
- The total number of risky behavior actions increase in a workday compared with a weekend day during the three-day study period. From Friday to Saturday risky behavior actions increasing by a percentage of 64.2%, while from Saturday to Sunday increasing with a percentage 33.8%. This is a considerable increase for three days. Friday is relatively less active than Saturday and Sunday, as activity usually begins in the afternoon.
- There are three peak periods with three distinct peak hours that were observed, which were as follows: the morning peak from 10:00 to 11:00 AM with 13 micromobility vehicles, the afternoon peak period from 16:30 to 17:30 PM with 19 micromobility vehicles, and the evening peak period from 20:00 to 21:00 PM with 33 micromobility

vehicles. It is to be noted that the late evening peak period is the highest. It is to be noted that this evening peak hour had the highest number of violations, and this may be due to the nature of delivery activity that continues during the evening hours, which could contribute to violating traffic laws.

3.6.2 Analysis of Turning Movements Behavior

To study and analyze the behavior of micromobility users turning movements at the representative intersection during the study period, the number of micromobility vehicles crossing the intersection and those committing a red light crossing violations are detected.

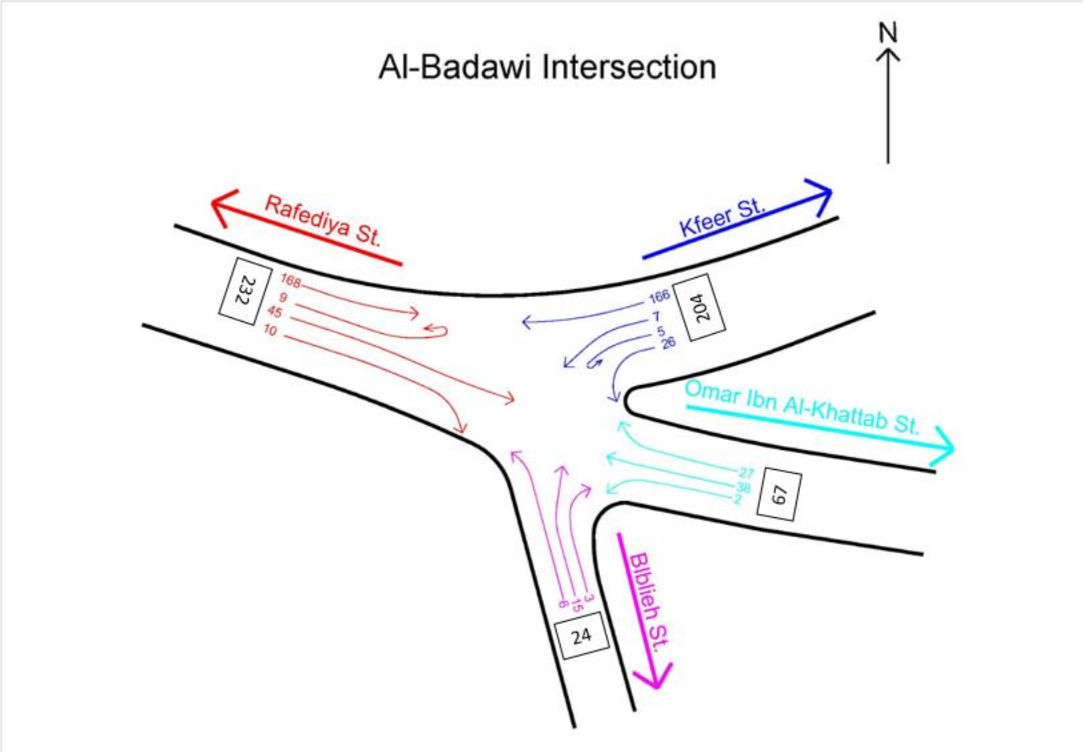
Figure 3.7 illustrates the micromobility turning movement during the study period. At Four-leg Al-Badawi intersection, the western approach (Rafidia Street), had the highest number of crossing micromobility vehicles, which formed 44.0%, followed by the eastern approach (Al-Kfeer Street) with 38.7%, and then the southern eastern approach (Omar Ibn Al-Khattab Street), and lastly the southern approach (Blebileh Street).

In terms of red light crossing behavioral violations, the western approach was the approach with the highest number of red light crossing violations with a percentage 45.3% of the total red light crossing violations at Al Badawi intersection, followed by the east approach with a percentage 31.3% of the total red light crossing violations and these approaches have the highest traffic volumes at this intersection which contributes to an increase in the number of violators as shown in Figure E.3 in Appendix E.

As for wrong/illegal overtaking behavioral violations, the western approach was the approach with the highest number of wrong/illegal overtaking violations with a percentage 39.3% of the total wrong/illegal overtaking violations at Al Badawi intersection, followed by the eastern approach with a percentage 34.7% of the wrong/illegal overtaking violations as shown in Figure E.4 in Appendix E and this is due to high traffic volume for those approaches as mentioned before.

Figure 3.7

Al-Badawi Intersection Micromobility Turning Movements During the Study Period (Friday, Saturday, and Sunday)



3.6.3 Testing Hypothesis Concerning Micromobility Users' Behavior

In this subsection, three hypotheses that have been defined in this study are examined. These hypotheses are presented hereafter:

HP1: There are no significant differences between different micromobility users' behavioral violations (red light crossing, wrong/illegal overtaking, driving in opposite direction, wrong U-turn, and maneuvering) and the time of micromobility users' violations (morning, afternoon, and evening) for each day and across the days during the study period.

HP2: There are no significant differences between certain micromobility users' behavioral violations (red light crossing, wrong/illegal overtaking, and driving in the opposite direction) and the peak period of micromobility users' violations (morning peak, afternoon peak, and evening peak) during the study period.

HP3: There are no significant differences between certain micromobility users' behavioral violations (red light crossing, wrong/illegal overtaking, and driving in the opposite direction) and the approaches of micromobility users' violations (eastern and western) being that these approaches have the highest traffic volume during the study period.

- **Testing hypothesis 1**

One-way ANOVA test was conducted to check if there are statistical differences between micromobility users' behavioral violations (red light crossing, wrong/illegal overtaking, driving in opposite direction, wrong U-turn, and maneuvering) and the time of micromobility users' violations (morning, afternoon, and evening) during the study period. The results show that there are significant differences between micromobility users' behavioral violations and the time of micromobility users' violations on Saturday, and for all days with a P-value of 0.019, 0.012, respectively, considering the significant level (α = 0.05), and therefore, the hypothesis HP1 is rejected. This can be explained by the fluctuation of traffic vehicle movement during the day and night hours, noticeably on Saturday, due to active commercial traffic. However, there are no significant differences between micromobility users' behavioral violations and the time of micromobility users' violations on Friday and Sunday with a P-values of 0.288, 0.410, respectively.

- **Testing hypothesis 2**

One-way ANOVA test was conducted to examine the second hypothesis, in order to check if there are statistical differences between certain micromobility users' behavioral violations (red light crossing, wrong/illegal overtaking, and driving in the opposite direction) and the peak period of micromobility users' violations (morning peak, afternoon peak, and evening peak) during the study period. The results show that there are no significant differences between certain micromobility users' behavioral violations and the peak period of micromobility users' violations on Friday, Saturday, and on all the studied days with a P-value of 0.135, 0.896, 0.050, respectively, considering than the significant level (α = 0.05), and therefore, the hypothesis HP2 is accepted. This can be explained by the fact that on Friday, there is light traffic movement during the day, so there is no noticeable difference between peak hours and the rest of the day, unlike Saturday and on all days, which is characterized by active traffic movement during the day. However, there are significant differences between most frequent micromobility users' behavioral violations and the peak period of micromobility users' violations on Sunday with a P- value of 0.020.

- **Testing hypothesis 3**

One-way ANOVA test was conducted to examine the third hypothesis, in order to check if there are a significant difference between certain micromobility users' behavioral violations (red light crossing, wrong/illegal overtaking, and driving in the opposite direction) and the approaches of micromobility users' violations (eastern and western) approaches being that these approaches have the highest traffic volume during the study period. The results show that there are no significant differences between certain micromobility users' behavioral violations (red light crossing, wrong/illegal overtaking, and driving in the opposite direction) and the approaches of micromobility users' violations (eastern, and western) approaches on Friday, Saturday, Sunday, and on all days with a P-value of 0.202, 0.202, 0.147, and 0.329, respectively, considering that the significant level ($\alpha = 0.05$), and therefore, the hypothesis HP3 is accepted.

The results can be summarized as follows:

- There are significant differences between micromobility users' behavioral violations and the time of micromobility users' violations on Saturday, and for all days.
- There are no significant differences between certain micromobility users' behavioral violations and the peak period of micromobility users' violations on Friday, Saturday, and on all days.
- There are no significant differences between certain micromobility users' behavioral violations (red light crossing, wrong/illegal overtaking, and driving in the opposite direction) and the approaches of micromobility users' violations (eastern and western) approaches on Friday, Saturday, Sunday, and on all days.

It can be concluded that behavioral violations committed by micromobility users may be affected by the time of the violation, especially at peak time and in case of traffic congestion. In general, it is necessary to control violations committed by micromobility users all the times, including during the various periods of Fridays and Saturdays, and in all the days, to improve traffic safety for its users and reduce micromobility crashes.

Chapter Four

Conclusions and Recommendations

4.1 Introduction

This thesis has been conducted to study and understand the reality of traffic safety for micromobility users in light of the increasing number of micromobility traffic crashes, and improve traffic safety for its users.

The traffic safety study required analysis of collected crash data in order to develop crash profiles, generate crash maps, and assess the behavior of micromobility users. Moreover, several interviews were conducted with relevant institutions representatives, to understand the problems and reality of traffic safety related to micromobility and to improve the safety of micromobility users.

Nablus City is selected as the study area to assess micromobility safety. Micromobility crashes data were collected from the Nablus Traffic Police Department, resulting in a total of 138 crashes during the period from January 2018 to December 2022. The crash data had been analyzed according to the characteristics of each crash and developed micromobility crash profile with different characteristics. Spatial analysis was then conducted for all collected crashes to identify the hazardous locations based on the location of micromobility crashes.

A questionnaire was also conducted, with the participation of 158 micromobility users, to understand the level of awareness of traffic safety among a segment of micromobility users in the city of Nablus, in addition to understanding the traffic issues they face.

A total of 527 micromobility vehicles in a three-day period were counted using observation cameras at one of the intersections in a location that was classified as one of the most hazardous locations. The behaviors of micromobility users were monitored in addition to the violations they committed in order to evaluate and understand the micromobility users' behavior that may lead to traffic crashes.

