An-Najah National University

Faculty of Graduate Studies

TRAFFIC SAFETY AT INTERSECTIONS: THE CASE OF TULKAREM, PALESTINE

By

Mohammad Wael Abed Al-Fatah Teebi

Supervisor

Dr. Khaled Al-Sahili

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This Thesis was Defended Successfully on 30 / 10 / 2022and approved by

Dr. Khaled Al-Sahili	
Supervisor	Signature
Dr. Huthaifa I. Ashqar	
External Examiner	Signature
Dr. Amjad Z. Issa	Amjad Issa
Internal Examiner	Signature

Dedication

It is my genuine gratefulness and warmest regard that I dedicate this thesis entitled "**TRAFFIC SAFETY AT INTERSECTIONS: THE CASE OF TULKAREM, PALESTINE"**

To

My parents who have given me the opportunity of an education from the best institutions and support throughout my life.

Also, it is dedicated to my Supervisor Dr. Khaled Al-Sahili who has been my mentor and guide.

To my friends who's been my inspiration and without whom this thesis would have not been completed.

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I'd also like to thank everyone who helped me gather data I needed to complete this thesis.

Finally, I must acknowledge my parents, without whom and without their support, I would not have been able to obtain a degree.

Declaration

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

TRAFFIC SAFETY AT INTERSECTIONS: THE CASE OF TULKAREM, PALESTINE

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: Mohammad Wael Teebi

Signature: 30/10/2022 M. Teebi

Date: 30/10/2022

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TRAFFIC SAFETY AT INTERSECTIONS: THE CASE OF TULKAREM, PALESTINE

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Abstract

Background: Research on traffic safety at intersections in Palestine urban areas is dearth. Data on traffic crashes between July 2016- 2021 for Tulkarem Governorate were obtained from the Traffic Police Department. Additional data were collected from the Palestinian Central Bureau of Statistics (PCBS) and the Ministry of Transportation.

Aim: The aim of this research was to draw a comprehensive profile of road crashes at intersections in Tulkarem Governorate areas.

Methodology: Two different approaches were used to identify the governorate's most critical sites: severity of injuries at intersections and crash rate per traffic volume. Analyses were performed on three levels: Tulkarem Governorate, Tulkarem city, and COVID-19 pandemic; examining trends, severity levels; and accident-causing factors, and spatial distribution.

Results: Results revealed that Tulkarem city and the city's Zone 6 were the most critical locations. Results also indicated that Thursday had the highest intersection crashes at all levels. The highest number of crashes at the governorate level occurred between 10:00-16:00, while for Tulkarem city the highest occurred between 12:00-20:00. During the pandemic, the highest were reported between 10:00-14:00. The spring season recorded the highest frequency at all levels, followed by summer, autumn, and winter. The percentage of males injured was higher than that of females at all levels. "Not giving right of way" was the highest cause in all intersection crashes in the governorate, while the ''over speeding" was the highest cause in the city. The number of crashes involving pedestrian injury was 15.88% of the total number of intersection crashes at the governorate level. Most injuries were for the 11-30 age group in the governorate and the city.

Conclusions: The majority of crashes were caused by users' behavior; therefore, it is strongly advised that nationwide awareness campaigns on traffic laws be launched targeting all road users (drivers, passengers, and pedestrians). The behavior of drivers and other road users should, therefore, be thoroughly studied. Another important and urgent need is the creation of a national traffic safety program.

Keywords: Intersection safety; COVID-19; Tulkarem; crashes; pedestrians; Palestine.

Chapter One

Introduction

1.1 General Background

Every day, we have different routine activities, whether going to work, universities, schools, or moving from one place to another. Therefore, every single person is a road user at a time, and that's based on the nature of individuals' activities. Therefore, we have to take the pedestrian needs and safety into account as well as other road users.

Tulkarem Governorate, which is the focus in this study, is one of the 11 governorates in the West Bank. Reports by the Palestinian Central Bureau of Statistics (PCBS) for year 2022 showed that the estimated population of Tulkarem Governorate was 202,401 of both sexes (1). Furthermore, the reports issued by the Ministry of Transportation (MOT) for year 2020 showed that the total number of registered and licensed vehicles in the Governorate was 31,122 registered vehicles with total licenses of 19,490 (2).

In general, intersections are designed to provide the necessary facilities and opportunities for traffic to move around in all directions so that these intersections are technically successful. Designers are looking at providing the space and time for the different traffic movements of all the road users, and their goal is to achieve safety first and foremost. On the other hand, the interaction between pedestrians and vehicles is generally more dangerous at the intersections, where a certain percentage of the space is shared. In 2020, road crashes in Tulkarem Governorate totaled 849 out of 10,319 total number of crashes in the northern governorates; West Bank (3). On the other hand, in 2020, 619 crashes were registered in the Governorate, out of 6,547 in the northern governorates (4).

Therefore, there is a need to evaluate the safety conditions with a focus on both pedestrians' and vehicles' safety, and there is a growing need to protect road users from vehicles' collisions and reduce road risks.

1.2 Significance of the Study

Tulkarem Governorate is located in the western center of historical Palestine, in the north of the West Bank, and thus it is distinguished by its geographical location. The Ministry of Tourism & Antiquities (MTA) for year 2015 gave Tulkarem City a title of the capital of the northern West Bank in terms of the presence of important commercial and tourist centers(5). It is also the main city in the governorate. Therefore, a large number of people visit it for business, employment, commerce, and higher education purposes. As a result, heavy traffic volumes exist. Based on that, consideration must be given to vehicular and pedestrian traffic system, traffic collisions, and their safety issues. On the other hand, Tulkarem Governorate clearly lacks proper studies and statistics about its transportation and traffic issues; therefore, there is a dire need to conduct a study on traffic safety for road users in Tulkarem Governorate.

According to the MOT annual report (2021), Tulkarem Governorate ranked seventh among West Bank governorates in terms of number of crashes; it formed 9.45% of total crashes in the West Bank governorates with 869 injuries of varying severity and 8 fatally injured (6). Therefore, crashes pose a threat to traffic safety for all road users. As such, there is a clear interest in making a detailed study on this topic and focusing on understanding and presenting the needed policies and improvements to make intersections safer for all users. It is necessary to focus on various sites in Tulkarem Governorate that are perceived as dangerous for road users. Therefore, this study will focus on intersections in Tulkarem Governorate in all its types (signalized intersections, roundabouts, and non-signalized intersections).

1.3 Study Objectives

The main objective of this thesis is to study the safety of road users at intersections in the Tulkarem Governorate. The particular objectives are:

- To identify the road traffic crashes patterns that exist in Tulkarem Governorate at intersections.
- To determine the geographical distribution and the spatial and temporal variation of intersection crashes in Tulkarem Governorate. Furthermore, the critical locations in terms of road crashes will be identified.

- To determine the major causes and contributing factors of road crashes with respect to drivers, pedestrians, vehicles, and road environments and link between them at intersections.
- Set policies and strategies to minimize the crashes to mitigate the problems, as much as possible.

1.4 Study Area

Tulkarem Governorate is an administrative district in Palestine located in the northwest of the West Bank, covering 300 km2, Figure 1-1 a. It consists of one city, 7 towns, 22 villages, and 2 refugee camps as shown in Figure 1-1 b (7).

The main study area is Tulkarem Governorate, with a focus on Tulkarem city. The study will cover most parts of the city with a focus on critical areas that witness considerable vehicles and pedestrians such as the roundabouts, school area, signalized intersections, central business district (CBD), etc.

Figure 1.1 a

Location of Tulkarem Governorate in the West Bank

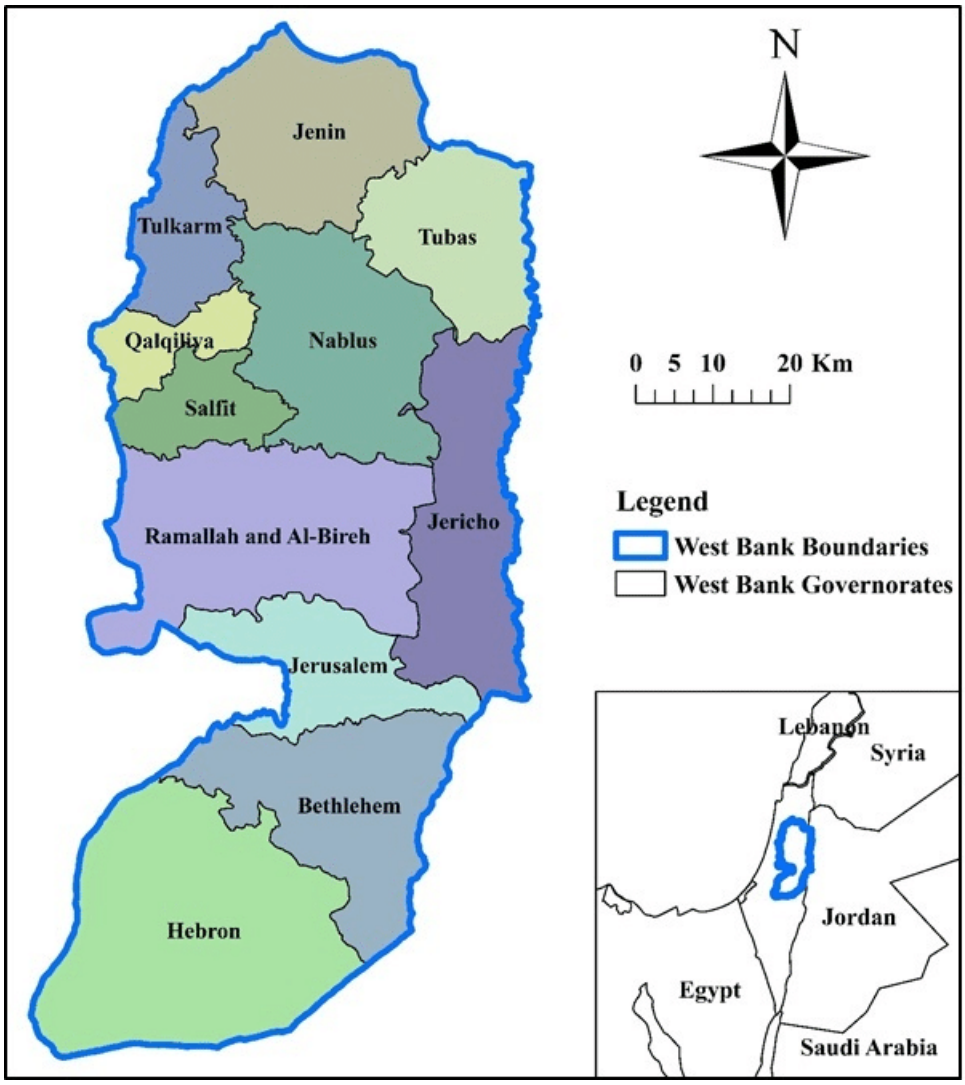
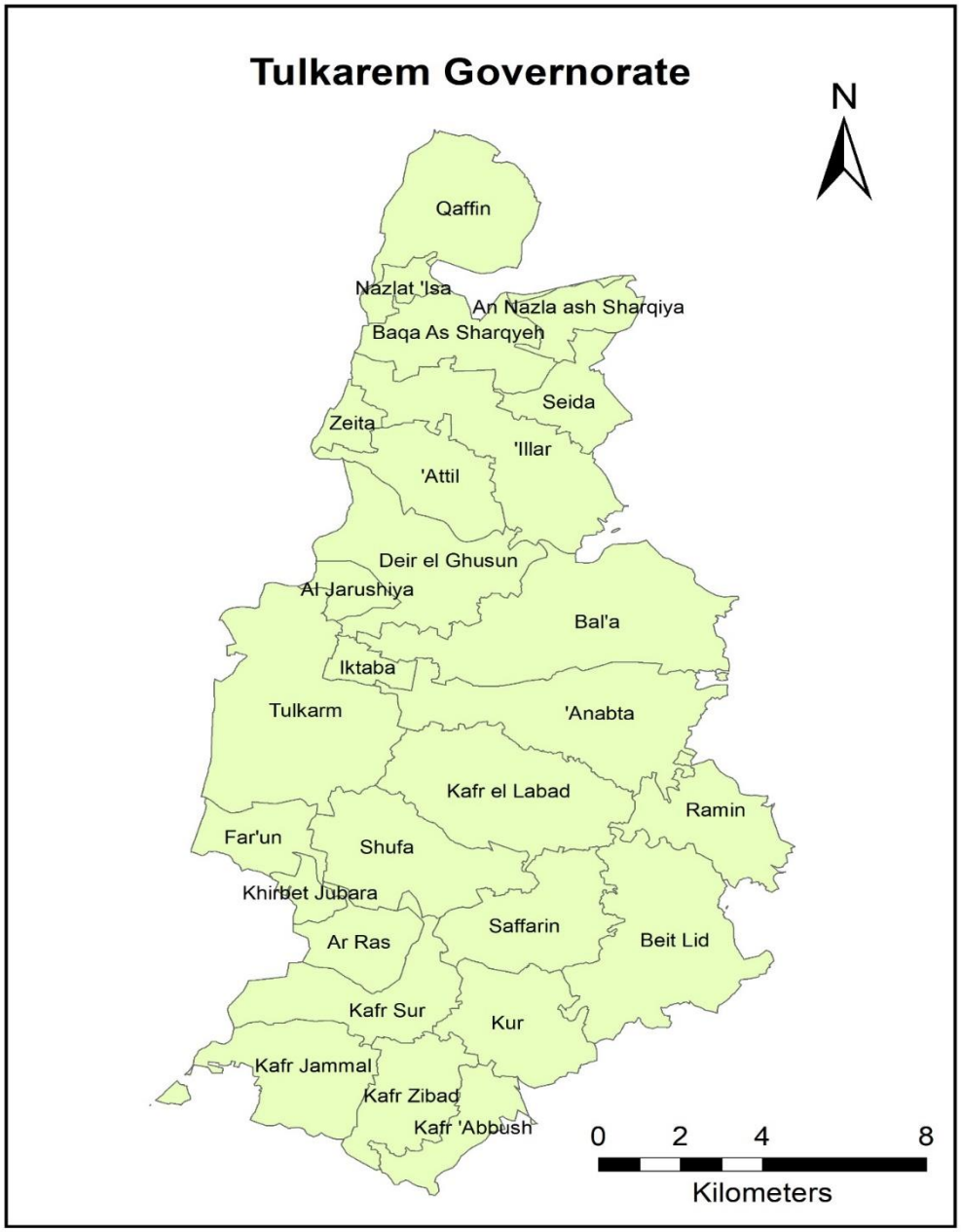


Figure 1.1 b

Localities of Tulkarem Governorate



There were 233 intersection crashes in Tulkarem Governorate in 2016, formed 27.67% of the total crashes in the Governorate; this number decreased in the following years. Table 1.1 shows the percentage of recorded intersection crashes for the study period (2016- July 2021) in Tulkarem Governorate.

Table 1.1

Percentage of Intersections Crashes in Tulkarem Governorate

Year	Total Crashes in Governorate	Total Crashes at Intersections	Percentage
2016	842	233	27.67%
2017	807	173	21.40%
2018	599	135	22.50%
2019	358	139	38.80%
2020	619	79	12.76%
Till July 2021	-	53	-

1.5 Literature Review

Intersection crashes and their trends have been a subject of interest for many researchers all over the world. Different related papers, reports, and articles that considered crashes and safety issues were reviewed. In the following sections, some of these studies are summarized. The studies are classified into three levels: intersection crashes, crashes involving pedestrians, and crashes as an impact of COVID-19. A summary of selected literature is presented here for different parts of the world.

