An-Najah National University

Faculty of Graduate Studies

STUDY OF MOTORCYCLE SAFETY IN NABLUS CITY

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Dedication

To my parents who have been my source of inspiration, support, and guidance. You have taught me to be unique, determined, to believe in myself, and to always preserve. I am truly thankful and honored to have you as my parents. Also, to my supervisor Prof. Sameer Abu-Eisheh who has been my mentor and guide.

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I owe this thesis to my parents and my family members who always stood by me and provided strength in perusing this work.

Declaration

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

STUDY OF MOTORCYCLE SAFETY IN 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: Mohammed Kamel Abdul Hadi

Signature: 

Date: 25/4/2023

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Abstract

Motorcycle safety needs to be studied in the light of the increasing use of this mode in Palestine. Nablus Governorate witnessed high increase in the rate of licensed motorcycles during 2015-2021, and, therefore, it was selected to study motorcycle safety.

The aim of this research is to highlight the motorcycle crashes characteristics, generate crash profile for Nablus City, and study the behavior of motorcyclists. This leads to propose countermeasures to improve motorcycle safety.

Motorcycle crash data were obtained from Nablus Traffic Police Department covering the period from January 2019 to November 2021 for the city of Nablus. Additional data were collected from the Palestinian Central Bureau of Statistics. Motorcycle crash profile is generated. Spatial analysis is conducted to generate motorcycle crash maps to identify the hazardous zones. Using footage from installed cameras at a representative intersection, the behavior of motorcyclists at the intersection is observed. Analysis-of-Variance Test is then used to determine if there are any significant differences between several aspects related to motorcyclists' behaviors.

The outcome of the research illustrates that May and September, Saturday, and the hour 15:00-16:00 were the most frequent and temporal during that period of time. The most frequent reason of motorcycle crashes was unsecured changing lanes. The most frequent motorcycle crashes zone is Al-Qirawan in Rafedia. Analysis of the behavior at a key intersection there shows that 70% of motorcyclists committed at least one behavioral violation. The study showed that the percentages of those with legal behavior and wearing helmets were only 12.7% and 5.1% of total, for the delivery and private use motorcyclists, respectively.

Based on the analysis, there is lack of respect of traffic regulations by motorcyclists, and there is no effective enforcement to deter violators. More efforts need to be exerted by traffic police for strict enforcement of traffic regulations and motorcyclists' violations. Proper education and awareness for the motorcyclists are needed.

Keywords: Motorcycle crashes; crash profile; crash spatial analysis; motorcyclists' behavior; Nablus; Palestine.

Chapter One

Introduction

1.1 Introduction

Nearly half of the world road deaths are vulnerable road users. In most of low and medium income countries, the majority of road users are vulnerable, including pedestrians and motorized two or three wheelers, who face more risk because they don't have outer frame to protect them based on the most recent published World Health Organization (WHO) Global Status Report of Road Safety [1]. These types of road user groups have been neglected during the planning of land use and road construction, and therefore, these road user groups are facing risks when they use the road.

Road safety may not be seriously and sufficiently considered especially in developing countries. There are 1.35 million people killed in road traffic crashes every year based on the most recent published WHO Global Status Report of Road Safety, which shows also that in the Eastern Mediterranean Region, the rates of road traffic deaths was of the highest worldwide, reaching 18 per 100,000 population in 2018 [1].

Safety studies are important to be conducted to assess and enhance road safety. The general aim of safety studies is to highlight the risks that road users face when using transportation modes and propose countermeasures and solutions to decision makers in order to minimize the risks that road users face.

Safety studies include generating crash profiles, analyzing crashes spatially and temporally, and studying the behavior of the road users. By doing so, the factors and causes that contribute to the crashes can guide to set proper policies, strategies, and actions to enhance traffic safety.

Motorcyclists are among vulnerable road user groups in terms of road safety. Motorcyclists are inherently susceptible to more injuries than car occupants due to the lack of protection. The motorcycle mode should be studied carefully because motorcyclists face risks when the transportation system is not sufficiently safe, as well as due to their own behavior, which in many cases can be described as irresponsible.

Although motorcycles sometimes are used for business purposes, such as for the delivery of food or goods. Many people, especially an increasing share of the youth, equate riding a motorcycle with fun and freedom, but sometimes such freedom comes with a cost.

Many studies involving the generation of profiles for motorcycle crashes have been conducted worldwide. Locally, there were no studies on motorcycle safety, nor on developing motorcycle crash profiles. Even when conducting traffic counts, the motorcycle mode is considered as part of "other modes".

The most recent published report by the Palestinian Central Bureau of Statistics (PCBS) on road traffic crashes in Palestine stated that there is a total of 14,105 road traffic crashes, from which 133 fatalities occurred in 2021 [2]. Hebron Governorate had the highest number of fatalities, which reached 43, followed by Nablus Governorate, with 20 fatalities in 2021. There is no published data concerning motorcycle crashes in the report.

Therefore, there is a need to conduct a safety study on motorcycle safety in Palestine. Nablus City was taken as the location of the case study, in order to generate related crash profile, conduct spatial analysis, and study the behavior of motorcyclists in order to assess motorcyclists' safety, and then to enhance safety of the motorcycle transportation mode.

1.2 Significant of the Study

Motorcycles in Palestine are in a growing pattern as can be noticed based on the publications of the PCBS [2-8]. This growth is expected as has been the case in many countries around the world, especially developing countries, because of the willingness of a considerable share of the youth, at specific, to have more mobility, and as part of socioeconomic and development needs especially in the urban areas. This mode is now more attractive in many cities and towns because more shops and restaurants are using motorcycles in their delivery system, especially after the beginning of the COVID-19 pandemic.

Motorcycles in the past three years began to be an important mode of transportation in Palestine beside other passenger modes of transportation. The analysis of motorcycle crashes can be challenging in this regard. Only few studies have been conducted regionally, but none locally. The importance of the study stems from the fact that despite

the percent of motorcycles and their involvement in crashes have increased, no studies have been conducted in Palestine to investigate this.

The aim of this thesis is to characterize the motorcycle crashes and study the behavior of motorcyclists in order to enhance safety of motorcyclists. This will be based on collected data of statistical and spatial analysis. This is important to be done in order to identify the hazardous location of crashes to observe the behavior of motorcyclists. The results will facilitate identifying the countermeasures and policies needed to enhance the safety of the motorcyclists.

1.3 Study Area: Nablus as a Case Study

In order to conduct a study on motorcycle safety in Palestine, Nablus City is selected as the case study. Nablus City is the major city in the north of West Bank, with an estimated population of 171,150 in 2022 [9].

In Nablus City, there is considerable growth in the number of vehicles. This is one of the reasons that causes an increase in travel delay for road users. Some motorcyclists consider the motorcycle mode as an affordable mode, which might provide a solution to the delay and traffic congestion problems. Many households consider motorcycle delivery as a way to avoid travel delay to get their goods. The motorcyclists sometimes do wrong behaviors to avoid delays. Another reason for using motorcycles by the youth is for having fun.

Table 1.1 shows the total number of licensed and new licensed vehicles per type in the West Bank for each governorate, including Nablus Governorate, as published by the PCBS for 2021 [2].

From Table 1.1a, the percent of licensed motorcycles formed about 0.37% from all the licensed vehicles in the West Bank in 2021, but in Nablus Governorate it was found to be 0.49%, which is more than that of the West Bank by about 32%. As for Nablus Governorate, it has 18.2% of all the motorcycles in the West Bank.

The percent of new licensed motorcycles in the West Bank formed 1.00% of all vehicles as found from Table 1.1b. The percentage of new licensed motorcycles in Nablus Governorate was found to be 1.64% from all new licensed vehicles, which is considerably higher than the respective percentage in the West Bank. Nablus Governorate came in second place after Ramallah & Al-Bireh Governorate in the number of new licensed

motorcycles with a percentage of 20.12% of all. It is to be noted that although the newly licensed vehicles in 2021 formed 10.3% of the total number of vehicles, while the newly new licensed motorcycles in 2021 formed 27.5% of the total number of motorcycles.

1.4 Objectives of the Study

Study of safety of motorcycles will be a main goal in this study. The research objectives for this study include:

1) Collect crash data to study the motorcycle mode safety status in Nablus City, and generate proper safety profile.
2) Investigate the main factors and reasons affecting motorcycles crashes.
3) Identify the hazardous locations where motorcycle crashes frequently occur in Nablus City.
4) Study the behavior of motorcyclists in a representative location in Nablus City.
5) Provide recommendations and propose countermeasures and policies to improve motorcycle safety, enhance the behavior of motorcyclists to minimize motorcycle crashes, and reduce the risks that motorcyclists face.

Table 1.1a

Number of Licensed Vehicles per Type for West Bank Governorates in 2021

Governorate	Private Cars	Taxis	Motorcycles andMoped	Private Buses	Public Buses	Trailers	Agricultural Tractors	Road Tractors	Trucks and Commercial Cars	Other Vehicles	Total
West Bank	**256248**	**9315**	**1119**	**1099**	**826**	**4235**	**732**	**30**	**26189**	**433**	**300226**
Jenin	27555	1055	80	124	140	1110	144	7	3727	9	33951
Tubas & Northern Valley	1786	83	3	20	20	17	36	2	168	2	2137
Tulkarm	17040	1022	28	105	44	97	46	5	1096	7	19490
Nablus	**35485**	**1879**	**204**	**189**	**88**	**1111**	**72**	**2**	**2485**	**24**	**41539**
Qalqiliya	5432	354	50	42	10	44	37	1	1071	2	7043
Salfit	2394	78	10	16	2	15	4	1	134	5	2659
Ramallah & Al-Bireh	98805	2475	541	268	200	1460	114	1	9194	357	113415
Jericho & Al Aghwar	2383	129	118	19	45	25	47	1	319	2	3088
Jerusalem	1122	31	6	40	15	7	0	0	166	0	1387
Bethlehem	22260	726	43	63	52	36	27	3	1553	5	24768
Hebron	41869	1483	33	209	210	305	192	7	6232	15	50555
Unclassified	117	0	3	4	0	8	13	0	44	5	194

Table 1.1b

Number of New Licensed Vehicles per Type for West Bank Governorates in 2021

Governorate	Private Cars	Taxis	Motorcycles and Moped	Private Buses	Public Buses	Trailers	Agricultural Tractors	Road Tractors	Trucks and Commercial	Other Vehicles	Total
West Bank	**25228**	**807**	**308**	**153**	**119**	**1179**	**123**	**3**	**2447**	**416**	**30783**
Jenin	3108	88	17	14	25	314	14	0	372	13	3965
Tubas & Northern Valley	260	10	3	5	5	10	7	0	31	0	331
Tulkarm	2186	117	15	19	5	10	8	0	100	8	2468
Nablus	**2761**	**152**	**62**	**30**	**11**	**547**	**13**	**0**	**185**	**7**	**3768**
Qalqiliya	352	53	7	6	1	1	5	1	64	15	505
Salfit	257	19	3	5	1	2	1	1	32	0	321
Ramallah & Al-Bireh	10621	200	161	22	36	232	23	0	807	292	12394
Jericho & Al Aghwar	111	13	23	2	4	0	7	0	45	7	212
Jerusalem	55	7	3	12	1	1	0	0	21	2	102
Bethlehem	1856	55	10	6	5	3	5	0	129	24	2093
Hebron	3661	93	4	32	25	59	40	1	661	48	4624

1.5 Methodology

1.5.1 Introduction

The methodology that was used to investigate motorcycle safety implies collecting crashes data, generating motorcycle crash profile, conducting spatial analysis of motorcycles crashes, and studying the behavior of motorcycle at a representative hazardous location. It also included making interviews with several ministries and agencies, such as the Ministry of Transportation, the Ministry of Health, Nablus Municipality, and Nablus Traffic Police Department.

After generating crash profile for the three-year study period (2019-2021), and conducting spatial analysis, proper countermeasures would be proposed.

When the crashes were analyzed spatially for Nablus City by splitting the city into census zones, the zones with high crash rates would then be classified to identify the hazardous ones.

The study of motorcyclists' behavior would highlight the main actions that motorcyclist takes while driving, which makes him/her susceptible to a traffic crash. Also, it would highlight the violations that motorcyclist does, and therefore, facilitating the proposal of countermeasures that could enhance motorcycle safety.

Interviews were conducted with the representatives of several ministries, agencies, and stakeholders in order to understand the reality of motorcycle mode, especially the safety-related aspects, the difficulties the motorcyclists face, as well as to know the deficiencies the motorcycle mode faces.

The methodological approach followed in this study is presented hereafter. This includes desk and internet research, study area identification, collection of the required data, and finally analysis of the collected data.

1.5.2 Literature Review

Desk studies and internet research were conducted by reviewing existing publications, studies, and literature related to motorcycles safety, generating motorcycle profiles, generating crash maps, and studies on the behavior of motorcyclists using the roads.

1.5.3 Study Area

As indicated earlier, Nablus City was selected as the study area, where there had been relatively high numbers of motorcycles, as well as new licensed motorcycles. Crash analysis was done in Nablus City based on the location, the time, and the reason of motorcycle crashes, as collected from Nablus Traffic Police Department. From the spatial analysis, hazardous locations were defined. An intersection in one of these hazardous zones was selected for further detailed study of the motorcyclists' behavior. Cameras were installed at that intersection to study the behavior of motorcyclists and to highlight the problems that motorcyclists face when crossing the intersection.

1.5.4 Data Collection

Data were collected on motorcycle crashes for Nablus City from the Traffic Police Department for the study period of 2019-2021 [10–12]. This is in addition to the general data on motorcycle registrations from published reports of PCBS in 2021 [2]. The detailed crash data would help to analyze the motorcycle safety conditions in the study area. These data include year, month, day, hour, location, type of injury, and the reason of crash.

Data on motorcyclists' behavior at the selected intersection were collected using cameras, installed especially for the purpose of the study. The study period of investigating the behavior of motorcyclists was selected to cover three consecutive days. A Friday was selected as a weekend vacation day, where there is less traffic than in any other day of the week, therefore, the behavior of motorcyclists need to be studied at low traffic volume conditions. Saturday was selected because the city attracts visitors from outside and employees are off, and where more shopping and entertainment activities are observed. Sunday was selected as a normal weekday, with observed peak traffic periods. Motorcyclists' behavior was studied on this day when institutions and business activities are in operation.

During the motorcyclists behavior study period (Friday, Saturday, and Sunday), for every motorcycle that crossed the intersection, several items were observed. General aspects were observed and recorded including day, hour, wearing helmet, presence of rear passenger, and the direction of motorcycle. In terms of behavioral aspects, violations of motorcycles were recorded, including overtaking, red light crossing, wrong mingling, driving in the opposite direction, and making a wrong U-turn.

1.5.5 Interviews

This section describes the interview process. Representatives of specific relevant entities were interviewed on motorcycles related aspects. For example, the Ministry of Transportation (MOT) representative was interviewed to understand their role in setting policies and regulations related to motorcycles. The Ministry of Health (MOH) representative was interviewed in order to understand the injury related aspects concerning motorcyclists' crashes. An insurance firm representative was interviewed, to understand the insurance and cost issues related to motorcyclists. Nablus Municipality Traffic Engineer was interviewed to understand the challenges concerning redesign of roads, considering motorcycles. Nablus Traffic Police Department representative was interviewed to understand what kind of violations that motorcyclists do more often, and the ticketing procedure. Finally, Nablus Chamber of Commerce and Industry (CCI) representative was interviewed to understand the effect of motorcycles on the economic status in the city.

1.5.6 Analysis

This involves conducting various analyses on the data that were collected from Nablus City Traffic Police Department and from the site cameras, in order to study and evaluate the crash profile of motorcyclists in Nablus City. Generating crash profile for the data extracted was based on the annual number of crashes, monthly number of crashes, days of the week, the causalities (if any), the gender of drivers and causalities (if any), and finally the reasons of crashes.

Nablus City was divided into census zones, and this was considered in the spatial analysis to highlight the hazardous zones based on distribution of crashes by zones, as well as by area and zonal population. This had helped to select the location in order to study the behavior of motorcyclists using the cameras at that location.

Analyses on collected data from video recordings were conducted to know the distribution of motorcycles in each day. More importantly, this was used to figure out what violations motorcyclists do when crossing the intersection. ANOVA Test was used to determine if there are significant differences between different violations done by motorcyclists between days or within the same day, between the two types of motorcycles use and within hours of a day.

1.6 Thesis Structure

This thesis is composed of four chapters, including Chapter One that introduces the subject of motorcycle safety in Nablus City. Chapter Two reviews literature related to motorcycle safety, including their involvement in crashes, the outcome of crashes, and the behavior of motorcyclists prior to crash. Chapter Three shows how the required data was collected from Traffic Police Department and extracted from the cameras that were installed at the representative intersection, and how these data have been analyzed. Finally, Chapter Four summarizes the results of the thesis, highlights the conclusions, and states the recommendations to improve motorcycle safety.

Chapter Two

Literature Review

2.1 Introduction

Due to the importance of the topic, many studies have been presented in developed as well as developing countries, but none has been done in Palestine. In this chapter, previous studies are discussed. These studies include general information about motorcycles crashes and safety profiles, analysis of motorcycle crashes spatially, and finally study of the behavior of motorcyclists using the roads.

2.2 Developed Countries

- **United States of America**

In the USA, the Federal Highway Administration study in 2019 [13] published the percent of motorcyclists' crash deaths to total crashes from all modes of travel varied among the states, and ranged between 6% in Mississippi and 30% in New Hampshire.

According to the another publication of the National Highway Traffic Safety Administration [14], there were 35,766 fatal motor vehicles crashes in the USA in 2020, where 25,536 deaths occurred. This resulted in 8.0 deaths per 100,000 people and 0.8 deaths per 100 million miles traveled. There was a total of 5,579 motorcyclists died in crashes in 2020 in the USA. The study shows that motorcyclists' deaths fluctuated since the start of the 1980s but continued to increase recently. Motorcycle deaths accounted for 14% of all motor vehicle crash deaths in 2019, which were almost doubled during the past two decades.

Florida Department of Transportation in 2018 investigated motorcycle crashes statewide, concerning geometric design impact on motorcycle crashes [15]. From the state's Department of Transportation's Roadway Characteristics Inventory Database, they identify 10,858 horizontal curves across the state. Data on pavement, geometry, curvature, and past crashes involving motorcycles were gathered from a variety of data sources and compared to the identified curves. Curves were present in 57% of fatal single motorcycle crashes, 36% of incapacitating injury single motorcycle crashes, and 26% of non-incapacitating injury single motorcycle crashes, despite only making up 5.8% of the

total mileage of Florida's roads. The issue of motorcycle safety is more serious on rural curves, especially on rural two-lane highways, due to the prevalence of horizontal curves on rural roads with comparatively high speeds and low safety standards. This research found that on rural two-lane roads, single-motorcycle crashes were 1.62-4.92 times more likely to occur on horizontal curves than on tangent segments.

- **Europe**

Theofilatos and Yannis investigated the patterns of road safety attitudes and behaviors of motorcyclists in 18 countries in Europe and Israel on the basis of the results of the pan-European questionnaire-based survey, carried out in late 2010 [16]. Throughout a three-year period, they tried to determine whether the attitudes, behaviors, and other traits of motorcyclists were linked to their involvement in crashes, where victims, including the rider, suffered injuries and needed medical attention. They apply means of principal component analysis on 38 survey variables to identify different aspects of motorcyclists' behavior, such as the motivations for riding a motorcycle, the usage of alcohol while driving, perceived risk factors, and risk-taking behavior. Then, a binary logistic regression model was used to correlate attitudes and behavior with reported involvement in prior crashes. It was discovered that younger motorcyclists and those with risk-taking attitudes and behaviors are more likely to have been in crashes.

Cordellieri et al. examined whether young student drivers and riders had different behaviors about difficulties with road safety, driving habits in particular imagined situations, risk perception, and risk concern [17]. A significant sample of participants in the study was taken from six different European nations. The results demonstrated that behaviors regarding traffic safety regulations are the same for both car drivers and motorcyclists. The willingness of motorcyclists to commit violations were reportedly higher than that of car drivers in some circumstances. Also, although while car drivers and motorcyclists perceived the same level of risk while driving, there were variances in the two groups' level of concern for that risk, with motorcyclists reportedly been less worried than drivers of cars about the possibility of a road crash. This could increase the likelihood of unsafe driving behavior in motorcyclists compared to car drivers.

- **Australia**

Motorcycle Rider Behavior Questionnaire (MRBQ) was created by Sakashita et al. to examine behavioral aspects impacting motorcyclists' crash risks through self-reports, including mistakes and violations as well as the use of motorcycle safety equipment [18]. The study examined and paired experienced riders' self-reported crashes in the UK and Turkey before determining whether the MRBQ would be applicable to a community of motorcyclists in Australia. The study included novice motorcyclists (N = 1305) from the State of Victoria. Confirmatory factor analyses revealed that the data from motorcycle riders in the UK and Turkey did not fit with the previously identified factor models.

Motorcyclists are overrepresented in traffic fatalities in Australia, according to Stephens et al. [19]. Motorcycle registrations made up only 4.5% of the total registered vehicle fleet, despite the fact that riders accounted for 18% of all fatalities on the road. The MRBQ was created with the goal of studying the behaviors that are most likely to be linked to crash risk. They consist of actions that are either deliberate (such as defying traffic or speed laws or performing stunts) or unintentional (such as mistakes in motorcycle control or traffic behavior), as well as defensive actions involving the use of safety equipment. The study's objectives were to identify which MRBQ characteristics are linked to crash involvement and to determine the best structure for a modified version of the MRBQ to be conducted to a representative sample of Australian motorcyclists. They collected data from 470 riders, 89% of whom were men. Riders generally reported using protective gear frequently and acting in a relatively safe manner, with aberrant behavior occurring only seldom. Although rare, speeding offenses and mistakes with the motorcycle's control raised the likelihood of a near-crash, while stunt driving was linked to higher crash involvement risks. To address these particular habits, interventions and preventative measures were found.

The purpose of the study of Budd et al. was to assess present and potential motorcycle-related road trauma in order to inform future research and successful safety actions [20]. For the years from 2005 to 2014, information on the registration of cars and motorcycles as well as police-reported crash data from South Australia, Western Australia, Queensland, Victoria, and New South Wales was gathered. In order to assess trends for injury crashes, registered vehicles, and crash rates per registered vehicle, these

data sources were integrated. The likelihood of a fatality or major injury outcome given involvement in an injury crash was also taken into account. According to the study's results, the average crash risk per registered motorcycle was 1% per year for injury crashes and 0.5% per year for fatal or serious injury crashes, with fatal and serious injuries occurring in just under half of all reported motorcycle injury crashes, which is roughly twice the rate for cars.