4.2 Summary of Results

The results of the analysis are summarized hereafter:

- The total number of recorded micromobility crashes during the study period (2018 to 2022) in Nablus City was 138, while it was 170 in Nablus Governorate. The micromobility crashes are increasing annually in an average of 37%.. The number of crashes in 2021 dropped by 26% compared to 2020, because of the use of micromobility during the COVID-19 pandemic was relatively increasing as a result of preventing the movement of traffic except in emergency cases, forcing many to use micromobility as a mode of transportation, which was associated with an increase in micromobility crashes.
- The casualties resulting from micromobility crashes in Nablus City are the highest for the age groups (12 to 18 years), and this is consistent with the questionnaire gathered from micromobility users, which showed that users within this age group (12 to 18 years) were the most who use micromobility.
- The summer season shows the highest number of micromobility crashes than any other season for the whole study period, while September is the month with the highest number of crashes.
- Mondays show the highest number of crashes, which is a working day, and vehicle movement is supposed to be active for all vehicgles, including micromobility, which may cause an increase in the probability of crashes occurrence.
- The evening peak hour from 20:00 to 21:00 PM had the highest number of micromobility crashes with a value of 33 crashes.
- Driving in the opposite direction was the highest reason to cause the crash and formed 20.3% from total micromobility crashes during the study period, followed by improperly changing lanes with a percentage 17.4%.
- About 85.5% of micromobility crashes were with private vehicles, followed by shared-taxi with a percentage 8.0%, without any run-over crashes that recorded on the Nablus Traffic Police Department.
- Regarding the outcome of crashes injuries resulting from micromobility crashes, the number of injuries resulting from micromobility crashes in Nablus Governorate is 170 injuries, including 148 injuries in Nablus City.
- Most of the injuries resulting from micromobility crashes within the city were slight

to moderate, with a very small percentage of severe injuries and no deaths. This is due to the limited speed within the city and the presence of traffic congestion that limits speed especially within the city center. Three fatal micromobility crashes had been recorded in the governorate, outside Nablus City, during the study period. This was due to driving at a speed not suitable with road conditions, in addition to failure to take safety measures for citizens.

- Property damage was not recorded in traffic police department records, this is due to the fact that the physical damage that a micromobility vehicle may cause is negligible when it does not constitute any injury to the micromobility vehicle driver.
- Depending on the location of the crashes that were marked on the map, these have been spatially analyzed. The highest frequency of micromobility crashes were in Rafidia area.
- The behavior of micromobility users was at one intersection in the most hazardous area of Rafidia, where 527 micromobility vehicle had crossed the selected intersection during a three-day of the study period. The number of violators reached 81, 133, and 178 with a percentage 81.0%, 61.9%, and 83.9% on Friday, Saturday, and Sunday, respectively, with an overall percentage of 74.4%.

4.3 Conclusions

Based on the results of the study, the conclusions are summarized hereafter.

- There is lack of studies related to micromobility traffic safety in Palestine. Moreover, there is lack or absence of strict regulatory governance for micromobility vehicles in Palestine.
- Until now, there is no database that includes statistics on the numbers of existing micromobility mode vehicles, as these are not registered by the MOT nor by the local authorities in Palestine. Moreover, there are no statistics about the mode vehicles involvement in traffic crashes.
- There is no due attention spent by the relevant institutions at the national level regarding the safety aspects, regulations, and strategies for micromobility vehicles in Palestine.
- There is a higher frequency of micromobility crashes during peak periods compared to off-peak periods due to higher exposure.
- The number of crashes and injuries of micromobility vehicles increases in a high

average annual rate, and therefore more is to be done in terms of policies, regulations, and strict enforcement, as well as infrastructure, that target this mode is needed.

- The primary cause of micromobility crashes during the study period was driving in the opposite direction, followed by improperly changing lanes.
- Micromobility crashes in Nablus City generally led to slight to moderate injuries, with few severe injuries and no reported fatalities. There are significant differences between micromobility users' behavioral violations and the time of micromobility users' violations on Saturday, and for all days, indicating lack of attention to proper conduct during the various periods of such days.
- There is no enforcement concerning violations committed by micromobility users. Such enforcement is necessary to improve traffic safety for this mode users and reduce related crashes.

4.4 Limitations

The limitations of this study can be summarized as follows:

- There are no statistics on the number of existing micromobility vehicles, nor on crashes or injuries related to this mode in Palestine, thus, ratios and comparisons related to such statistics were no feasible
- The process of gathering crash data from the Nablus Traffic Police Department was conducted manually, resulting in a prolonged time for computerization. Moreover, the documentation of crash events was occasionally unclear.
- The crash location is not precise in the records of the Traffic Police Department, where each crash should be documented with its exact coordinates.
- Some micromobility crashes were not documented in Traffic Police records, as there is no registration of running over pedestrian crashes by micromobility vehicles or property damage crashes in the five-year study period within study area, as was observed and then confirmed by Traffic Police.

4.5 Recommendations

Based on the outcome of this study, recommendations can be summarized as follows:

- Defining micromobility vehicles in the new amendment of the Palestinian Traffic Law, which is being prepared and the necessity of regulating the use of micromobility vehicles and maintaining the safety of their users, as the micromobility mode vehicles is new and wide spreading.
- Conducting and publishing statistics on existing numbers of micromobility vehicles and crashes and injuries involving this mode vehicles, with the participation of relevant entities, including the MOT, Traffic Police, MOH, PNIPH, and the PCBS, in order to establish an accurate database and to facilitate research on various aspects related to micromobility.
- Ensuring an enhanced process that marked the specific locations of crashes with sufficient accuracy using modern technologies such as GPS by the traffic police.
- Computerizing the data related to crashes in a more effective manner, ensuring the efficiency and accuracy of obtaining any information related to crashes, and enabling the Traffic Police departments in the governorates to issue periodic reports on a regular basis more effectively.
- Ensuring the registration of micromobility vehicles by local authorities and linking this to a system with the MOT. It is also strongly recommended to impose fine on micromobility violators by local authorities.
- Developing a vehicle licensing system for micromobility, and studying the possibility of obliging micromobility users, specifically e-bikes and e-scooters, to obtain driving license for the users who are 16 years or older to be issued by the MOT, as this is the trend in many developed countries and in number of developing countries.
- Giving due consideration in the infrastructure for accommodating micromobility vehicles, such as allocating bike or lanes, and taking into account the public safety conditions for its users in cooperation among the MOLG, the municipalities, and the MOT.
- Launching awareness campaigns for micromobility users on the issues related to traffic safety, especially in schools, since the age group with most frequent micromobility crashes is that from 12 to 18 years. This should include educating the users on the importance of taking traffic safety measures to protect users from the risk of crashes.
- Encouraging researchers, through government institutions, ministries, and universities

to conduct studies related to traffic safety of micromobility vehicles, their uses, and ways to improve infrastructure in a way that helps to advance the transportation sector, especially concerning micromobility as a new mode of transportation, which has become as a solution to traffic congestion within the city.

- Identify hazardous locations for micromobility crashes annually by Traffic Police and the MOT, then provide local authorities and relevant ministries with such information to take action for reducing the number and severity of repeated micromobility crashes in the same location.

List of Abbreviations

Abbreviation	Meaning
ANOVA	Analysis of Variance
ATCEMS	Austin-Travis Country Emergency Medical Services
COVID-19	Coronavirus Disease-19
CSCRS	Collaborative Sciences Center for Road Safety
GIS	Geographic Information System
GUI	Global United Insurance
ITF	International Transport Forum
MOLG	Ministry of Local Government
MOT	Ministry of Transportation
NACTO	National Association of City Officials
NEISS	National Electric Injury Surveillance System
NTSB	National Transportation Safety Boards
PCBS	Palestinian Central Bureau of Statistics
PEV	Personal Electrical Vehicle
PMD	Personal Micromobility Devices
PNIPH	Palestinian National Institute of Public Health
SEV	Small Electrical Vehicle
UAE	United Arab Emirates
WHO	World Health Organization

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Appendices

Appendix A

Interviews Information

Table A.1

Interviewees Details

Ministry/Agency	Date	Name	Title
Ministry of Transportation	20 August 2023	Mr. Mohammad Hamdan	Head of the Engineering and Traffic Safety Sector
Nablus Traffic Police Department	15 June 2023	Mr. Wajed Al-Halabi	Head of Traffic Crash Department
Palestinian National Institute of Public Health	20 August 2023	Dr. Ezat Rayyan	Director of the Institute
Global United Insurance	8 June 2023	Mr. Raed Salman	Director of the Agency - Bidya Branch
Store for Selling and Maintaining Bicycles, E-bikes, and Scooters	15 July 2023	Mr. Jamil Amer	Owner of the Store

Appendix B

The Study Questionnaire Form

عزيزي المستخدم:

يهدف هذا الإستبيان إلى دراسة وفهم مستوى الوعي بالسلامة المرورية لدى شريحة سائقي مركبات التنقل الدقيق في مدينة نابلس، بالإضافة إلى فهم التحديات المرورية التي تواجههم. هذا الإستبيان موجه إلى الأشخاص الذين يستخدمون مركبات التنقل الدقيق سواء كوسيلة مواصلات أو للترفيه أو لأي من الرحلات الأخرى بشكل منتظم. يأتي تنفيذ هذه الدراسة استكمالاً لمتطلبات الحصول على درجة الماجستير في هندسة الطرق والمواصلات، من كلية الدراسات العليا، في جامعة النجاح الوطنية، نابلس- فلسطين.

الجنس:

○ ذكر ○ أنثى

العمر:...............

المستوى التعليمي:

○ شهادة ابتدائية أو اعدادية ○ شهادة ثانوية ○ دبلوم ○ شهادة جامعية ○ دراسات عليا

نوع الرحلة:

- ☐ عمل
- ☐ سفر
- ☐ رياضة وترفيه
- ☐ التعليم (سواء للمدرسة أو الكلية أو الجامعة)
- ☐ احتياجات يومية (مثل الذهاب للتسوق)
- ☐ خدمة توصيل (Delivery)
- ☐ أخرى (...........................)

مسار الرحلة:

- ☐ نقطة الانطلاق (منزل، عمل، ترفيه، تعليم، احتياجات يومية، خدمة توصيل)
- ☐ نقطة الوصول (منزل، عمل، ترفيه، تعليم، احتياجات يومية، خدمة توصيل)

نوع مركبة التنقل الدقيق؟

- ☐ دراجة هوائية
- ☐ دراجة كهربائية
- ☐ سكوتر كهربائي
- ☐ أخرى

كم مرة تقوم بقيادة مركبة التنقل الدقيق؟

- ☐ يومياً (كم مرة:............)
- ☐ أسبوعياً (كم مرة:.........)
- ☐ شهرياً (كم مرة:...........)

معدات أو أدوات السلامة التي تستخدمها عادة أثناء قيادة مركبة التنقل الدقيق؟

○ خوذة ○ نظارات قيادة ○ بنطال خاص للدراجة ○ سترة جلدية/عاكسة ○ قفازات الدراجة ○ حذاء الدراجة

كم حادث مروري تعرضت له خلال السنة الماضية؟...............

ما مدى خطورة الحادث؟

○ بسيطة ○ متوسطة ○ صعبة

في أي من الأوقات تفضل قيادة مركبة التنقل الدقيق؟

- ☐ صباحاً
- ☐ بعد الظهر
- ☐ مساءً

في أي من الظروف الجوية تمارس قيادة مركبة التنقل الدقيق؟

- ☐ أجواء حارة
- ☐ أجواء معتدلة
- ☐ أجواء ماطرة بشكل خفيف
- ☐ أجواء ماطرة كثيراً

هل تلتزم بقوانين السير أثناء قيادة مركبة التنقل الدقيق؟

○ نعم ○ لا

ما هي أكثر التجاوزات التي تقوم بها أثناء القيادة؟

- ☐ الدخول بعكس السير
- ☐ التحول عن مسلك السير بين المركبات بشكل عشوائي
- ☐ عدم اتخاذ التدابير اللازمة لسلامة المواطنين
- ☐ عدم الامتثال للإشارات المرورية والضوئية
- ☐ عدم السير على المسلك الأيمن
- ☐ أخرى

هل تمتلك الأسرة مركبة خصوصية في المنزل؟

○ نعم ○ لا

اذا كان لدى الأسرة مركبة خصوصية في المنزل لماذا تستخدم مركبة التنقل الدقيق؟

- ☐ تجنب الأزمة المرورية
- ☐ تقليل وقت الرحلة لسهولة وصولها تحديداً داخل مركز المدينة
- ☐ رياضة وترفيه
- ☐ أخرى (..)