1.5.1 International Studies

As some general statistics, the World Health Organization (WHO, 2021) reported that road traffic injuries cause approximately 1.30 million deaths each year worldwide. Moreover, road traffic crashes cost most countries 3.00% of their gross domestic product. More than half of all road traffic deaths are among vulnerable road users: pedestrians, cyclists, and motorcyclists (8).

The US National Highway Traffic Safety Administration (NHTSA) presented annual statistics for intersection-related traffic fatalities; there were 10,180 fatal motor vehicle crashes in the United States at intersections, in which there were 36,096 fatalities (9).

The United States and a number of European countries have converted hundreds of signalized intersections into roundabouts in the recent past. A research based on 44 intersection safety studies was carried out between 1975 and 2014 in different European countries, the United States, and Australia. The research concluded that “It is therefore clear beyond reasonable doubt that roundabouts improve road safety and are particularly effective in reducing fatal accidents” (10)

1.5.1.1 Intersection Studies in the USA

Intersection's geometric design is one of the most significant factors that contribute to intersection crashes, which are influenced by traffic volumes, design speed, lane numbers or width, etc. Therefore, Bhuiyan et al. (2017) analyzed crashes at 17 signalized intersections in the Los Angeles and Long Beach area in the United States as a case study. The research studied the independent variables contributing to intersection crashes, such as the annual average daily traffic (AADT), travel speed, the average number of lanes, presence of medians, pedestrian crossings, types of left-turn control, and travel speed. The researchers performed a regression analysis using the average accident data for five years as a dependent variable and established the relationship with independent variables. The resulting relationship is expressed as follows:

$$Acc = 1.52 \ln(AADT) - 4.64L + 1.57MDN - 2.51PED + 6.57LTSGNAL + 0.34SPD - 5.81$$

where:

Acc = average number of crashes,
AADT = annual average daily traffic
L = total number of lanes at the intersection
MDN = total number of medians at the intersection
PED = total number of pedestrians at the intersection
LTSGNAL = type of left-turn signal control
SPD = travel speed.

The results showed that the average number of crashes at signalized intersections was strongly correlated with the number of lanes and the type of left-turn control. In the same context of the factors that can cause intersection crashes (11), Choi (2010) conducted a study to understand the factors and presented different scenarios about driver behavior and the impact of external factors such as weather conditions, distraction, and illegal maneuvers, etc. The study aimed to provide a better understanding of the scenarios of intersection-related crashes and the state of the activities of the drivers involved, such as inattention, distraction, illegal maneuvers, etc. The study considered some general characteristics of motor vehicle traffic crashes that were investigated at the crash scenes. The data were analyzed to examine the association of the critical reasons for intersection-

related crashes, with several factors such as a critical pre-crash event (an event or action that puts a vehicle on a course that makes the collision unavoidable), the driver's sex and age, traffic control devices, and atmospheric conditions. The researcher concluded that most of the collisions occurred at intersections because of the activities that take place there; for example, turning left or right or pedestrians crossing, and therefore giving rise to conflicts that may lead to collisions. The results could be used to evaluate intersection collision avoidance systems designed to help prevent intersection-related crashes. This might also help to improve road design, the use of traffic control devices, and driver training (12).

The crash rate is one important indicator of a dangerous intersection. Green and Agent (2003) studied crash rates at intersections in cooperation with the Kentucky Transportation Center in Kentucky, USA. The study aimed to develop a database of intersections, match traffic crashes to the intersections, calculate crash rates for various types of intersections, and identify intersections with the highest crash rates. About 7,000 intersections were identified with almost 19,000 crashes for the three-year period of 2000–2002. The researchers calculated the actual crash rate based on the number of crashes and the average daily traffic (ADT). The analysis identified 428 intersections that had a critical rate factor (CRF) of one or more, while only 36 intersections had a CRF above two. The crash rates were higher in urban than in rural areas. In both rural and urban areas, the rate was highest for four-lane undivided highways and lowest for four-lane divided highways. Moreover, the researchers found that 35% of all crashes in Kentucky occurred at intersections.

As for the measures and foundations of public safety at intersections, the traffic volume is one of the most important ones. Many researches and reports have presented the relationship between traffic flow and accidents at intersections. For example, Hauer et al. (1988) studied one of the largest cities in Canada, Metropolitan Toronto to find the relationship between the traffic flow and the frequency of intersection accidents based on the analysis of 145 intersections. The researchers used a Generalized Linear Model (GLM), where the normal linear regression predicts the expected value of a given unknown quantity (the frequency of accidents, traffic flow) as a linear combination of a set of observed values (predictors). This means that a continuous change in an indicator leads to a continuous change in the response variable (i.e. a linear response model). The

developed model used constants specific to the intersection type, posted speed and location, and used traffic volumes (AADTs) as explanatory variables. Among the most important findings was that the relationship between the frequency of accidents and traffic flow varies according to the engineering design of the intersections. Another study by Sayed and Rodriguez (1999) developed an adaptive crash prediction model for estimating safety at unsignalized urban intersections using the GLM approach. The study estimated the model parameters of an error structure of Poisson distribution and calculated a suitable dispersion parameter based on Pearson's λ^2 distribution, the number of observations, and the number of model parameters. The study identified and ranked crash-prone locations, developed critical crash frequency curves, and evaluated before-and-after studies.

An understanding of the contributing factors to severe intersection crashes is essential to develop strategies to lower crash frequency and severity at high-risk crash locations. Billah et al. (2017) analyzed intersections in San Antonio. They determined the basic variables and factors that contributed to the accidents at intersections in San Antonio using data collected in the period of 2013–2017. The researchers used bivariate analysis and logistic regression to identify the most important variables and linked them to the severity of the collision. The results indicated that accidents were predominantly in downtown and that male and older drivers, weekend driving, night driving, poor light conditions, ramp and ridge road alignment, cross lanes, split lanes, and marked lanes significantly increased the risk of collision at intersections. The researchers recommended that priority be given to allocating resources to high-risk intersections, separating bike lanes and sidewalks from the road, improving lighting facilities, and increasing law enforcement activity during the late-night hours of the weekend (13).

1.5.1.2 Crashes Involving Pedestrians in the USA

A pedestrian path is a section of a road designated for pedestrian crossing, but essentially also a section of a street where pedestrians are at some risk from passing transportation. And at intersections, pedestrians are potential points of conflict with vehicles, and the probability of danger is high.

The National Highway Traffic Safety Administration (NHTSA) statistics showed that there were 6,516 pedestrians killed in traffic crashes, a 3.90% increase from the 6,272 pedestrian fatalities in 2019; and an estimated 54,769 injuries in traffic crashes, a 28.00%

decrease from the 75,650 pedestrians injured in 2019 in the United States. On average, a pedestrian was killed every 81 minutes and injured every 10 minutes in traffic crashes in 2020; crashes involving pedestrians at intersections constituted 15% of all traffic crashes (9).

Understanding the behavior of traffic components (driver and pedestrian) is necessary. Therefore, some studies have presented scenarios for pedestrian and driver collisions in an effort to identify the most common scenarios that need to be addressed. For instance, Das et al (2021) prepared the largest and most comprehensive study of fatal crashes involving pedestrians at intersections in the USA during the period 2014–2018. The authors analyzed data from 28,842 pedestrian fatalities that occurred in the USA, finding that pedestrian fatalities at intersections represented 26.00% of all pedestrian fatalities. The authors presented 34 scenarios of crashes involving pedestrians at intersections to understand the behavior of both pedestrians and drivers. The following three scenarios were found to represent almost 40.00% of all these pedestrian fatalities:

- Scenario 1: A pedestrian within the crosswalk area traveled from the motorist's left (vehicle going straight ahead): 15.21% (1233/8105).
- Scenario 2: A pedestrian within the crosswalk area traveled from the motorist's right (vehicle going straight ahead): 12.78% (1036/8105).
- Scenario 3: A pedestrian outside the crosswalk area traveled from the motorist's left (vehicle going straight ahead): 11.79% (956/8105).
- Scenarios 4 to 34 account for the remaining 60.21% (4880/8105).

Through the results presented by the authors, it turned out that California, New York, and Texas had the largest numbers of fatal intersection crashes involving pedestrians (14).

In order to better understand pedestrian behavior during transit, Tracy (2012) looked into the relationship between pedestrian perceptions of their right of way in marked versus unmarked crosswalks and the amount of caution they exercise when crossing. The survey data showed that many pedestrians believe they have the right of way only in marked crosswalks. When observing pedestrian behavior in three different crosswalk treatments, however, pedestrians surprisingly showed higher levels of cautiousness in marked crosswalks than in unmarked crosswalks. These findings suggested that marked crosswalks do not give pedestrians a false sense of security or correlate with reckless

behavior. In addition to the significance of crosswalks, Zegeer et al (2001), prepared the largest and most comprehensive study of marked crosswalks in the USA at that time. The authors analyzed data from 1,000 marked crosswalk sites and 1,000 matching unmarked sites in 30 US cities. Information was collected at each of the 2,000 sites, including the pedestrian crash history (an average of five years per site), daily pedestrian volume, traffic volume, number of lanes, speed limit, area type, type of median, type and condition of crosswalk marking, location type (midblock vs. intersection), and other site characteristics. All the study sites were at intersections or midblock locations with no traffic signals or stop signs on the approaches. The study found that on two-lane roads, the presence of a marked crosswalk alone at an uncontrolled location was not associated with any statistical difference in the pedestrian crash rate, compared to an unmarked crosswalk (15).

Nithin (2011) conducted a study in the United States between 1982 and 2006; the population in the United States had increased by 28.40% whereas the number of motor vehicle drivers had increased by 36.2% (FARS, National Highway Traffic Safety Administration, 2009). This increase in the number of drivers consequently increased the number of vehicles per 1000 people from 800.30 in 2000 to 841.67 in 2008. These statistics indicated the dominance of automobiles in the United States and a rise in the exposure level for potential conflicts with other road users such as pedestrians. This exposure level was important since the rate of infrastructure development was unable to keep up with the rising demands, which created a problem in efficiently and safely segregating road users. As a consequence of the increasing number of vehicles, interactions between pedestrians and vehicles increased, especially at intersections where they compete to use a common space at the same time. According to the Fatality Analysis Reporting System (FARS) maintained by the FHWA, about 4092 pedestrians were killed in 2009, which accounted for over 12.00% of all road fatalities of the total 33,808 in the United States (FARS, 2010). According to the FARS database the percentage of crashes involving pedestrians had been consistent for over a decade (16).

1.5.2 European Crash Statistics

According to European Commission reports, road crash fatality rates (i.e., deaths per million inhabitants) were reported as the highest in Romania (93 per million population) followed by Bulgaria (81 per million population), Latvia (78 per million population), and

Croatia (72 per million population). On the other hand, the European countries with the lowest rates were Norway (16 per million population) followed by Malta (17 per million population) and Sweden (18 per million population) (17).

Raicu et al. (2014) analyzed the intrinsic factors contributing to urban road crashes in Bucharest, Romania. The paper developed tools to enable the analysis of different intrinsic factors (characteristics of the urban area and of the road network) that affect traffic safety performance. According to the study, the impact of risk associated with traffic is rarely included in the evaluation of projects for increasing urban traffic fluency, although the social costs of traffic crashes are estimated as very high. They presented an analysis of the traffic crashes registered in Bucharest in the period of 2008–2014, as shown in Figure E1 in Appendix E. The highest values of the average number of crashes were identified for signalized intersections that include tram infrastructure (18).

Keep and Rutherford (2013) indicated that in 2011 there were 203,950 reported casualties on the roads of Great Britain, including 1901 fatalities and 23,122 serious casualties. In the same year, there was an increase of 3% in the number of people killed and 2% in the number of people seriously injured in road crashes compared with 2010. In 2011, the United Kingdom (UK) had a lower death rate than all other European Union (EU) member states. The death rate in the United States was around 3 times higher than that in the UK (19).

1.5.2.1 Crashes Involving Pedestrians in European Countries

Yuruk et al. (2017) created a profile about pedestrian safety in Turkey. The study analyzed individual provinces as well as the country as a whole for the years from 2013 to 2015 using data maintained by the Turkish Statistical Institute. An examination of the national level results indicated that, despite the equal distribution of women and men in the national population, men constituted 70.00% of the fatalities in crashes involving pedestrians and 57.00% of the injuries. It was found that the 65+ age group had the highest rate of crashes and fatality rates per million population. The lowest crash involvement rates were observed in the 25–64 age group, while the lowest fatality rates were observed in the 15–24 age group. Province level analysis provided a comparative analysis of pedestrian safety records across the 81 provinces. The comparisons were performed in relative terms. The crashes involving pedestrians and fatalities per million registered

vehicles and population were used as the measures of exposure. Clustering analysis was performed to reveal some patterns based on the geographic location of the provinces. The results showed that the crashes involvement and fatality rates per million population were not significantly clustered. The fatality rates per million registered vehicles were significantly clustered at the 90% confidence level, and the rates of crashes involving pedestrians per million registered vehicles were significantly clustered at the 95% confidence level (20).

1.5.3 Regional Traffic Crash Studies

The WHO (2021) ranked South Sudan in first place in the Middle East and 16th worldwide with a rate of 39.81 per 100,000 for the occurrence of traffic crash deaths (21).

Based on the study by Elvik (2017) noticed that the United Arab Emirates (UAE) was going against the trend seen in other countries by converting roundabouts into signalized intersections. Elzaher and Albuquerque (2021) compared the differences between signalized intersections and roundabouts in Abu Dhabi, one of the largest of the UAE. The research aimed to conduct an in-service safety evaluation of signalized intersections and roundabouts in the UAE. According to the Abu Dhabi Traffic Police database during the period 2012–2017, there were 1282 crashes at signalized intersections, representing 59.71%, while roundabouts had 865 crashes representing 40.29%. The authors took into consideration factors that might be related to intersection crashes, and the severity of the crash levels between the two intersection types were compared while controlling for factors such as the posted speed limit, number of vehicles involved in the crash, and vehicle class. The authors recommended safety audits to be conducted in a sample of the signalized intersections and roundabouts included in their study (22).

Anowar et al. (2014) studied the factors influencing the severity of intersection crashes in Bangladesh during the period 1998–2006. The study noticed that the severity at intersections increases on undivided highways, when intersections are located in rural areas, on dry pavement, or during adverse weather. On the other hand, a crash is likely to be less severe when the intersection is attended by traffic police. The study divided the crash severity into four classes: property damage only (PDO) 13.20%, slight injuries 6.70%, medium injuries 30.30%, and fatal injuries 49.80% (23).

Alrefay et al. (2011) conducted a study on the use of the dangerous traffic collision technique (TCT) in the city of Damascus, where they considered intersections as potential locations for black spots that cause many accidents. The study focused on analyzing traffic accidents at intersections controlled by traffic lights. The study applied the traffic conflicts technique to four-arm intersections in order to assess the traffic safety at the intersections, and investigated the relationship between the conflicts and traffic accidents. It was found that traffic accidents and conflicts were related to each other through a linear relationship. The results showed that there was an unclear correlation between the conflicts and the traffic density entering those intersections and classified the intersections based on their degree of danger and prioritization. When relying solely on traffic accident data, there might be unrecorded or reported accidents, certain documentation errors, or insufficient information, in addition to which the drivers' behavior must be understood. Hence, the idea of applying traffic conflicts to measure the probability of an accident without waiting for the actual occurrence was proposed as "the incident" based on the results obtained from the traffic data, and finding a relationship between the traffic conflicts with the annual accidents (24).