- **Italy**

In Florence, Italy, Piantini et al. studied 40 powered two-wheeler (PTW) to other vehicle urban crashes to identify crash configurations and associate injuries with the cause [21]. Each crash had at least one rear passenger who was critically hurt. According to the results, a head-on slide collision (45%) was the most common crash configuration. The frontal portion of the PTW was used by the motorcyclists to hit another vehicle in 75% of the cases. Motorcyclists lost control and fell before the crash formed 22%. The most severely hurt parts of the body were the head and thorax. The front glove box of the scooter was responsible for a significant portion of injuries. The results made it possible to pinpoint potential safety devices or vehicle component redesigns that could be used to lessen injuries in this subset of crashes. The data analysis produced a number of potential actions that could improve motorcycle safety. While some technology solutions were being researched, other tools or systems may be created and evaluated using crash data from actual crashes. In particular, it was determined that PTW/vehicle interaction needed to be improved in order to prevent the motorcyclist from coming into contact with those car portions that were most dangerous.

2.3 Developing Countries

- **Brazil**

By analyzing a sample of 285 motorcycle crash victims in Sao Paulo, Brazil, Greve et al. [22] analyzed the parameters related to traffic motorcycle crashes. Details about the victims' conditions, security measures, and road and vehicle conditions were gathered from 24-hour emergency service shifts. The victims were mostly young men (92%); 23% worked on motorcycles (on average for 8 hours per day); 45% had owned motorcycles for less than two years; 77% were licensed motorcycle drivers; 33% had less than four years of experience; and 31% had taken a defensive driving course. The majority (90%)

wore helmets, although only 18% did so with boots and a jacket. In 21% of the victims, there were positive alcohol (7%) and drug (14%) tests. The majority of crashes happened as a result of careless behavior (88%), during the day (67%), and in dry weather (94%). The driver of the other involved vehicle was 51 percent of the time the crash's primary cause. According to the study's results, young adult male motorcyclists who use their motorcycles for transportation and disregard safety constitute the majority of those involved in collisions. Also, the results of this study showed that the primary causes of motorcycle crashes were inadequate or nonexistent qualifications, drug usage, recklessness, speed, poor visibility, and a lack of security.

- **Indonesia**

Rahmawati and Widyanti explored the differences between motorcyclist behavior and repetitive violation behavior in Indonesia [23]. Convenience sampling was used to choose respondents, and they were asked to complete a driving behavior questionnaire that contained 51 questions with Likert scales ranging from 1 (very often) to 6 (rarely) (never). The results of this study demonstrated that there were considerable behavioral differences between motorcyclists in rural and urban areas. In comparison to riders in rural regions, urban riders were more determined to breaking the law. This finding contradicted earlier Australian and American studies, which found that motorcyclists in rural regions tended to speed more often than those in cities. This led to the conclusion that affluent countries like Australia and the USA and underdeveloped countries behave differently when it comes to motorcyclists (Indonesia).

- **Pakistan**

Pervez et al. aimed to find the relationship between potential risk factors and injury outcomes of motorcycle crashes [24]. To investigate the variables connected to the seriousness of the motorcyclist injury, they built a random parameter logit model. The research was based on information gathered during a two-year period (2014–2015) by Karachi City, Pakistan's road traffic injuries surveillance system. The results showed that while the presence of rear passengers and motorcycle-to-motorcycle crashes were inversely related with fatalities, the summer season, weekends, nightfall, older riders, heavy vehicles, and single-vehicle collisions were positively associated with fatalities. Most noticeably, morning hours, youth riders, and female rear passengers whose

garments became caught in the wheel considerably raised the likelihood of fatal injury outcomes in the particular areas of Pakistan. This study suggested some solutions to increase motorcycle safety, including severe enforcement to limit risky conduct and speeding by motorcyclists, the establishment of designated lanes just for motorcycles, and education of female rear passengers. The study's conclusions recommended raising awareness of motorcycle riders' safety.

- **Malaysia**

In Malaysia, main roadways account for the bulk of fatal motorcycle accidents, particularly at entry points along straight road segments. In order to develop working hypotheses for a subsequent quantitative study, a qualitative observational study was conducted by Abdul Manan and Varhelyi [25] with the goal of examining the behavioral factors that may cause motorcyclists to become involved in dangerous situations at these locations. Six of the subject riders were seen leaving from a primary road's entry point. The observations were described in detail, then coding was utilized to analyze them, break them down into categories (and subcategories), and group them into themes. The study's results led to the development of several theories based on a variety of combination themes.

Abdul Manan et al. examined the effects of road characteristics, motorcyclists' riding behavior, motorcyclists' and motorcycles' characteristics on the occurrence of riding at excessive speeds using data from observations of 8,277 motorcyclists on various types of roads of the road hierarchy in Malaysia [26]. A new of software was created for data collection and analysis. Motorcycles go more quickly than other vehicles on dual carriageway principal roads with three lanes and dual carriageway collector roads with four lanes, according to a speed analysis. Generally speaking, 42.2% of the observed motorcycles traveled faster than the posted speed limit, and 28.6% of them surpassed the 85th percentile of traffic speed. To identify the parameters linked to motorcycle riders going too fast, they employed a logistic regression model. A primary road, a road with no shoulder, a motorcycle with an engine larger than 150cc, one that is not overloaded, one that is bright, a motorcycle driven by a man who is wearing a helmet and shoes, riding in the middle of the lane or shoulder, lane splitting (i.e., passing between two vehicles), and weaving between vehicles were among the fixed parameters factors.

A study by Abdul Manan et al. intended to identify the risk factors that contributed to the 9,176 fatal motorcycle accidents that occurred in Malaysia between 2010 and 2012 [27]. They employed multinomial and mixed models of motorcycle fatal crash outcomes based on estimates of the number of vehicles involved for this aim. According to the model, there were three possible outcomes for fatal motorcycle crashes: single-vehicle fatalities, motorcycle fatalities involving other vehicles, and motorcycle fatalities involving two or more vehicles. The type of road in the hierarchy, the location, the geometry of the road, the posted speed limit, the kind of road markings, the time of day, and the weather during the fatal crash were all taken into account. The estimation results indicated that the likelihood of motorcycling single-vehicle fatal crashes was increased by curve road portions, lack of road markings, smooth, rutted, and corrugated surfaces, as well as early morning hours (between 12 and 6 am).

Abdul Manan et al. investigate factors associated with red light running motorcycle (RLR-MC) behavior during their approach and crossing of signalized 3-leg and 4-leg intersections along major roads in Malaysia [28]. They chose 27 intersections with pre-timed and actuated traffic lights and observed them throughout peak and off-peak hours. According to this observation, the average RLR-MC rate was 3.61%, with the greatest RLR-MC rate ever recorded being 22% and the lowest rate ever recorded being 0.6%. Also, they concluded from their observations that there were three ways that RLR-MC may approach a signalized intersection: (1) weaving or lane splitting; (2) approaching from the middle of the lane; and (3) approaching from the left side or the shoulder. RLR-MC may pass the signalized intersection in one of three ways: (1) through an illegal maneuver (for example, an illegal U-turn, a contra-flow, or a banned left turn); (2) by halting at or before the stop line; or (3) without stopping at the stop line. Of all observations 51.15% show that most people cross the SI without stopping at the stop line. The recommendations made as a result of this study are for SI with high RLR-MC to have a sufficient traffic island, to switch SI signal type to an actuated traffic signal, and to build a traffic light pole rather than a gantry.

- **Cambodia**

Yamaguchi studied motorcycle safety in Cambodia, where a rider's license is not required for motorcycles below 125 cc [29]. Unlicensed riders were found to be involved in 73%

of traffic crash fatalities among people aged 15 to 19. Motorcycle riding is different from driving a car in that it more closely reflects the rider's expertise, making inexperienced riding considerably more strongly connected with crashes. This study suggested that motorcycle riders learn fundamental, particular riding tactics in addition to learning about traffic safety. In particular, reducing the amount of motorcycle crashes can be accomplished by requiring motorcyclists to learn and perform the three essential motorcycle riding maneuvers (breaking, leaning, and exiting). University students, teachers, and police officers received hands-on riding instruction on a pylon-based course as part of a new project to enhance riding proficiency. Participants in the program saw the possibility to become motorcycle role models while learning riding methods in a fun environment.

- **Jamaica**

There are limited data available on the prevalence of motorcycle crashes, their resultant injuries and the demand on the health care services in Jamaica [30]. Crandon et al. performed a descriptive analytical study to evaluate the extent of this problem and the need for preventative national policy measures. A prospective database was created between January 1, 2000, and January 1, 2007, and it contained demographic and medical information on all motorcycle crash victims admitted to the University Hospital of the West Indies. A data study for 270 motorcycle crash victims was done. Legislation that proposed measures to prevent motorcycle crashes and reduce the injuries that resulted from them can help save the valuable resources that are used in these situations. Active initiatives like awareness campaigns, adherence to traffic laws, and enforcement of helmet laws can help achieve this.

- **Thailand**

The Theory of Planned Behavior (TPB) paradigm was used in the study by Satiennam et al. [31] to examine teenage motorcycle riders' intentions and conduct when they run red lights (RLR). It was determined which behavioral, normative, and controlling ideas underlie the rider's RLR. A TPB questionnaire for young cyclists (N = 246) included direct and belief-based measurement items. The exploratory factor analysis method identified TPB-compliant factors. By building Block Equation, the modeling outcomes provided fair to good fits to the measured data and offered qualified evidence for the

usefulness of TPB in elucidating traffic infraction behavior. The results showed that attitude and perceived norm influence violation intentions. RLR intentions were influenced by beliefs about normative referents and undesirable outcomes. Intentions had an impact on conduct, especially when riders don't feel autonomous. Weather and riders' perceptions of facilitating circumstances had an impact on the rider's level of control.

- **Nepal**

In Nepal's Manipal Teaching Hospital, Niraj et al. conducted a prospective descriptive research [32]. Between May and August 2015, they examined 140 patients with a history of motorcycle crashes who were seen in the emergency room and outpatient department. According to the results, 121 males (86.4%) were involved in motorcycle crashes. Highest age group was between 31 and 40 years old, 61 (43.5%). Motorcycles with a single rider made up 22.8% of the cases, and the average speed was between 50 and 70 km/h (76.4%). In 75.7% of the cases, the motorcycle driver was heavily involved.

- **Chile**

To evaluate if crash clusters with high crash-related variable values likely to persist between 2011 and 2015, Blazquez and Fuentes performed a global and local spatial autocorrelation of motorcycle crashes in Chile at the commune level using spatial statistical methods [33]. At signalized intersections in the spring, there were observed high global spatial patterns of motorcycle crashes that resulted in fatalities over the course of the five-year study period. Due to the loss of control of the vehicle, the recklessness of the driver or a pedestrian, and involving male young adults, large local spatial clustering of motorcycle crashes frequently occurred in the morning on weekdays and on bright days.

- **Egypt**

Bolbol and Zalat assessed the risky behaviors and the safety measures in a group of Egyptian motorcycle riders who experienced road traffic crashes, and studied the possible underlying causes of crashes [34]. Motorcyclists who were injured in crashes and were admitted to Zagazig University Hospital (319) were the subject of a cross-sectional study. Together with other sociodemographic information, a questionnaire was employed to gather details regarding the risky behaviors and safety concerns of the riders. A majority

of motorcyclists (87.1%) lack a driver's license, only 1.9% wear helmets, and more than half (54.5%) often used a cell phone while riding, according to the survey. The bulk of motorcyclists (around 58.0%) traveled on highways and violated traffic regulations like traffic lights and road signs. Crash causes were primarily due to improper riding technique (73.4%). The two-wheel riders with less than ten years of riding experience performed more stunts. The results of this investigation revealed that dangerous human behaviors was one of the primary causes of crashes. This highlighted the need for proper motorcyclist safety education and training in conjunction with traffic law enforcement, particularly with regard to driving privileges and safe riding techniques, which can undoubtedly contribute to lowering the frequency of traffic crashes and preserving human lives.

- **Lebanon**

Akl et al. studied motorcycle safety in Lebanon [35]. They claimed that wearing a helmet had a significant impact on motorcycle injuries. This study's main objective was to evaluate helmet quality and helmet use among motorcyclists in Lebanon. There had been quantitative and qualitative investigations conducted. Between 1997 and 2017, nine observational studies in the same locations were conducted over nine separate years, together with a qualitative study carried out in May 2017. The results of the observational studies demonstrated a distinct variation in the use of helmets (6–42% range). The proportion of users rose whenever law enforcement was present. The percentage of helmet use declined as enforcement was discontinued. The lack of a certification on almost 64% of the helmets evaluated suggested that they did not adhere to international requirements. Individuals who had purchased their helmets for less than $15 US were discovered to be donning an uncertified helmet. They came to the conclusion that the nation had failed to pursue the adoption of helmet use enforcement in a successful and sustainable manner. Although strong enforcement is crucial, it is almost equally important to forbid the import of bad helmets into Lebanon and ensure that taxes on helmets were low so that customers may purchase superior helmets at lower prices.

- **Motorcycles Crashes Among Countries**

Based on publications of the International Road Federation (IRF) for the year 2020 [36], a comparison between a number of countries in terms of motorcycle crash rates per

100,000 capita in the five continents is discussed hereafter. In the countries of India and China, in Asia continent, these have crash rates of 4.47 and 0.74 crashes per 100,000 capita, respectively. The USA and Colombia, in North and South America continent, have crash rates of 1.70 and 5.98 crashes per 100,000 capita, respectively. In Africa, Kenya and Morocco have crash rates of 2.18 and 2.98 crashes per 100,000 capita respectively. In Europe, Italy and France have crash rates of 1.10 and 0.85 crashes per 100,000 capita respectively. In Oceania, Australia and New Zealand have crash rates of 0.73 and 1.08 crashes per 100,000 capita respectively. For Palestine, there is no reports concerning the number of motorcycle crashes that were reflected in the IRF indicated publication. However, in Nablus City, 64 crashes occurred in 2020, as extracted from Nablus Traffic Police Department (explained earlier in Chapter 1), which result in motorcycle crash rate of 38.8 crashes per 100,000 capita. This is very high rate compared with the indicated rates in various countries.

2.4 Chapter Conclusion

As a summary, conducted literature review indicated that some studies focused on the location of motorcycle crashes, others on analyzing number of motorcycle crashes, while few other studies focused on correlating injuries of the motorcyclists with crashes and how technology could be used to reduce the severity of the injury. Studies, whether in developed or developing countries, have focused on investigating and understanding the link between behaviors of motorcyclists (whether intentional or unintentional) and other motorcycle characteristics, with crashes, like the use of safety equipment such as helmets. Some studies measured the behavioral factors influencing motorcyclists' crash risks including errors and violations.

The outcome of these studies differ according to the purpose of the study. In certain studies about the location of motorcycle crashes, it was found out that motorcycle crashes were overrepresented on horizontal curves. As for the severity of injuries, fatal and serious injuries for motorcycles crashes were around twice those for cars. As for behavioral attitudes, many studies had agreed that motorcyclists who tend to have dangerous attitudes were more likely to have been involved in crashes. Also, stunt actions increased the odds of crash involvement. Moreover, motorcyclists were willing to do

more traffic rules violations than car drivers. Finally, motorcyclists' violations were more in urban than in rural areas.

Most of the injuries had characteristics that could be identified as, mostly young men, most of them wore helmet, but, few of them wore the full equipment (boots and jackets), and most of crashes were caused of irresponsible actions.

Finally, in the studies that had focused on correlating crashes with injuries and how these could be reduced, possible countermeasures were identified in terms of safety devices using technological solutions in order to reduce the injuries in the crashes.

A comparison among motorcycle crash rates per 100,000 capita in 2020 show that developing countries had higher crashes rates than those for developed countries. While no such rates are found for Palestine, Nablus City had the highest rate of motorcycle crashes per 100,000 capita compared with these countries.

Chapter Three

Data Collection and Analysis

3.1 Introduction

In this chapter, interviews outcome, as well as data collection and analysis outcome are presented. Motorcycles crash data were collected from Nablus Traffic Police Department to develop motorcycle crash profile. Nablus City census zones, as identified by the PCBS, were used to develop motorcycle crash related maps in order to highlight the hazardous zones. Field observations data were also collected to detect the behavior of motorcyclists at one of the hazardous locations in the city using cameras, and to assess their adherence to traffic regulations.

Relevant statistical tests were applied on the collected data. ANOVA Test was applied to the collected statistical data in order to examine if there are any statistical differences temporally. Moreover, ANOVA Test was applied to the observation data to find if there are any statistical differences in the behavior of the motorcyclists across user types and temporally.

3.2 Interviews

The following is a summary of the results of the interviews with several agencies on the reality of motorcycle transportation mode in Nablus City. More on the specific names of the interviewees and their affinities, as well as the dates of the interviews is found in Table F1 in Appendix F.

- **Ministry of Transportation**

Motorcycle as well as motorcyclists licensing was investigated in the interview with the representative of the MOT. There have been procedures set by the MOT in this regard in order to reduce motorcycle crashes. It is important to note that there are requirements set for granting motorcycles licenses, and for importing motorcycles to ensure adherence with technical specifications, and for having the required insurance. Requirements are also set for owning a motorcycle in terms of age and the parent's approval in case the driver's age is less than 21 years. Moreover, granting a license for a person to drive a

motorcycle (license category A) is regulated by passing special theoretical and practical tests, as well as physical fitness assessment.

In terms of the number of those who want to obtain a motorcycle license, there is significant increase due to the increase in demand for delivery services by motorcyclists to avoid traffic jams within cities and reduce the time required to reach the consumers.

Recently, motorcycles with a motor larger than 500cc were licensed. This has resulted in irresponsible use by drivers, most of whom are under the age of 35, and this in turn has resulted in noise and dangerous maneuvers, and could increase the potential for crashes. Note that motorcycle insurance is very expensive, and few companies insure motorcycles because of the seriousness in case of crashes.

It is recommended by the ministry to work on increasing awareness campaign for motorcyclists on the importance of adhering to the traffic law and regulations, safe use of the motorcycle, and commitment to security and safety aspects, such as using the helmet and safety clothing, while adhering to the legal speed to reduce crashes and injuries.

- **Nablus Traffic Police Department**

It was clarified by the representative of the traffic police that the motorcycle is considered a vehicle subject to traffic law and regulations like any other vehicle and it requires valid insurance and valid license, and the driver is fined when not adhering to traffic law and regulations, and when there is no insurance for the vehicle.

Through the discussion, it was also identified that most traffic violations committed by motorcyclists include non-compliance with traffic signals and traffic law and regulations, excessive speed, and drifting. Among the observations and violations that are monitored by the traffic police is driving recklessly and negligence by the motorcyclists.

When reporting the number of violations by the traffic police, it was found that 20% of motorcycles are legal and 80% of them are illegal. The legal status of a motorcycle is defined by the validity of the license and insurance. There is a decision to confiscate illegal motorcycles by the traffic police department.

It was also recommended to increase the commitment to security and safety aspects, such as using the helmet and safety clothing, while adhering to the legal speed to avoid crashes and injuries, and design and implementation of particular motorcycle lanes.

- **Ministry of Health**

Through the discussion, the MOH representative emphasized that the obligation to wear the helmet and safety clothing by the motorcycle driver has a significant impact in reducing the level of injury to the driver in the event of a crash, especially since there is no external structure in the motorcycle to protect the driver, unlike other vehicles.

It was recommended to strictly control motorcyclists to ensure adhering to traffic law and regulations in order to prevent and reduce traffic crashes, through proper follow up on that by the traffic police. This implies to focus on wearing helmets and safety clothing, the necessity of continuous communication and monitoring of motorcyclists by the delivery companies for this specific use, in order to follow up with their motorcycle drivers to comply with traffic law and regulations, and increase awareness campaigns for motorcyclists on the importance of adhering to traffic law and regulations, and that courses need to be held periodically before and after getting the license.

- **Nablus Chamber of Commerce and Industry (CCI)**

The CCI representative confirmed that the presence of motorcycles is an economic benefit for the citizen and the country, as motorcycles are currently operating in many economic establishments, especially in the process of delivering goods and food, and providing services to citizens.

It was found from the discussion that the motorcycle service reduces the number of unemployed for those who work in the delivery service and provides a significant net personal income if the motorcycle is owned.

The representative of the CCI believes that it is better to have motorcycles because they provide good job opportunities and also because of their importance in providing quick service to the owner of the establishment, the customer, and the owner of the motorcycle, due to the existence of common interest between the three parties.

The CCI recommended to adhere to the basics of public safety by wearing a helmet and safety clothing that will prevent any risk of expected injuries, as well as reducing the speed, modifying the streets to serve the citizens, and allocating special areas and streets for driving motorcycles, if possible. The CCI recommends to significantly expand the use of motorcycles, because they meet the needs of citizens and economic establishments quickly as far as these are legitimate means of transportation.

- **Nablus Municipality**

From the discussion with the Traffic Engineer at Nablus Municipality, the municipality gives due attention for developing facilities for vehicles, where motorcycles can use these facilities. The Traffic Engineer indicated that there is also a need to educate motorcyclists about how to use these facilities properly.

The discussion included the possibility of adopting the motorcycle mode as a means of solving traffic problems; however, in the Traffic Engineer opinion, the behavior of the motorcyclists and the potential safety threats could not make this mode reliable. On the other hand, the bicycle mode can be relied upon because they are more safe and secure. A proposal has been set by the municipality to solve traffic problems between the two campuses of An-Najah National University encouraging the use of bicycles.

The main issue to achieve proper safety related to motorcycles is proper enforcement of existing regulations.

It was recommended to conduct awareness campaigns by the traffic committee, and enhance the riding behavior and culture among the motorcycling users.

- **Insurance Agencies**

A representative of one of the insurance agencies was interviewed. It was found that the minimum insurance cost of motorcycles is issued by the Capital Market Authority, and approved by the Council of Ministers. The cost of insurance is specified according to the motorcycle engine capacity, and ranges from 50cc to 250cc. It turns out that the cost of insurance ranges from 1,105 NIS to 1,355 NIS, as a minimum. There is flexibility for insurance companies to determine the cost of insurance. The insurance price for motorcycles is determined according to the purpose of using the motorcycle (for work (delivery use) or personal use), as well as the driver's violations and age.

The insurance companies, in general, do not want to work with motorcycles insurance, because the motorcyclists do not adhere to the traffic law and regulations, thus raising the risks for crashes.

It was recommended by the representative of the insurance agency to have stricter monitoring by the traffic police to compel motorcyclists with security and safety regulations in terms of wearing helmets, and safety clothing, as well as adherence to traffic law and regulations and to forbid using of sound amplifiers and to focus on motorcycles illegal parking. It was suggested to reconsider the age of those who want to acquire a motorcycle license, which the interviewee believed that it should not be less than 35 years.