هل تعتقد بأنّ استخدامك لمركبة التنقل الدقيق كبديل عن المركبة الخصوصية/العمومية يقلل وقت الرحلة؟

○ نعم ○ لا

كم تحتاج من الوقت للذهاب لنفس الوجهة باستخدام مركبة التنقل الدقيق مقارنة باستخدام المركبة الخصوصية/العمومية؟

نوع المركبة	وقت الرحلة لنفس الوجهة (بالدقائق)
المركبة الخصوصية/ العمومية	
مركبة التنقل الدقيق	

انتهى الاستبيان،،،

Appendix C

Figures Related to Questionnaire Analysis

Figure C.1

Distribution of Total Number of Respondents to the Questionnaire in Nablus City by Age Group

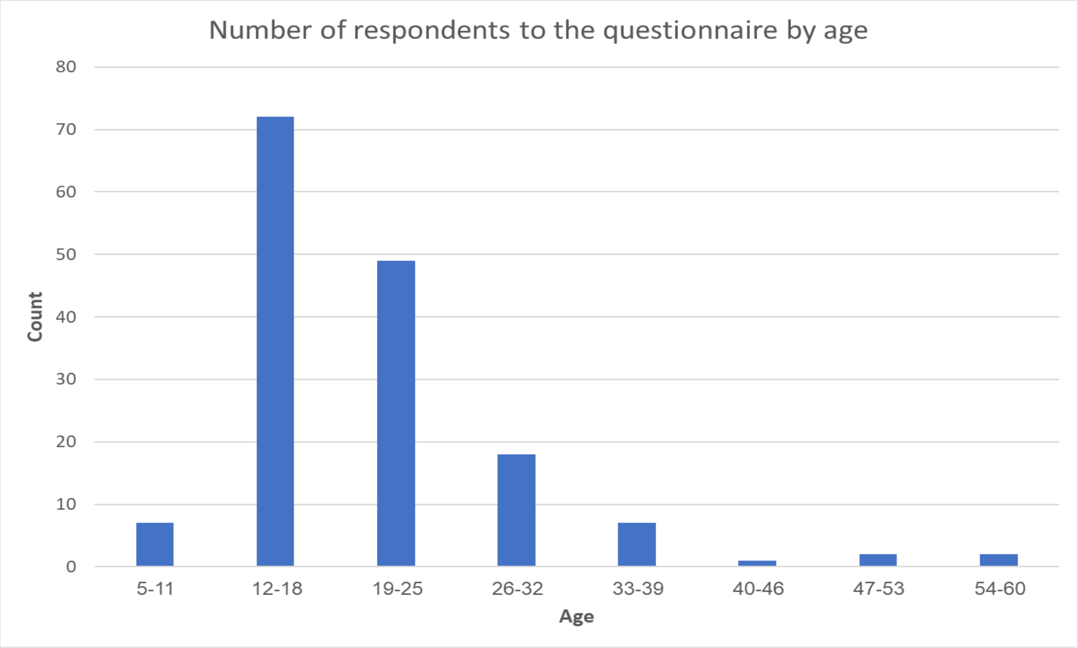


Figure C.2

Distribution of Total Number of Respondents to the Questionnaire in Nablus City by Educational Level

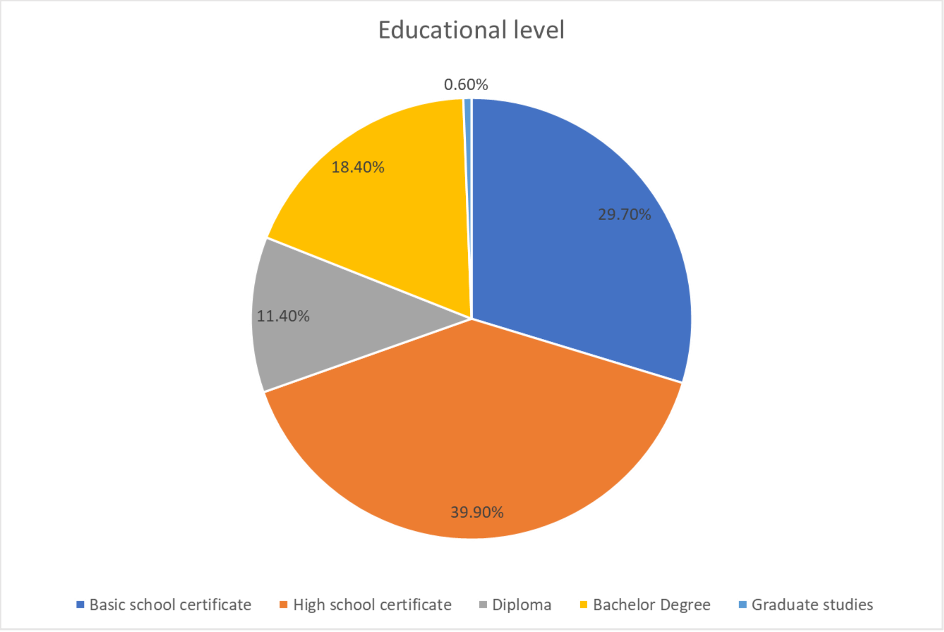


Figure C.3

Distribution of Origin-Destination Activity by the Respondents to the Questionnaire in Nablus City

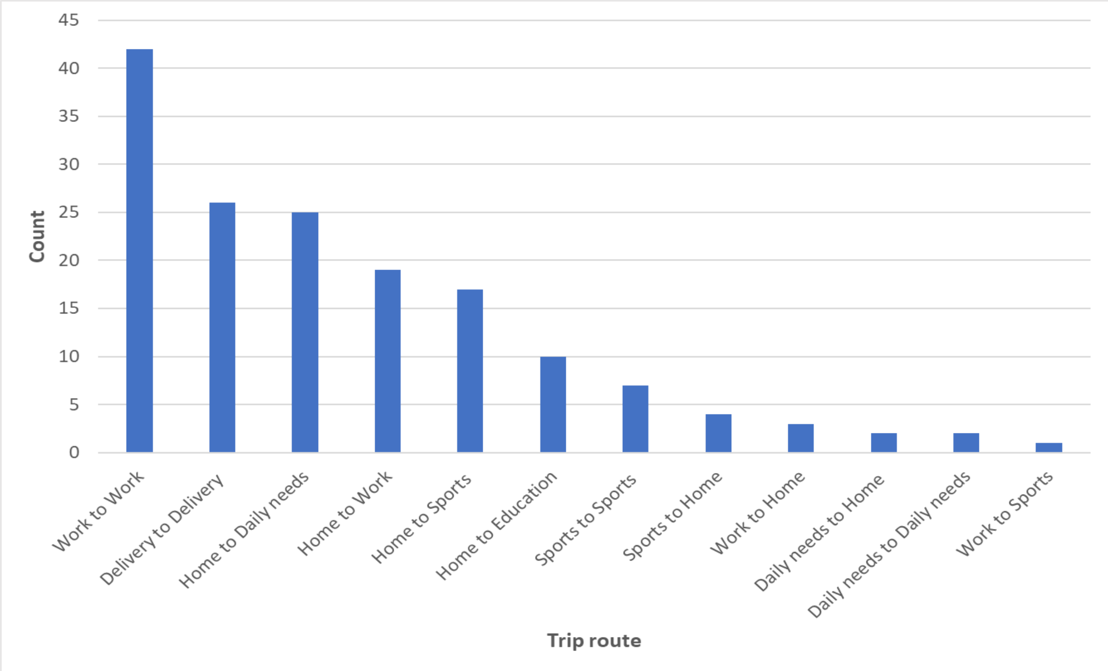


Figure C.4

Distribution of the Number of Times Do a Micromobility Users Drive a Micromobility Vehicle