Some studies focused on traffic safety conditions at intersections in Iraq, such as that by Al-Ali (2018). The study evaluated the level of service (LOS) and the geometry of the Al-Rayat unsignalized intersection in Al-Nasiriyah City. The results showed that the cycle length was classified as high, and the LOS was (F). One of the solutions that Al-Ali proposed was to make a signalized intersection, and recommended increasing the number of lanes for some approaches to reduce the cycle length to 120 seconds. The study also recommended preventing public and private vehicles from stopping at the intersection, and constructing physical barriers on some approached (25).

Tarti et al. (2014) conducted a statistical analysis of fatalities from traffic accidents in Khartoum, Sudan, in the period of 2005–2014. The study used two-way analysis of variance methods based on the most important basic elements that cause traffic accidents (time, driver, vehicle, and road). The researchers analyzed the unilateral variance and descriptive measures of accidents throughout the period in terms of the damage type, month, day, time, and the interaction between them, and whether there were differences or not. They concluded that the most important causes of traffic accidents were the driver 85.00%, road 10.00%, and vehicles 5.00% (26). In the same context, Hakkert and Mahalel

(1978) included a statistical analysis of the general trends in the number of intersection accidents, their severity, and an analysis of types of accidents at intersections in “Israel”. The increase in the number of accidents at intersections, relative to non-junction accidents, might be explained by the basic fact that an increase in the number of vehicles on the road is generally accompanied by an increase in the number of collisions, which rise at a faster rate than single-vehicle accidents. Generally, more than 50.00% of the collisions occurred at intersections. The study showed that the number of intersection accidents had increased at a faster rate than other accidents (27)

According to the Jordan Traffic Institute (JTI), the problem of traffic crashes in Jordan started to appear as a serious issue in the mid-1990s. Statistics published by the JTI in 2007 showed that traffic crashes were considered the second leading cause of death in Jordan (28). Another report by the JTI in Jordan for the year 2021 showed that traffic accidents caused 589 deaths, where passengers formed 38.90%, pedestrians formed 24.40%, and drivers formed 36.70% (29). Al-Masaeid (2009) investigated the characteristics of traffic crashes in Jordan and evaluated the safety impact of policy measures undertaken in 2008, including the intensification of police enforcement and implementation of a traffic law with stiff penalty levels. The data on crashes for 1998 through 2007 were obtained from the Jordan Traffic Institute and other related sources. The results revealed that Jordan has experienced huge human and economic losses as well as social and emotional negative impacts. Children and the elderly have been exposed to an elevated pedestrian crash risk. Young drivers aged less than 25 years and elderly aged over 60 years are over-involved in crashes. Carelessness and aggressive driving behavior were the major causes of traffic crashes. The results of the analysis also indicated that the motorization level could be used to explain variations in traffic crashes and fatalities. Furthermore, the intensifying of traffic enforcement and implementing traffic law with stiff penalty levels were found to have a strong positive safety impact on crashes and fatalities. Al-Masaeid recommended restructuring and empowering the Higher Council for Traffic Safety to be able to draw up a comprehensive strategy with a clear vision and rational safety policies to tackle the problem of traffic crashes (30).

Between 1999 and 2001, pedestrian accidents in Irbid City, Jordan, were examined by Al-Omari and Obaidat (2013). The analysis was based on the following factors: crash time, collision location, weather, road surface, illumination, vehicle features, speed limit,

crash severity, pedestrian faults, and driver faults. According to the study's findings regarding the different types of vehicles, buses were a factor in 0.65% of collisions involving pedestrians. Private vehicles made up 61.40% of all such crashes, whilst public vehicles made up 32.90%, according to the kind of vehicle license. Drivers with private licenses were responsible for 45.60% of pedestrian-related crashes, while those with public licenses or above were responsible for 50.30% of such crashes (31).

1.5.4 Palestinian Studies

According to annual reports published by the Palestine Police (2016-2021) (32), the year 2021 had the highest recorded year for crash injuries in Palestine, followed by the year 2019, while the year 2020 had the lowest recorded injuries due to the impact of the COVID-19 pandemic which will be covered in Chapter 3 &4; and it was noted that the results were stable for the period (2016-2018). At the level of the Tulkarem Governorate, it is apparent that the number of injuries in all traffic crashes is gradually declining, whereas it increased in the year 2021, this may be due to the gradual return to normal life after the COVID-19 pandemic's effects have subsided. See Figure E2 in Appendix E.

Hassouna et al. (2020) applied an autoregressive integrated moving average (ARIMA) model to predict road crashes in Palestine. Road crash data for the period of 1970 to 2017 were analyzed based on the annual number of crashes, number of registered vehicles, population, and Gross National Product (GNP) for the West Bank and Gaza Strip. The main objective of this study was to assess the frequency of road crashes in Palestine and assess the main changes in the variables, particularly the relevant socio-economic changes that were expected to have a role in road crashes. The study used time series techniques for prediction using the Ljung–Box test, which was applied in order to determine the normality of the residuals for the selected model. The ARIMA (3, 2, 3) was specified for predicting the number of traffic crashes at any point in time. The diagnostic process for each of these models, accompanied by 92.00% confidence intervals for their predicted values, indicated the good fit of these models. The results showed differences of 7.80% and 6.10% between the observed and predicted values for 2016 and 2017, respectively; therefore, the model’s prediction capability is judged to be reasonable (33).

Hassoun (2022) prepared a study to analyze the role of public transportation (PT) in road safety in Palestine’s Nablus Governorate. The research divided the study into the

following three levels: Nablus Governorate, rural versus urban and Nablus City. Moreover, the research focused on traffic crashes in which PT vehicles were involved between 2015 and 2019. There were 2,204 PT crashes in Nablus Governorate, and 1766 PT crashes in Nablus City (urban). The study analyzed the crashes by the location, time and day, month, causes, type of crash, and which of the parties involved caused the crash. The results of the analysis showed that highest percentages occurred during the afternoon hours (12.00–18.00). The author made some recommendations aimed at reducing public transport vehicle traffic crashes, such as uniting the efforts of the institutions responsible for the traffic sector to impose strict deterrents for violators of traffic laws, and not to tolerate any violation, conducting detailed studies on drivers' and road users' behavior and developing a national traffic safety program (34).

Al-Sahili and Khader (2016) studied the reality of traffic safety conditions at selected locations in Nablus City. Traffic crash data and information were collected based on crash reports from the Police Directorate in Nablus City for the study period of 2009–2011. Analysis was done for several patterns of traffic conditions that might have an effect on traffic safety at these sensitive locations, such as the crash rate, weather, lighting, road surface, road geometry, types and causes of crashes, etc. Several results emanated from this study. For example, the highest intersection crash rate was at Al-Ghawi Intersection, followed by the Western Graveyard Intersection and Al-Salam Mosque Intersection. As for streets, the highest rates were on Sufian Street, followed by Omar Ibn Al-Khattab Street and Faisal Street. Furthermore, crashes involving pedestrians formed approximately 20% of all crashes. The study recommended, among others, conducting detailed studies of pedestrian collisions at the critical locations in the City (35).

Some master theses focused on traffic safety conditions in Nablus City, such as that by Kobari (2000), who built a GIS database for crashes in Nablus City for two consecutive years (1997 and 1998) (36). Analysis of crash records enabled preliminary identification of hazardous locations. Abu-Zant (2001) used the database created by Kobari and conducted detailed analyses of crash frequencies and rates for various locations in Nablus City. Abu Zant also identified mechanisms for determining the hazardous locations and threshold values for various classes of roadways or intersections. According to the study, Al-Hesba Intersection was the most hazardous location, so a detailed study was conducted for this intersection (37).

Jaber (2019) developed a profile of pedestrian crashes in Nablus Governorate during the period of 2012–2016. The aim of this study was to analyze and evaluate pedestrian crashes, study the geographical distribution of pedestrian crashes, and determine the highest crash rates in the Governorate. The results indicated that, according to police reports, the highest number of crashes involving pedestrians occurred in 2015 with 22.33 %, while the lowest year was 2013 with 18.97% and most of the crashes occurred on Thursday and in the spring season. Nablus City, Hawara and Beita saw the most recorded crashes involving pedestrians in the Governorate. As for the death rate from crashes involving pedestrians, Beit Wazan is the second city in the Governorate after Nablus City (38).

Al-Masry (2011) conducted a study in the Gaza Strip and the results showed that one of the most important reasons for some pedestrians not committing to walking on the sidewalks was encroachment by sellers or shops in commercial areas. Another important reason for some pedestrians not adhering to walking on pedestrian paths was their lack of traffic awareness, as well as vehicles parking on pedestrian corridors. With regard to the pedestrian evaluation of the facilities and their satisfaction with them, the results indicated that they were not satisfactory and that the facilities needed further development. Among the most important recommendations referred to in the study were the necessity of clearly marking pedestrian paths, the maintenance of sidewalks and pedestrian traffic lights, in addition to law enforcement (39).

1.5.5 Studies Related to the Impacts of COVID-19 on Road Crashes

A decrease in crashes was noted for the year 2020 as a result of the Covid 19 pandemic and the closures ordered by the Palestinian Council of Ministers to deal with the epidemic's outbreak, according to the annual reports of the Palestinian Police (2016–2021), see Figure E3 in Appendix E (32)

The COVID-19 pandemic affected traffic levels across the world, after many countries were forced to impose strict restrictions on movement and non-essential activities, in order to curb the spread of the COVID-19 virus. As the roads became empty due to the "pandemic" procedures, it was natural that the number of recorded traffic crashes decreased in many countries of the world.

In contrast to 2019, the number of miles traveled in the US decreased by 13.20% in 2020, while the percentage of fatalities from traffic crashes rose by 7.20%. In 2020, there were 1.37 fatalities for every 100 million miles driven by a car (40).

According to the "California Personal Injury Lawyer" website, traffic volumes decreased in California, which is the most crowded state in America, and thus traffic congestion and death and injury rates also decreased. The crash rates across the state decreased by 75.00 % from 19 March 2020 compared to 2019. From the beginning of 2020, specifically in February and March, a noticeable increase in accidents was observed in California compared to 2019, and then gradually began to decline with the start of the closures introduced by the government, see Figure E4 in Appendix E (41).

The annual road safety report published by the International Transport Forum (ITF, 2021) on the impact of COVID-19 analyzed crashes, injuries, and deaths for the year 2020 and compared them to the 2017–2019 average in the 34 participating countries, and included the government regulations and the degree of adherence to them. The report showed that Argentina and Italy were the most stringent in general, with Great Britain and Italy being the hardest in Europe, while Japan, New Zealand, and Finland were the most moderate in their measures to contain the epidemic, see Figure E5 in Appendix E. The report indicated a decline in the number of traffic fatalities, which fell significantly in April compared to the years prior to the pandemic, before gradually rising again. This was closely related to government actions, because there is a direct correlation between movement and fatalities; the more traffic is permitted, the higher the risk of death is, and vice versa, see Figure E6 in Appendix E. The countries with the fewest fatalities were Italy, Argentina, and Hungary, which is attributable to their success in enforcing government regulations. In contrast, it was found that the United States, New Zealand, and Ireland moved in the opposite direction, where a pronounced rise in the number of traffic fatalities was noted,(42) .See Figure E7 in Appendix E.

Al-Ahmadi and Al-Qaradi (2021) conducted a study on the impact of the COVID-19 pandemic on the spatial and temporal characteristics of Medina in Saudi Arabia. The aim of this paper was to determine the statistics of traffic accidents in Medina, their pattern and distribution during 2020–2019, analyzing the temporal and spatial characteristics of traffic crashes in Al-Madinah Al-Munawara before and during the pandemic, and the

impact of the Corona pandemic on the characteristics of traffic crashes in Al-Madinah Al-Munawara. The study found that traffic crashes in Al-Madinah Al-Munawara were concentrated in the central region, due to the importance of this region, as it contains the Prophet's Mosque, which led to congestion and traffic jams. The number of traffic accidents in 2019 reached about 1,118, with a monthly rate of 93 crashes, with the exception of the months of November and December. This compared with 961 crashes with a rate of 96 per month before COVID-19, while the number of crashes in 2020 was about 636 traffic crashes, with a rate of 53 crashes per month. The authors found that the decrease in the number of crashes in the city especially in the months of April and May was due to government measures to limit the spread of the virus, which included the prohibition of movement within and between cities. Moreover, with the decrease in crashes, the number of injured and dead in crashes decreased by 31.00%, and this, in turn, contributed to preserving human wealth and avoiding pressure on the health sector in the time of crisis. With the decrease in the number of crashes, the index of injuries and deaths due to traffic crashes decreased by 37.00% compared to previous years (43).

1.5.6 Summary of the Literature

The previous studies provide some insight towards achieving the objectives of this study. Each one has its own methodology, results, data, location, etc. Knowing this wide-ranging information enables benefits to be drawn directly from these studies, or later comparisons to be made with those studies.

The studies showed that there is a clear interest in intersection safety issues all over the world, searching for causes and trying to minimize, as much as possible, the crashes and fatalities at intersections. Also, some studies focused specifically on pedestrian safety at intersections. Some of these results can be used for comparison with pedestrian accidents in Tulkarem Governorate.

A comparison could also be made with some other studies from the literature in terms of causes, rates, patterns, etc.

1.6 Thesis Outline

The thesis contains the following chapters; introduction which presents general background, significance of the study, objectives, the study area, and a review of previous

literature. The methodology is presented in chapter two. Data collection and analysis of Tulkarem Governorate is presented and discussed in chapter three, while the analysis of Tulkarem City is presented and discussed in chapter four. Finally, conclusions and recommendations are presented in chapter five.

Chapter Two

Methodology

Tulkarem Governorate was chosen in this study due to the lack of such studies in the Governorate. Moreover, in Palestine, studies about intersection safety are limited; therefore, this will be an essential direction for stakeholders to develop an action plan for road safety in Tulkarem and to benefit the rest of the governorates in the West Bank.

The components of the methodology to achieve the main objective are as follows:

I. Literature review: Desk studies and internet research by reviewing existing publications, studies, and literature related to intersection crashes around the world.
II. Data collection: In this thesis, data were collected on intersection crashes for the period 2016 to July 2021 in collaboration with the Department of Traffic Accidents in the Police Directorate of Tulkarem Governorate. This database is used in analyzing the intersection safety in the study area.

The crash data are filed manually in the Police Directorate of Tulkarem Governorate, with the information hand-written by the police officers. This was a challenge and careful attention had to be paid to obtain the most accurate information possible.

Data originated from the crash report were filed in a special logbook at the police department, which includes details of the traffic crashes. This information includes:

- Time and date of crash: date, day, and hour.
- Location of crash: indicating the place where the crash occurred, also sometimes the name of the locality, street or neighborhood, and sometimes the name of the surrounding area and general location.
- Demographic parameters: the crash reports provide the age and gender of the victims in each crash.
- Severity: traffic crashes can cause a number of different injuries, depending on the circumstances of the crash and the severity of the impact at the intersection. Injuries from intersection crashes were divided in the police report into four types: minor, moderate, serious, and fatal.