3.3 Motorcycles Crash Profile

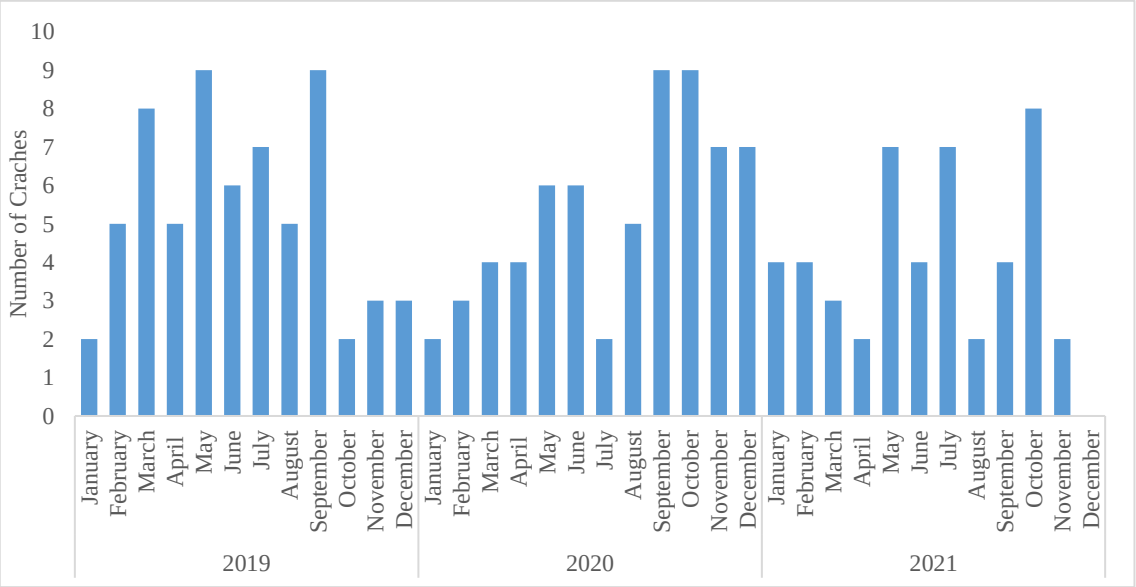
In this section, collected crashes data from the records of traffic police are presented and analyzed temporally and based on crash characteristics such as (gender, reason of crash, vehicle/pedestrian crash involvement, and type of injury).

It is to be noted that analysis of collected data shows that all users of this mode who were involved in crashes were males. This is in line of the observation that riders of the motorcycles were male dominant. On the other side, the type of motorcycle use is not showed in police crash reports.

The total number of recorded motorcycle crashes was 175 during the study period (January 2019 to November 2021). The yearly distribution of motorcycle crashes is shown in Figure A1 in Appendix A. The monthly distribution of the motorcycle crashes is shown in Figure 3.1.

Figure 3.1

Distribution of Total Motorcycle Crashes in Nablus City by Month During the Study Period (January 2019 – November 2021)



It can be seen that the first three quarters in 2020 exhibit lower values than those in 2019. This can be explained due to lockdowns that were applied in the city during this period in 2020, with a total of 70 days. As for the fourth quarter in 2020, the figure shows higher values than in the last quarter of 2019. This might be because no lockdowns were imposed in the city in this quarter.

As for the year 2021, the first quarter shows similar values of motorcycle crashes to the respective quarter in 2020, but lower values than those in 2019. This is because there were lockdowns in the first quarter of 2021. The second, third, and fourth quarters of 2021 show lower values than in 2019 and 2020. This might be explained by the relatively more efforts of traffic police in maintaining law.

Spring and summer seasons show higher numbers of motorcycle crashes than in fall and winter seasons for the whole study period, as shown in Figure A2 in Appendix A. This might be attributed to the relatively better weather and the increasing use of motorcycles during these seasons for fun by the youth.

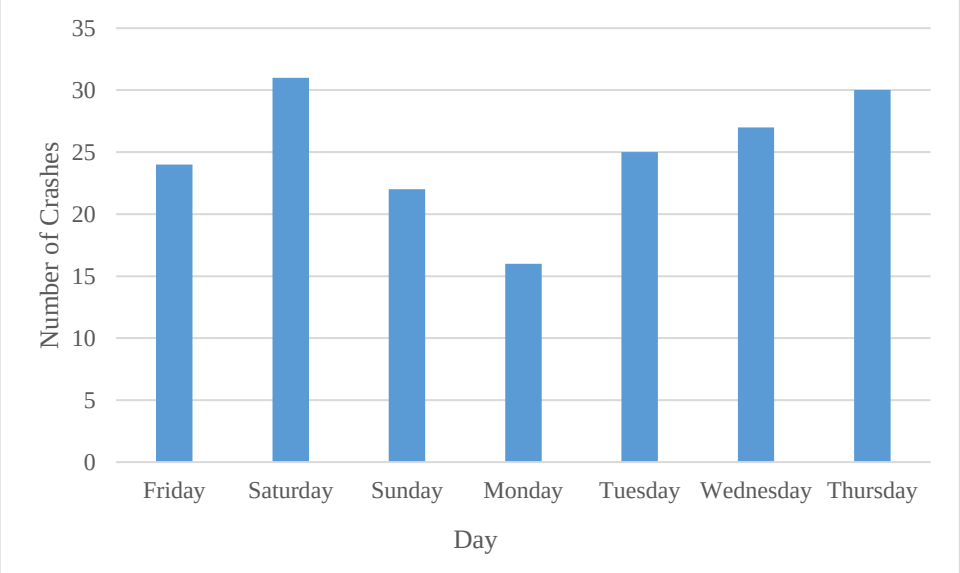
From Figure 3.1, it can be stated that there is cyclic pattern in motorcycle crashes throughout the years, in general. There are peaks in summer seasons, and the months just before and after, and low values in winter seasons. There are some breaks in the pattern

and this is because of the lockdowns that were imposed in the city to overcome the spread of COVID-19 pandemic.

In terms of the daily distribution of motorcycle crashes as shown in Figure 3.2, Saturdays have the highest number of crashes with 31 crashes followed by Thursdays with 30 crashes. Saturday is part of the weekend, where many employees are on vacation. Nablus City suffers from high congestion on Saturdays as many visitors from outside the city come for shopping and entertainment. One of the reasons for use of motorcycles is due to the belief that it can be more efficient during congestion periods. Fridays has nearly same values as other weekdays. This might be because of increasing use of motorcycles on Fridays by young riders who want to have fun.

Figure 3.2

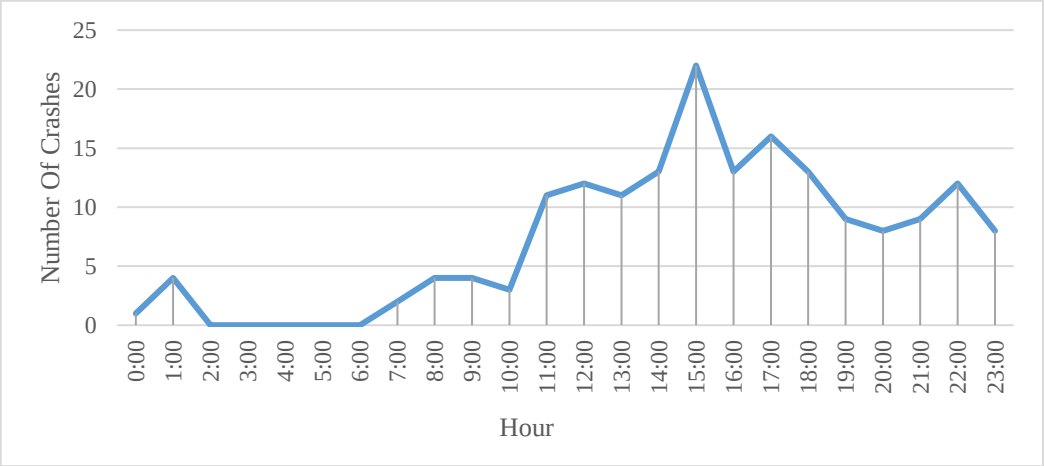
Distribution of Total Motorcycle Crashes in Nablus City by Day During the study Period (January 2019 – November 2021)



Regarding the hourly distribution of motorcycle crashes in Nablus City, the values vary during the day as shown in Figure 3.3. The afternoon peak hours have the highest number of crashes, where the hour with the peak number of crashes is during 15:00 – 16:00 with a value of 22 crashes, followed by that during 17:00 – 18:00 with 16 crashes.

Figure 3.3

Distribution of Total Motorcycle Crashes in Nablus City by Hour During the study Period (January 2019 – November 2021)

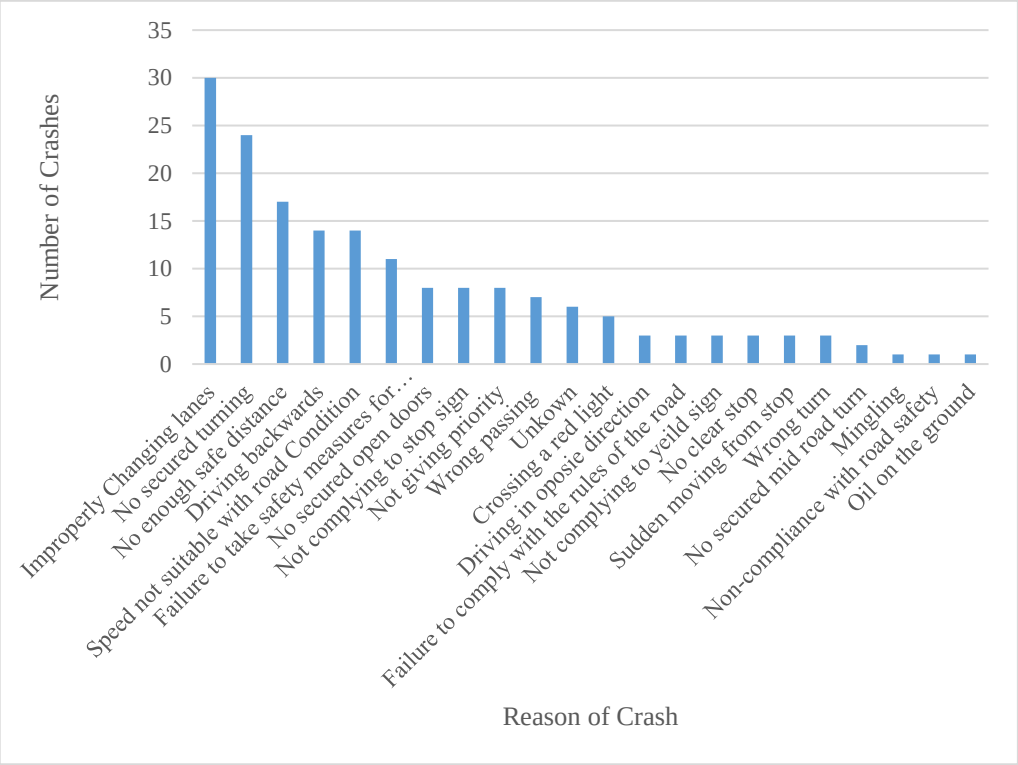


As for the reason of crashes, the more frequent reason was “improperly changing lanes” with a value of 30 crashes. Figure 3.4 shows the distribution of motorcycle crashes based on the reason of the crash. The next higher values of crashes are due to “no secured turning” followed by “not maintaining enough safe distance”, with values of 24 and 17 crashes, respectively.

“Improperly changing lanes” had the highest percentage of 17.1% followed by “no secured turning” with a percentage of 13.7%. “Not maintaining safety distance” formed of 9.7%. In addition, “driving backwards” and “speeding” formed 8.0% each. However, the illegal behavior by the motorcyclists was the main reason of crash with a percent of 96.0%, while crashes that happened due to reasons other than the behavior of motorcyclists mainly (road and road environment) and unknown reasons formed 4%. It is to be noted that such high percentage of human behaviors related reasons of crashes was more than that observed in other studies, such as the study of Greve et al. [22] on Brazil, which found that this percentage was 88.0%, the study of Niraj et al. [32] on Nepal, which was 75.7%, and in Bolbol and Zalat [34] on Egypt, which was 58.0%.

Figure 3.4

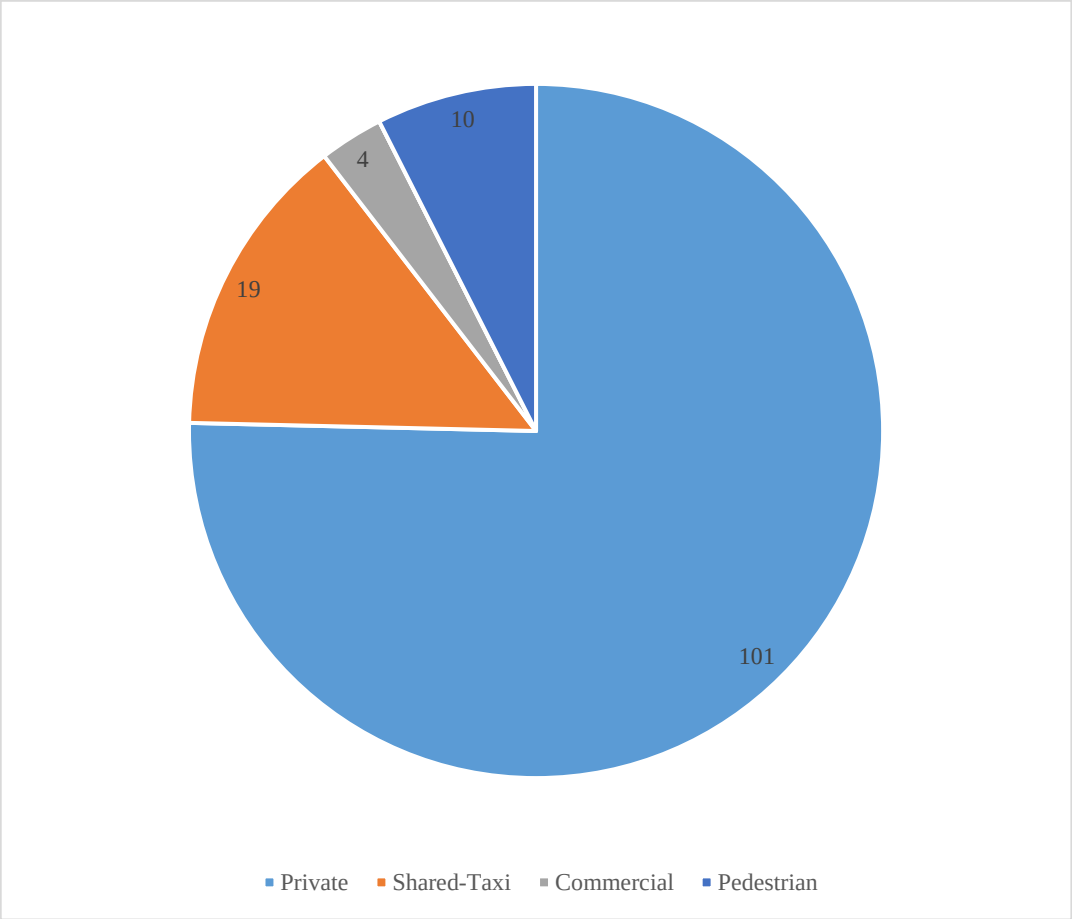
Distribution of Total Motorcycle Crashes in Nablus City by Reason of Crash During the study Period (January 2019 – November 2021)



When the motorcycle was involved in a crash with another vehicle, private cars formed 75.4% of total involvement of such vehicles in crashes, followed by shared taxis which formed a percentage of 14.1%, and the commercial vehicles of 3.0% as shown in Figure 3.5. It is to be noted that pedestrian overrun crashes formed 7.5% of the total. These results, in a way or another, reflect the distribution of vehicles type in Nablus City, where private cars formed 85.4% of total vehicles in Nablus City in 2021. However, despite that shared-taxi formed 4.5%, the vehicle-km traveled of taxis is much higher than private cars.

Figure 3.5

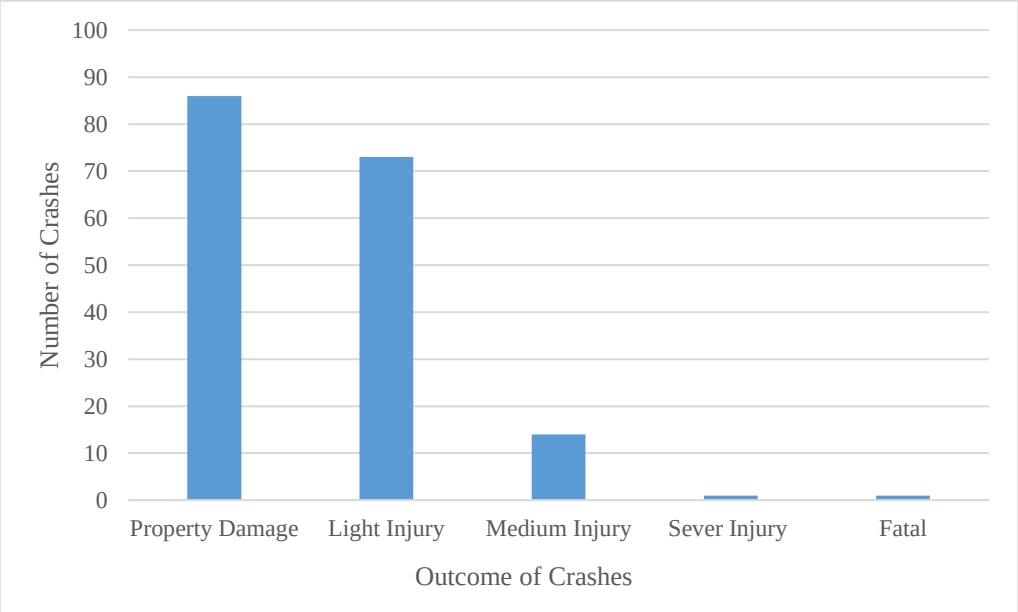
Distribution of Total Motorcycle Crashes in Nablus City by Vehicle/Pedestrian Crash Involvement During the study Period (January 2019 – November 2021)



In terms of the resulting crashes outcome, 49.1% of crashes were classified as property damage only, and 50.9% as crashes with injuries or fatalities as shown in Figure 3.6. Of the injuries, 82% were described as light injuries, and 15.8% as medium injuries. However, sever injuries and death crashes accounted each at 1.1%.

Figure 3.6

Distribution of Total Motorcycle Crashes in Nablus City by Type of Injury During the study Period (January 2019 – November 2021)



Property damage formed almost half of the total motorcycle crashes which is much lower than regular vehicle crashes. This can be explained due to that crashes were located in congested zones in general, where speeds are generally low. Similarly, light and medium injuries formed about 49.7% of total, which also can be attributed to low speeds.

3.4 Spatial Distribution of Crashes

Nablus City was divided into 40 census zones as defined by the PCBS and obtained from Nablus Municipality. Based on crash location, as obtained from the traffic police records, each crash was assigned to the respective zone. When doing that, crash map was then generated. Spatial distribution of crashes was also conducted considering the number of crashes divided by area of the zone (i.e., crashes per km^2), as well as, crashes per 1,000 capita for each zone.

3.4.1 Zonal Distribution of Motorcycles Crashes

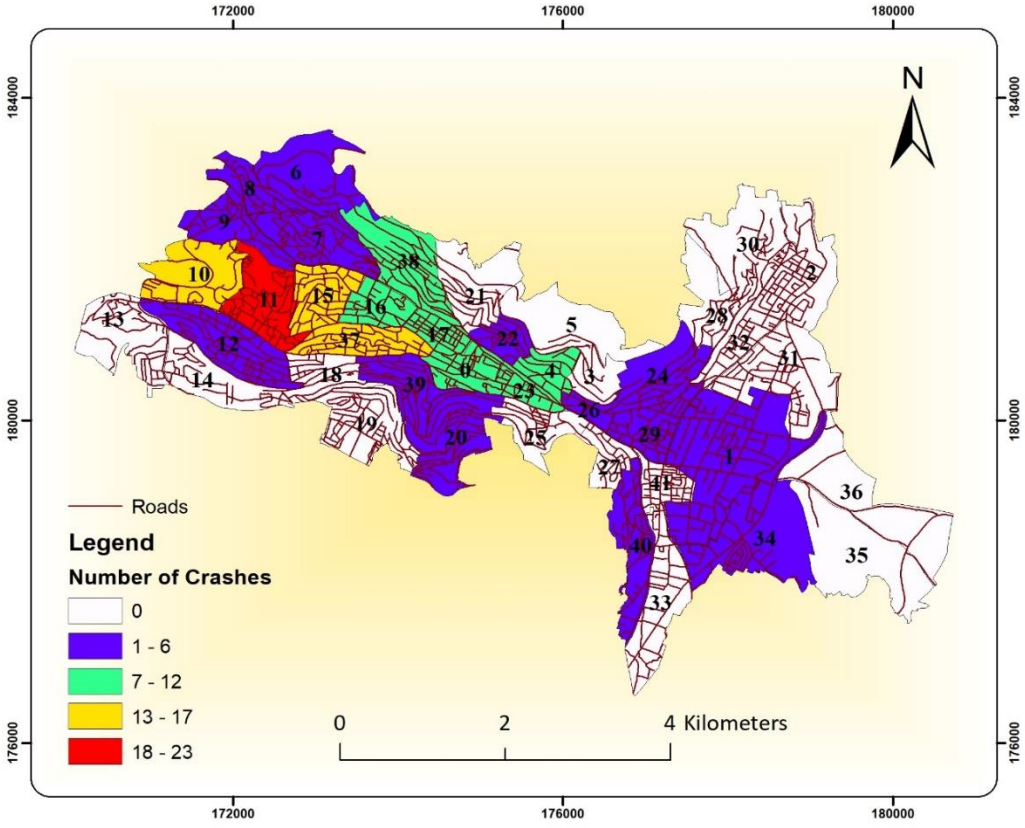
As noticed in Figure 3.7, Zone 11 (Al-Qirawan Neighborhood) in Rafedia had the highest number of motorcycles crashes of 23, followed by Zone 15 (Al-Mraij Neighborhood) in Rafedia with 17 crashes, Zone 37 (Al-Khulafa Al-Rashidin Neighborhood) in Rafedia with 16 crashes, and Zone 10 (An-Najah National University New Campus

Neighborhood) with 15 crashes. Therefore, Rafedia neighborhood exhibits the highest number of crashes which has a lot of shops and restaurants, therefore, it attracts people to do shopping and entertainment activities, and also produces many motorcycle delivery trips.

To test the statistical significance of crash data related to these zones, ANOVA test was conducted. The results show that there are significant differences between zones, with a P-value of 0.000, considering the significant level ($\alpha = 0.05$), therefore, the zones could be analyzed individually.

Figure 3.7

Zonal Distribution of Total Motorcycle Crashes in Nablus City During the Study Period (January 2019 – November 2021)



3.4.2 Distribution of Motorcycle Crashes per km^2

As can be seen in Figure B1 in Appendix B, based on area analysis, the middle part of the city has the highest crashes per km^2. Zone 17 (CBD) has the highest rate of 43.7 crashes per km^2, followed by Zone 15 (Al-Mraij) in Rafedia with a rate of 31.8 crashes per km^2, and then Zone 11 (Al-Qirawan) in Rafedia with a rate of 31.5 crashes per km^2.