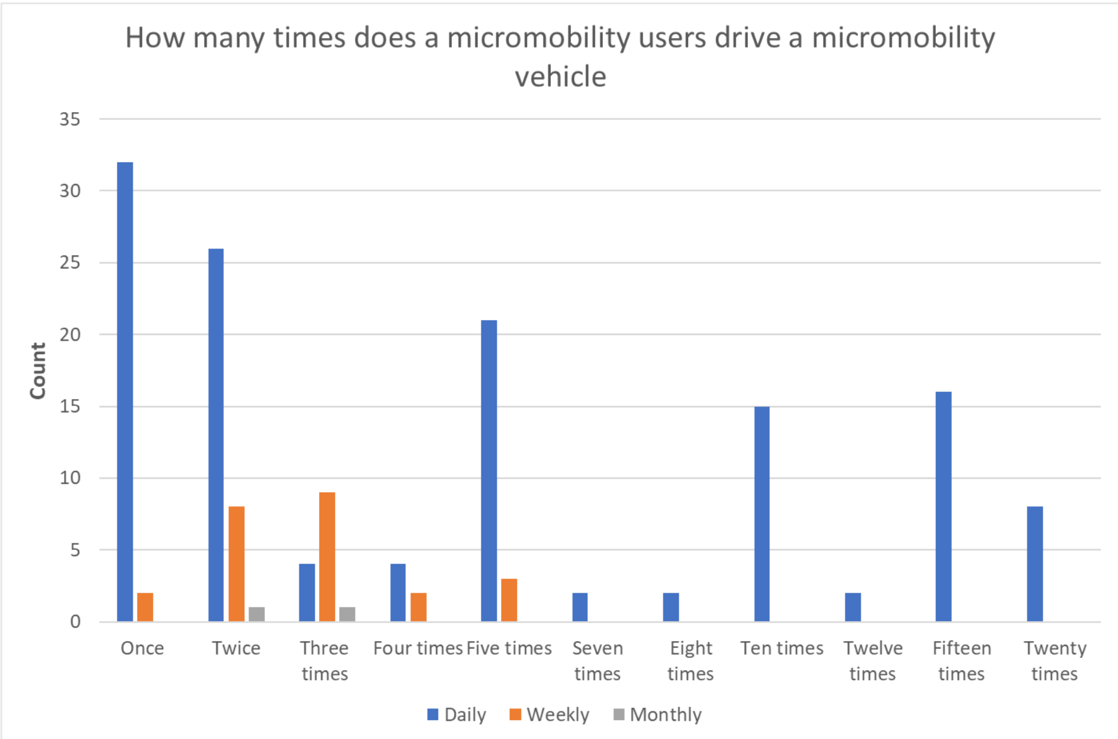


Figure C.5

Distribution of Micromobility Users According to Times During the Day

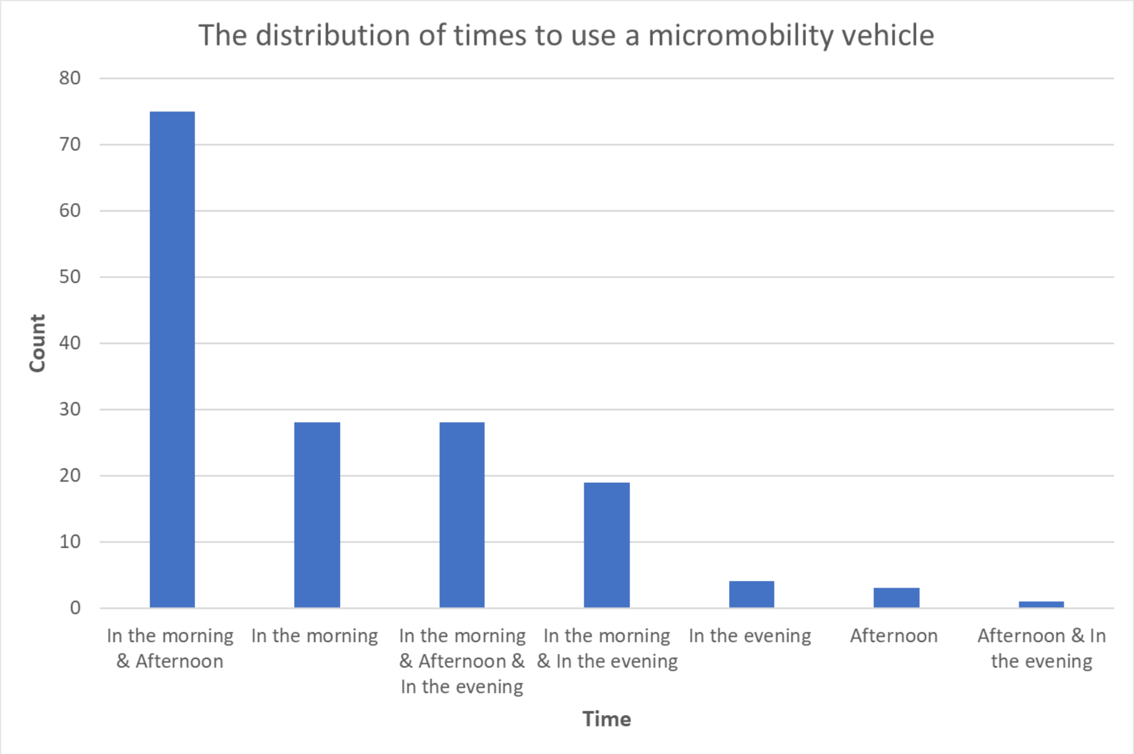


Figure C.6

Distribution of Micromobility Users According to Weather Conditions

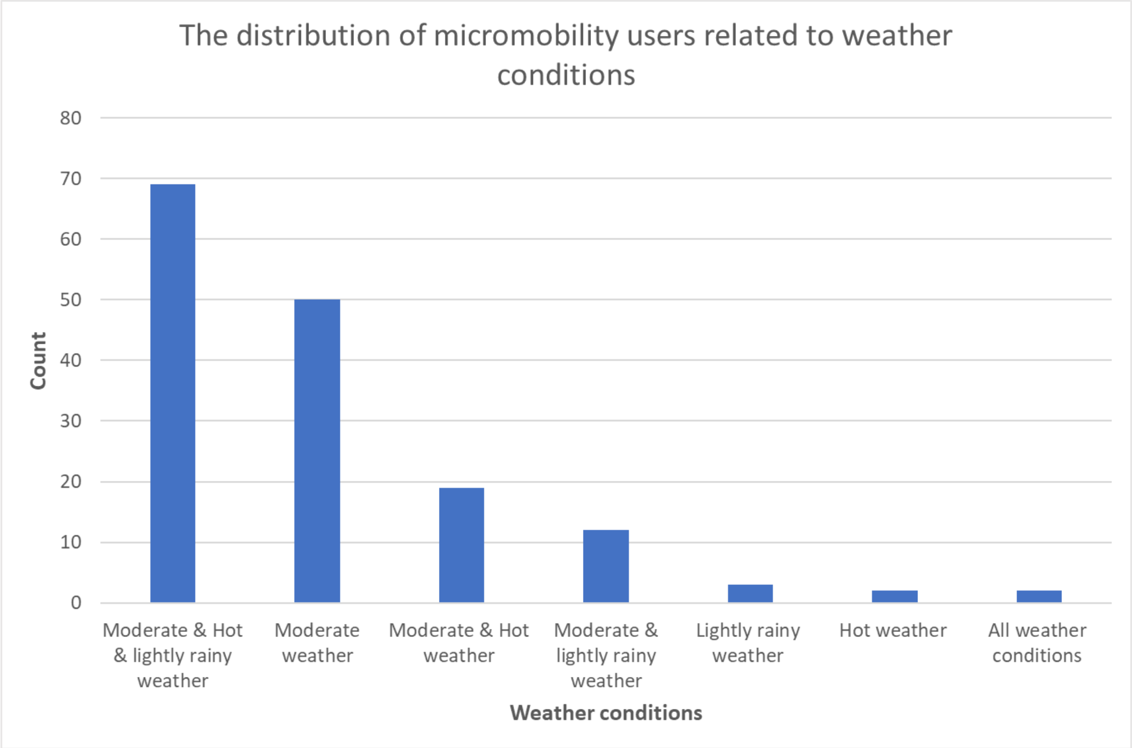


Figure C.7

Distribution of the Safety Equipment or Tools Used by Micromobility Users while Driving

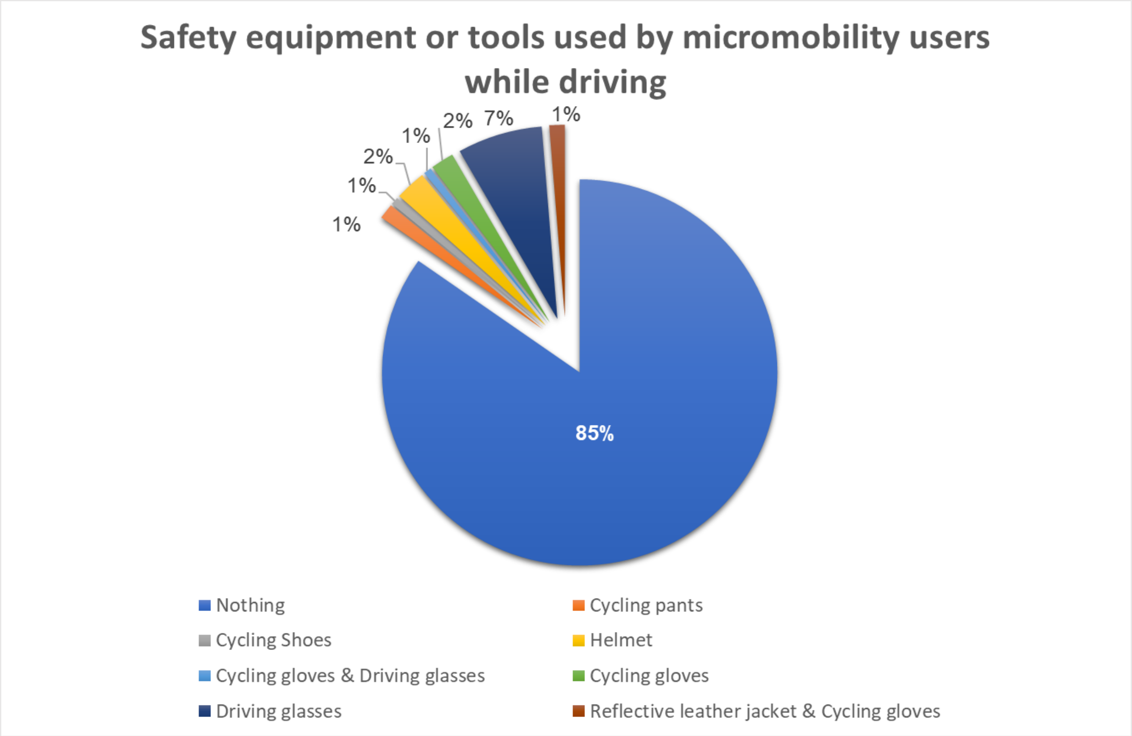


Figure C.8

Distribution of the self-reported violations by Micromobility Users

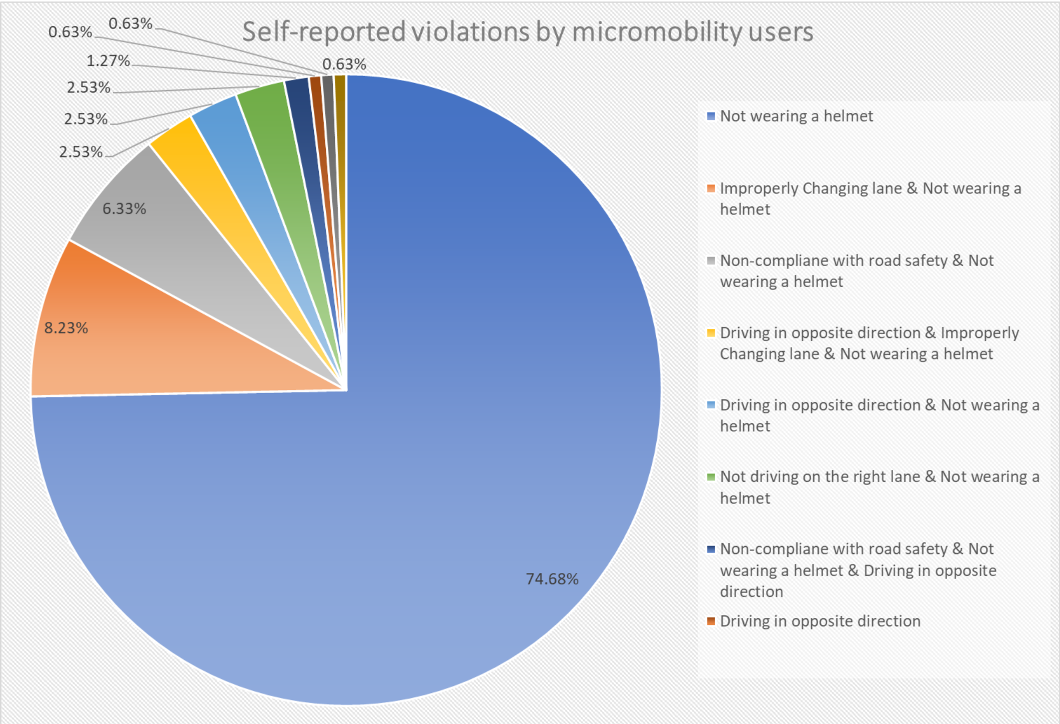


Figure C.9

Distribution of the Self-reported Crashes the Micromobility Driver was Involved in During the Past Year