- Type of vehicles: every crash is characterized by the type of vehicle involved in the intersection crash, which includes private, shared taxi, commercial, agricultural, and (motor) bike.

Some additional information was collected from different sources; these include:

1- Maps: obtained (from Tulkarem Municipality) to illustrate the spatial distribution of crashes and to identify locations with high crash rates.
2- Number of vehicles: annual reports published by the Ministry of Transportation (MOT) for 2010–2020 about the total number of registered and licensed vehicles in Tulkarem Governorate.
3- Demographic statistics: population and area statistics for all the localities in Tulkarem Governorate were taken from the PCBS website. The population statistics were taken for the period of analysis 2016–2021.
4- Average daily traffic (ADT): collected from previous studies for the year 2016 and 2018, with a prediction made also for future years based on the estimated growth rate.

III. Analyzing intersection crashes for Tulkarem Governorate, showing the critical locations spatially, and their characteristics and creating intersection safety profiles. The profiles include the number of crashes per time (such as hour, day, and month), the age of victims, severity, type of vehicles involved, gender of victims, causes, weather conditions, etc. The analysis was done on different levels, namely the Governorate, Tulkarem City, and during the COVID-19 pandemic.

a. Tulkarem City: Tulkarem City was divided into zones based on the PCBS zones showing the locations of the intersections within the zones, and developing intersection safety profiles for these zones based on results obtained from actual crash data to determine the high crash zones.

b. Developing profiles of intersection crashes during the COVID-19 pandemic to make a comparison within the study period.

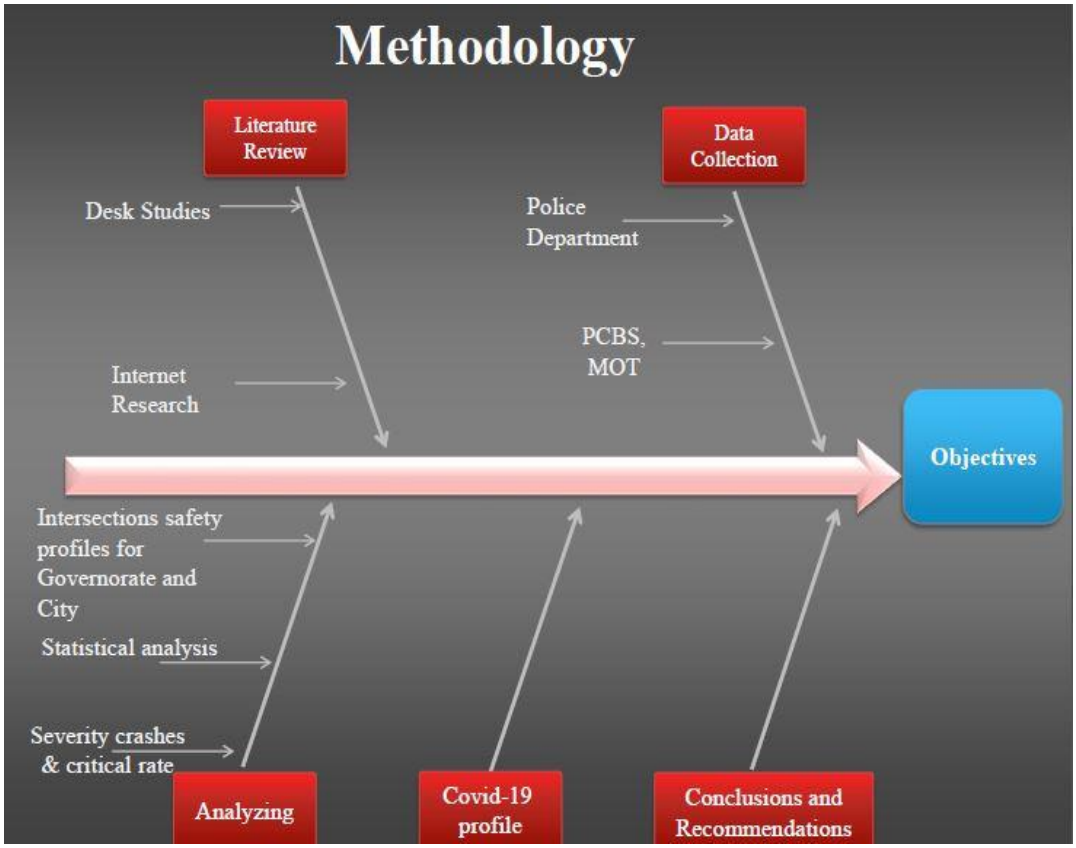
In the analysis, crash rate profiles were developed using two methods; first, based on the severity and critical rate of crashes, and then relating those to the intersection's level of services (LOS) using synchro software.

IV. Setting proposed recommendations based on the data analysis and reviewing safety conditions, in coordination with stakeholders.

The general methodology followed in this thesis is illustrated in Figure 2.1.

Figure 2.1

Layout of the methodology used



Chapter Three

Data Collection and Analysis of Tulkarem Governorate Crashes

This chapter provides detailed overviews of traffic crashes at intersections in Tulkarem Governorate, especially in some critical areas, and a detailed presentation of intersection crashes at the city level will be presented in a separate chapter.

There are some social and economic ties and activities that may have an impact on the crashes at intersections in Tulkarem Governorate. For example, economic activities are typically concentrated on Saturdays and Thursday, and the nature of the working hours is predominantly from 8:00 a.m. until 4:00 p.m. In different seasons of the year, the nature of activities also varies. Therefore, the impact of various activities on traffic crashes at intersections is evaluated.

3.1 Profile of Tulkarem Governorate

This section addresses, spatially and temporally, intersection crashes all over Tulkarem Governorate, in addition to identifying the characteristics of the road users who were involved in these crashes.

According to annual data from the General Directorate of Palestinian Police (GDPP), the number of registered traffic crashes in Tulkarem Governorate was 4,430 in the period of 2016–2021 (8). During the study period a total of 812 crashes occurred at intersections in the Governorate. Figure F1 in Appendix F shows the total number of intersection crashes in each year in the Governorate. The observation is that intersection crashes are decreasing over the years.

Intersection crashes constituted 27.67%, 21.44%, 22.54%, 38.83%, 12.76%, and 6.24%, of the total crashes in the Tulkarem Governorate for the years 2016, 2017, 2018, 2019, 2020, 2020, and till July 2021, respectively.

A t-test and analysis of variance (ANOVA) was conducted using the Statistical Package for the Social Sciences (SPSS program) to test the significance for each crash pattern (using alpha = 0.05). The ANOVA test shows that crashes per year are significant at 95 % or higher, as shown in Table B1 in Appendix B.

Meanwhile, as indicated in Figure F2 in Appendix F, Thursday had the highest frequency of crashes at intersections 17.20%, while Friday had the lowest with 12.40%. This is fair because Thursday is the end of the working day of the week, when numerous activities and the traffic volume increase, particularly in the afternoon and evening hours for all road users. On the other hand, Friday is the weekly holiday when traffic and activities reduce considerably. The ANOVA test shows that the day of crash is not significant at 95 % or higher, indicating that the days when crashes occur are significantly different as shown in Table B2 in Appendix B.

As for the hour when crashes occur, Figure F3 in Appendix F shows that the period of 10:00–16:00 had the highest frequency, and accounted for 71.55% of the total intersection crashes. Within this period, the hours of 10:00 a.m. to 12:00 noon were the highest, with the highest number of intersection crashes occurring at 11:00 a.m. The period 11:00–18:00 is an active period; it includes the active movement of people, and the traffic volume is generally high. Students head home from their schools, employees leave their workplaces, and shopping activities are apparent as well. These contribute to increasing the number of crashes. The ANOVA test for the time of crashes shows that F is larger than F critical, which means that one of the groups is statistically different. Moreover, the statistical significance value is smaller than the alpha (0.05), which means that the groups are statistically different, as shown in Table B3 in Appendix B.

Based on the analysis of intersection crash records by month, May recorded the highest number of intersection crashes with 79 crashes 9.72%. Furthermore, the spring season had the highest number of intersection crashes 225 crashes; 27.71%, being the preferred season for people to go out and for outdoor activities in general, and consequently there are increased commercial activities and increased demand for travel. This is followed by the summer 26.35% and autumn 23.52%, while the winter season witnessed the lowest frequency 22.40% due to a decrease in both activities and transportation because of the general bad weather conditions. Figure F4 and Figure F5 in Appendix F show the distribution of intersection crashes by month and season for the study period. The ANOVA test shows that the crashes per month are not significant at 95%, indicating that the number of crashes per month is not significantly different, and the season of the year is not significant at 95%, as shown in Table B4 in Appendix B.

In contrast to the results of the Tulkarem Governorate, Tarte's statistical differences results show that there are differences with the year. Day, month, and season don't significantly differ from one another, which is consistent with the results from the Tulkarem Governorate.

The severity of crashes is one of the important indicators to be taken into consideration. Most of the injuries at the intersections in the Governorate were classified as slight injuries 84.24%, then moderate 13.55%, while severe and fatal injuries accounted for 2.21 %, as shown in Figure F6 in Appendix F.

By analyzing the injuries in traffic crashes at intersections, it was found that 66.33% of the victims (passengers, pedestrians, and drivers) in traffic crashes were males, and 33.67% were females. On the other hand, males in the 16–20 age group were the most vulnerable to injuries, constituting 13.44% of the total injuries among both sexes, and the same age group of female injuries constituted 6.53%. The 11–30 age group formed a clear high percentage of injuries 64.07% of all injuries. This could generally be attributed to the lack of awareness among users, reckless driving, or poor safety measures on the road. Meanwhile, a much lower involvement in crashes was observed among the older age groups, as shown in Figure F7 in Appendix F. Statistical testing of the age and gender of the injured parties using the paired t-test showed that they are statistically different at 95 % or higher, as shown in Table B5 in Appendix B.

Seven types of crashes were recorded in Tulkarem Governorate. The highest number of crashes occurred due to the "Two vehicles collided" 74.30%, followed by a "Vehicle collided a pedestrian" 16.00%, "Self-Collision" 4.61%, and then three vehicles collided 4.36%. Figure F8 in Appendix F illustrates the percentages of crash types in the Tulkarem Governorate for the study period. The type of crash is significant at 95% or higher.

Nine types of crash details were recorded in Tulkarem Governorate, the highest number of crashes occurred due to the "Two private cars collided" 77.25%, followed by a "Taxi collided a private car" 11.15%, "Three private cars collided" 3.82%, and then "Bus collided a private car" 3.36%. Figure F9 in Appendix F illustrates the percentages of crash type details in Tulkarem Governorate for the study period. The detail of crash is significant at 95% or higher.

Crashes have several causes and the records show 10 of these causes. One of the most important causes of crashes was the “failure to give the right of way at the intersections” 30.20%, followed by speeding 27.10%, as shown in Figure F10 in Appendix F.

As a general observation, the signalized intersections have lower percentages of traffic congestion than roundabouts and un-signalized intersection, which have higher percentages of conflicts areas.

Table 3.1 illustrates the number of study locations, percentage of intersection crashes, percentage of injuries, percentage of pedestrian crashes, and critical location for each type of intersection (unsignalized, signalized, and roundabout).

Table 3.1

Type of intersection crashes summaries in Tulkarem Governorate

Comparison Item	Unsignalized intersection	Roundabout intersection	Signalized intersection
Number of study locations	50	20	3
Percentage of crashes	71.18%	22.66%	6.16%
Percentage of Injuries	81.99%	14.42%	3.58%
Percentage of pedestrian crashes	72.09%	22.48%	5.42%
Critical location	Nablus Street Intersections	Mohammed Al-Qasim Roundabout	Dama Intersection

Results of Choi's (2010) study showed that intersections accounted for 36.00% of all crashes in the USA in 2008, among which signalized intersections accounted for 52.50%. While in Tulkarem Governorate, intersection crashes accounted for a less percentage (24.42% of total crashes in the Governorate), this difference shows the different natures of both locations and it also might be affected by the different levels of comprehensiveness between studies.

In the same context, Al-Sahili and Khader (2015) reported that Nablus City had 36.00% of crashes at signalized intersections, while Tulkarem City had only (6.16%). This is clearly related to the difference in the number of signalized intersections in the two cities; signalized intersections in Tulkarem City are few and they are fairly recent; installed in

2017. The ANOVA test shows that the causes of crashes at intersections are significant at 95% or higher, indicating that the cause of the crash is significantly different, while the same test was applied for the causes of crashes and type of intersection (unsignalized, signalized, and roundabout), where the results show that they are not significant at 95%.

3.2 Profile of Crashes Involving Pedestrians at Intersections in Tulkarem Governorate

Pedestrians are among the most prominent users of the road, and should have permanent priority in traffic safety especially when designing and implementing intersections in urban and other areas. At the intersections in the study area, there is chaos when pedestrians cross due to the lack of clear pedestrian crossings and facilities for their movement. The NHTSA (2022) noted that 15% of all traffic crashes involving pedestrians occurred at intersections (9). This is consistent with results for Tulkarem Governorate, which showed 15.88% of pedestrian-involved crashes at intersections.

Pedestrian crash at intersections records showed that such crashes were highest in 2016. It is also noticed that in the period of (2019–2021) there was a clear decrease in such crashes, as shown in Figure F11 in Appendix F. This is attributed to the closures and mobility restrictions imposed during the spread of the Coronavirus (COVID-19), when the mobility of vehicles and pedestrians decreased especially in urban areas. When asking the Police Department about the reasons for the decrease in traffic crashes for the period of (2017–2019), several reasons were given; these include:

- Rehabilitation of some intersections
- Installing traffic signals at some, such as in the City Center and the intersections of Nablus Street
- Deployment of traffic police officers at some intersections classified as dangerous in the city (Paris Street Intersection, City Center, and Al Moqat'a intersection).
- The continuous efforts to raise traffic awareness especially for school students, and checking the annual examination of vehicles with expired registration or licensing.

Crashes involving pedestrians occurred in the Governorate mostly at the end and beginning of the week. Thursday witnessed the highest percentage of such crashes at intersections, as it is the end of the working week and people like to go for a walk or

engage in social and shopping activities. Sunday, also, which is the beginning of the working days, had a high number of crashes involving pedestrians as it witnesses busy work and school movements. Saturday was the third highest day for pedestrian crashes, being the weekend when there are higher levels of shopping and leisure activities. On the other hand, Friday had the lowest number of such crashes due to being the official holiday when economic and work activities are almost non-existent. Figure F12 in Appendix F shows the distribution of crashes involving pedestrians at intersections in Tulkarem Governorate by day. The ANOVA test shows that the day of the crash at intersections is not significant at 95% or higher, while the year of the crash is significant.

There is a difference in the hours when crashes involving pedestrians occurred. The morning period between 07:00 and 09:00 constituted 18.60% of the total such crashes Figure F13 in Appendix F, being the period with the highest level of pedestrian activities for traveling to work and school. The period of 12:00–14:00 had the highest percentage 28.00%; this is the period when workers start leaving work and might go shopping and when students leave school. At the hours of 17:00 and 21:00, there are additional peaks. These periods experience increased pedestrian activities for late evening and night time shopping and leisure activities. The ANOVA test shows that the time of the crash is significant at 95% or higher.