3.4.3 Distribution of Motorcycle Crashes per 1,000 capita

By analyzing motorcycle crashes based on number of crashes per 1,000 capita, the spatial distribution of motorcycle crashes, as illustrated in Figure B2 in Appendix B, showed that Zone 10 (An-Najah National University New Campus Neighborhood) had the highest number of 8.67 crashes per 1,000 capita, followed by Zone 17 (CBD) with 7.17 crashes per 1,000 capita, and then Zone 23 (Al-Horriya) close to the CBD, with 5.89 crashes per 1,000 capita.

It has to be stated that crashes locations are not very precise in the crash reports obtained from Nablus Traffic Police. There were only 57 locations of 175 (32.6% of total) with precise locations. Moreover, crash locations were reported considering street names for 81 of the crashes (46.3% of total). It is to be noted that 37 crashes (21.0% of total) occurred on Rafedia Street, and therefore, this street is considered as the most hazardous street. There were 12 crashes that occurred at the intersections located on Rafedia Street.

As indicated above, and as the neighborhood in Rafedia are considered as the most hazardous in the city, one of the intersections on the Rafedia Street that connects these neighborhoods, which is Al-Badawi Intersection, is selected to study the motorcyclists' behavior. This intersection had two crashes of the 12 that occur on the street during the study period.

3.5 Behavior Observation and Analysis

To study the behavior of motorcyclists at Al-Badawi intersection, two cameras were installed at a building located within Al-Badawi-Intersection zone to detect the behavior of motorcyclists during a three-day study period (Friday 29/7/2022, Saturday 23/7/2022, and Sunday 31/7/2022). Moreover, the motorcycles had been observed from 9:00 to 24:00, where very limited number of motorcycle crashes happened between mid-night and 9:00.

3.5.1 Overall Behavioral Analysis

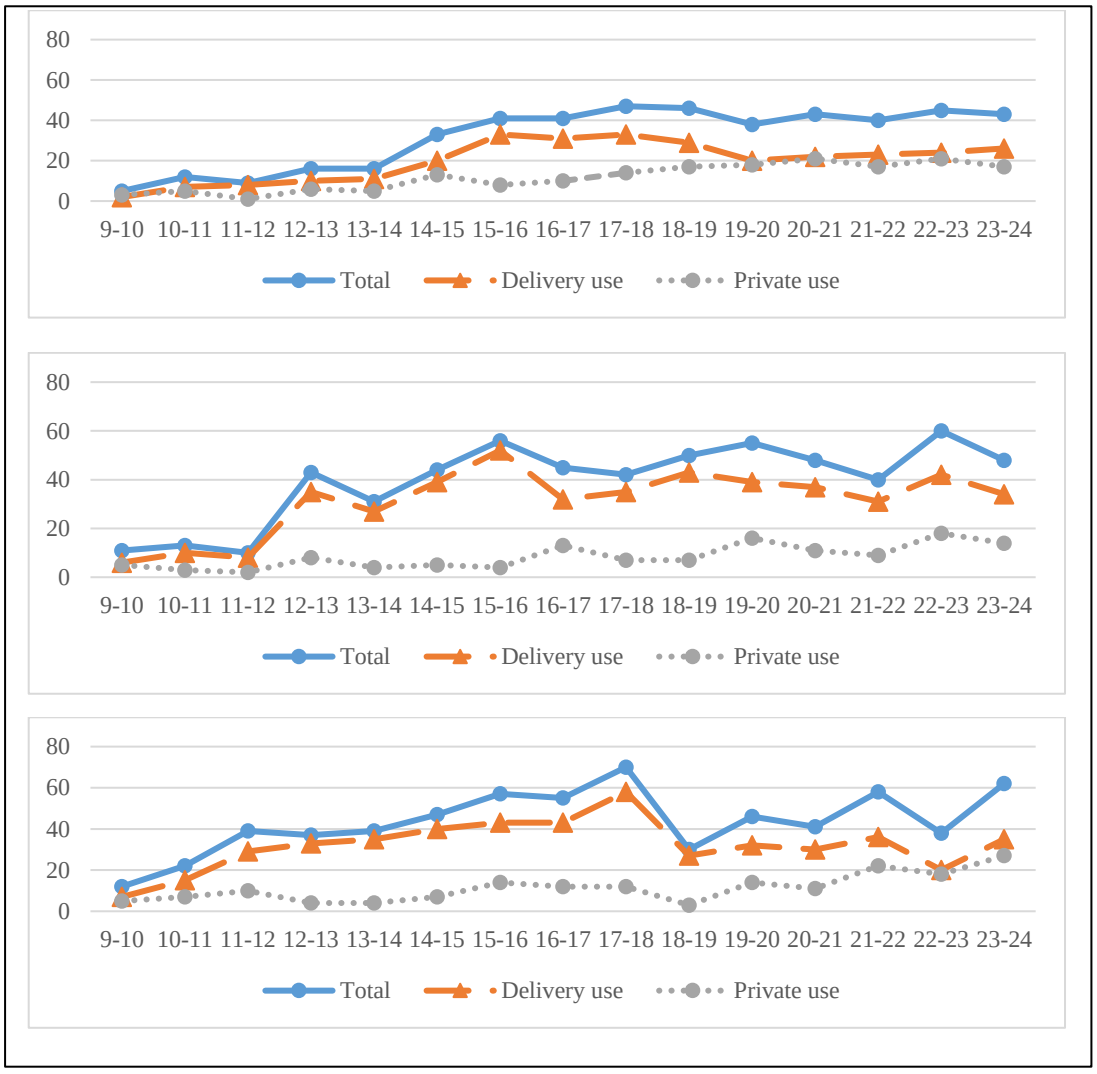
At the studied intersection, there were 1,724 motorcycles that crossed the intersection during the study period (Friday, Saturday, and Sunday). The distribution of motorcycles in the three days is shown in Figure C1 in Appendix C. The total number of motorcycles is in an increasing trend throughout these days. There has been an increase of 25.4% in the number of crossing motorcycles between Friday and Saturday and 9.5% between Saturday and Sunday.

There are two classes of motorcycles by trip purpose or nature of use; delivery use and private use. As for delivery use, motorcycles experience an increasing trend from day to another by order, where there has been an increase in the number of delivery motorcycles between Friday, Saturday, and Sunday. On the other hand, the number of private use motorcycles declined from Friday and Saturday, but then increased from Saturday to Sunday. Such trends are also presented in Figure C1 in Appendix C.

The hourly distribution of motorcycles in the study period is shown in Figures 3.8a, 3.8b, and 3.8c, as obtained from the recorded videos. The behavior of each of the motorcyclists was carefully observed. The motorcyclists' behavioral violations (i.e., lack of adherence to traffic regulations) in the study period is shown in Figures 3.9a, 3.9b, and 3.9c.

Figure 3.8

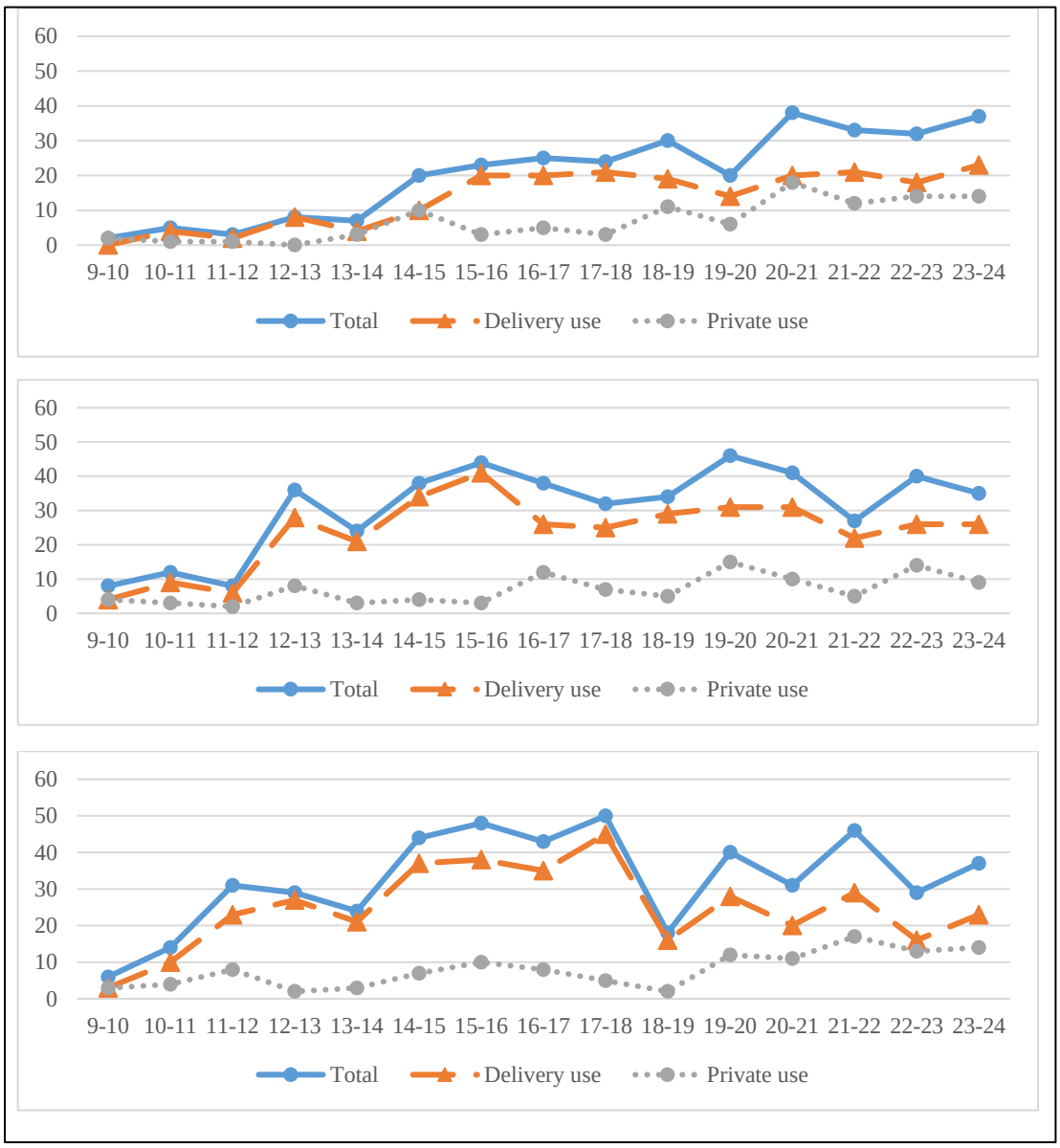
Hourly Distribution of Motorcycles during the Study Period



Note: Friday, Saturday, Sunday

Figure 3.9

Hourly Distribution of Violating Motorcyclists during the Study Period



Note: Friday, Saturday, Sunday

Table 3.1, as well as Table C1 and C2 in Appendix C, summarize the number of total, delivery, and private motorcycles and the percentage of violation for each type through hours of day in the study period.

From Figures 3.8 and 3.9, as well as Table 3, C1, and C2, it can be seen that there is a direct relation between the number of motorcycles and the number of violations; as the number of motorcycles increases, the number of violations of the motorcyclists' increases too. In addition, the following can be concluded:

- Motorcyclists violations are increasing in the afternoon and evening, and this differs among the three days. A noticeable increase is observed on Friday beginning after 13:00. This is because Friday is a vacation day, where people usually make less activities in the mornings before this hour. As for Saturday, the peak period starts earlier than Friday, which began after 11:00, as shops open slightly earlier and activities usually begin afterwards. On Sunday, a typical workday, the A.M peak period starts early after 9:00. This is because people start to move around for work and education purposes, which usually starts at 8:00.
- Mid-day violations fluctuate up and down on Saturday, along with the fact in the number of motorcycles, in general, but almost shows stability on Friday and Sunday.

Table 3.1

Hourly Distribution of Total Motorcycles and Number of Violating Motorcyclists for the Study Period

Hour	Friday			Saturday			Sunday			All Days		
	# of Motorcycles	# of Violations	% of Violation	# of Motorcycles	# of Violations	% of Violation	of Motorcycles	# of Violations	% of Violation	# of Motorcycles	# of Violations	% of Violation
9-10	5	2	40.0	11	8	72.7	12	6	50.0	28	16	57.1
10-11	12	5	41.7	13	12	92.3	22	14	63.6	47	31	66.0
11-12	9	3	33.3	10	8	80.0	39	31	79.5	58	42	72.4
12-13	16	8	50.0	43	36	83.7	37	29	78.4	96	73	76.0
13-14	16	7	43.8	31	24	77.4	39	24	61.5	86	55	64.0
14-15	33	20	60.6	44	38	86.4	47	44	93.6	124	102	82.3
15-16	41	23	56.1	56	44	78.6	57	48	84.2	154	115	74.7
16-17	41	25	61.0	45	38	84.4	55	43	78.2	141	106	75.2
17-18	47	24	51.1	42	32	76.2	70	50	71.4	159	106	66.7
18-19	46	30	65.2	50	34	68.0	30	18	60.0	126	82	65.1
19-20	38	20	52.6	55	46	83.6	46	40	87.0	139	106	76.3
20-21	43	38	88.4	48	41	85.4	41	31	75.6	132	110	83.3
21-22	40	33	82.5	40	27	67.5	58	46	79.3	138	106	76.8
22-23	45	32	71.1	60	40	66.7	38	29	76.3	143	101	70.6
23-00	43	37	86.0	48	35	72.9	62	37	59.7	153	109	71.2
Total	475	307	64.6	596	463	77.7	653	490	75.0	1724	1260	73.1

- In the evening of Friday and Sunday, there is considerable drop in number of motorcycles by 18:00. Then, the results show almost a stable trend with some ups and downs in the number of crossing motorcycles. As for Saturday, decline in motorcycle traffic volume starts earlier around 15:00.

Several items were taken into consideration while collecting data on motorcyclists' behaviors, as obtained from recorded videos from the installed cameras. These include the use of motorcycle (delivery or private), absence of wearing helmet, the existence of rear passenger, as well as other information focusing on the illegal behaviors of the motorcyclists, especially on what would affect the safety aspects. Tables 3.2a, 3.2b, and 3.2c summarize the collected data during the study period. Tables C3, C4, and C5 in Appendix C, summarize the collected data for Friday, Saturday and Sunday, respectively.

- **Study Period**

  - Use: Of the total number of observed motorcycles of 1,724, there were 1,252 motorcycles used for delivery use (73%) and 472 for privately use (27%).
  - Wearing helmet:
    Table 3.2a summarizes different characteristics and acts that motorcyclists do related on wearing helmet.
  - Rear Passenger:
    Table 3.2b summarizes different characteristics and acts that motorcyclists do while having a rear passenger
  - Behavioral violations:

    Table 3.2 c summarizes different acts that motorcyclists do when crossing the intersection.

From Tables 3.2, C3, C4, and C5, the following can be concluded:

- There is more commitment by delivery motorcyclists to wear helmet compared with private motorcyclists through the three days with percentages of 50.2% and 16.3%, respectively.
- Private motorcyclists tend to have higher rear passengers for the three days compared with delivery use with percentages of 80.2% and 19.8, respectively. This is because

private use motorcycles are generally allowed to have a rear passenger, while motorcycles used for delivery are not allowed.

- The total number of behavioral violations (other than not wearing helmets) is in increasing trend, in general, throughout the days from Friday to Sunday by a percentage of 50.8% from Friday to Saturday and 5.8% from Saturday to Sunday. This is a considerable increase for the delivery motorcyclists, but it is almost stable for the private motorcyclists. This can be explained as delivery motorcyclists tend to do more behavioral violations than private motorcyclists in crowded situations, where on Fridays there are less activities compared with Saturdays and Sundays.
- During peak periods and in crowded situations, such as between 13:00 and 15:00, delivery use motorcycles tend to illegally overtake vehicles in front of them to rush during their peak activity period trying to avoid delay. This can be noticed in Tables 3.1a and 3.1b, where the percentage of overtaking for delivery is increasing from Friday to Sunday as discussed earlier, with the increase of activities and congestion.
- The number of motorcyclists wearing helmet and without committing any violation is the same for Fridays and Sundays, but Saturdays show lower values. Overall, those with legal behavior and wearing helmets were 183 out of the total of 1,724 forming only 10.6% of total.

Table 3.2a

Motorcyclists' Wearing Helmet Characteristics during the Study Period

Item	Total	Delivery Use			Private Use		
		Number	% of delivery	% of total	Number	% of private	% of total
With Helmet	706	629	50.2	89.1	77	16.3	10.9
Without Helmet	680	370	29.6	54.4	310	65.7	45.6
No Obvious Helmet	338	253	20.2	74.9	85	18.0	25.1
Total	1724	1252	100	72.6	472	100	27.4
With Helmet + No Violation	183	159	12.7	86.9	24	5.1	13.1
With Helmet + Violation	523	470	37.5	89.9	53	11.2	10.1
Without Helmet + No Violation	188	93	7.4	49.5	95	20.1	50.5
Without Helmet + Violation	492	277	22.1	56.3	215	45.6	43.7
No Obvious Helmet + No Violation	129	86	6.9	66.7	43	9.1	33.3
No Obvious Helmet + Violation	209	167	13.3	79.9	42	8.9	20.1
Total	1724	1252	100	72.6	472	100	27.4

Table 3.2b

Motorcyclists' Rear Passenger Characteristics during the Study Period

Item	Total	Delivery Use			Private Use		
		Number	% of delivery	% of total	Number	% of private	% of total
Rear Passenger	156	31	2.5	19.9	125	26.5	80.1
Rear Passenger With Helmet	6	1	0.1	16.7	5	1.1	83.3
Rear Passenger Without Helmet	133	24	1.9	18.0	109	23.1	82.0
Rear Passenger No Obvious Helmet	17	6	0.5	35.3	11	2.3	64.7
Total	156	31	2.5	19.9	125	26.5	80.1
Rear Passenger + Violation	112	28	2.2	25.0	84	17.8	75.0
Rear Passenger + Legal	44	3	0.2	6.8	41	8.7	93.2
Total	156	31	2.5	19.9	125	26.5	80.1

Table 3.2 c

Behavioral Characteristics of Motorcyclists' during the Study Period

Item	Total	Delivery Use			Private Use		
		Number	% of delivery	% of total	Number	% of private	% of total
Legal	464	318	25.4	68.5	146	30.9	31.5
Violations	1260	934	74.6	74.1	326	69.1	25.9
Total	1724	1252	100.0	72.6	472	100.0	27.4
Overtaking Only	698	502	40.1	71.9	196	41.5	28.1
Red Light Crossing Only	128	109	8.7	85.2	19	4.0	14.8
Mingling Only	57	42	3.4	73.7	15	3.2	26.3
Illegal U-Turn Only	9	6	0.5	66.7	3	0.6	33.3
Opposite Direction Only	12	9	0.7	75.0	3	0.6	25.0
Overtake With Red Light Crossing	343	282	22.5	82.2	61	12.9	17.8
Overtake With Mingling	62	47	3.8	75.8	15	3.2	24.2
Red Light Crossing With Mingling	18	15	1.2	83.3	3	0.6	16.7
Overtake With Red Light Crossing and Mingling	13	11	0.9	84.6	2	0.4	15.4
Others	23						
Total Violations	1260						

3.5.2 Behavioral Analysis of Turning Movements

In this sub-section, analysis of intersection's turning movements considering each of the approaches during the study period are analyzed in terms of number of motorcycles crossing the intersection and committing certain behavioral violations, which are red light crossing and overtaking.

Figures 3.10a illustrates the turning movement for both types of motorcycle use during the study period. As illustrated in Appendix D, Figure D1 for the delivery use motorcycles, and Figure D2 for the private use motorcycles, the west approach (Rafedia Street) had the highest number of crossing motorcycles, followed by the east approach (Al-Kfair Street), and then the south east approach (Omar Ibn Al-Khattab Street), and lastly the south approach (Blebli Street).

As can be noticed from Figures D1 and D2, most of the delivery and private use motorcycles come from Rafedia Street towards Al-Kfair Street. For the east approach, most of the motorcycles travel to Rafedia Street. Most of motorcycles come from Omar Ibn Al-Khattab Street cross the intersection towards Rafedia Street. Finally, most of the motorcycles that come from Blebli Street cross the intersection towards Al-Kfair Street.

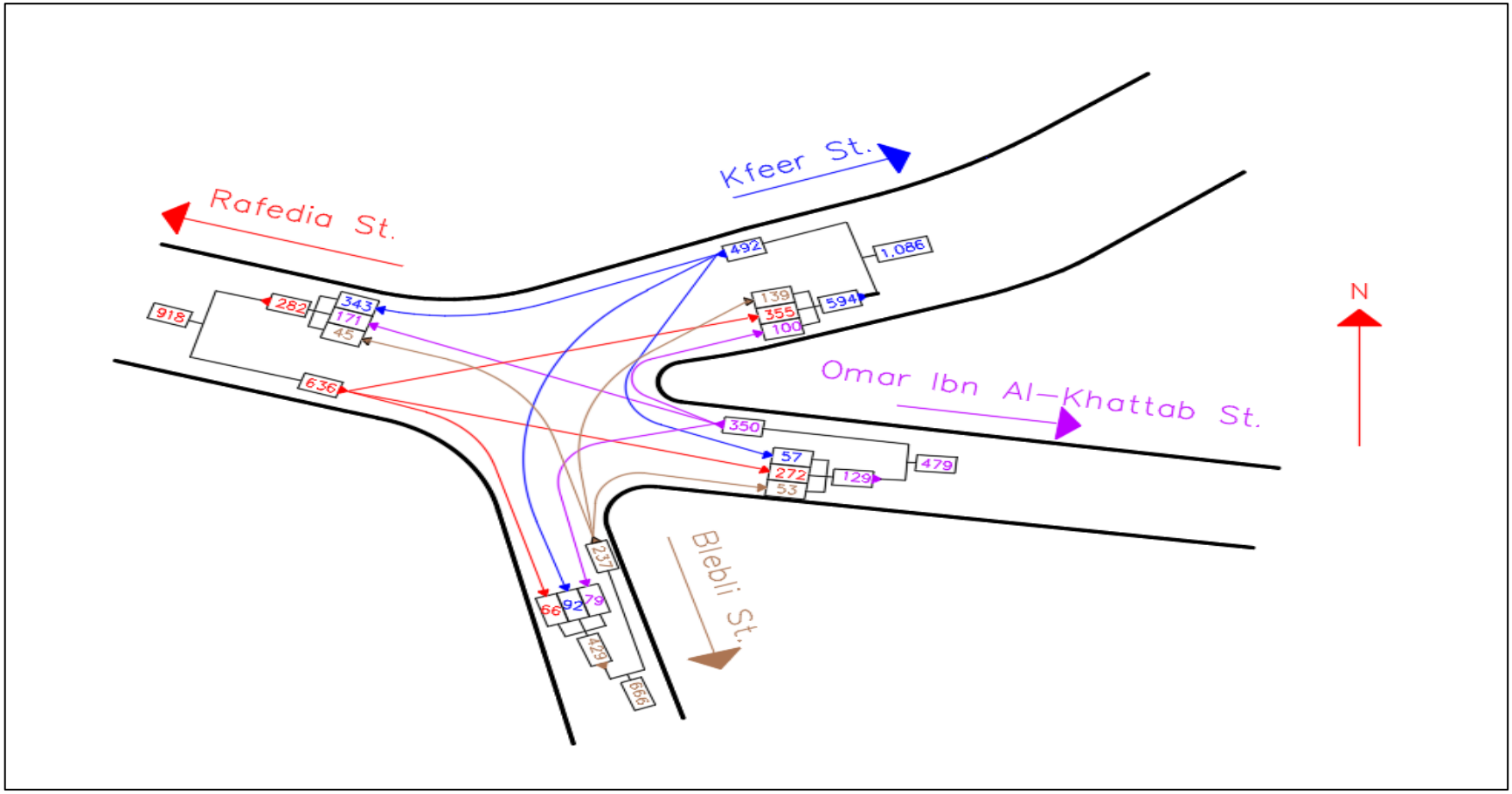
In terms of the overtaking behavioral violation, the east approach was the approach with the highest number of such behavioral violation, for such types of motorcycles use (delivery use and private use) as seen in Figure 3.10b.