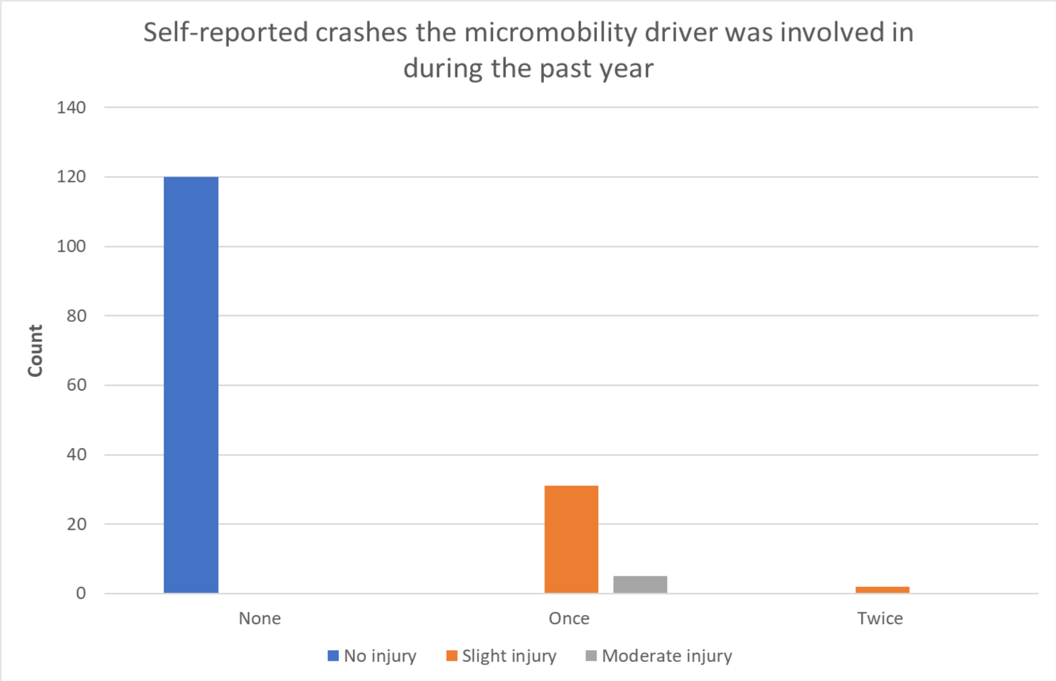
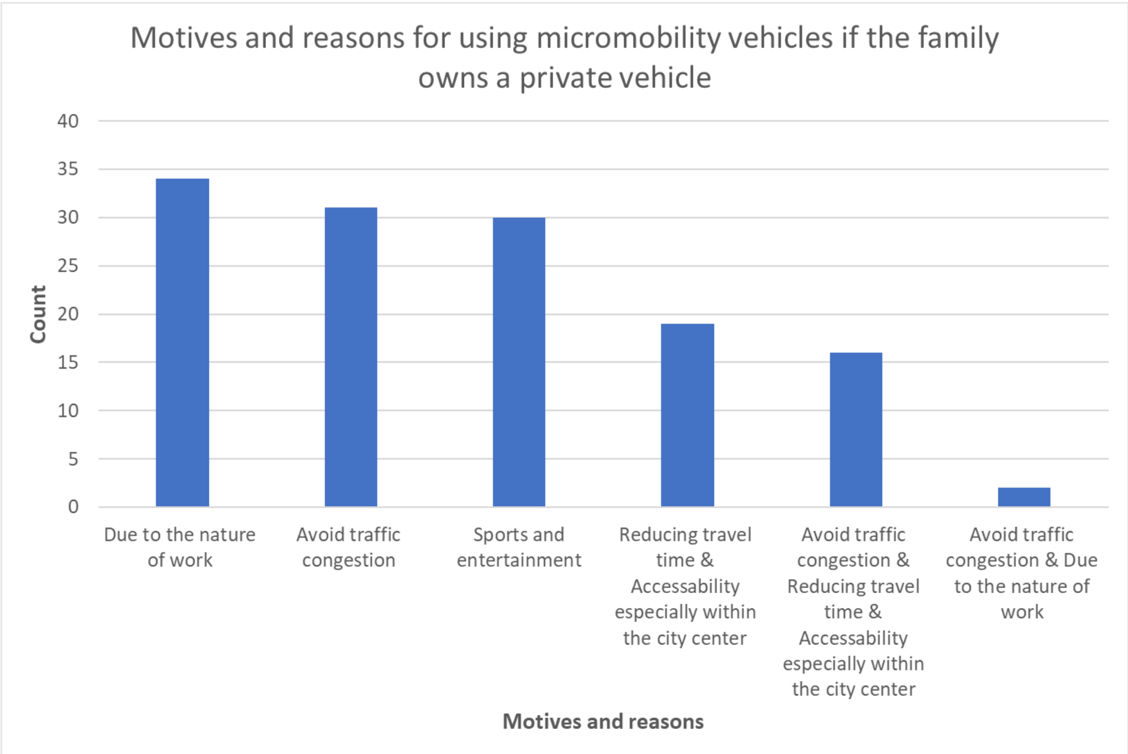


Figure C.10

Distribution of the Number of Micromobility Users related to Motives and Reasons for Using Micromobility Vehicles



Appendix D

Figures Related to Micromobility Crash Profile

Figure D.1

Distribution of Total Number of Casualties Micromobility Crashes in Nablus City by Age Group During the Study Period (2018 –2022)

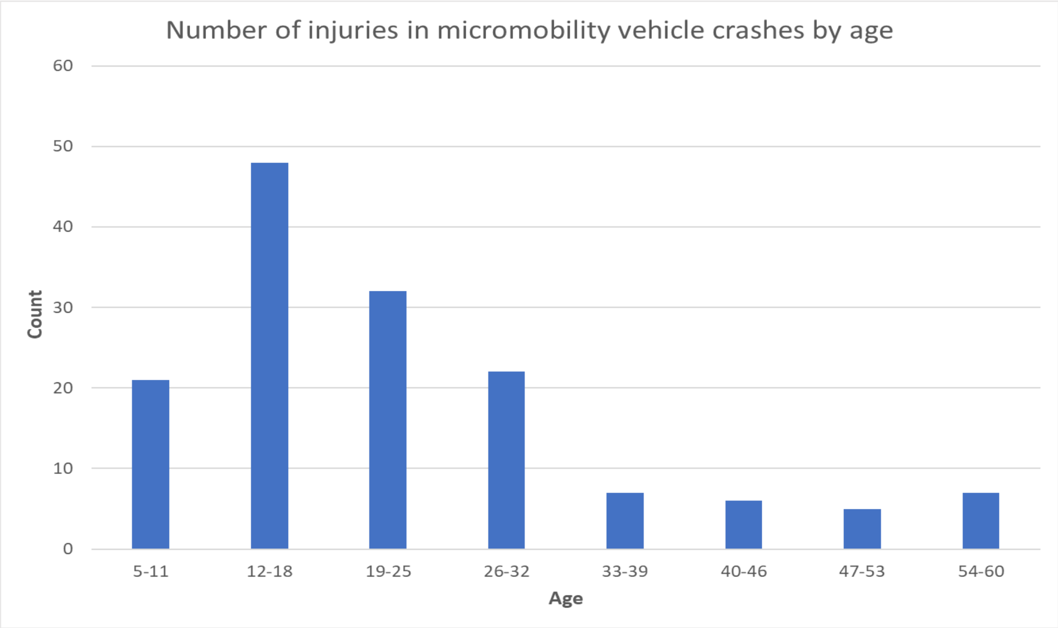


Figure D.2

Distribution of Total Micromobility Crashes in Nablus City by Quarters of the Year During the Study Period (2018–2022)

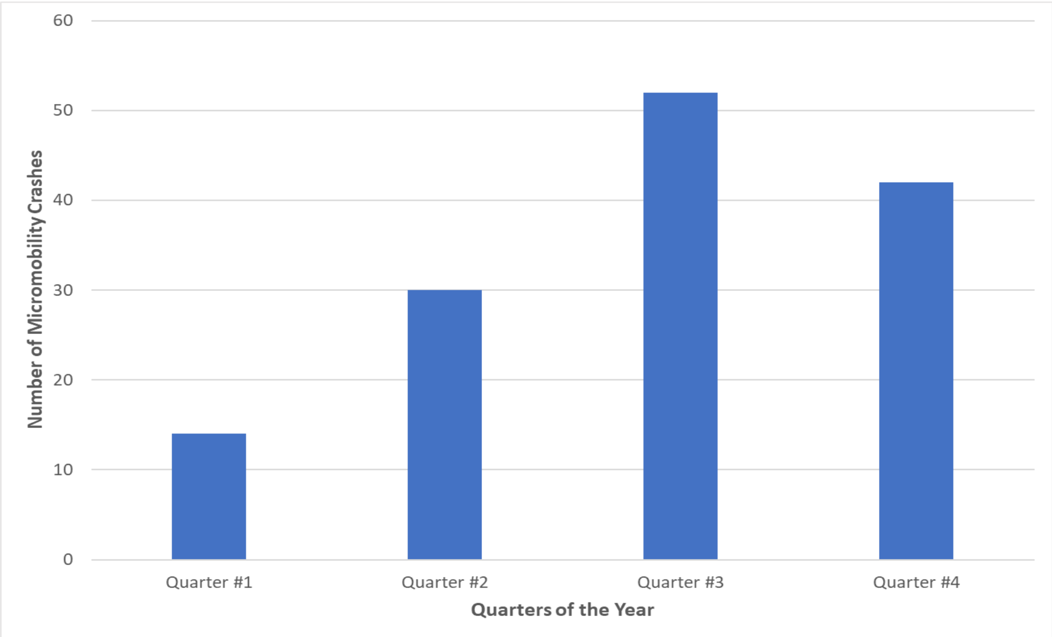


Figure D.3

Distribution of Total Micromobility Crashes in Nablus City by Period of Occurrence Within the Day During the Study Period (2018 –2022)

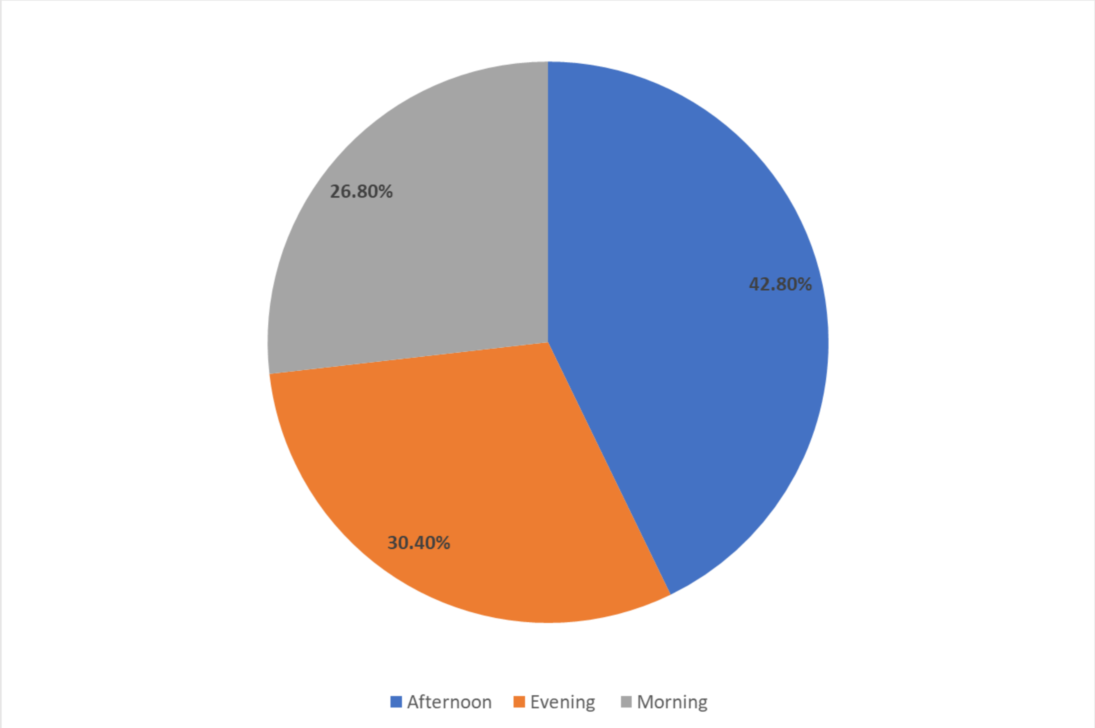


Figure D.4

Distribution of Total Micromobility Crashes in Nablus City by Reason of Crash During the Study Period (2018 –2022)