July was the critical month with the most recorded pedestrian crashes at intersections, followed by September and May. This indicates the high rates of crashes involving pedestrians in the spring and summer seasons, while in the winter months such crashes were relatively low in number. In general, these findings are consistent with the total numbers of traffic crashes at intersections, as shown in Figure F14 in Appendix F. The ANOVA test shows that the season when the crash occurs is not significant at 95%, and the month of the crash is also not significant at 95%.

The analysis of crashes involving pedestrian injuries shows that the percentage of males who were injured as a result of such crashes at intersections was 58.91%, while the percentage of females was 41.09%. For female pedestrian injuries, the 11–20 age group had the highest number of pedestrian injuries, constituting 45.20% of all pedestrian female injuries, while the same age group for male pedestrian injuries constituted 38.09 % of all pedestrian male injuries, as shown in Figure F15 in Appendix F.

Females recorded 55, 15, 3, and 0 slight, medium, severe, and fatal injuries at intersections, respectively. Males recorded 44, 16, 3, and 0 slight, medium, severe, and fatal injuries at intersections, respectively, as shown in Figure F16 in Appendix F.

Statistical testing of the age of injuries with gender using the paired t-test showed that they are statistically different at 95% or higher. Moreover, the ANOVA test shows that the severity of crashes is also significant at 95% or higher.

It is necessary to study the causes of crashes involving pedestrians at intersections. Figure F17 in Appendix F shows the most frequent causes of such crashes, where the most prominent reason was the failure to take safety measures when crossing the intersection. This is an indication of the lack of awareness of traffic laws. When linking this reason with the age categories, the age group that was most affected was 6–15 years old; these are the most vulnerable pedestrians. Excessive speed was the second cause of such crashes; therefore, it is necessary to increase traffic awareness campaigns for school students since the peak of pedestrian crashes occurs between the hours of 12:00 and 13:00, which is the period when some students of the basic level leave schools. Furthermore, it is possible to increase traffic police officers or install traffic lights at some dangerous intersections, allowing pedestrians to be given priority. The ANOVA test shows that the cause of crashes at intersections is significant at 95% or higher.

Four types of a pedestrian crash at intersections were recorded in Tulkarem Governorate, the highest number of pedestrian crashes had "Private car collided a pedestrian" 84.50%, followed by a "Taxi collided a pedestrian" 7.75%, "Motorcycle collided a pedestrian" 4.65%, and then "Bus collided a pedestrian" 3.10%. Figure F18 in Appendix F illustrates the percentage of pedestrian crashes in Tulkarem Governorate for the study period. The pedestrian crash is significant at 95% or higher.

3.3 Spatial Analysis of Crashes at Intersections in Tulkarem Governorate

As mentioned before, the estimated population of Tulkarem Governorate was 200,629 including both sexes; the Governorate includes 25 localities, cities and towns (PCBS, 2021). It is noted that Tulkarem City had the most registered crashes 47.66%. It is also noted that there are towns in the governorate with large numbers of injuries despite the fact that their geographical area or population is small. However, it was found that some

of these areas have some special importance. For example, Khirbet Jubara had a high number of crashes, although the neighboring areas had only a few. This is because it is one of the places where it is possible to cross the Israeli military checkpoint into the 1948-Occupied Palestine; therefore, it witnesses high levels of activities and movements of both vehicles and workers. Thus, the number of crashes involving pedestrians, though not severe, was relatively high. Furthermore, the intersection between the towns of A'ttil, 'Illar, Zeita, and Nazlat 'Isa together constitute a high population, and there are; therefore, high traffic volumes in those areas, which resulted in a relatively high number of crashes and severity. The t-test shows that the locality of the crash is significant at 95% or higher.

Tulkarem City had the most injuries 42.40%, while the other localities accounted for the remaining 57.60% of the total injuries. The t-test shows that the injuries from crashes per locality are significant at 95% or higher.

By analyzing the intersection crash rate per locality area (square kilometer), it was found that Zeita recorded 33 crashes per km2; the highest in the governorate, followed by Khirbet Jubara with 25 crash/km2, and Tulkarem City with 14.90 crash/km2. The t-test shows that the crash rate per locality area (square kilometer) is significant at 95% or higher. The intersection crash rate per 1,000 capita (of the locality's population) was calculated for all localities in Tulkarem Governorate; this method was chosen in the absence of data on the vehicle-kilometers of travel. Tulkarem City, Anabta, Bala'a, Deir el Ghusun, and A'ttil had the highest rates, in that order. Figures 3.1a to 3.1d show the spatial distribution of crashes, injuries, crashes per km^2 and crashes per 1,000 capita in the governorate by locality.

Figure 3.1 a

Distribution of crashes at intersections in Tulkarem Governorate by locality

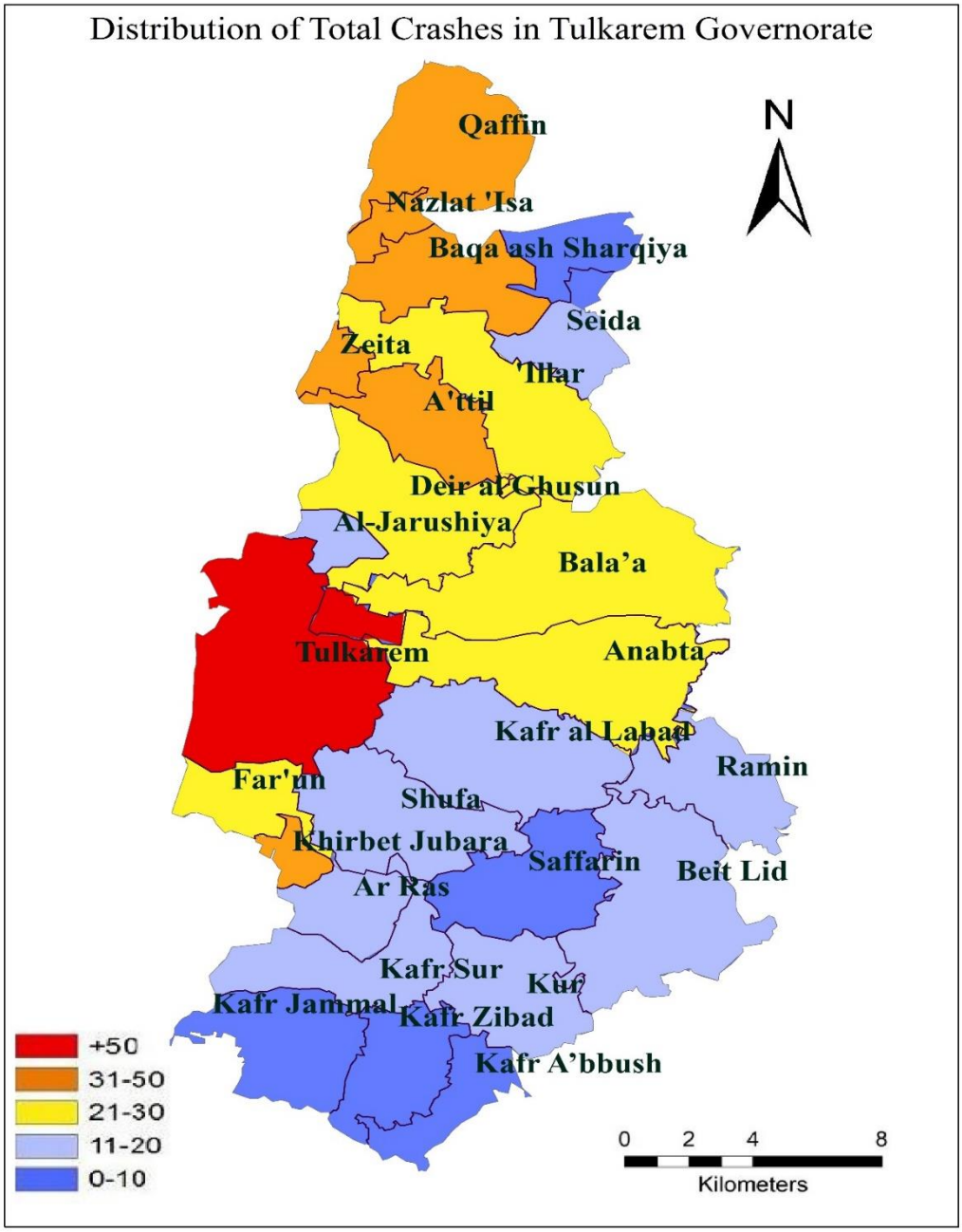


Figure 3.1 b

Spatial distribution of injuries from crashes at intersections in Tulkarem Governorate by locality

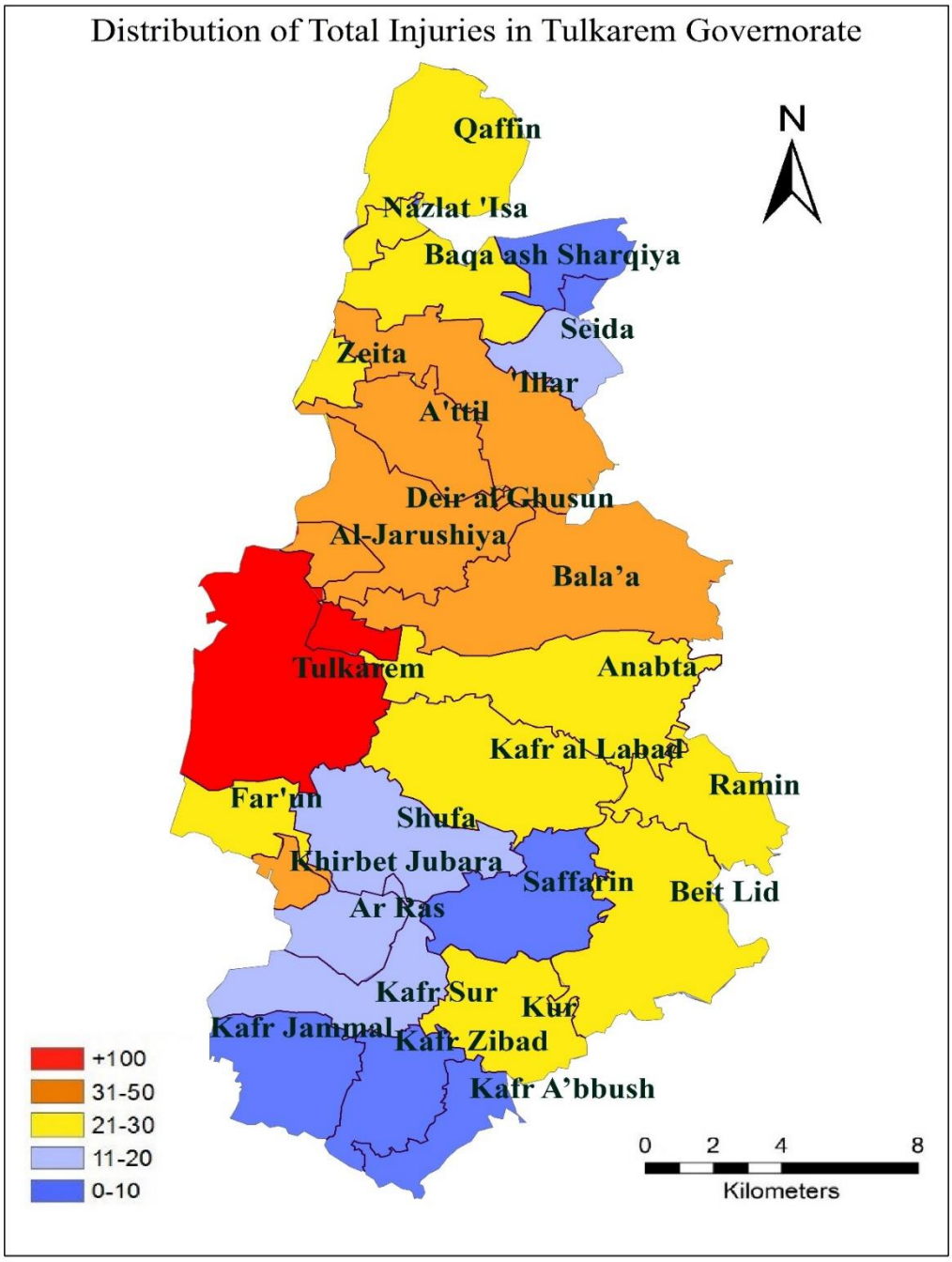


Figure 3.1 c

Spatial distribution of intersection crashes per km^2 in Tulkarem Governorate by locality