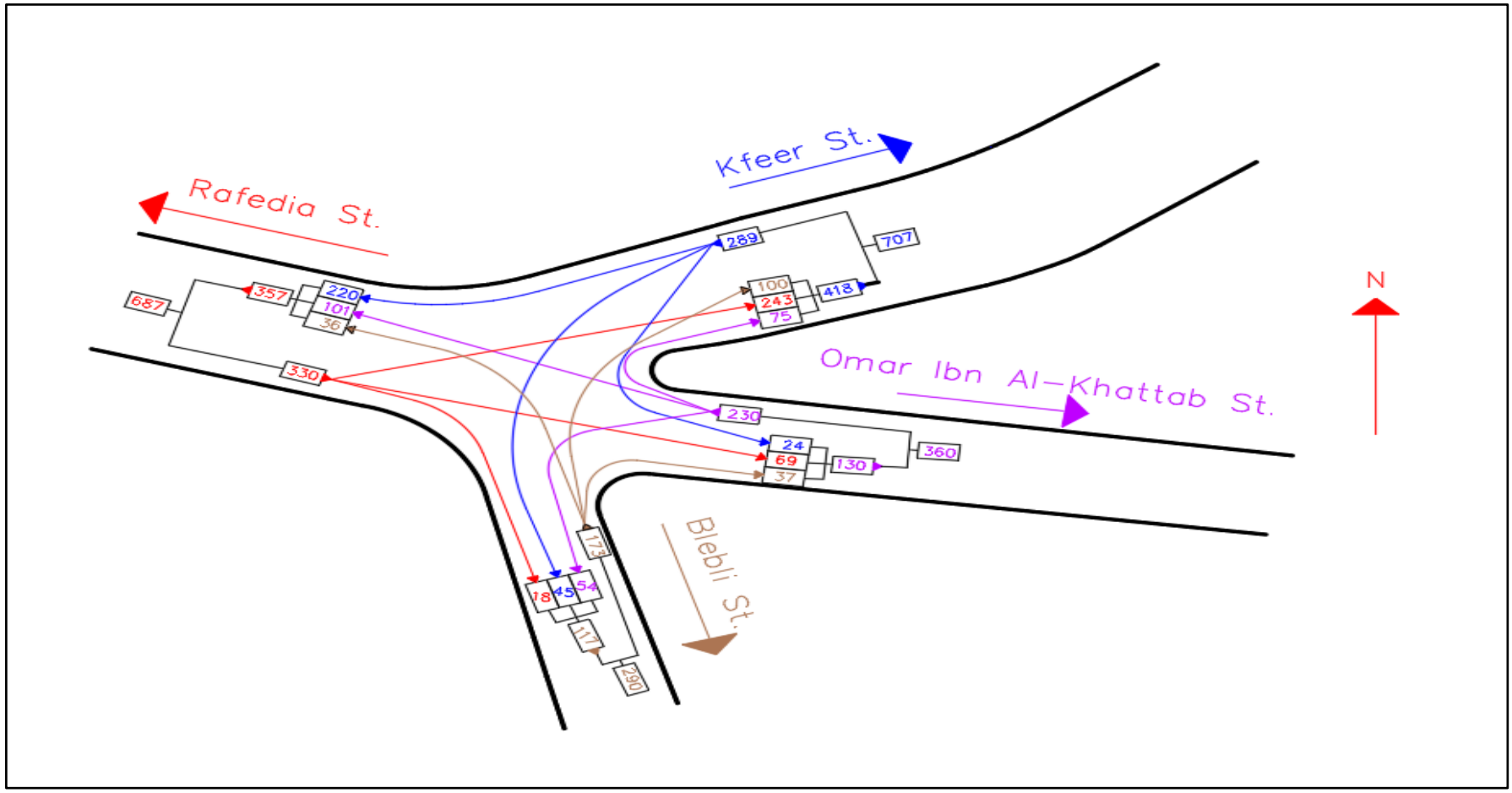
Delivery use motorcycles who travel from Rafedia Street into Al-Kfair Street and commit an overtaking were the highest compared with the other directions with a percentage of 73.8% of all other directions, as seen in Figures D3 and D4 in Appendix D. The private use motorcycles who travel from Rafedia Street into Al-Kfair Street and commit an overtaking were the highest compared with the other directions with a percentage of 73.3% of all other directions.

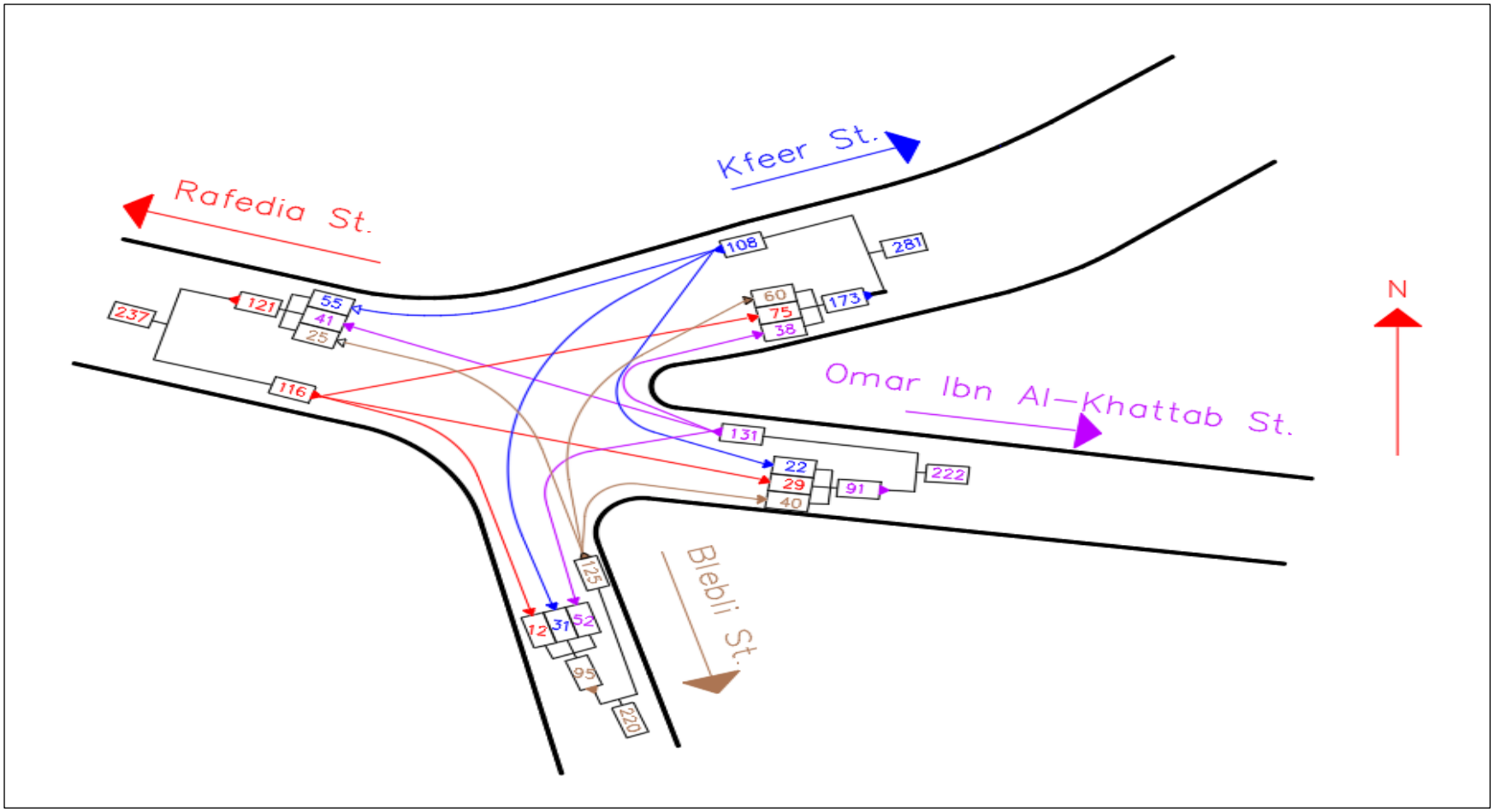
In terms of the red light crossing behavioral violation, the east approach was the highest approach while this behavioral violation for both types of motorcycles use as shown in Figure 3.10c. As shown in Figures D5 and D6 in Appendix D, delivery use motorcycles who travel from Rafedia Street into Al-Kfair Street and cross a red light formed 66.7% of all other directions. Also, private use motorcycles who travel from Rafedia Street into Al-Kfair Street and cross a red light formed 58.6% of all other directions.

Figure 3.10

Al-Badawi Intersection Turning Movements during the Study Period




Rafedia St.
Kfeer St.
Omar Ibn Al-Khattab St.
Blebli St.
N
289
707
100
243
75
418
357
220
101
36
687
330
230
24
69
37
130
360
173
18
45
54
117
290



Note: Al-Badawi Intersection Overtaking Motorcycles for Both Type of Use during the Study Period

Al-Badawi Intersection Red Light Crossing Motorcycles for Both Type of Use during the Study Period

3.5.3 Testing Hypothesis Concerning Motorcyclists Behavior

In this section, the main hypotheses in this study are examined. These hypotheses are presented hereafter:

HP1: There are no significant differences between motorcycle use (delivery use or privately use) and different behavioral charecteristics of the motorcyclists (status of wearing helmet, comitting a behavioral violation, and presence of a rear passenger) during the study period.

HP2: There are no significant differences between behavioral characterestics and actions of the motorcyclists (status of wearing helmet, comitting a behavioral violation, and presence of a rear passenger) during the study period.

HP3: There are no significant differences between behavioral characterestics and actions of the motorcyclists (status of wearing helmet, comitting a behavioral violation, and presence of a rear passenger) during the study period for motorcyle use (delivery use or privately use).

HP4: There are no significant differences between motorcycle use (delivery use or privately use) and committing to do a certain behavioral violation (crossing red light and overtaking vehicles) during the study period.

- **Testing HP1**

One-way ANOVA Test was conducted to check if there are statistical differences between motorcycle use and different behavioral charecteristics of the motorcyclists during the study period. The results show that there are significant differences between motorcycle use and the status of wearing helmet on Friday, with a P-value of 0.000, considering the significant level ($\alpha = 0.05$), and therefore, the hypothesis HP1-1 is rejected. Similarly, there are significant differences for crossing motorcycles on Saturday, Sunday, and in all days. P-values for the study period are summerized in Table 3.3.

Table 3.3

P-values for HP1

#	Category	Friday	Saturday	Sunday	All*
HP1-1	Status of wearing helmet	0.000	0.000	0.000	0.000
HP1-2	committing a behavioral violation	0.033	0.141	0.078	0.021
HP1-3	Presence of rear passenger	0.000	0.000	0.000	0.000

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

Wearing helmet differs between delivery use and private use as can be seen from the results of one-way ANOVA Test in Table 3.5 for all days in the study period. As discussed earlier, delivery motorcyclists tend to wear helmet more than private motorcyclists, as indicated in Tables C1a , C2a ,and C3a in Appendix C, where the percentage of wearing helmet for delivery use for Friday, Saturday, and Sunday are 82.2%, 93.1%, and 90.3%, respectively, of total delivery use motorcycles. This can be explained due to requirements of the delivery companies towards their motorcyclists.

In terms of committing a behavioral violation, statistical analysis shows that delivery use motorcyclists differ from private use motorcyclists when committing a behavioral violation on Friday and in all days. The results (Tables C1c, C2c, and C3c in Appendix C) show that delivery use motorcyclists tend to commit behavior violations more than private use motorcyclists.

In the presence of a rear passenger, statistical results show that there are differences between delivery use and private use motorcyclists. From Tables C1b, C2b, and C3b in Appendix C, private use motorcyclists tend to have a rear passenger significantly more than delivery use motorcyclists. As discussed earlier, private use motorcycles are allowed to have a rear passenger, but a delivery use motorcycles are not.

- **Testing HP2**

One-way ANOVA Test was conducted to examine the second hypothesis, in order to check if there are statistical differences between behavioral characterestics and actions of the motorcyclists (status of wearing helmet, comitting a behavioral violation, and presence of a rear passenger) during the study period.

The results show that there are no significant differences between status of wearing helmet and a motorcyclist conducting a behavioral violation on Friday, with a P-value of

0.068, considering than the significant level ($\alpha = 0.05$), and therefore, the hypothesis HP2-1 is accepted. Similarly, there are no significant differences for crossing motorcycles on Saturday, Sunday, and in all days. P-values for the study period are summerized in Table 3.4.

Statistical results show that status of wearing helmet for delivery use or private use motorcyclists doesn't differ when doing a behavioral violation during the study period as shown in Table 3.4. But, the status of wearing helmet for delivery use or private use motorcyclists differ when having a rear passenger. Finally, having a rear passenger does not affect making a behavioral violation or not, whether for delivery use or private use motorcyclists.

Table 3.4

P-values for HP2

#	Category	Friday	Saturday	Sunday	All*
HP2-1	Status of wearing helmet with committing a behavioral violation	0.068	0.247	0.160	0.740
HP2-2	Status of wearing helmet with presence of rear passenger	0.000	0.000	0.000	0.000
HP2-3	Presence of rear passenger with committing a behavioral violation	0.881	0.954	0.805	0.703

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

- **Testing HP3**

One way ANOVA Test was conducted to check if there are statistical differences between behavioral characterestics and actions of the motorcyclists (status of wearing helmet, comitting a behavioral violation, and presence of a rear passenger) during the study period for motorcyle use (delivery use or privately use).

The results show that there are no significant differences between status of wearing helmet and delivery use motorcyclist do a behavioral violation on Friday, with a P-value of 0.683, considering the significant level ($\alpha = 0.05$), and therefore, the hypothesis HP3-1 is accepted. Similarly, there are no significant differences for crossing motorcycles on Saturday, Sunday, and in all days. P-values for the study period are summerized in Table 3.5.

Table 3.5

P-values for HP3

#	Category		Friday	Saturday	Sunday	All*
HP3-1	Status of wearing helmet with committing a behavioral violation	Deliver Use	0.683	0.220	0.221	0.960
		Private Use	0.020	0.263	0.031	0.980
HP3-2	Status of wearing helmet with presence of rear passenger	Deliver Use	0.201	0.032	0.004	0.000
		Private Use	0.005	0.182	0.202	0.004
HP3-3	Presence of rear passenger with committing a behavioral violation	Deliver Use	0.092	0.480	0.144	0.042
		Private Use	0.601	0.231	1.000	0.599

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

Statistical results show that there are no significant differences between delivery use motorcyclists in the status of wearing helmet and committing a behavioral violation during the study period. But, for private use motorcyclists, results show that there are significant differences on Friday and Sunday, but also show that there are no significant differences on Saturday and in the three days. In Saturday, private use motorcyclists who wore helmet is less than those on Friday and Sunday. Also, the number of those who committed behavioral violations is higher on Saturday than those on Friday or Sunday.

In terms of status of wearing helmet while having a rear passenger, statistical results show that delivery use motorcyclists differ in Saturday, Sunday, and among days. But, the results show that there are no significant differences in Friday. This might be because in Friday the percentage of delivery use motorcycles who have a rear passenger is half than that in Saturday. Also, the percentage of wearing helmet in Friday is less than that in Sunday.

In the presence of rear passenger and committing a behavioral violation, the statistical results show that there are no significant differences between delivery use motorcyclists in Friday, Saturday, and Sunday. But, the results show that there are significant differences in the three days. For the private use motorcyclists, the results show that there are no significant differences during the study period.

- **Testing HP4**

One-way ANOVA Test was conducted to check if there are statistical differences between motorcycle use (delivery use or privately use) and commiting a certain behavioral

violation by the motorcyclists (crossing red light and overtake vehicles) during the study period.

The results show that there are significant differences between a delivery use and private use motorcyclists committing a violation in crossing the red light on Friday, with a P-value of 0.000, considering the significant level ($\alpha = 0.05$), and therefore, the hypothesis HP4-1 is rejected. Similarly, there are no significant differences for crossing motorcycles on Sunday, and all days. P-valuse for the study period are summerized in Table 3.6.

Table 3.6

P-values for HP4

#	Category	Friday	Saturday	Sunday	All*
HP4-1	Crossing Red Light	0.000	0.103	0.001	0.000
HP4-2	Overtaking	0.989	0.199	0.257	0.377

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

Statistical results show that there are significant differences between motorcycle use and crossing a red light on Friday, Sunday, and in all days. Moreover, for overtaking violations, statistical results show that there are no significant differences between motorcycle use and commit to overtake during the study period.

From these results, the status of wearing helmet and the occurrence of rear passenger are related to the type of motorcycle use, whether delivery use or private use. Also, committing a crossing red light violation is related to the type of motorcycle use. However, overtaking behavioral violation is not found to be related to the type of motorcycle use.

In general, there is a need to control the behavioral violations for both type of motorcycle use. There is a need for more effort to control the status of wearing helmet in general, but for private use motorcycles at specific as well.

Chapter Four

Results and Conclusions

4.1 Introduction

This study has been conducted to assess and enhance traffic safety of motorcycles, in order to better understand the reality of the motorcycle mode and its safety related aspects. The traffic safety study required analysis of collected crashes data in order to develop crash profile, generate crash maps, and assess the behavior of motorcyclists. Moreover, the study has benefited from the outcome of conducted interviews to achieve a safe and reliable motorcycle mode.

Nablus City is selected to be studied in order to assess motorcycle safety. Data were collected for a total of 175 crashes from Nablus Traffic Police Department during the period from January 2019 to November 2021. The collected data were analyzed to develop the relevant profiles and for spatial analysis. Zonal analysis was conducted, as Nablus City is divided into 40 census zones. Every crash was allocated to the respective zone based on location of crash to identify the hazardous zones.

A total of 1,724 motorcycles in a three-day period were observed and studied at Al-Badawi intersection located in the most hazardous zone, in order to study and assess motorcyclists' behavior. The observed data were sorted and analyzed.

4.2 Summary of Results

The distribution of crashes per month during the study period showed a cyclic pattern of crashes, with the summer months having the highest number of motorcycle crashes, while the winter months exhibited the lowest.

The first quarter of year 2019 showed higher values than those of 2020 and 2021. This can be explained by the lockdowns imposed on the city in the first months of 2020 and in a short period 2021 after the beginning of the spread of COVID-19 Pandemic.

In terms of the daily distribution, Saturday had the highest number of crashes compared with other days, with a total of 31 crashes. Also, weekends showed higher values of crashes. Normally, shopping and entertainment activities were higher in the weekends.

Based on the hourly distribution, the results showed that the afternoon peak periods (13:00-16:00) had the highest values of the number of crashes that happened in these hours. As can be seen from the hourly distribution of motorcycles in the studied three days (Friday, Saturday, and Sunday), the same hours had the highest number of motorcycles crossing the intersection. Also, the highest number of violations committed by motorcyclists were found to be in these studied hours.

The most frequent reason of the crashes was changing lanes with a value of 30 crashes. Changing lanes can be described in terms of behavior of motorcyclists by overtaking, which was found to be the violation with the highest value among other types of violations in the three days. The private cars class was the dominant vehicle class involved in crashes with motorcycles with a percent of 75%.

In terms of the outcome of motorcycles crashes, property damage has a percent of 49.1% from all the crashes. The data collected from crash reports does not show the status of helmet nor the safety clothes when the crash happened. Of the crashes with injuries, which formed about 50.9% of all the motorcycles crashes, light injuries formed 82.0%, medium injuries of 15.8%, while sever and death injuries formed percentage of 1.1% each.

Spatially, the highest number of crashes occurred in the western part of the city, specifically in Zone 11 (Al-Qirawan Neighborhood). Rafedia Street is located inside this neighborhood, which is a main road connecting several important facilities in the city. This area contains also a large number of restaurants, cafes, shops and entertaining sites, which attract citizens or visitors to the city. Delivery motorcycles are used a lot in this area, for delivering of food and goods, due to its importance, the percentage of the delivery use motorcycles from all the motorcycles crossing the studied intersection, Al-Badawi Intersection, formed 82.5%, while private use motorcycles formed 17.5%.

There is more commitment by delivery use motorcyclists to wear helmet (50.2% of total) compared with the private use motorcyclists (16.3% of total). That might be because of the rules that delivery companies have obliging their workers to wear helmet. For rear passengers, private use motorcyclists tend to have more rear passenger compared with delivery use motorcyclists, as the delivery use motorcycles are not allowed to have a rear passenger.

There were 1,724 motorcycles that crossed the studied intersection between 9:00 and 24:00 during the three studied days, of which 1,252 were for delivery use and 472 for private use.

Motorcyclists who commit behavioral violations formed 73% of total motorcycles. For delivery use, the percentage was 74% and for private use, the percentage was 69%.

4.3 Conclusions

The conclusions from the results of the study are summarized hereafter:

- There are temporal variations in the motorcycle crashes, summer months show higher values of crashes than winter months, weekends more than weekdays, and peak periods more than off-peak periods.
- There is lack of respect of traffic regulations by motorcyclists, and there is no effective enforcement to deter violators. More efforts need to be exerted by traffic police for strict enforcement of traffic regulations and motorcyclists' violations of. Proper education and awareness for the motorcyclists are needed.
- The analysis of the crashes in which motorcycles were involved in the city during the study period shows that the wrong behavior of the motorcyclists contributed to 96% of the causes of these crashes.
- There is more commitment by delivery use motorcyclists to wear helmets, compared with the private use motorcyclists. In case of rear passenger, private use motorcyclists tend to have rear passenger compared with delivery use motorcyclists.
- Changing lanes is the highest reason of motorcycle crashes. Property damage is dominant, while light injuries are the most frequent in injuries crashes.
- Al-Qirawan Neighborhood in Rafedia has the highest motorcycle crashes reported in Nablus City based on distribution of motorcycle crashes. The CBD has the highest rate of crashes per km^2. But, in case of distribution of crashes per 1,000 capita, New Campus Neighborhood (which is right to the west of Al-Qirawan Neighborhood), shows the highest motorcycle crash rates as reported in this zone.
- Analysis of the motorcyclists' behavior at the studied intersection indicates that about 60% were not wearing helmets, while the vast majority (70%) of motorcyclists who

crossed the intersection had committed at least one behavioral violation, with most as illegal overtaking, crossing the red light, and mingling. Delivery use motorcyclists tend to commit more violations than private use motorcyclists.