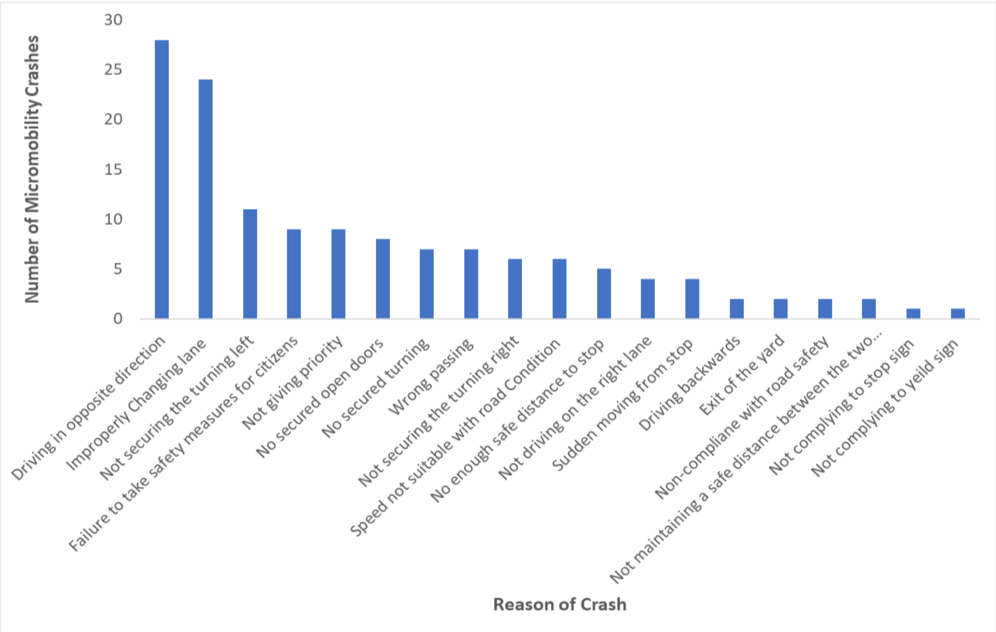


Figure D.5

Distribution of Total Micromobility Crashes in Nablus City by Vehicle Crash Involvement During the Study Period (2018 –2022)

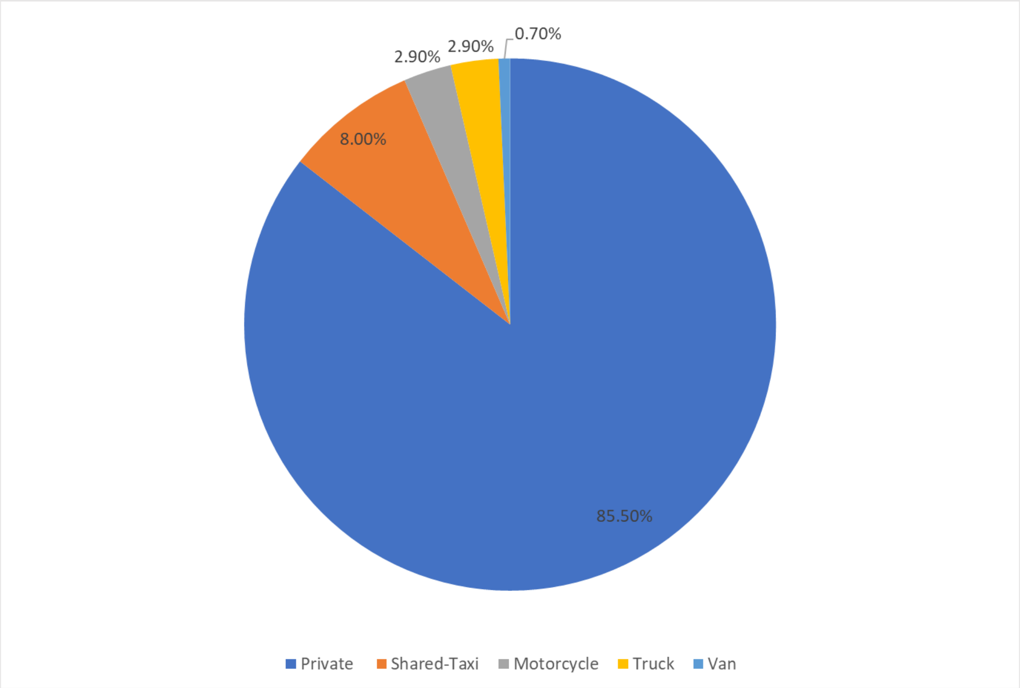


Figure D.6

Distribution of Total Micromobility Crashes in Nablus City and Nablus Governorate by Type of Micromobility During the Study Period (2018 – 2022)

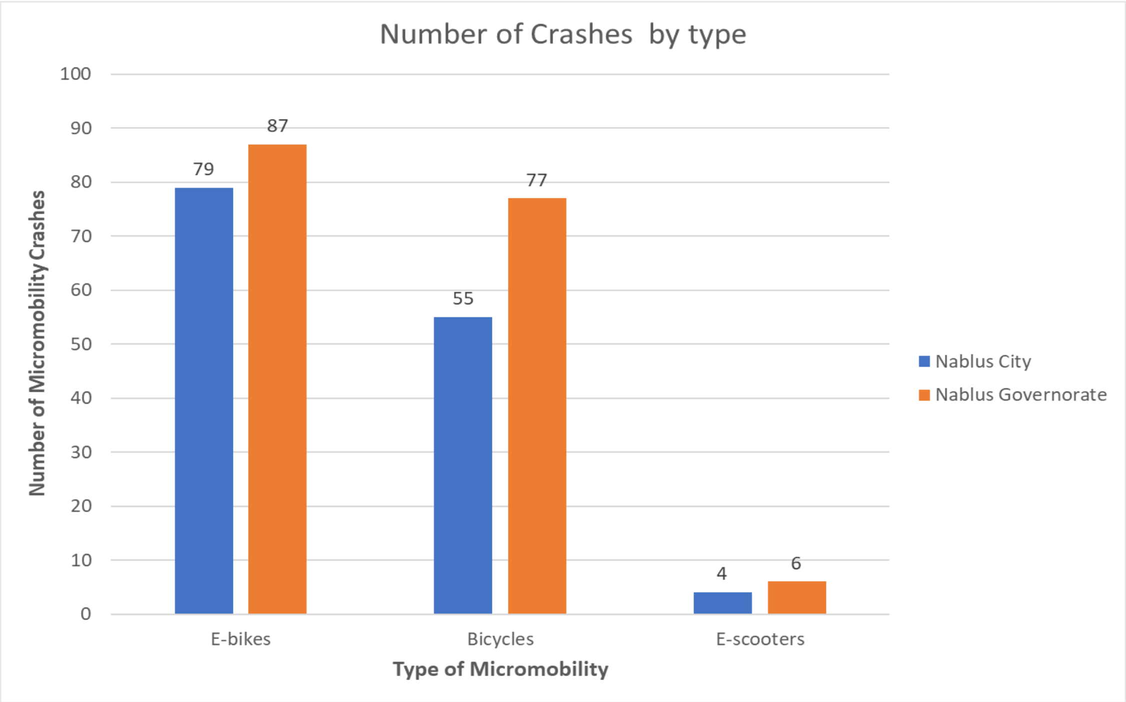


Figure D.7

Distribution of Total Micromobility Crashes in Nablus City by Day of the Week During the Study Period (2018 –2022)

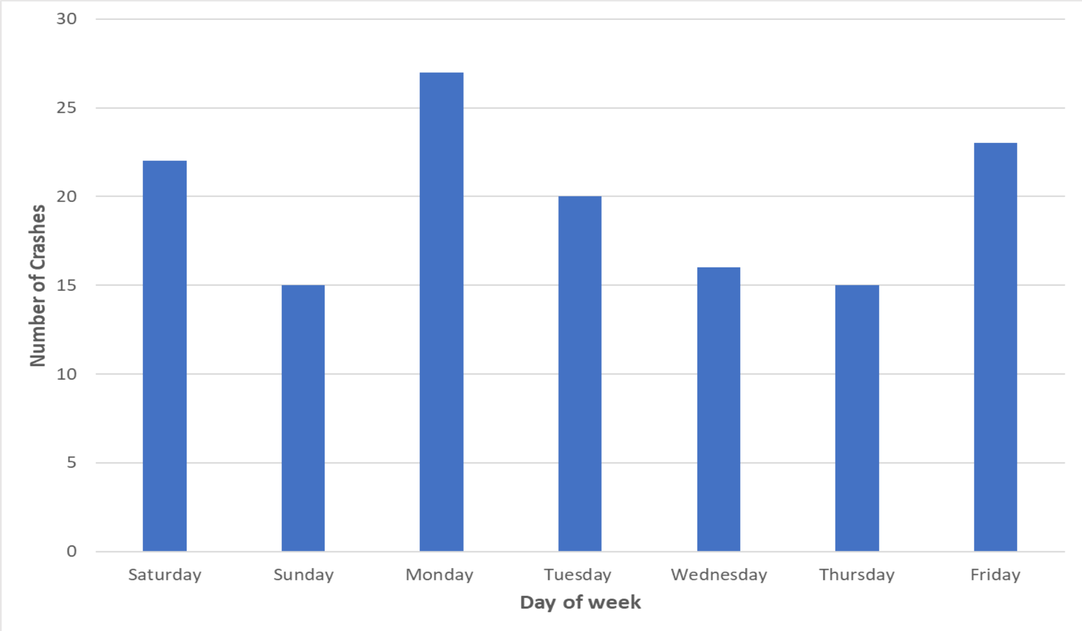


Figure D.8

Distribution of Total Micromobility Crashes in Nablus City by Hour of the Day During the Study Period (2018 –2022)

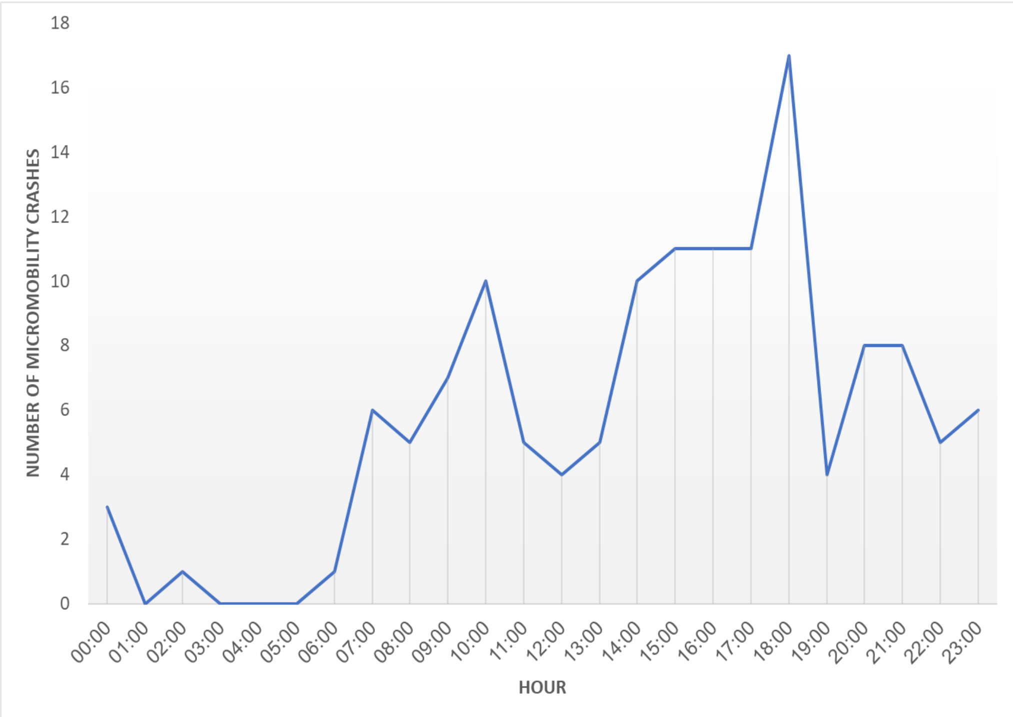


Figure D.9

Zonal Distribution of Total Micromobility Crashes in Nablus City During the Study Period (2018–2022)