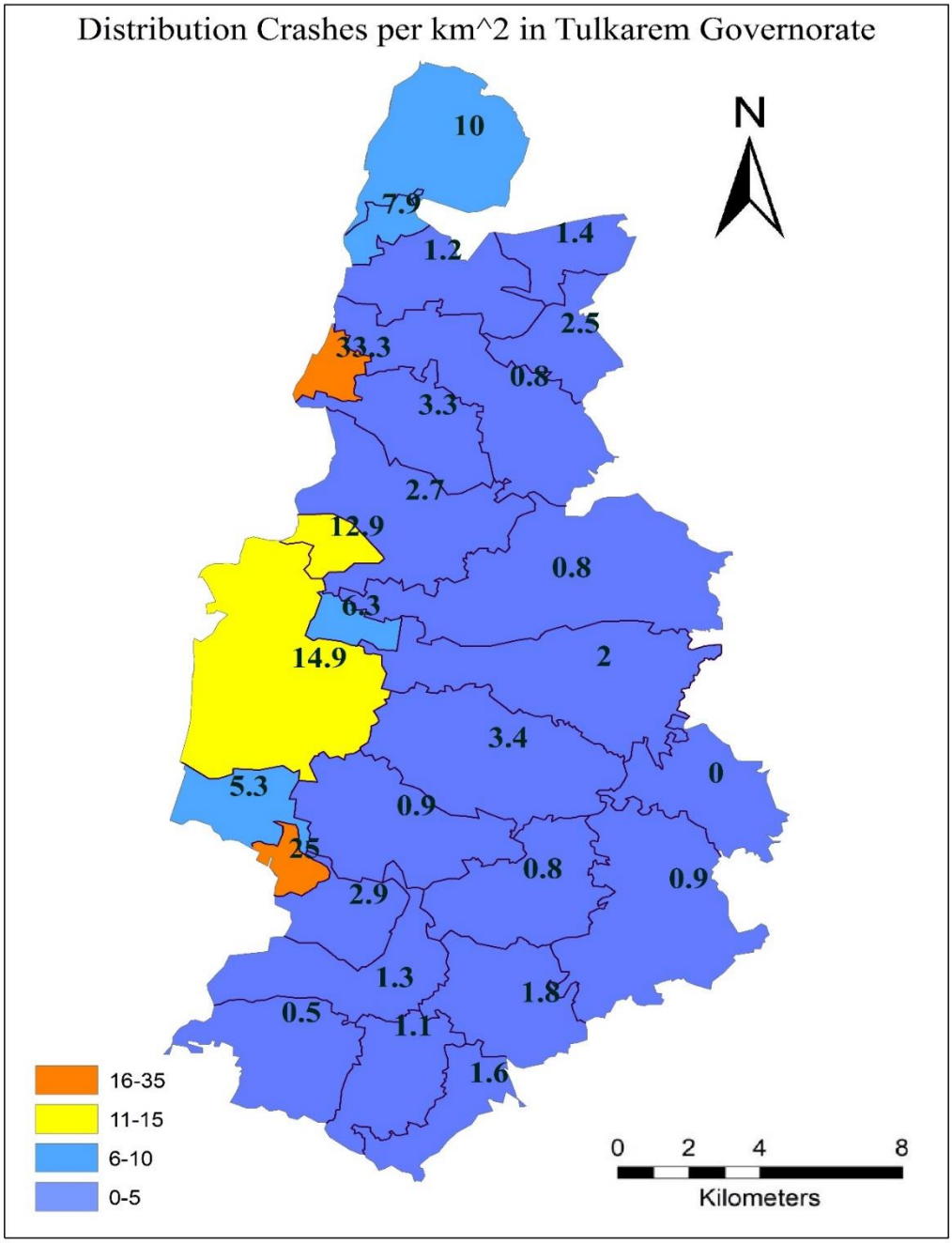
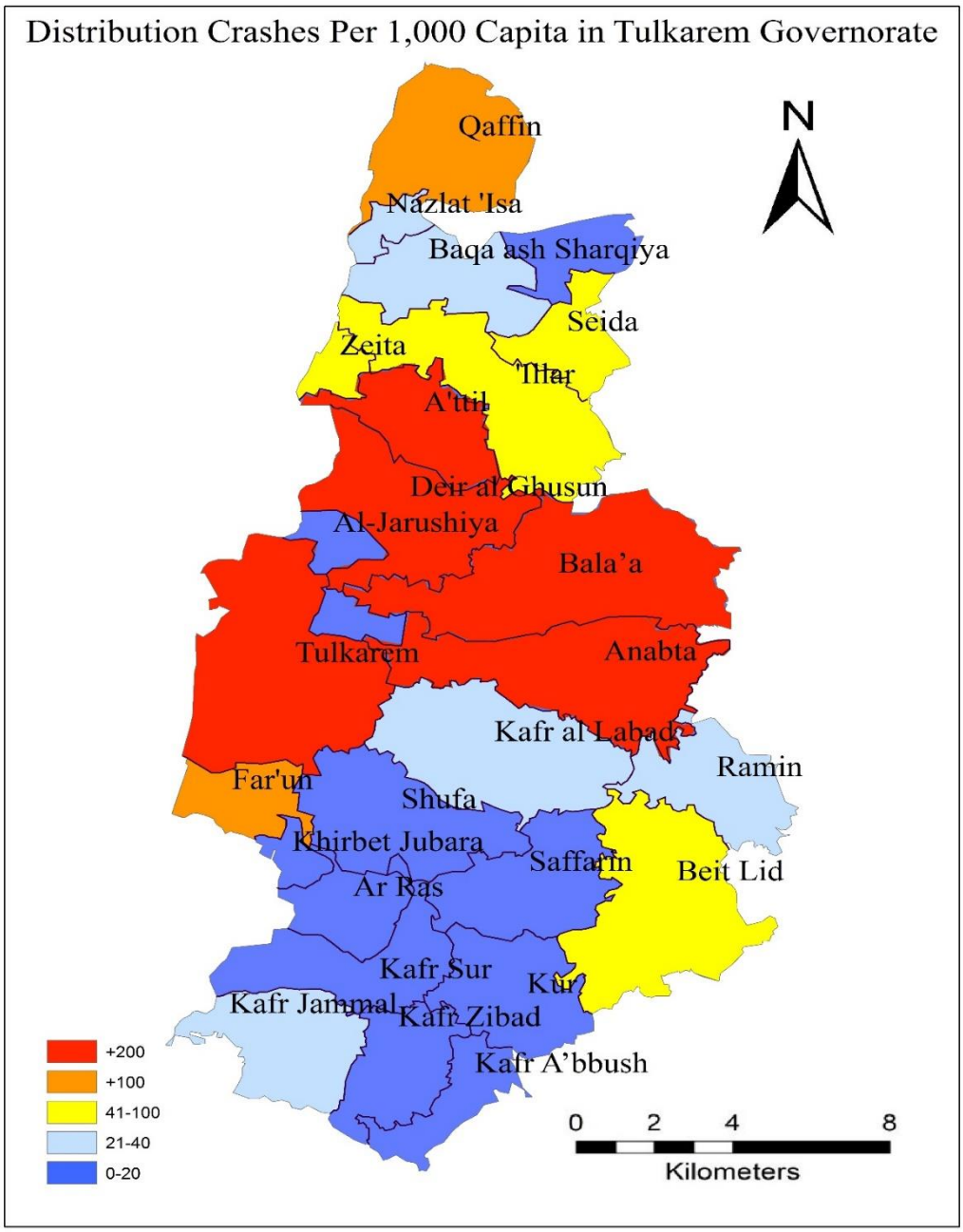


Figure 3.1 d

Intersection crashes per 1,000 capita in Tulkarem Governorate



However, it is realized that these rates might not be representative of the severity levels, since some of these localities have a relatively low population, which is the reason for the a high rate. Furthermore, some of these localities experience a high percentage of traffic passing through, thus yielding a higher crash frequency (for example, A'ttil and Anabta). The t-test shows that the crash rate per 1,000 capita is significant at 95% or higher.

3.4 Killed or Seriously Injured (KSI) Analysis for Tulkarem Governorate

KSI is used as an indicator where safety policies might be formulated. Tulkarem Governorate had 20 KSI, and Tulkarem City had the most KSI intersection crashes (11); A'ttil had 3, Khirbet Jubara 2, while Al Jarushiya, and Bala'a, Ar Ras, & Beit Lid had 1 each. Sunday experienced the highest frequency of total KSI at the intersections, as shown in Figure F19 in Appendix F. The t-test shows that the KSI per locality is significant at 95% or higher.

In terms of the hour, it is clear that there were two peak hours, as shown in Figure F20 in Appendix F; from 09:00 to 10:00 with 25.00% and from 12:00 to 13:00 with 20.00% of the total KSI intersection crashes. The ANOVA test shows that the day of the crash is not significant at 95%, while the time of the crash is significant at 95% or higher.

The spring season witnessed the highest occurrence of KSI crashes, with 45.00%, and April was the most critical month with 5 KSI, i.e. 25.00%. Figure F21 in Appendix F illustrates this. The ANOVA test shows that the season of the crash is significant at 95% or higher while the month of the crash is not significant at 95%.

By analyzing the gender of victims, it is found that 65.00% of the KSI were males and 35.00% were females. Figure F22 in Appendix F shows the distribution of KSI intersection crashes by age. The 11–15 age group constituted 31.25% of the total KSI. Statistical testing of the age of injuries with gender using the paired t-test showed that they are statistically different at 95% or higher.

3.5 Severity of Intersection Crashes in Tulkarem Governorate

According to the Road Safety Audit and Review published by the High Traffic Council (HTC, 2011), there are different methods to locate frequent crashes, which may indicate the seriousness of the intersection. One of these is by rating them according to the severity (seriousness) of the crashes (44) .

Crashes are weighted according to their risks using an indicator as an assessment measure as shown in Table 3.2, with crashes classified into three categories: slight injuries, moderate injuries, serious injuries, and fatal. In such a method, different weights are used for each type of crash; for example, the Ministry of Public Works and Housing (MPWH)

refers to the use of the following weights for each type of crash: slight injuries = 1, moderate injuries = 2, serious injuries =10, and fatal = 20 (MPWH, 2022)(45) .

With a rating of 524, Tulkarem City was the most hazardous city in the governorate, followed by A'ttil (107), Bala'a (82), and Khirbet Jubara (76), due to high population density and their geographical location, which forms a link with neighboring localities, while in the south, Khirbet Jubara formed a high total of severity rating, due to its link with the Israeli entity and daily high traffic density of vehicles and pedestrians. The rest of the governorate was relatively safe. The geographical distribution of the severity ratings in the Governorate is depicted in Figure F23 in Appendix F. In 2014, the High Traffic Council (HTC) identified more than ten locations in Tulkarem City with high crash rates and classified some intersections in the governorate as hazardous (black spot), including the major intersection of Bala'a and the intersection between A'ttil and Deir el Ghusun; therefore, these results were expected (HTC, 2014). While, the MPWH identified eight locations in Tulkarem Governorate with high crash rates during the period (2016-2020) such as Far'un Intersection, Bala'a Intersection, Deir el Ghusun Intersection, Qaffin - Nazlat 'Isa Intersection, Bizaria - Anabta Intersection, Nablus Street Intersections (MPWH, 2020).

Table 3.2

Severity rating of localities in Tulkarem Governorate

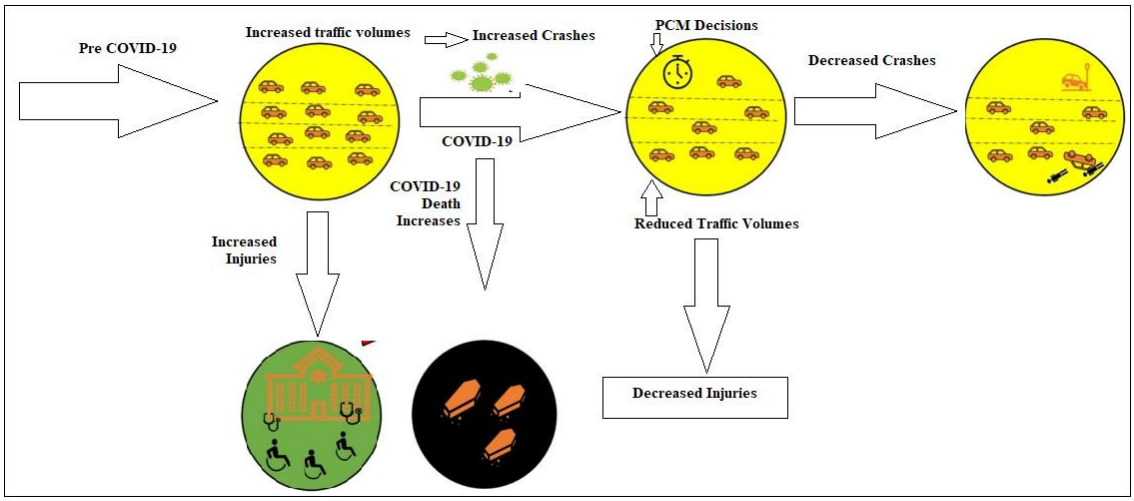
W: Weight				S: Sum			T: Total			R: Rank				
	Slight injuries			Medium injuries			Serious injuries			Fatal				
Locality	No. of injuries	W	S	No. of injuries	W	S	No. of injuries	W	S	No. of fatal	W	S	T	R
Bala'a	52		52	5		10	0		0	1		20	82	3
A'ttil	47		47	5		10	3		30	1		20	107	2
Ar Ras	12		12	1		2	0		0	1		20	34	11
Deir el Ghusun	33		33	2		4	0		0	0		0	37	8
Zeita	20		20	5		10	0		0	0		0	30	12
Kafr Sur	21		21	2		4	0		0	0		0	25	13
'Illar	11		11	1		2	0		0	0		0	13	19
Baqa ash Sharqyeh	22		22	0		0	0		0	0		0	22	15
Khirbet Jubara	34		34	6		12	1		10	1		20	76	4
Qaffin	25		25	7	2	14	0		0	0	20	0	39	7
Beit Lid	17		17	7		14	2		20	0		0	51	5
Ramin	19		19	2		4	0		0	0		0	23	14
Al-Jarushiya	38		38	0		0	1		10	0		0	48	6
Seida	10		10	2		4	0		0	0		0	14	18
Kafr A'bbush	13		13	0		0	0		0	0		0	13	19
Kafr Jammal	10		10	2		4	0		0	0		0	14	18
Kafr Zibad	11	1	11	0		0	0	10	0	0		0	11	20
Saffarin	9		9	3		6	0		0	0		0	15	17
Kur	7		7	0		0	0		0	0		0	7	21
Anabta	16		16	10		20	0		0	0		0	36	9
Shufa	12		12	3		6	0		0	0		0	18	16
Nazlat 'Isa	29		29	4		8	0		0	0		0	37	8
Far'un	31		31	2		4	0		0	0		0	35	10
Tulkarem City	282		282	46		92	15		150	0		0	524	1

3.6 COVID -19 Impacts at Intersection Crashes in Tulkarem Governorate

At the end of 2019, COVID-19 pandemic emerged, and to stop the virus from spreading, countries around the world imposed strict restrictions on movements and activities. With the outbreak of the COVID-19 pandemic in Palestine in March 2020, the government took precautionary measures to limit the disease's spread, including the partial and total closure of service facilities and government institutions. This had an impact on the temporal and spatial characteristics of traffic crashes in the governorate as a result of the disruption of transportation movement. This chapter focuses on determining the impact of the COVID-19 pandemic and closures in the Tulkarem Governorate during the pandemic compared to the years before. Figure 3-2 explains the impacts of COVID-19 on intersection crashes.

Figure 3.2

Flowchart showing the impacts of COVID-19 on intersection crashes in Tulkarem Governorate



The analysis is divided into two parts: the first period runs from March to December 2020 and the second from January to July 2021. During the study period, there were 102 intersection crashes in Tulkarem Governorate.

Part I: The first period of the pandemic (March to December 2020)

The calculation of the rate of decrease in the number of crashes in this period showed that there was a decrease by 74.00 compared to the year 2016, followed by the years 2017, 2018, and 2019 respectively, as shown in Figure F24 in Appendix F. The average decrease

as compared to the average of the four years was 65.25%. The percentage decrease in the crash rate was compared for the period from March to December of each year.

The Palestinian Council of Ministers (PCM) issued a set of decisions in March 2020 to deal with the COVID-19 pandemic and reduce the spread of infection, and these affected many sectors and institutions (46). According to the Police Directorate, these measures helped to reduce traffic crashes, which is also shown in the presented statistics. Table C1 in Appendix C explains the PCM's precautionary decisions and link them to traffic crashes at intersections in Tulkarem Governorate during the first period of the pandemic (March to December 2020).

In general, these decisions reduced the total number of traffic crashes; however, the peak number of traffic crashes occurred in March, the month when the first cases of COVID-19 were announced in Palestine and the decisions were implemented, and then the number of crashes gradually decreased until August as compared to pre-pandemic years. These results are regarded as reasonable and expected.

During the first study period, Thursday was the day of the week with the highest number of intersection crashes in the Governorate, as shown in Figure F25 in Appendix F. It is clear that there was a decrease in the number of crashes during that period as compared to the years before the pandemic.

Figure F26 in Appendix F depicts the number of intersection crashes observed from one hour to the next in Tulkarem Governorate during the first period of the pandemic. There was a significant decrease in the number of crashes during daytime hours, with the peak of crashes in the first period of the pandemic occurring at 17:00 pm, which coincided with the time of the PCM's decisions of daily closures. This is the period when people start rushing to buy their supplies at the last minute before the start of the closure. It is also noted that the number of crashes began to increase between 12:00 and 18:00 pm, which was the period during which movement was allowed and shops and various sectors were open.

In terms of the monthly distribution of intersection crashes in the Governorate, March was the critical month, followed by April and August. Figure F27 in Appendix F depicts

the number of intersection crashes observed from one month to the next before and during the first period of the pandemic.

Part II: The second period of the pandemic (January 2021 to July 2021)

In comparison to the number of crashes before the second period of the pandemic, there was a decrease of 54.00% from 2016 in the months between January and July, while there was a 71.00% increase in the number of crashes compared to the first period of the pandemic Figure F28 in Appendix F.

More crashes were recorded during this period than in the first period of the pandemic, which could be due to decision-making flexibility, the gradual increase in activities, and the partial return to normal life, see Table C2 in Appendix C.