- For the delivery use and private use motorcyclists, the percentages of those with legal behavior and wearing helmet were only 12.7% and 5.1% of total, respectively. Overall, such percentage of those with legal behavior and wearing helmets where 183 out of the total of 1,724, reaching only 10.6% of total.
- The percentages of delivery use and private use motorcyclists who travel on the major movement on Rafedia Street and commit an overtaking, formed 73.8%, and 73.3%, respectively. Moreover, the percentage for those crossing a red light for the same turning movement formed 66.7%, and 58.6%, respectively.
- The most common violation that motorcyclists tend to commit is overtaking vehicles and then crossing red light.
- Statistical analysis shows that there is a need to control the behavioral violations for both type of motorcycle use.
- It is been observed that there is a potential relation between behavior of motorcycle and the reason of crashes. This can be found when comparing how motorcycles act through field observations (for example overtaking was the most frequent observed violation), and the reason of motorcycle crashes (where changing lanes was the most frequent reason).

4.4 Limitations and Recommendations

4.4.1 Limitations

- The cameras quality was not superior, the footage quality was limited, where the researcher was not able, in a limited number of cases, to define whether a motorcyclist was wearing helmet or not. Also, the license plate couldn't be always observed in order to assist in examining the legality of the motorcycle.
- The manual collection process of data from Nablus Traffic Police Department was time consuming and few records were not clear.
- There were no previous studies that were conducted on motorcycle crashes in Palestine to benefit from.

4.4.2 Recommendations

From the results of this study, recommendations can be summarized as follows:

- Traffic Police needs to record detailed data on motorcycle crashes. These include wearing of helmets, occurrence of rear passenger, wearing safety clothes, type of collision, as well as the crash location coordinates by using GPS. Such data will help to identify the relation between wearing helmet and safety clothes with level of injury, type of collision, and exact crash location, in order to determine the possible corrective measures.
- Ministries that are involved in traffic safety (including that related to motorcycles safety), such as MOT, MOH, and Traffic Police, should better collaborate and make campaigns in order to enhance safety of motorcycles.
- It is recommended that crashes, including motorcycle crashes, need to be recorded by smart systems cameras installed by municipalities or traffic police at road sections and intersections, in order to study of motorcyclists' behavior, and detect and ticket any illegal actions.
- Students and researchers are encouraged to do more studies on motorcyclist behavior that focus on the effect of wearing helmet, status of licensing, and the health related aspects.
- It is recommended to continue studying the behavior of motorcyclists at the identified hazardous zones and study the geometric and control aspects.
- Motorcycles should be considered as a separate vehicle category when conducting traffic counts.
- More detailed data on motorcycles, such as details of age and other relevant information of people who have motorcycle licenses and of valid insurance, are suggested to be made available to researchers, in order to be considered for forecasting motorcycle crashes and observing the trend in motorcycle crashes by developing Autoregressive Integrated Moving Average (ARIMA) models.
- Traffic Police should strictly enforce the traffic law and regulations concerning violations of motorcyclists, such as the modifications that applied on the motorcycle,

sound amplifiers, invalidity of license for motorcycle and the motorcyclists, invalidity of motorcycle insurance.

– Install speed check device on the delivery use motorcycles in order to control their speeds.

List of Abbreviations

Abbreviation	Meaning
ANOVA	Analysis of Variance
ARIMA	Autoregressive Integrated Moving Average
CBD	Central Business District
CCI	Chamber of Commerce and Industry
COVID-19	Coronavirus Disease-19
MOT	Ministry of Transportation
MRBQ	Motorcycle Rider Behavior Questionnaire
PCBS	Palestinian Central Bureau of Statistics
PTW	Powered Two Wheelers
RLR-MC	Red Light Running Motorcycle
TPB	Theory of Planned Behavior
WHO	World Health Organization

References

1. World Health Organization. Global Status Report of Road Safety. 2018.

2. Palestinian Central Bureau of Statistics. Transportation and Communication Statistics, Annual Report of 2021 [Internet]. 2021. Available from: https://www.pcbs.gov.ps/Downloads/book2612.pdf

3. Palestinian Central Bureau of Statistics. Transportation and Communication Statistics, Annual Report of 2020 [Internet]. 2020. Available from: https://www.pcbs.gov.ps/Downloads/book2571.pdf

4. Palestinian Central Bureau of Statistics. Transportation and Communication Statistics, Annual Report of 2019 [Internet]. 2019. Available from: https://www.pcbs.gov.ps/Downloads/book2530.pdf

5. Palestinian Central Bureau of Statistics. Transportation and Communication Statistics, Annual Report of 2018 [Internet]. 2018. Available from: https://www.pcbs.gov.ps/Downloads/book2447.pdf

6. Palestinian Central Bureau of Statistics. Transportation and Communication Statistics, Annual Report of 2017 [Internet]. 2017. Available from: https://www.pcbs.gov.ps/Downloads/book2380.pdf

7. Palestinian Central Bureau of Statistics. Transportation and Communication Statistics, Annual Report of 2016 [Internet]. 2016. Available from: https://www.pcbs.gov.ps/Downloads/book2278.pdf

8. Palestinian Central Bureau of Statistics. Transportation and Communication Statistics, Annual Report of 2015 [Internet]. 2015. Available from: https://www.pcbs.gov.ps/Downloads/book2208.pdf

9. Palestinian Central Bureau of Statistics. Projected Mid -Year Population for Nablus Governorate by Locality 2017-2026 [Internet]. 2021. Available from: https://www.pcbs.gov.ps/statisticsIndicatorsTables.aspx?lang=en&table_id=698

10. Nablus Traffic Police Department. Monthly Crashes Unpublished Reports. Nablus; 2019.

11. Nablus Traffic Police Department. Monthly Crashes Unpublished Reports. Nablus; 2020.

12. Nablus Traffic Police Department. Monthly Crashes Unpublished Reports. Nablus; 2021.

13. Federal Highway Administration. Highway Statistics 2019. Washington, DC; 2019.

14. National Highway Traffic Safety Administration. Traffic Safety Facts, 2020: Motorcycles. Washington, DC; 2020.

15. Wang Z, Lee C, Lin P-S, Guo R, Xin C, Kolla R, Yang R, Vasili A. Study on Motorcycle Safety in Negotiation with Horizontal Curves in Florida and Development of Crash Modification Factors [Internet]. 2018. Available from: http://ftp.fdot.gov/file/d/FTP/FDOTLTS/CO/research/Completed_Proj/Summary_TE/FDOT-BDV25-977-21-rpt.pdf%0Ahttps://trid.trb.org/view/1566777

16. Theofilatos A, Yannis G. Relationship Between Motorcyclists' Attitudes, Behavior, and Other Attributes With Declared Accident Involvement in Europe. Traffic Injury Prevention 2014;15(2):156-164.

17. Cordellieri P, Sdoia S, Ferlazzo F, Sgalla R, Giannini AM. Driving Attitudes, Behaviours, Risk Perception and Risk Concern Among Young Student Car-Drivers, Motorcyclists and Pedestrians in Various EU Countries. Transportaion Research Part F Traffic Psychology and Behaviour. 2019;1(65):56–67.

18. Sakashita C, Senserrick T, Lo S, Boufous S, Rome L de, Ivers R. The Motorcycle Rider Behavior Questionnaire: Psychometric Properties and Application Amongst Novice Riders in Australia. Transportaion Research Part F Traffic Psychology and Behaviour. 2014;(22):126-139.

19. Stephens A, Brown J, de Rome L, Baldock M, Fernandes R, Fitzharris M. The Relationship Between Motorcycle Rider Behaviour Questionnaire Scores and Crashes for Riders in Australia. Accident Analysis and Prevention. 2017;(102):202-212.

20. Budd L, Allen T, Newstead S. Current Trends in Motorcycle-Related Crash and Injury Risk in Australia by Motorcycle Type and Attributes. 2018.

21. Piantini S, Pierini M, Delogu M, Baldanzini N, Franci A, Mangini M, Peris A. Injury Analysis of Powered Two-Wheeler Versus Other-Vehicle Urban Accidents. International Reseach Council on Biomechanics of Injury Conference Proceedings. 2016;840-853.

22. Greve J, Resende M, Silva H, Andreuccetti G, Bernini C, Leyton V. Factors Related to Motorcycle Accidents with Victims: An Epidemiological Survey. Medical Express. 2018;(6):1–8.

23. Rahmawati N, Widyanti A. Comparison Between Motorcyclist' Violation Behavior and Accidents in Urban and Rural Area in Indonesia: A Comparative Study. In: IOP Conference Series: Materials Science and Engineering. Institute of Physics Publishing; 2017;1–7.

24. Pervez A, Lee J, Huang H. Identifying Factors Contributing to the Motorcycle Crash Severity in Pakistan. Journal of Advanced Transportation. 2021;1–10.

25. Abdul Manan M, Várhelyi A. Exploration of Motorcyclists' Behavior at Access Points of a Malaysian Primary Road - A Qualitative Observation Study. Safety Science. 2015;1(74):172-183.

26. Abdul Manan M, Ho J, Aref S, Abdul Ghani M, Várhelyi A. Factors Associated with Motorcyclists' Speed Behaviour on Malaysian Roads. Transportation Reseasrch Part F Traffic Psychology and Behaviour. 2017;(50):109-127.

27. Abdul Manan M, Várhelyi A, Çelik A, Hashim H. Road Characteristics and Environment Factors Associated with Motorcycle Fatal Crashes in Malaysia. International Association of Traffic and Safety Sciences Research. 2018;42(4):207-220.

28. Abdul Manan M, Arif S, Sim H, Khaidir N, Jamil H, Abd Ghani M. Red Light Running Motorcyclists at Signalized Intersection in Malaysia: An Empirical Study. In: IOP Conference Series: Materials Science and Engineering. Institute of Physics Publishing; 2019;1–16.

29. Yamaguchi T. The Need for Building Role Models for Motorcycle Riders' Education in the Kingdom of Cambodia. International Association of Traffic and Safety Sciences Research. 2018;42(4):190-196.

30. Crandon I, Harding H, Cawich S, McDonald A, Fearron-Boothe D. Motorcycle Accident Injury Profiles in Jamaica: An Audit From the University Hospital of the West Indies. International Journal Injury Contrtrol and Safety Promotion. 2009;16(3):8-175.

31. Satiennam W, Satiennam T, Triyabutra T, Rujopakarn W. Red Light Running by Young Motorcyclists: Factors and Beliefs Influencing Intentions and Behavior. Transportaion Research Part F Traffic Psychology and Behaviour. 2018;(55)234-245.

32. Niraj R, Sapkota K, Onta P, Thapa P, Thapa U, Dware P, Sharma S. Motorcycle Accident Profile in Manipal Teaching Hospital. American Journal of Public Health Research. 2015;3(5A):190–193.

33. Blazquez C, Fuentes M. Global and Local Spatial Autocorrelation of Motorcycle Crashes in Chile. In: Proceedings of the 5th International Conference on Vehicle Technology and Intelligent Transport Systems. Science and Technology Publications. 2019;159-170.

34. Bolbol S, Zalat M. Motorcycle Riders' Risky Behaviors and Safety Mesaures: An Hospital-Based Study. Egypt Journal of Occupational Medicine. 2018;42(3):453-468.

35. Akl Z, Akl M, Eriksson C, Gifford M, Koustuv D. Evaluating Helmet Use Among Motorcycle Drivers in Lebanon. The Open Public Health Journal. 2018;(11):393–400.

36. International Road Federation. World Road Statistics. 2020

Appendices

Appendix A

Figures Related to Motorcycle Crash Profile

Figure A.1

Distribution of Total Motorcycle Crashes in Nablus City by Year During the Study Period (January 2019 – November 2021)

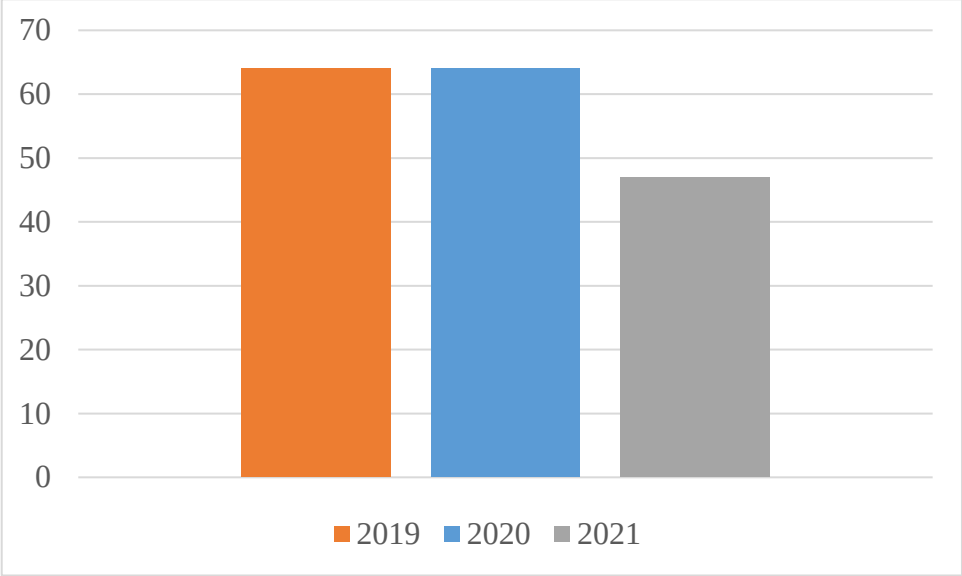
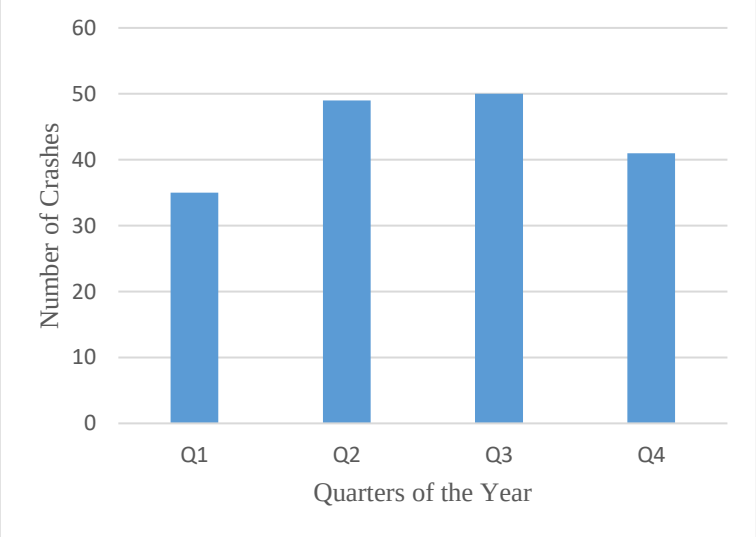


Figure A.2

Distribution of Total Motorcycle Crashes in Nablus City by Seasons of the Year During the Study Period (January 2019 – November 2021)



Appendix B

Figures Related to Spatial Analysis

Figure B.1

Analysis of Total Motorcycle Crashes per km2 During the Study Period (January 2019 – November 2021)

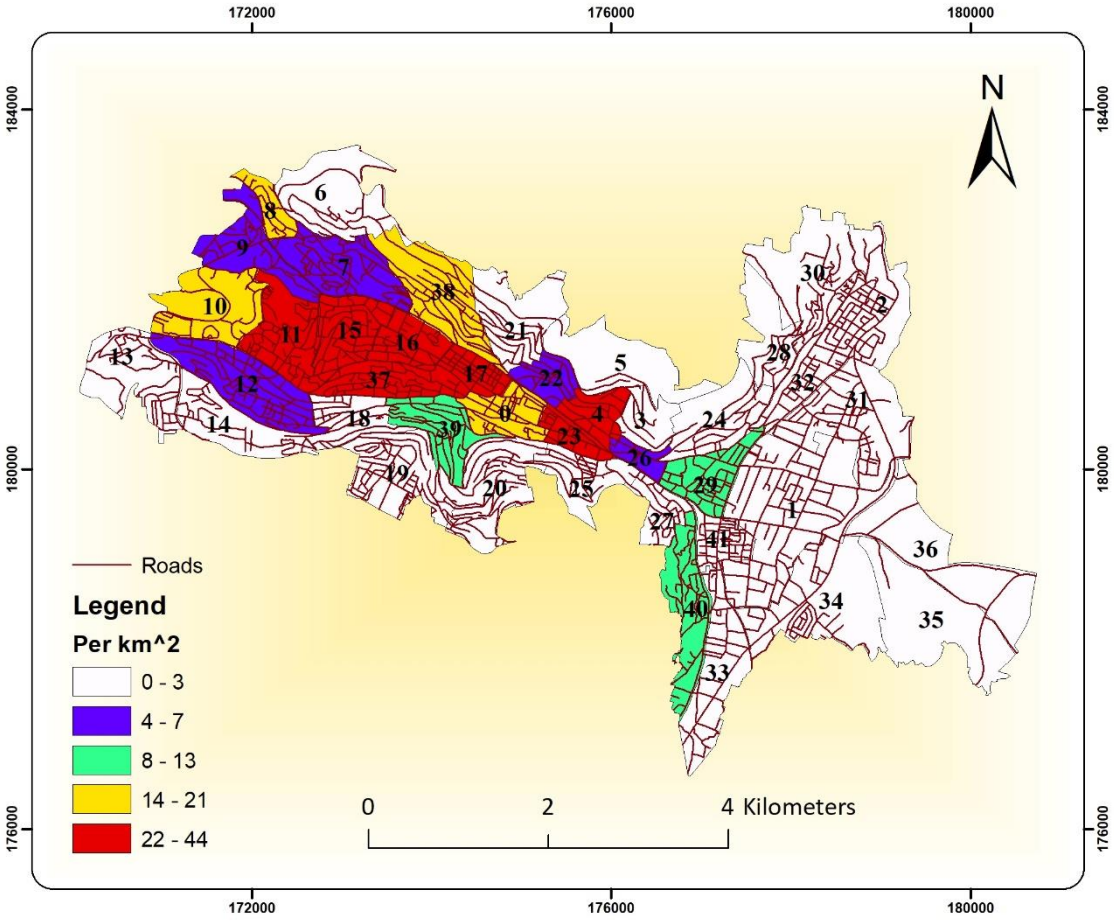
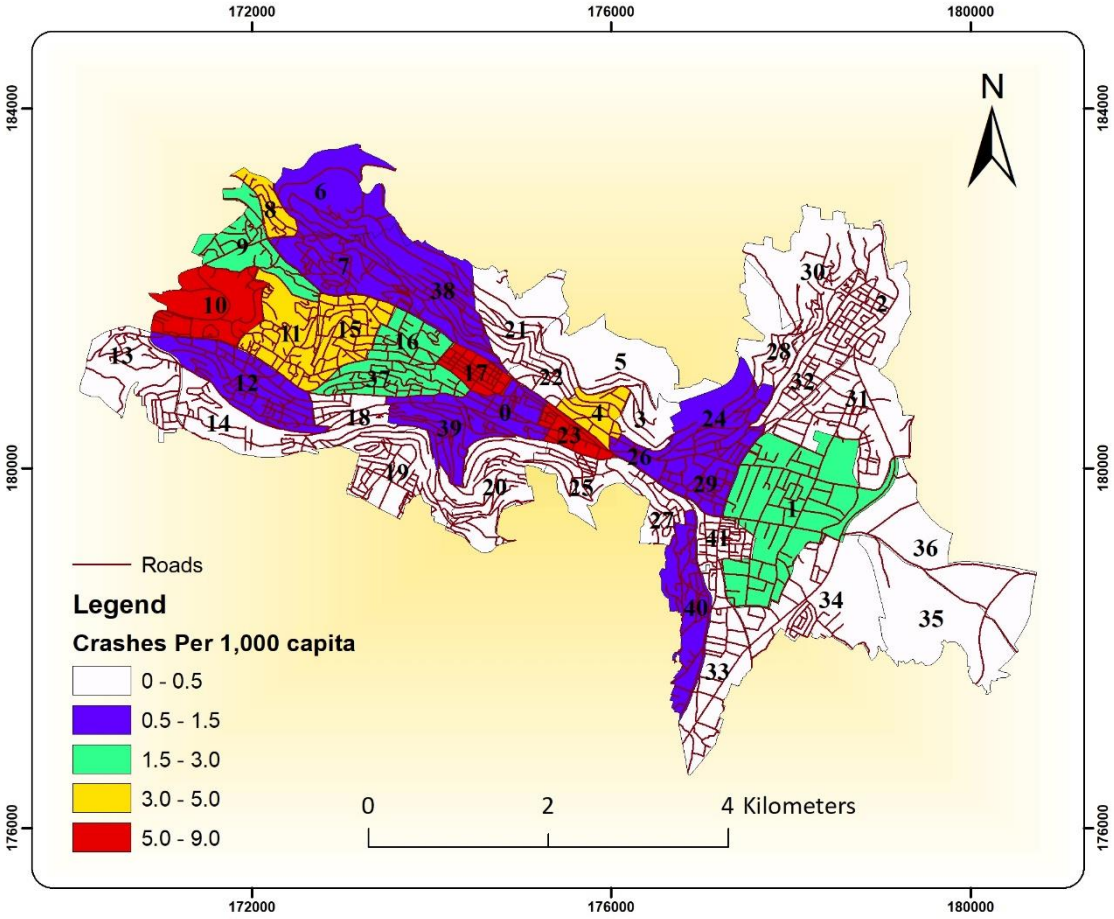


Figure B.2

Analysis of Total Motorcycle Crashes per 1,000 capita During the Study Period (January 2019 – November 2021)