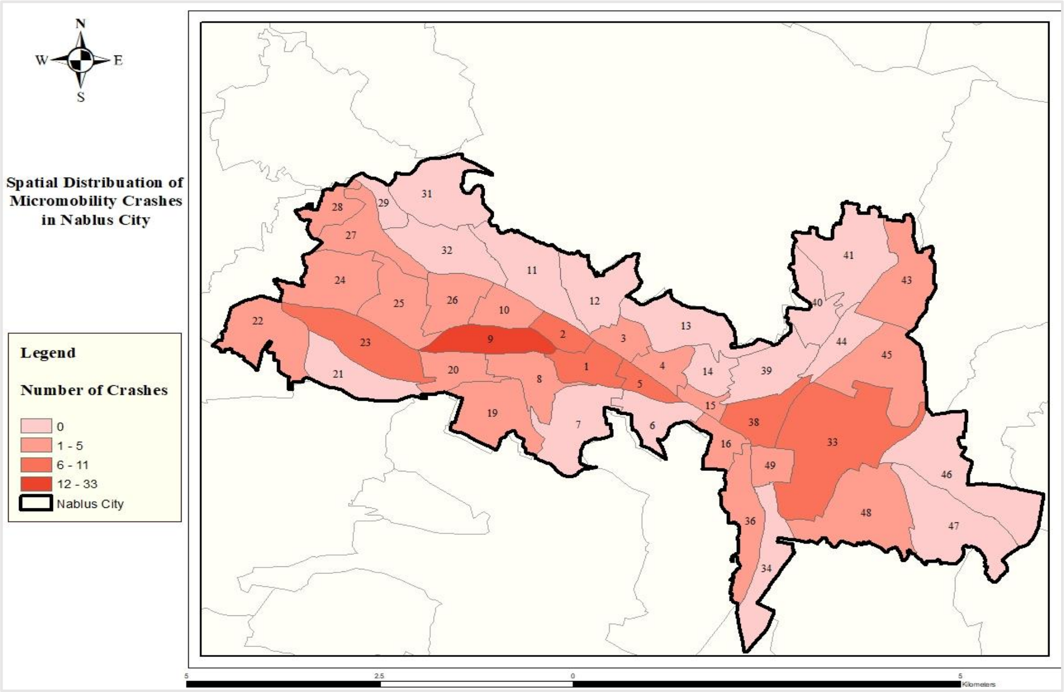
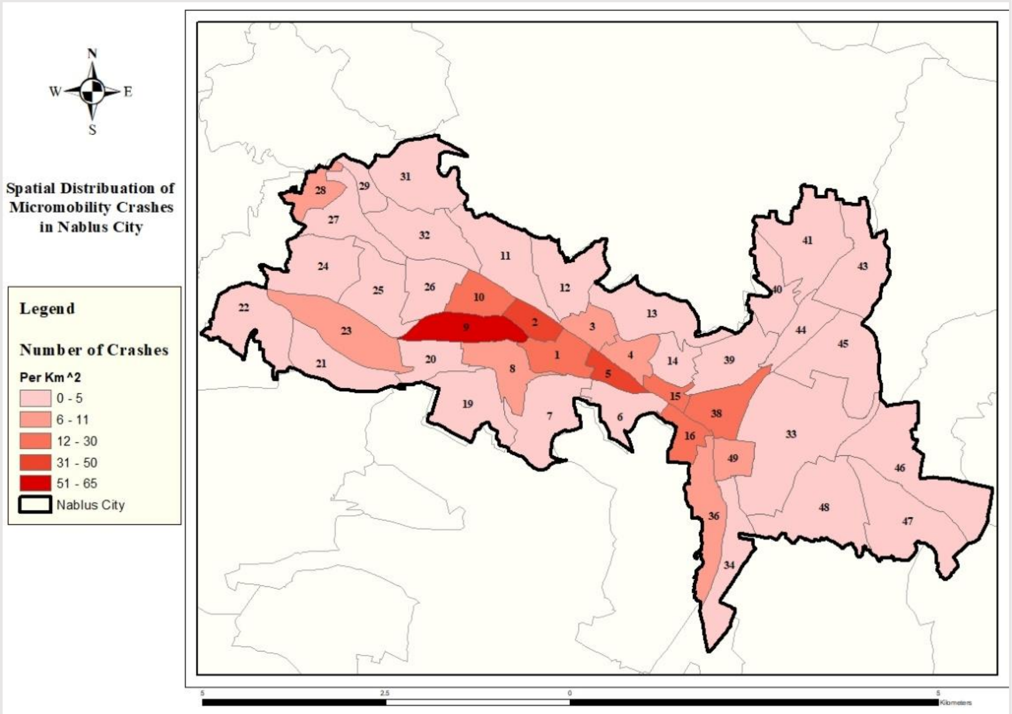


Figure D.10

Spatial Distribution of Total Micromobility Crashes per km2 in Nablus City During the Study Period (2018–2022)



Appendix E

Micromobility Distribution and Characteristics

Figure E.1

Daily Distribution of Micromobility During the Study Period

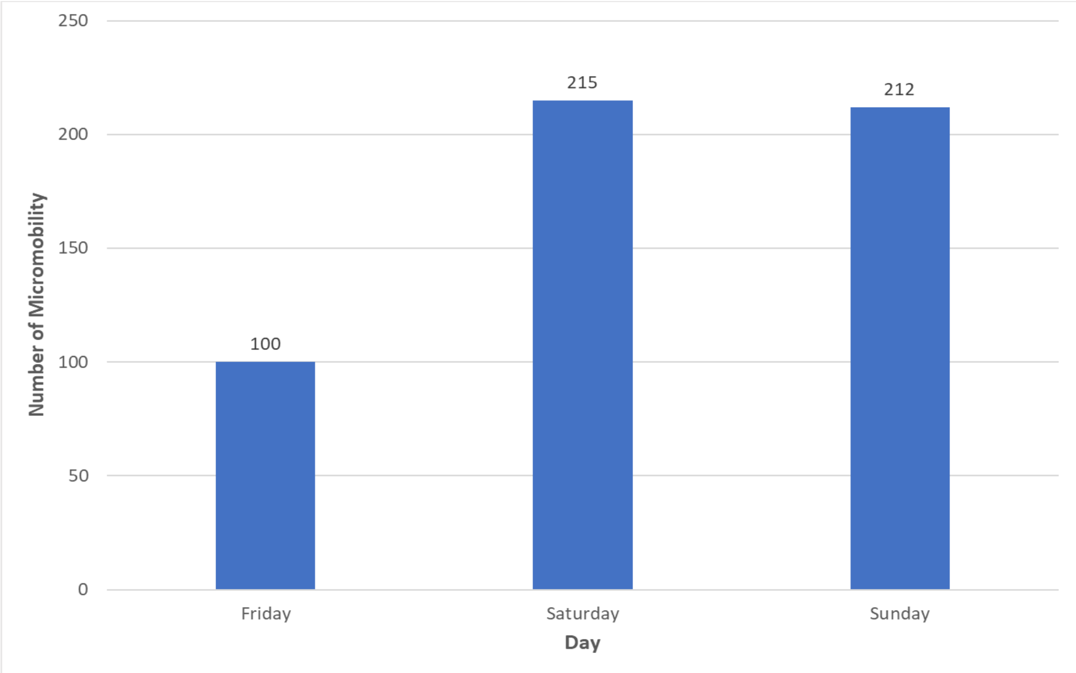


Figure E.2

Hourly Distribution of Total Micromobility Vehicle During the Study Period (Friday, Saturday, and Sunday)

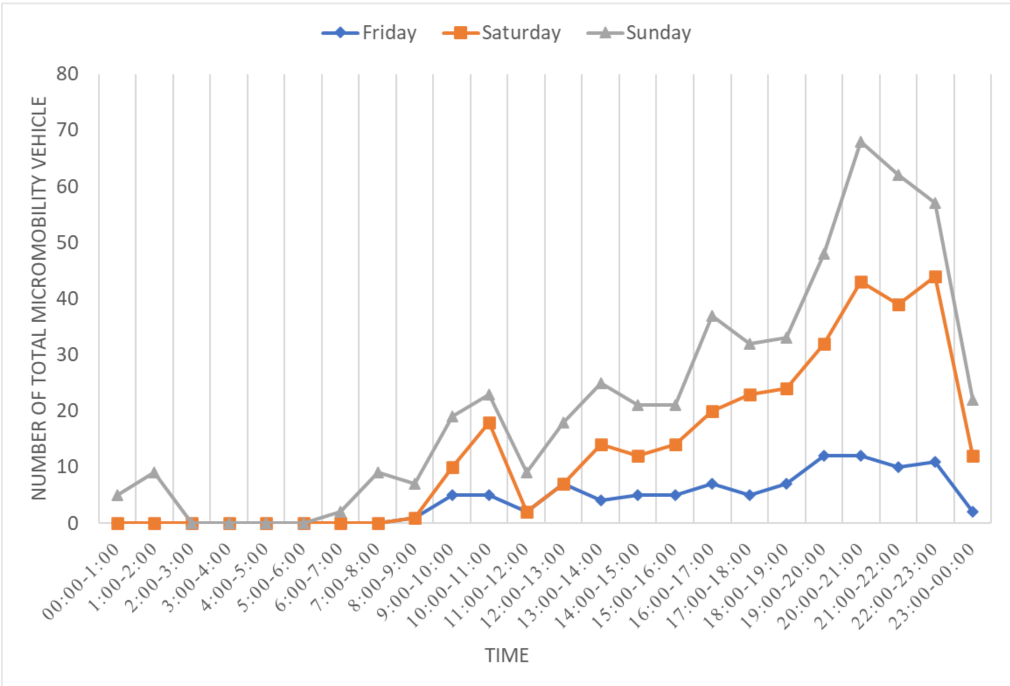


Figure E.3

Al-Badawi Intersection Micromobility Red Light Crossing Behavioral Violation During the Study Period (Friday, Saturday, and Sunday)