The monthly distribution of intersection crashes in the second period of the pandemic shows that there was a noticeable increase in the number of crashes due to decisions issued by the PCM and a partial return to normal life compared to the first period of the pandemic. Furthermore, Figure F29 in Appendix F depicts the differences in the number of crashes compared to the same prior to the outbreak of the pandemic, demonstrating a significant reduction in the number of crashes. Thursday was the day of the week with the highest number of intersection crashes in the Governorate, as shown in Figure F30 in Appendix F.

According to a 2021 road safety annual report published by the International Transport Forum (ITF), the global health crisis and the accompanying closure measures were reflected in a decline in traffic, which led to a decrease in traffic deaths in the world during the first months of 2020. The report indicated that "the strict closure measures aimed at curbing the Coronavirus outbreak led to a slowdown in the economy and the movement of people, and thus in the number of traffic crashes" (ITF, 2021). For instance, the percentage of fatalities from traffic crashes fell by 13.00% in the Zionist entity when compared to the previous period (2017–2019) (ITF, 2021).

The PCM's decisions helped to curtail commercial and social activities, which in turn reduced traffic on the roads and at intersections, which in turn reduced the number of crashes and injuries. Table 3-3 a, shows the percentage change and average intersection crashes before and during COVID-19 in Tulkarem Governorate, where the average

percentage change before and during COVID-19 in winter decreased by 58.10%, spring recorded the lowest decrease with -43.46%, while summer recorded the largest decrease of -85.98%, and autumn -77.80%. Table 3-3 b shows the percentage change and average number of intersection injuries before and during COVID-19 in Tulkarem Governorate, where the average percentage change before and during COVID-19 in winter was -83.48%, spring recorded the lowest decrease of -81.55%, while summer recorded the largest decrease of -94.70%, followed by autumn with -93.44%.

Table 3.3 a

Percentage change and average number of intersection crashes before and during COVID-19 in Tulkarem Governorate.

Month	(2016-2019)	(2020-July 2021)	Percentage change (%)
January	12.25	7	-42.86
February	8	5	-37.50
March	10.25	5	-51.22
April	12	2.5	-79.17
May	5	5	0.00
June	8.25	2	-75.76
July	10.5	2.5	-76.19
August	9	0	-100.00
September	10.5	5	-52.38
October	8.25	0.5	-93.94
November	7.75	1	-87.10
December	8.25	0.5	-93.94

Table 3.3 b

Percentage change and average intersection Injuries before and during COVID-19 in Tulkarem Governorate.

Month	(2016-2019)	(2020-July 2021)	Percentage change (%)
January	11.5	1.5	-86.96
February	6.25	3	-52.00
March	15.75	3.5	-77.78
April	22	1.5	-93.18
May	13.75	4.5	-67.27
June	13.25	2	-84.91
July	18	0.5	-97.22
August	16	0	-100.00
September	16.25	3	-81.54
October	14.25	0	-100.00
November	15.25	0	-100.00
December	9.5	0	-100.00

Compared to the results of Al-Madinah Al-Munawara study (Al-Ahmadi and Al-Qaradi, 2021), authors found that the decrease in the number of crashes in the city, especially in the months of April and May due to government measures to limit the spread of the virus, which included the prohibition of movement within and between cities, decreased by 37.00% compared to previous years' data. As for Tulkarem Governorate, the reduction in crashes during the COVID-19 pandemic period was much higher, as shown in Table 3-5b.

Figure F31 in Appendix F depicts the number of intersection crashes observed for each hour in Tulkarem Governorate during the second period of the pandemic. There was a significant decrease in the number of crashes during daytime hours, with the peak in the number of crashes in the second period of the pandemic occurring at 14:00 pm.

The most significant descriptive statistical variables showing the differences before and during COVID-19 are shown in Table B6 in Appendix B. Before the pandemic, the month of June had the most recorded, whereas, during the pandemic, the month of May had the most recorded. This difference may be attributed to the decisions made by the PCM. As for the days of the week, Tuesday had the most recorded crashes before the COVID-19 pandemic because the middle of each week was made available for commercial activities at specific times, and Thursday had the most recorded before the pandemic.

During both periods of the pandemic, crashes involving pedestrians accounted for 19.10% of the total intersection crashes in Tulkarem Governorate. Additionally, the percentage of crashes in which injuries occurred was approximately 64.00%, broken down as 86.00% slight injuries, 9.00% moderate, and 5.00% severe, while the percentage of injured males was 67.00%.

The (21–30)-year age group had the most frequently recorded traffic crashes during the two periods of the pandemic, compared to the years before the pandemic, and the younger age groups were the most affected.

3.6.1 Spatial Analysis of Intersection Crashes during the COVID-19 Pandemic in Tulkarem Governorate

For the spatial distribution of crashes during the COVID-19 pandemic by locality Tulkarem City had the highest number of reported crashes 40.91%, decreased by 11.80% for each period, followed by Anabta 8.30%. The severity in Qaffin, Nazlat 'Isa, Baqa ash Sharqiya, Zeita, A'tiil, and Khirbet Jubara changed from orange severity to blue; this is an indication of a decrease in the number of crashes during the Covid-19 period. Since the road network in these northern localities is an open network that connects to one another, the imposed closures prevented movement to the Tulkarem City, which affected traffic volumes and lowered the likelihood of crashes. This indicates the decline in collisions at intersections in these localities. In addition, Khirbet Jubara has an Israeli military checkpoint, and Israeli closures restricted worker and traveler movement to Tulkarem City, which decreased crashes as well. Moreover, during COVID-19, Tulkarem City had the most injuries 77.01%, while the other localities accounted for the remaining 22.99% of the total injuries. Figure 3-3 a and b show the distribution of intersection crashes and injuries in Tulkarem Governorate by locality during the COVID-19 pandemic.

Figure 3.3 a

Distribution of intersection crashes in Tulkarem Governorate by locality during the COVID-19 pandemic

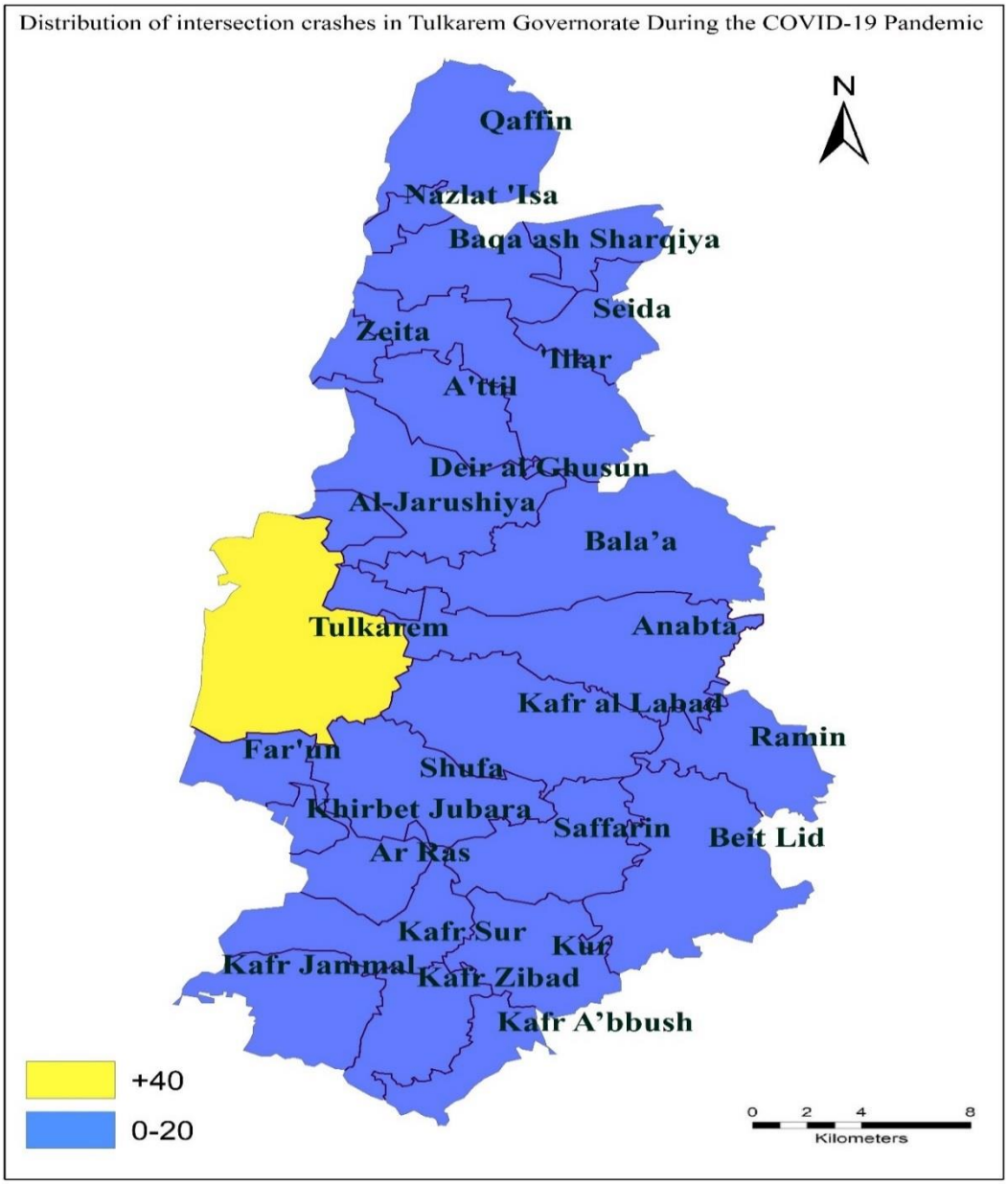
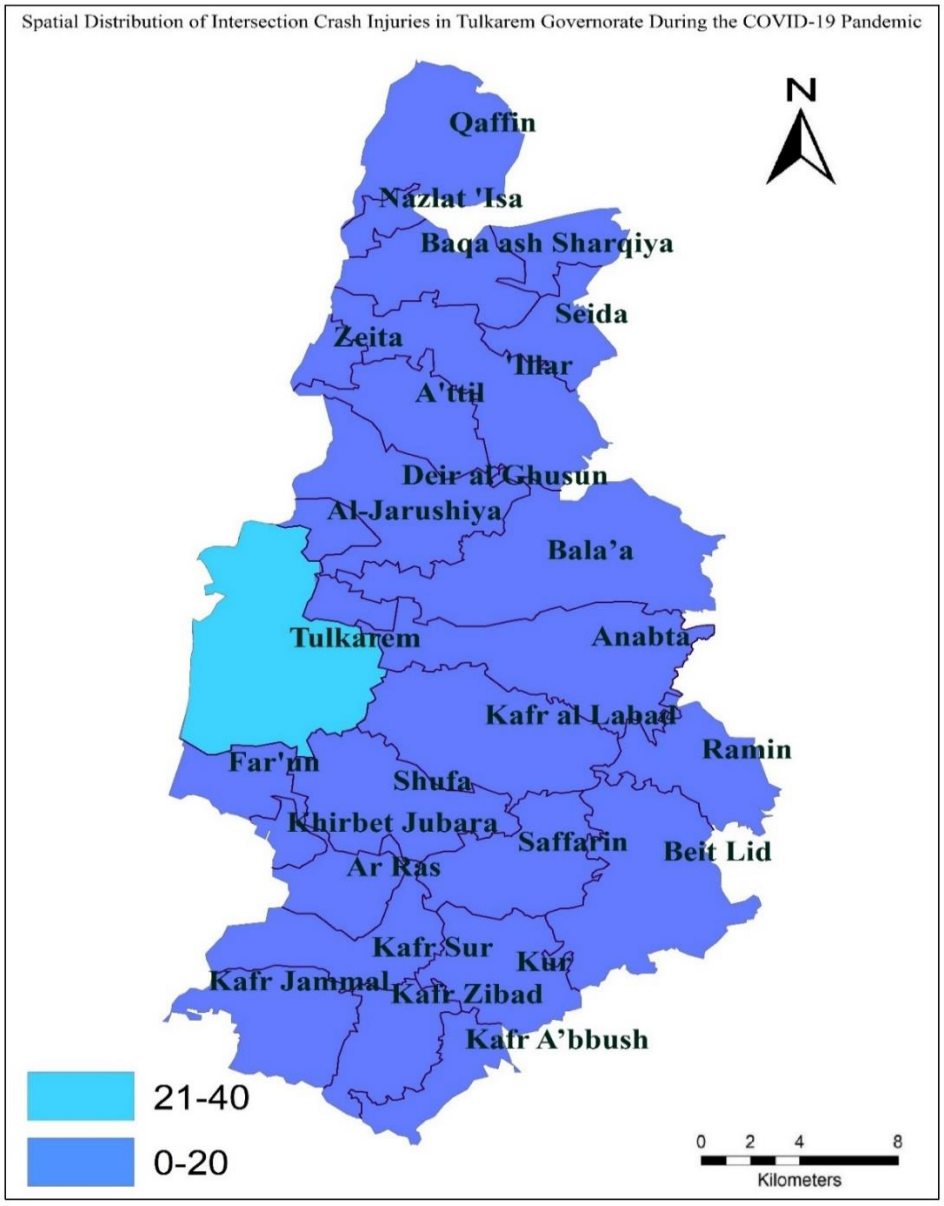


Figure 3.3 b

Spatial distribution of intersection crash injuries in Tulkarem Governorate by locality during the COVID-19 pandemic



By analyzing the intersection crash rate per locality area (square kilometer) during COVID-19, Zeita recorded 6.67 crashes per km^2, the highest in the governorate, followed by Qaffin with 4.00 crash/km^2, and Tulkarem City with 1.88 crash/km^2. For the intersection crash rate per 1,000 capita (of the locality's population) during COVID-19, Tulkarem City, Anabta, Bala'a, Deir el Ghusun, and A'ttil had the highest rates in that order, and this arrangement is consistent with the pre-pandemic period , as shown in Table 3.4.