Appendix C

Motorcycles Distribution and Characteristics

Figure C.1

Daily Distribution of Motorcycles during the Study Period by Type of Use

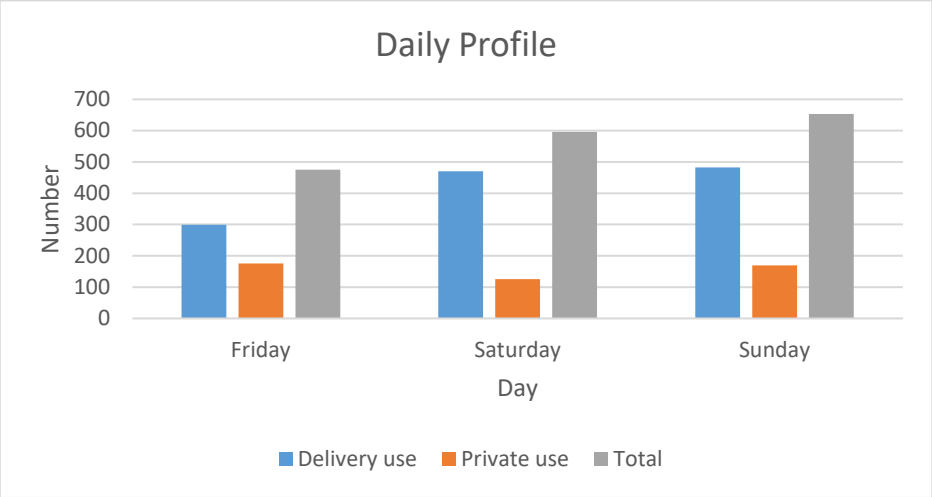


Table C.1

Hourly Distribution of Delivery Use Motorcycles and Number of Violated Motorcyclists for the Study Period

Hour	Friday			Saturday			Sunday			In all Days		
	# of Motorcycles	# of Violations	% of Violation	# of Motorcycles	# of Violations	% of Violation	# of Motorcycles	# of Violations	% of Violation	# of Motorcycles	# of Violations	% of Violation
9-10	2	0	0.0	6	4	66.7	7	3	42.9	15	7	46.7
10-11	7	4	57.1	10	9	90.0	15	10	66.7	32	23	71.9
11-12	8	2	25.0	8	6	75.0	29	23	79.3	45	31	68.9
12-13	10	8	80.0	35	28	80.0	33	27	81.8	78	63	80.8
13-14	11	4	36.4	27	21	77.8	35	21	60.0	73	46	63.0
14-15	20	10	50.0	39	34	87.2	40	37	92.5	99	81	81.8
15-16	33	20	60.6	52	41	78.8	43	38	88.4	128	99	77.3
16-17	31	20	64.5	32	26	81.3	43	35	81.4	106	81	76.4
17-18	33	21	63.6	35	25	71.4	58	45	77.6	126	91	72.2
18-19	29	19	65.5	43	29	67.4	27	16	59.3	99	64	64.6
19-20	20	14	70.0	39	31	79.5	32	28	87.5	91	73	80.2
20-21	22	20	90.9	37	31	83.8	30	20	66.7	89	71	79.8
21-22	23	21	91.3	31	22	71.0	36	29	80.6	90	72	80.0
22-23	24	18	75.0	42	26	61.9	20	16	80.0	86	60	69.8
23-00	26	23	88.5	34	26	76.5	35	23	65.7	95	72	75.8
Total	**299**	**204**	**68.2**	**470**	**359**	**76.4**	**483**	**371**	**76.8**	**1252**	**934**	**74.6**

Table C.2

Hourly Distribution of Private Use Motorcycles and Number of Violated Motorcyclists for the Study Period

Hour	Friday			Saturday			Sunday			In all Days		
	# of Motorcycles	# of Violations	% of Violation	# of Motorcycles	# of Violations	% of Violation	# of Motorcycles	# of Violations	% of Violation	# of Motorcycles	# of Violations	% of Violation
9-10	3	2	66.7	5	4	80.0	5	3	60.0	13	9	69.2
10-11	5	1	20.0	3	3	100.0	7	4	57.1	15	8	53.3
11-12	1	1	100.0	2	2	100.0	10	8	80.0	13	11	84.6
12-13	6	0	0.0	8	8	100.0	4	2	50.0	18	10	55.6
13-14	5	3	60.0	4	3	75.0	4	3	75.0	13	9	69.2
14-15	13	10	76.9	5	4	80.0	7	7	100.0	25	21	84.0
15-16	8	3	37.5	4	3	75.0	14	10	71.4	26	16	61.5
16-17	10	5	50.0	13	12	92.3	12	8	66.7	35	25	71.4
17-18	14	3	21.4	7	7	100.0	12	5	41.7	33	15	45.5
18-19	17	11	64.7	7	5	71.4	3	2	66.7	27	18	66.7
19-20	18	6	33.3	16	15	93.8	14	12	85.7	48	33	68.8
20-21	21	18	85.7	11	10	90.9	11	11	100.0	43	39	90.7
21-22	17	12	70.6	9	5	55.6	22	17	77.3	48	34	70.8
22-23	21	14	66.7	18	14	77.8	18	13	72.2	57	41	71.9
23-00	17	14	82.4	14	9	64.3	27	14	51.9	58	37	63.8
Total	**176**	**103**	**58.5**	**126**	**104**	**82.5**	**170**	**119**	**70.0**	**472**	**326**	**69.1**

- **Friday**

- Use: Of the total number of observed motorcycles of 475, there were 299 motorcycles used for delivery (63%) and 176 for privately use (37%).

- Wearing helmet:

Table C3a summarizes different characteristics and acts that motorcyclists do related on wearing helmet.

Table C3.a

Motorcyclists' Wearing Helmet Characteristics on Friday

Item	Total	Delivery Use			Private Use		
		Number	% of delivery	% of total	Number	% of private	% of total
With Helmet	179	147	49.1	82.2	32	18.1	17.8
Without Helmet	226	110	36.8	48.7	116	65.9	51.3
Not Obvious	70	42	14.0	60.0	28	15.9	40.0
Total	**475**	**299**			**176**		
With Helmet + No Violation	62	49	16.3	79.0	13	7.3	21.0
With Helmet + Violation	117	98	32.7	83.7	19	10.7	16.3
Without Helmet + No Violation	89	35	11.7	39.3	54	30.7	60.7
Without Helmet + Violation	137	75	25.0	54.7	62	35.2	45.3
Not Obvious + No Violation	53	31	10.3	58.5	22	12.5	41.5
Not Obvious + Violation	17	11	36.8	64.7	6	6.25	35.3
Total	**475**	**299**			**176**		

- Rear Passenger:

  Table C3b summarizes different characteristics and acts that motorcyclists do while having a rear passenger

Table C3.b

Motorcyclists' Rear Passenger Characteristics on Friday

Item	Total	Delivery Use			Private Use		
		Number	% of delivery	% of total	Number	% of private	% of total
Rear Passenger	58	6	2.0	10.3	52	29.5	89.7
Rear Passenger with helmet	2	0	0.0	0	2	3.44	100.0
Rear Passenger without helmet	54	6	100.0	11.1	48	92.3	88.9
Rear Passenger not obvious Helmet	2	0	0.0	0	2	3.84	100.0
Total	**58**	**6**			**52**		
Rear Passenger violation	38	6	100.0	15.8	32	61.5	84.2
Rear Passenger + Legal	20	0	0.0	0	20	38.4	100.0
Total	**58**	**6**			**52**		

Behavioral violations:

Table C3c summarizes different acts that motorcyclists do when crossing the intersection.

Table C3.c

Behavioral Characteristics of Motorcyclists' on Friday

Item	Total	Delivery Use			Private Use		
		Number	% of delivery	% of total	Number	% of private	% of total
Legal	168	95	32.4	57	73	41.4	43.0
Violations	307	204	68.2	66.5	103	58.5	33.5
Total	**475**	**299**			**176**		
Overtaking only	145	83	27.8	57.2	62	35.2	42.8
Red light crossing only	35	28	9.4	80.0	7	4.0	20.0
Mingling only	18	14	4.7	77.8	4	2.3	22.2
Illegal U-Turn only	3	1	0.3	33.3	2	1.1	66.7
Opposite Direction only	2	1	0.3	50.0	1	0.6	50.0
Overtaking with red light crossing	75	58	19.4	77.3	17	9.7	22.7
Overtaking with mingling	13	5	1.7	38.5	8	4.5	61.5
Red light crossing with mingling	10	8	2.7	80.0	2	1.1	20.0
Overtaking with red light crossing and mingling	3	3	1.0	100.0	0	0.0	0.0
Others	3						
Total	**307**						

- **Saturday**

- Use: Of the total number of observed motorcycles of 596, there were 470 motorcycles used for delivery (79%) and 126 were for privately use (21%).

- Wearing helmet:

  Table C4a summarizes different characteristics and acts that motorcyclists do related on wearing helmet.

Table C4.a

Motorcyclists' Wearing Helmet Characteristics on Saturday

Item	Total	Delivery Use			Private Use		
		Number	% of delivery	% of total	Number	% of private	% of total
With Helmet	218	203	43.2	93.1	15	11.9	6.9
Without Helmet	228	144	30.6	63.2	84	66.7	36.8
Not Obvious	150	123	26.2	82.0	27	21.4	18.0
Total	**596**	**470**			**126**		
With Helmet + No Violation	42	40	8.5	95.2	2	1.6	4.8
With Helmet + Violation	176	163	34.7	92.6	13	10.3	7.4
Without Helmet + No Violation	51	38	8.1	74.5	13	10.3	25.5
Without Helmet + Violation	177	106	22.5	59.9	71	56.3	40.1
Not Obvious + No Violation	40	33			7		
Not Obvious + Violation	110	90			20		
Total	**596**	**470**			**126**		

- Rear Passenger:

Table C4b summarizes different characteristics and acts that motorcyclists do while having a rear passenger.

Table C4.b

Motorcyclists' Rear Passenger Characteristics on Saturday

Item	Total	Delivery Use			Private Use		
		Number	% of delivery	% of total	Number	% of private	% of total
Rear Passenger	41	18	3.8	43.9	23	18.3	56.1
Rear Passenger with helmet	3	1	5.6	33.3	2	8.7	66.7
Rear Passenger without helmet	32	13	72.2	40.6	19	82.6	59.4
Rear Passenger not obvious Helmet	6	4	22.2	66.7	2	8.7	33.3
Total	**41**	**18**			**23**		
Rear Passenger violation	32	15	83.3	46.9	17	73.9	53.1
Rear Passenger + Legal	9	3	16.7	33.3	6	26.1	66.7
Total	**41**	**18**			**23**		

- Behavioral violations:

Table C4c summarizes different acts that motorcyclists do when crossing the intersection.

Table C4.c

Behavioral Characteristics of Motorcyclists' on Saturday

Item	Total	Delivery Use			Private Use		
		Number	% of delivery	% of total	Number	% of private	% of total
Legal	133	111	23.6	83.5	22	17.5	16.5
Violations	463	359	76.4	77.5	104	82.5	22.5
Total	**596**	**470**			**126**		
Overtaking only	243	177	37.7	72.8	66	52.4	27.2
Red light crossing only	37	31	6.6	83.8	6	4.8	16.2
Mingling only	12	11	2.3	91.7	1	0.8	8.3
Illegal U-Turn only	4	3	0.6	75.0	1	0.8	25.0
Opposite Direction only	6	6	1.3	100.0	0	0.0	0.0
Overtaking with red light crossing	119	100	21.3	84.0	19	15.1	16.0
Overtaking with mingling	24	21	4.5	87.5	3	2.4	12.5
Red light crossing with mingling	1	0	0.0	0.0	1	0.8	100.0
Overtaking with red light crossing and mingling	6	6	1.3	100.0	0	0.0	0.0
Others	11						
Total	**463**						

- **Sunday**
  - Use: Of the total number of observed motorcycles of 653, there were 483 motorcycles used for delivery (74%) and 170 were for privately use (26%).
  - Wearing helmet:

Table C5a summarizes different characteristics and acts that motorcyclists do related on wearing helmet.

Table C5.a

Motorcyclists' Wearing Helmet Characteristics on Sunday

Item	Total	Delivery Use			Private Use		
		Number	% of delivery	% of total	Number	% of private	% of total
With Helmet	309	279	57.7	90.3	30	17.6	9.7
Without Helmet	226	116	24	51.3	110	64.7	48.7
Not Obvious	118	88	18.2	74.5	30	17.6	25.5
Total	**653**	**483**			**170**		
With Helmet + No Violation	79	70	14.5	88.6	9	5.3	11.4
With Helmet + Violation	230	209	43.2	90.8	21	12.3	9.2
Without Helmet + No Violation	48	20	4.14	41.7	28	16.5	58.3
Without Helmet + Violation	178	96	19.8	53.9	82	48.2	46.1
Not Obvious + No Violation	36	22			14		
Not Obvious + Violation	82	66			16		
Total	**653**	**483**			**170**		

- Rear Passenger:

  Table C5b summarizes different characteristics and acts that motorcyclists do while having a rear passenger.

Table C5.b

Motorcyclists' Rear Passenger Characteristics on Sunday

Item	Total	Delivery Use			Private Use		
		Number	% of delivery	% of total	Number	% of private	% of total
Rear Passenger	57	7	1.4	12.3	50	29.4	87.7
Rear Passenger with helmet	1	0	0	0	1	2	100
Rear Passenger without helmet	47	5	71.5	10.6	42	84	89.4
Rear Passenger not obvious Helmet	9	2	25.5	22.2	7	14	77.8
Total	**57**	**7**			**50**		
Rear Passenger violation	42	7	100	16.7	35	70	83.3
Rear Passenger + Legal	15	0	0	0	15	30	100
Total	**57**	**7**			**50**		

- Behavioral violations:

  Table C5c summarizes different acts that motorcyclists do when crossing the intersection.

Table C5.c

Behavioral Characteristics of Motorcyclists' on Sunday

Item	Total	Delivery Use			Private Use		
		Number	% of delivery	% of total	Number	% of private	% of total
Legal	163	112	23.1	68.7	51	30	31.3
Violations	490	371	76.8	75.7	119	70	24.2
Total	**653**	**483**			**170**		
Overtaking only	248	180	37.3	72.6	68	40.0	27.4
Red light crossing only	49	43	8.9	87.8	6	3.5	12.2
Mingling only	23	13	2.7	56.5	10	5.9	43.5
Illegal U-Turn only	0	0	0.0	-----	0	0.0	-----
Opposite Direction only	3	1	0.2	33.3	2	1.2	66.7
Overtaking with red light crossing	132	107	22.2	81.1	25	14.7	18.9
Overtaking with mingling	17	13	2.7	76.5	4	2.4	23.5
Red light crossing with mingling	5	5	1.0	100.0	0	0.0	0.0
Overtaking with red light crossing and mingling	4	2	0.4	50.0	2	1.2	50.0
Others	9						
Total	**490**						