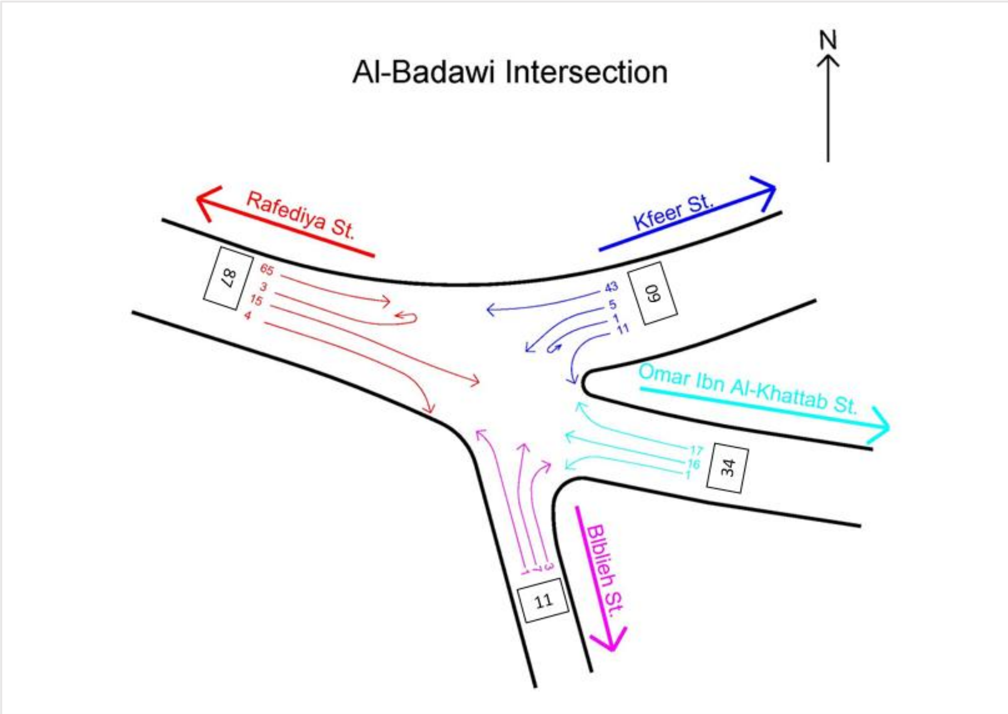
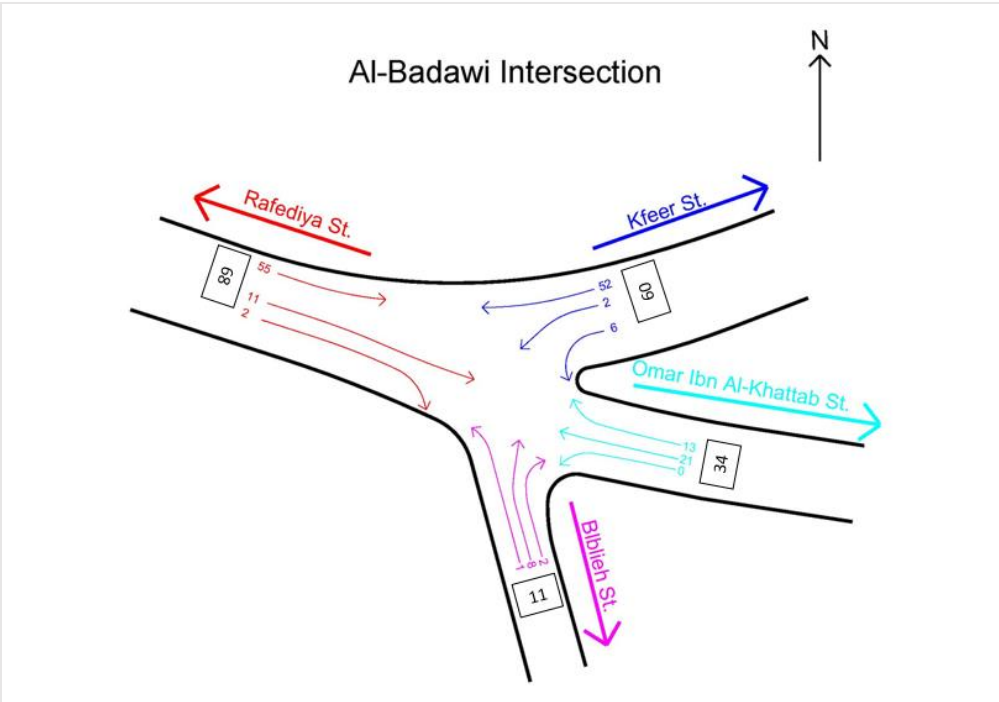


Figure E.4

Al-Badawi Intersection Micromobility Wrong/Illegal Overtaking Behavioral Violation During the Study Period (Friday, Saturday, and Sunday)



Appendix F

Results of ANOVA tests

Table F.1a

Results of Behavioral Violations with Time ANOVA Test on Friday

ANOVA					
	Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	1.170	2	0.585	1.260	0.288
Within Groups	45.020	97	0.464		
Total	46.190	99			

Table F.1b

Results of Behavioral Violations with Time ANOVA Test on Saturday

ANOVA					
	Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	2.247	2	1.124	4.058	0.019
Within Groups	58.711	212	0.277		
Total	60.958	214			

Table F.1c

Results of Behavioral Violations with Time ANOVA Test on Sunday

ANOVA					
	Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	1.109	2	0.554	0.895	0.410
Within Groups	129.434	209	0.619		
Total	130.542	211			

Table F.1d

Results of Behavioral Violations with Time ANOVA Test on All days

ANOVA					
	Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	4.884	2	2.442	4.442	0.012
Within Groups	288.068	524	0.550		
Total	292.953	526			

Table F.2a

Results of Certain Behavioral Violations with Peak Time ANOVA Test on Friday

ANOVA					
	Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	1.995	2	0.997	2.153	0.135
Within Groups	12.973	28	0.463		
Total	14.968	30			

Table F.2b

Results of Certain Behavioral Violations with Peak Time ANOVA Test on Saturday

ANOVA					
	Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	0.058	2	0.029	0.111	0.896
Within Groups	8.177	31	0.264		
Total	8.235	33			

Table F.2c

Results of Certain Behavioral Violations with Peak Time ANOVA Test on Sunday

ANOVA					
	Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	4.514	2	2.257	4.210	0.020
Within Groups	29.486	55	0.536		
Total	34.000	57			

Table F.2d

Results of Certain Behavioral Violations with Peak Time ANOVA Test on All days

ANOVA					
	Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	2.993	2	1.497	3.063	0.050
Within Groups	58.633	120	0.489		
Total	61.626	122			

Table F.3a

Results of Certain Behavioral Violations with East & West Approaches ANOVA Test on Friday

ANOVA					
	Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	0.611	1	0.611	1.658	0.202
Within Groups	28.376	77	0.369		
Total	28.987	78			

Table F.3b

Results of Certain Behavioral Violations with East & West Approaches ANOVA Test on Saturday

ANOVA					
	Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	0.396	1	0.396	1.642	0.202
Within Groups	44.362	184	0.241		
Total	44.758	185			

Table F.3c

Results of Certain Behavioral Violations with East & West Approaches ANOVA Test on Sunday

ANOVA					
	Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	1.109	1	1.109	2.118	0.147
Within Groups	88.517	169	0.524		
Total	89.626	170			

Table F.3d

Results of Certain Behavioral Violations with East & West Approaches ANOVA Test on All days

ANOVA					
	Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	0.433	1	0.433	0.955	0.329
Within Groups	196.540	434	0.453		
Total	196.972	435			

جـــامعــــة النجاح الوطنية

كليـــة الدراســـــات العليــــا

تحليل السلامة لمركبات التنقل الدقيق:

مدينة نابلس كحالة دراسية

إعداد

أُسيد ماجد حمدان سلمان

إشراف

أ.د. سمير أبو عيشة

قدمت هذه الرسالة استكمالا لمتطلبات الحصول على درجة الماجستير في هندسة الطرق والمواصلات، من كلية الدراسات العليا، في جامعة النجاح الوطنية، نابلس– فلسطين.

2024

تحليل السلامة لمركبات التنقل الدقيق: مدينة نابلس كحالة دراسية

إعداد

أُسيد ماجد حمدان سلمان

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أ.د. سمير أبو عيشة

الملخص

خلفية الدراسة: مع تزايد انتشار مركبات التنقل الدقيق في الآونة الأخيرة كوسيلة نقل جديدة في فلسطين، ومع زيادة أعداد حوادث المرتبطة بوسيلة النقل هذه، إلى جانب عدم وجود إطار لحوكمة وتنظيم استخدام هذه المركبات، فإنه من المهم دراسة وتحليل السلامة المرورية لمستخدمي هذه الوسيلة.

أهداف الدراسة: الهدف الرئيسي من الدراسة هو تسليط الضوء على خصائص حوادث مركبات التنقل الدقيق، وفهم الأنماط والأسباب الكامنة وراء وقوع مثل هذه الحوادث. علاوة على ذلك، تسعى الدراسة إلى فهم سلوك مستخدمي وسيلة النقل هذه. وتهدف الدراسة أيضاً لتقديم توصيات وإجراءات مضادة مقترحة تعمل على تحسين السلامة المرورية لمستخدمي مركبات التنقل الدقيق.

المنهجية: تم جمع بيانات حوادث مركبات التنقل الدقيق من شرطة مرور نابلس خلال فترة الدراسة (2018 إلى 2022). وتمت عملية التحليل مكانياً وزمانياً بناءً على خصائص كل حادث. واعتماداً على موقع الحادث، تمت دراسة الحوادث مكانياً لتحديد المواقع الأكثر تكراراً لوقوع الحوادث. كما تم تصميم وتوزيع استبيانة على عينة من مستخدمي مركبات التنقل الدقيق، ثم تم تحليلها لمعرفة سلوك مستخدمي هذه المركبات، ومستوى الوعي بالسلامة المرورية لديهم. كما تمت ملاحظة سلوك مستخدمي مركبات التنقل الدقيق باستخدام كاميرات تم تركيبها عند أحد التقاطعات الهامة في المدينة. علاوة على ذلك، تم اختبار طريقة تحليل التباين الأحادي (ANOVA) باستخدام برنامج (SPSS) للتحقق مما إذا كانت هناك فروقات ذات دلالة إحصائية بين خصائص سلوك مستخدمي مركبات التنقل الصغيرة والمخالفات التي يرتكبونها. وأخيراً، تقديم التوصيات واقتراح الاجراءات اللازمة لتحسين سلامة مستخدمي مركبات التنقل الدقيق.

نتائج الدراسة: أظهرت نتائج الدراسة أن العدد الإجمالي لحوادث مركبات التنقل الدقيق المسجلة في مدينة نابلس هو 138 خلال

فترة الدراسة (2018 إلى 2022). وكانت الحوادث الأكثر شيوعاً في فصل الصيف وشهر أيلول ويوم الاثنين ومن الساعة 17:30 إلى 18:30. وتعتبر الإصابات الناجمة عن حوادث مركبات التنقل الدقيق للفئة العمرية (12 إلى 18 سنة) هي الأعلى. وكانت القيادة بعكس اتجاه السير هي السبب الأكبر لوقوع الحادث، وشكلت ما نسبته 20.3% من إجمالي حوادث مركبات التنقل الدقيق. وقد وقعت ثلاث حوادث مميتة خارج المدينة في محافظة نابلس. وقد بيّنت نتائج دراسة سلوك مستخدمي مركبات التنقل الدقيق بعد ملاحظة 527 مستخدماً لوسيلة النقل هذه الذين عبروا التقاطع المحدد خلال فترة الدراسة على مدى ثلاثة أيام أن عدد المخالفين بلغ 392، بنسبة 74.4%.

الاستنتاجات من الدراسة: هناك نسبة مرتفعة من زيادة أعداد حوادث مركبات التنقل الصغيرة في مدينة نابلس خلال الخمس سنوات في فترة الدراسة، حيث بلغت الزيادة بمعدل 37% سنوياً، وتعود الأسباب الرئيسية لهذه الحوادث كما تم استنتاجها من سجلات شرطة المرور إلى السلوك الخاطئ في استخدام هذا النوع من المركبات، وقد تأكد ذلك من خلال النسبة المرتفعة للمخالفين من مستخدمي مركبات التنقل الصغيرة حسب ما لوحظ خلال الثلاثة أيام التي تم رصدها على أحد التقاطعات الخطرة الممثلة. هذا ولا توجد أي أنظمة مطبقة خاصة بتسجيل ملكية أو تشغيل مركبات التنقل الدقيق، كما لا يتم القيام بأي إجراءات رادعة لتقليل المخالفات المرتكبة من قبل مستخدمي هذه المركبات.

الكلمات المفتاحية: السلامة المرورية لمركبات التنقل الدقيق؛ خصائص الحوادث المرورية، التحليل المكاني للحوادث المرورية، سلوك مستخدمي مركبات التنقل الدقيق، نابلس، فلسطين.