Appendix D

Figures Related to Turning Movements

Figure D.1

Number of Delivery Use Motorcycles

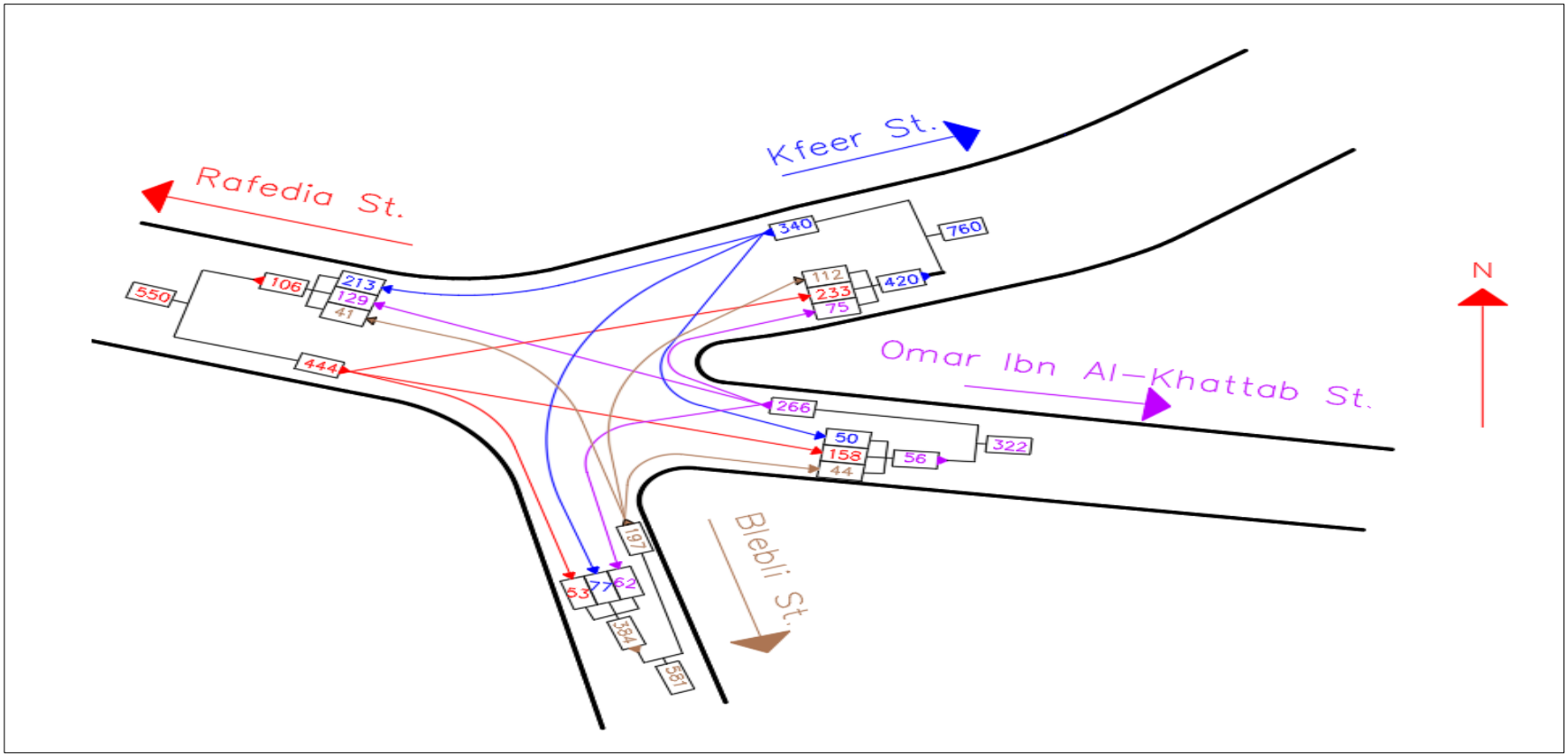


Figure D.2

Number of Private Use Motorcycles

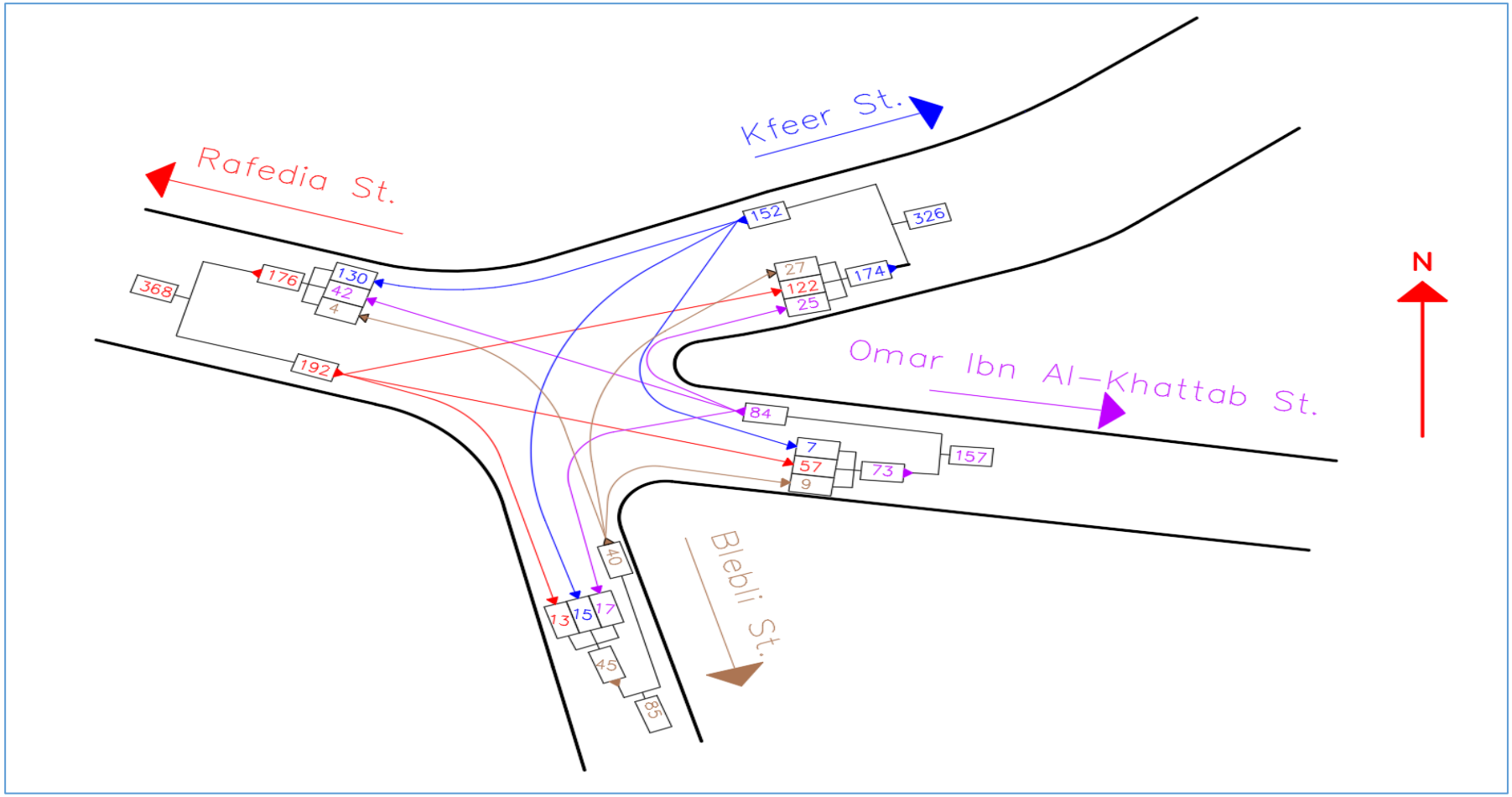


Figure D.3

Number of Overtaking Delivery Use Motorcycles

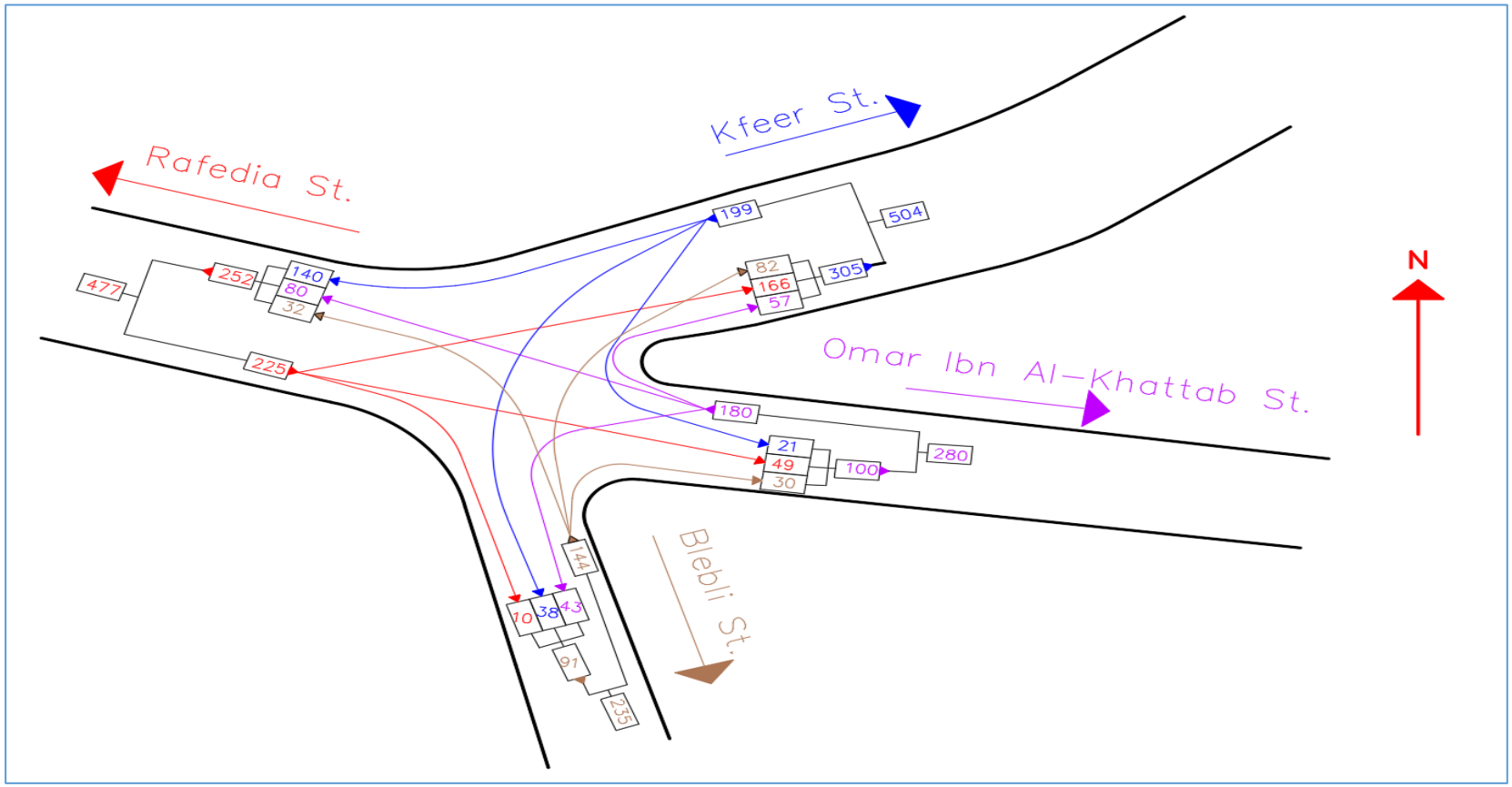


Figure D.4

Number of Overtaking Private Use Motorcycles

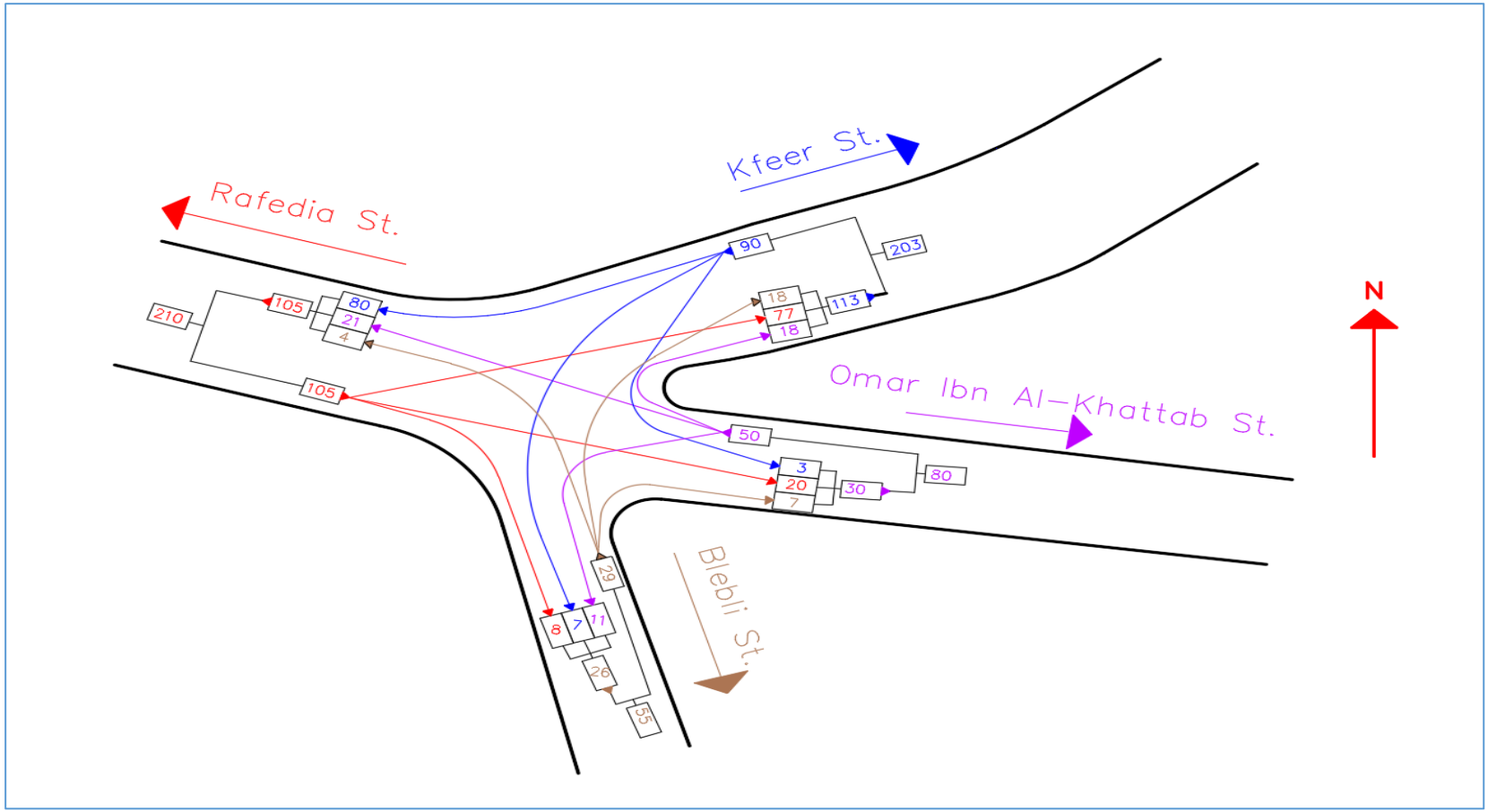


Figure D.5

Number of Red Light Crossing Delivery Use Motorcycles

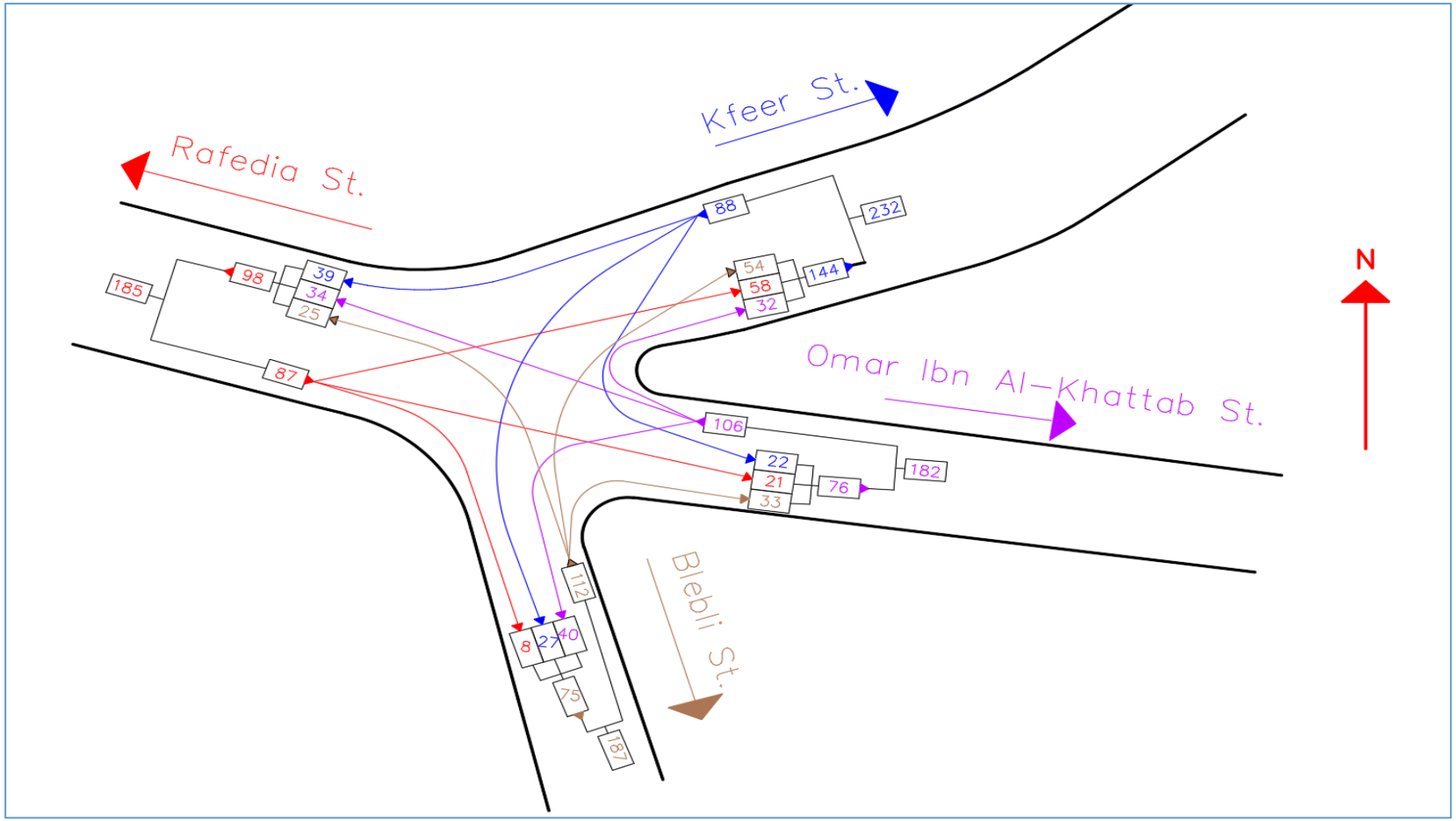
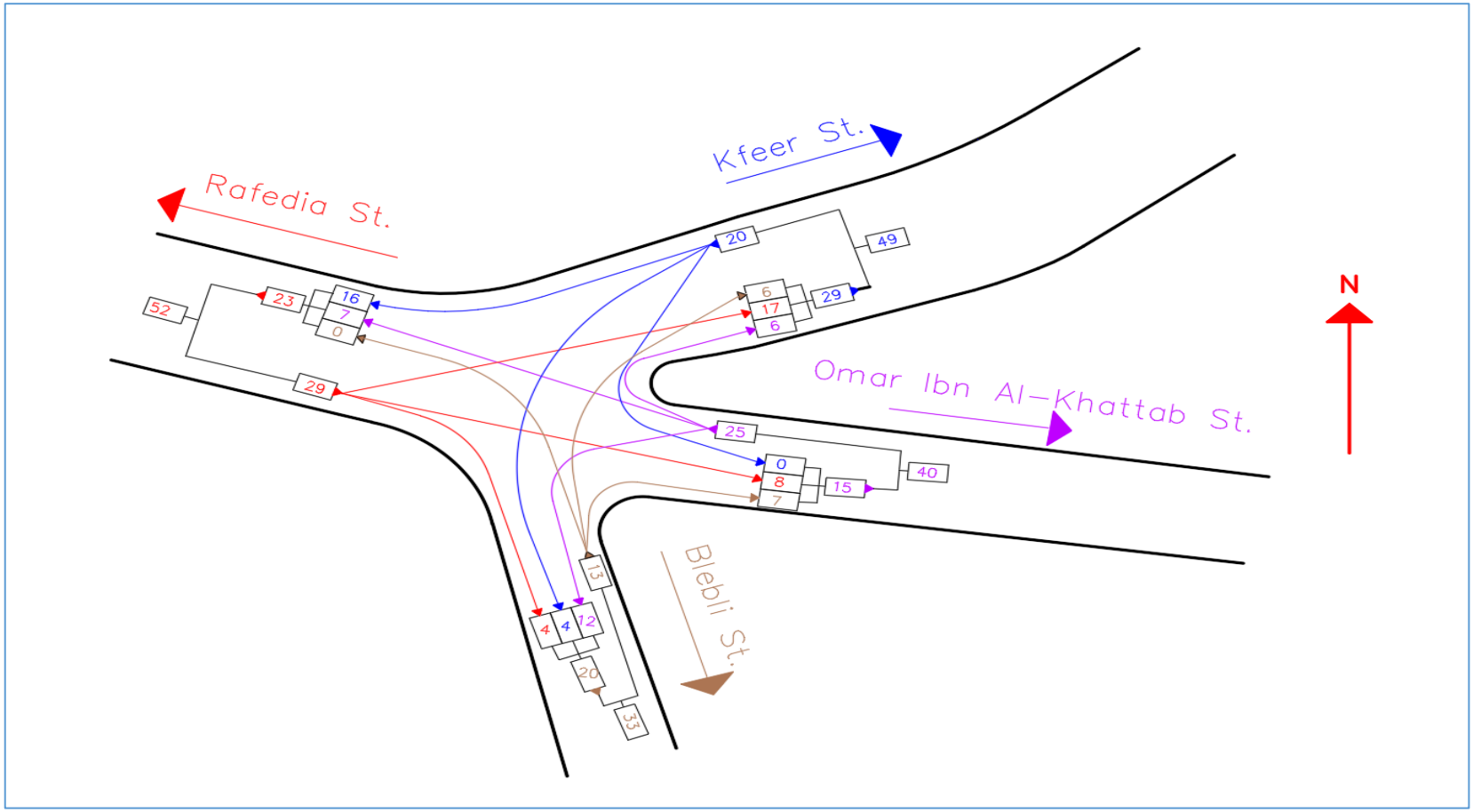


Figure D.6

Number of Red Light Crossing Private Use Motorcycles



Appendix E

SPSS Tables

Table E1.a

Results of Status of Helmet ANOVA Test on Friday

ANOVA					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	11.089	2	5.544	26.298	0.000
Within Groups	99.302	471	0.211		
Total	**110.390**	**473**			

Table E1.b

Results of Status of Helmet ANOVA Test on Saturday

ANOVA					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	10.202	2	5.101	33.926	0.000
Within Groups	89.161	593	0.150		
Total	**99.362**	**595**			

Table E1.C

Results of Status of Helmet ANOVA Test on Sunday

ANOVA					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	19.822	2	9.911	60.822	0.000
Within Groups	105.920	650	0.163		
Total	**125.743**	**652**			

Table E1.D

Results of Status of Helmet ANOVA Test during Study Period

ANOVA					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	41.872	2	20.936	119.743	0.000
Within Groups	300.903	1721	0.175		
Total	**342.775**	**1723**			

Table E2.a

Results of Occurrence of Rear Passenger ANOVA Test on Friday

ANOVA					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	18.281	1	18.281	93.473	0.000
Within Groups	92.506	473	0.196		
Total	**110.787**	**474**			

Table E2.b

Results of Occurrence of Rear Passenger ANOVA Test on Saturday

ANOVA					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	5.380	1	5.380	34.005	0.000
Within Groups	93.982	594	0.158		
Total	**99.362**	**595**			

Table E2.c

Results of Occurrence of Rear Passenger ANOVA Test on Sunday

ANOVA					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	23.763	1	23.763	151.698	0.000
Within Groups	101.979	651	0.157		
Total	**125.743**	**652**			

Table E2.d

Results of Occurrence of Rear Passenger ANOVA Test during Study Period

ANOVA					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	47.727	1	47.727	278.549	0.000
Within Groups	295.048	1722	0.171		
Total	**342.775**	**1723**			

Table E3.a

Results of Overtaking ANOVA Test on Friday

ANOVA					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	0.000	1	0.000	0.000	0.989
Within Groups	118.737	473	0.251		
Total	**118.737**	**474**			

Table E3.b

Results of Overtaking ANOVA Test on Saturday

ANOVA					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	0.364	1	0.364	1.657	0.199
Within Groups	130.488	594	0.220		
Total	**130.852**	**595**			

Table E3.c

Results of Overtaking ANOVA Test on Sunday

ANOVA					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	0.303	1	0.303	1.284	0.257
Within Groups	153.749	651	0.236		
Total	**154.052**	**652**			

Table E3.d

Results of Overtaking ANOVA Test during Study Period

ANOVA					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	0.187	1	0.187	0.781	0.377
Within Groups	412.228	1722	0.239		
Total	**412.415**	**1723**			

Table E4.a

Results of Red Light Crossing ANOVA Test on Friday

ANOVA					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	3.329	1	3.329	18.029	0.000
Within Groups	87.336	473	0.185		
Total	**90.665**	**474**			

Table E4.b

Results of Red Light Crossing ANOVA Test on Saturday

ANOVA					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	0.537	1	0.537	2.666	0.103
Within Groups	119.669	594	0.201		
Total	**120.206**	**595**			

Table E4.c

Results of Red Light Crossing ANOVA Test on Sunday

ANOVA					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	2.167	1	2.167	10.510	0.001
Within Groups	134.198	651	0.206		
Total	**136.364**	**652**			

Table E4.d

Results of Red Light Crossing ANOVA Test during the Study Period

ANOVA					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	5.709	1	5.709	28.747	0.000
Within Groups	341.973	1722	0.199		
Total	**347.682**	**1723**			

Table E5.a

Results of Behavioral Violation ANOVA Test on Friday

ANOVA					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	1.065	1	1.065	4.589	0.033
Within Groups	109.723	473	.232		
Total	**110.787**	**474**			

Table E5.b

Results of Behavioral Violation ANOVA Test on Saturday

ANOVA					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	0.362	1	0.362	2.173	0.141
Within Groups	99.000	594	0.167		
Total	**99.362**	**595**			

Table E5.c

Results of Behavioral Violation ANOVA Test on Sunday

ANOVA					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	0.600	1	0.600	3.120	0.078
Within Groups	125.143	651	0.192		
Total	125.743	652			

Table E5.d

Results of Behavioral Violation ANOVA Test during the Study Period

ANOVA					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	1.061	1	1.061	5.345	0.021
Within Groups	341.714	1722	0.198		
Total	**342.775**	**1723**			

Appendix F

Interviews Information

Table F.1

Interviewees Details

Ministry/Agency	Date	Name	Title
Ministry of Transportation	November 2022	Dr. Jamil Hamadneh	PE in Traffic Safety and Engineering
Nablus Traffic Police Depratment	July 2022	Mr. Wajed Al-Halabi	Head of Traffic Crash Department
Ministry of Health	July 2022	Dr. Ramez Dwekat	Manager of Ministry of Health
Nablus Chamber of Commerce and Industry	August 2022	Mr. Omar Hashem	Former Head of the Chamber
Nablus Municiplaity	July 2022	Eng. Rania Doleh	Head of Traffic Engineering Department
Insurance Agency	September 2022	Mr. Naser Shaheen	Owner of the Agency

جـامعـــة النجاح الوطنية

كليـــة الدراســـات العليـــا

دراسة سلامة الدراجات النارية في مدينة نابلس

إعداد

محمد كامل جلال عبد الهادي

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.

2023

دراسة سلامة الدراجات النارية في مدينة نابلس

اعداد

محمد كامل عبد الهادي

إشراف

أ.د. سمير أبو عيشة

الملخص

في ضوء الاستخدام المتزايد للدراجات النارية في فلسطين، فإن هناك ضرورة لدراسة ما يتصل بالسلامة المرورية لهذا النمط من المواصلات. وقد شهدت محافظة نابلس زيادة كبيرة في معدل الدراجات النارية المرخصة خلال الفترة 2015–2021، وبالتالي تم اختيارها لدراسة سلامة الدراجات النارية.

الهدف من هذا البحث هو تسليط الضوء على خصائص حوادث الدراجات النارية، ودراسة سلوك راكبي الدراجات النارية، وما ينتج عن ذلك من اقتراحات لتحسين سلامة الدراجات النارية.

تم الحصول من دائرة شرطة مرور نابلس على بيانات حوادث الدراجات النارية والتي تغطي الفترة من كانون الثاني 2019 إلى تشرين الثاني 2021 في مدينة نابلس. كما تم جمع بيانات إضافية من الجهاز المركزي للإحصاء الفلسطيني. وباستخدام البيانات التي تم جمعها، تم إجراء تحليل خصائص السلامة لهذا النمط. كما تم القيام بالتحليل المكاني وإنشاء خرائط حوادث الدراجات النارية لتحديد المناطق الخطرة. وكذلك تمت ملاحظة سلوك راكبي الدراجات النارية باستخدام تسجيلات الكاميرات التي تم ثبيتها عند تقاطع تمثيلي في المدينة. وتم استخدام اختبار طريقة تحليل التباين الأحادي (ANOVA) لتحديد ما إذا كانت هناك أية فروق ذات دلالة إحصائية بين العديد من الجوانب المتعلقة براكبي الدراجات النارية وسلوكياتهم.

توضح نتائج البحث أن شهري أيار وكانون الأول والسبت وما بين الساعة 15:00 – 16:00 كانت الأكثر تكرارًا لحوادث الدراجات النارية. وكان السبب الأكثر شيوعًا لحوادث الدراجات النارية هو تغيير المسارات بشكل غير قانوني. وكشفت النتائج أن أكثر مناطق حوادث الدراجات النارية شيوعاً هي حي القيروان في

منطقة رفيديا. ويُظهر تحليل السلوك عند التقاطع أن هنالك 70٪ من راكبي الدراجات النارية ارتكبوا انتهاكًا سلوكيًا واحدًا على الأقل. وبالنسبة لراكبي الدراجات النارية الذين يستخدمونها لغرض التوصيل أو للاستخدام الخاص، كانت النسب المئوية لمن لديهم سلوك قانوني ويرتدون الخوذات 12.7٪ و 5.1٪ فقط من الإجمالي، على التوالي.

بناءً على تحليل حوادث الاصطدام، هناك عدم احترام لقواعد المرور من قبل راكبي الدراجات النارية، ولا توجد إجراءات فعالة لردع المخالفين. لذا يتوجب بذل المزيد من الجهود من قبل شرطة المرور من أجل التطبيق الصارم لأنظمة المرور وانتهاكات راكبي الدراجات النارية للقانون، كما أن هناك ضرورة لتكثيف الجهود الخاصة بالتثقيف والتوعية لهذه الفئة من السائقين.

الكلمات المفتاحية: حوادث الدراجات النارية، خصائص الحوادث المرورية، التحليل المكاني للحوادث المرورية، دراسة سلوك راكبي الدراجات النارية، نابلس، فلسطين.