Table 3.4

Spatial distribution of intersection crashes per km^2 and crashes per 1,000 Capita in Tulkarem Governorate by locality during COVID-19

Crashes per Area (km^2)			
Locality Name	During COVID-19	Pre COVID-19	Percentage Change (%)
Qaffin	4.00	10.00	-60.00
Nazlat 'Isa	0.49	7.90	-94.00
An Nazla ash Sharqiya	0.00	1.40	-100.00
Baqa ash Sharqiya	0.48	1.20	-60.00
Zeita	6.67	33.30	-80.00
Seida	0.59	33.30	-98.00
Illar	0.14	0.80	-83.00
A'ttil	0.82	3.30	-75.00
Deir al Ghusun	0.69	2.70	-74.00
Al Jarushiya	3.57	12.90	-72.00
Bala'a	0.30	2.20	-86.00
Tulkarem	1.88	14.9	-87.00
Anabta	0.71	2.00	-65.00
Kafr al Labad	0.00	3.40	-100.00
Ramin	0.47	1.80	-74.00
Far'un	0.80	5.30	-85.00
Shufa	0.17	0.90	-81.00
Khirbet Jubara	1.67	25.00	-93.00
Saffarin	0.10	0.80	-88.00
Beit Lid	0.06	0.90	-93.00
Ar Ras	0.00	2.90	-100.00
Kafr Sur	0.18	1.30	-86.00
Kur	0.00	1.80	-100.00
Kafr Zibad	0.00	1.10	-100.00
Kafr Jammal	0.00	0.50	-100.00
Kafr A'bbush	0.00	1.60	-100.00
Crashes per 1,000 (capita)			
Locality Name	During COVID-19	Pre COVID-19	Percentage Change (%)
Qaffin	43	173	-75.00
Nazlat 'Isa	2	24	-92.00
An Nazla ash Sharqiya	0	12	-100.00
Baqa ash Sharqiya	10	25	-60.00
Zeita	19	96	-80.00
Seida	11	49	-78.00
Illar	15	84	-82.00
A'ttil	64	255	-75.00
Deir al Ghusun	91	364	-75.00
Al Jarushiya	6	22	-72.00
Bala'a	80	360	-78.00
Tulkarem	3526	27947	-87.00
Anabta	92	259	-64.00
Kafr al Labad	0	24	-100.00
Ramin	8	6	27.00
Far'un	29	31	-6.00
Shufa	3	195	-98.00
Khirbet Jubara	1	17	-94.00
Saffarin	1	10	-90.00
Beit Lid	6	6	-6.00
Ar Ras	0	87	-100.00
Kafr Sur	3	11	-72.00
Kur	0	18	-100.00
Kafr Zibad	0	5	-100.00
Kafr Jammal	0	10	-100.00
Kafr A'bbush	0	23	-100.00

Chapter Four

Data Collection and Analysis of Tulkarem City Crashes

In terms of population, Tulkarem is the seventh largest city in the West Bank (47), with a land area of more than 32,610 dunums (7). The city is located in the north-west of the West Bank, about 15 kilometers (9.3 mi) west of Nablus and 64 kilometers (39.7 mi) south of Jerusalem.

Tulkarem City is one of the most important and prominent cities in economic, cultural, tourist and political terms, in view of the abundance of recreational places in the city, particularly in the summer, when there are numerous visitors from all over Palestine. In addition, Tulkarem hosts three universities within its territory that attract many students from around the country. Economically, the city of Tulkarem is well known for attracting visitors and for providing various projects and jobs. Figure G1 in Appendix G shows a map of Tulkarem City. According to the estimated population for Tulkarm Governorate by locality, Tulkarem City has the largest city's population in the Governorate with a percentage of 43.31% (PCPS, 2021). According to the WAFA news, the area of Tulkarem City represents 10.87% of the governorate (48).

4.1 Profile of Tulkarem City

Based on the geographical distribution of intersections in the city and the road network, Tulkarem is divided into seven zones to facilitate an accurate analysis of crashes in the city. Figure 4-1 illustrates the distribution of the road network and zones in Tulkarem City, which represent a longitudinal transition from north to south and east to west, in different geographic lengths and distributions. Table 4-1 describes the nature of these zones in Tulkarem City.

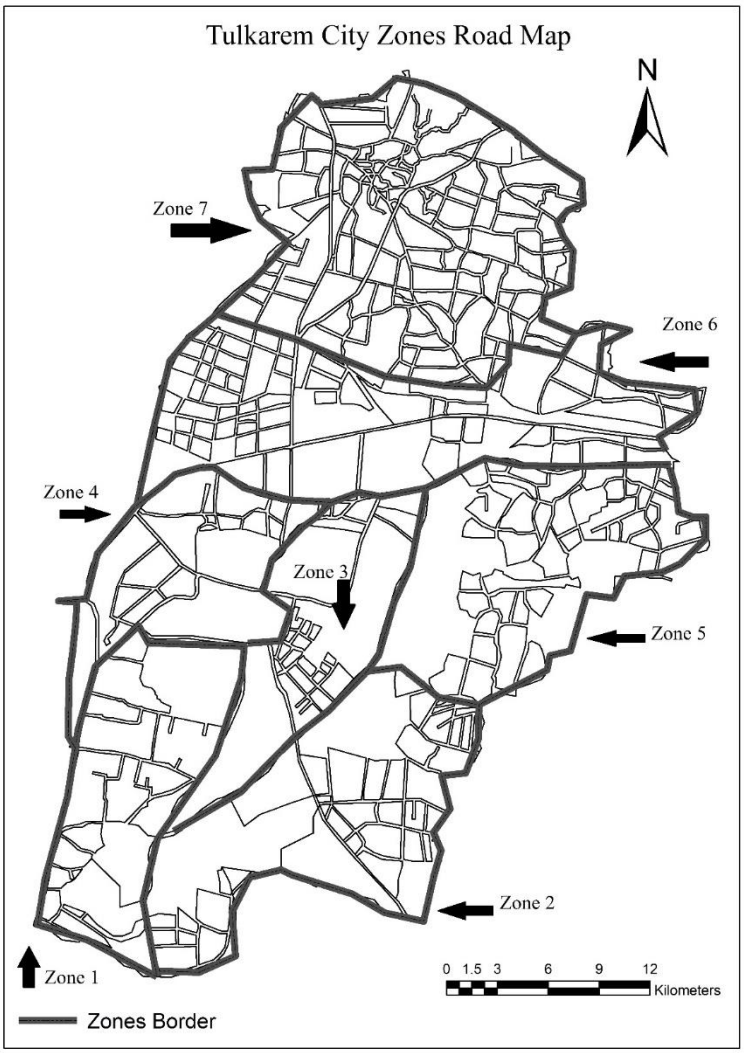
Table 4.1

Study zones in Tulkarem City

Zones	Locality
Zone 1	Southern district and Irtah
Zone 2	Far'un Street, Al-Sawana district and Eizbat Al-Jarad
Zone 3	CBD area, Eastern district, and Old Town
Zone 4	Western district
Zone 5	Thenaba
Zone 6	Northern plain and Iktabah
Zone 7	Shweika

Figure 4.1

Tulkarem City road map and zones



During the study period, there were 123, 87, 75, 86, 34, and 23 intersection crashes in Tulkarem City, which accounted for 52.71% of all intersection crashes in the Governorate. Furthermore, pedestrian crashes accounted for 16.35% of all intersection crashes in the city.

As shown in Figure G2 in Appendix G, the percentage of intersection crashes varied over the study period. The year 2016 with the highest percentage was 28.74%, and the period with the lowest percentage (till July 2021) was 5.37%. An ANOVA test revealed that crashes per year are significant at 95% or higher.

On the other hand, Thursday was the day of the week with the highest number of intersection crashes in the city, as shown in Figure G3 in Appendix G, while Wednesday was the lowest with only 13.08% of the total intersection crashes in the city for the study period. This is reasonable; Thursday is the end of the week, which means more activities as people are preparing for the weekend, so the traffic volume is generally high; however, the day of the crashes was not significant at 95%.

In terms of the time distribution of intersection crashes in Tulkarem City, Figure G4 in Appendix G illustrates the temporal trend of these crashes; increases gradually until midday hours, then decreases again. The afternoon period (12:00-20:00) had the highest concentration of intersection crashes, accounting for 60.51% of all intersection crashes. The highest frequency (42; 9.81%) was recorded at 12:00, followed by 13:00 (41 crashes). These are high-activity hours, as indicated at the governorate level. The hours are significantly different at 95% or higher.

Based on traffic volume studies, the peak hour for each intersection was determined. For each intersection, the percentages of crashes during its peak hour is calculated, as shown in Table 4-2. Due to an increase in both activities and transportation, the Omar bin Abed Al-Aziz Intersection had the highest percentage of crashes occurred during its peak hour 55.56%, followed by the Paris Street Intersection 38.46%, while the Al-Alimi Intersection had the lowest percentage 7.60%. This can be explained by the fact that the Al Alimi Intersection has lower traffic volumes due to its location on the city's outskirts, which increases the likelihood of no crashes. In contrast, the Omar bin Abdul Aziz Intersection connects the City Center with its southern, eastern, and western outskirts, increasing traffic demand and increasing the likelihood of crashes.

Table 4.2

Percentage of crashes during the peak hour at each intersection in Tulkarem City

No	Name of intersection	Peak hour	Percentage of crashes during peak hour (%)
1	Al-Dama Intersection	16:45 -17:45	18.18
2	Zanoubia Intersection	15:30 - 16:30	25.00
3	Tulkarem Camp Intersection	15:30 - 16:30	15.38
4	Nablus Street Intersection	16:30 - 17:30	15.00
5	Hasouna Roundabout	15:45 - 16:45	15.70
6	Al-Younis Intersection	15:45 - 16:46	10.70
7	Al-Salam Intersection	16:30 - 17:30	11.11
8	Al-Alimi Intersection	16:15 - 17:15	7.60
9	Ahmed Yassin (Shweika) Roundabout	16:45 - 17:46	26.67
10	Omar bin Abed Al-Aziz Intersection	14:00-15:00	55.56
11	Jamal Abed Al-Naser Intersection	14:00-15:00	21.42
12	Al-Jallad Intersection	14:00-15:00	10.00
13	City Center	14:00 - 15:00	13.13
14	Schools Area intersection	7:30 - 8:30	28.00
15	Al Moqat'a intersection	14:00-15:00	16.67
16	Paris Street Intersection	14:00-15:00	38.46

In terms of the monthly distribution of city's crashes, May was the critical month with (42 crashes; 9.80%), followed by April, June, and August with (39, 38, and 37) crashes, respectively. Furthermore, it is clear that spring was the season in which most intersection crashes 27.00% took place, followed by summer 26.00%, autumn 25.00%, and winter 22.00%. This is natural and logical because activities decrease in the winter, see Figure G5 in Appendix G. An ANOVA test shows that crashes per month are not significant at 95%, while the season is significant at 95% or higher.

According to the police reports, 29.21% of the causes of these crashes was "speeding", followed by "not giving right of way" 21.03%, "failure to maintain a safe stopping distance" 17.99%, and "failure to take safety measures for pedestrians" 11.21%, whilst the remaining types accounted for 20.56%. Table 4-3 depicts the number and percentages of crashes by cause in Tulkarem City, while Figure G6 in Appendix G demonstrates the

number of crash causes. An ANOVA test showed that the causes of intersection crashes is significant at 95% or higher.

Table 4.3

Causes of crashes in Tulkarem City

Cause of intersection crashes	Total number of intersection crashes	Percentage (%)
Not giving right of way	90	21.03
Speeding	125	29.21
Deviation from the lane to the left	10	2.34
Failure to take safety measures for pedestrians	48	11.21
Reckless driving	11	2.57
Failure to maintain a safe stop distance	77	17.99
Wrong deviation	9	2.10
Ignoring signs	31	7.24
Reversing	13	3.04
Hit an object	14	3.27

Several types of crashes were recorded in Tulkarem City. The highest number of crashes occurred between “Private cars” (601 crashes; 72.66%), followed by a "Vehicle collided with a pedestrian" (139; 15.42%), "Shared Taxi" (89; 9.11%), and other crashes (26; 2.80%). Figure G7 in Appendix G illustrates the percentages of crash types in Tulkarem City for the study period. An ANOVA test revealed the type of crash is significant at 95% or higher.

The analysis of crashes involving injuries shows that the number of females who were injured as a result of intersection crashes in Tulkarem City throughout the study period was 102, a percentage of 28.65%, while the number of males was 254, a percentage of 71.34%. Females recorded 77, 21, 4, and 0 slight, medium, severe, and fatal injuries, respectively. For females, the age group of (11-20) had the highest number of injuries. Males recorded 214, 34, 6, and 0 slight, medium, severe, and fatal injuries, respectively, as represented in Figure G8 in Appendix G. No fatalities were recorded for either males or females during the study period. For males, the age group of (16-30) had the highest number of injuries as shown in Figure G9 in Appendix G. Males tend to drive more recklessly than females and at a faster speed than females, despite the fact that females generally adhere to traffic laws more than males do. This is one of the reasons that lead

to an increase in crashes caused by males. This could generally be attributed to the lack of awareness among users, reckless driving, or poor safety measures on the road. Moreover, the lack of fatalities in the city may be attributable to slower driving speeds and traffic congestion, especially during rush hours, which may lessen the likelihood of collisions. The analysis of crashes and age groups is significant at 95% or higher.

4.2 Profile of Pedestrian Crashes at Intersections in Tulkarem City

Each year, the number of pedestrian crashes appears to decrease slightly. However, in comparison to the period of (2016-2018), the number of collisions decreased sharply in 2019 by an estimated percentage of 11.43%.

For male, most of the pedestrian injuries at the intersections in the city were classified as slight injuries 44.46%, then moderate 15.72%, while severe injuries accounted for 1.46%. For female pedestrian injuries, slight injuries accounted 32.86% then moderate 5.72 %, with no severe and fatal injuries as shown in Figure G10 in Appendix G.

The reasons for the observed decrease in pedestrian crashes, according to the police department, are the continuous traffic awareness campaign, particularly for school students, traffic improvements at certain intersections, the deployment of traffic police personnel in areas classified as dangerous, such as the intersection of Paris Street, as well as the delineation of pedestrian markings on intersections (49). However, the year (2020-till July 2021) was affected by COVID-19 Pandemic, which will be discussed in the next chapter. Table B7 in Appendix B, shows the results of pedestrian crashes and Table D1 in Appendix D shows the type of pedestrian injury results for the study period.

A comparison is made to other similar studies with similar environment (Jaber (2019) in Nablus City and Al-Omari and Obaidat (2013) in Irbid City). All three studies agreed that Thursday had the highest number of crashes involving pedestrians and most of the injuries were male with slight injuries. Moreover, the highest causes of crashes involving pedestrians for all three studies were failure to take safety measures.

4.3 Killed or Seriously Injured (KSI) Analysis for Tulkarem City

There were 11 KSI crashes in Tulkarem City during the study period, with Sunday having the highest number of overall KSI crashes at the intersections with 54.54%. Male victims

comprised 60.00%, and female victims 40.00%. Furthermore, the age group of (16-20) had the highest frequency, accounting for 36.36% of the total KSI.

In terms of the monthly distribution of total KSI, April was the most critical month for crashes 36.36%, and spring witnessed the most occurrences of KSI 54.45%. Moreover, zone four had the most KSI recorded in terms of location. This can be explained by the absence of traffic calming devices at the intersections in zone 4 and the presence of four schools and the Palestine Technical University – Khadoorie, which result in high vehicular/pedestrian traffic volumes and conflicts. In addition, there are a series of intersections (Cinema Al-Andalus intersections) that are close and challenging for drivers due to their restricted sight distances as they are situated between residential buildings in a heavily built-up area. Crashes per year, hour, age and gender are significant at 95% or higher, while crashes per day, month, and season were not. The main profile of KSI crashes in Tulkarem City is shown in Table D2 in Appendix D.

ANOVA and T-tests showed that time, season, victim's gender, and age group of KSI crashes are all significant at 95% or higher, although the day and month of crashes are not.

4.4 Analysis of City's Zones

As previously stated, the city was divided into seven zones based on the locations of the intersections analyzed. These zones were investigated to determine which intersections are the most affected by the crashes that have occurred within these locations. Tulkarem City zone crashes are significant at 95% or higher.

After examining the spatial distribution of intersection crashes in Tulkarem City, it is found that zone 6; the eastern entrance of the city (Nablus Street Intersection, Al-Dama Intersection, Al-Salam Intersection, Al-Younis Intersection, Hasouna Roundabout, and Iktaba Roundabout) had the highest number of crashes 32.94% among all zones in the city. As expected, this zone is very vital and attracts people and vehicles, has intersections located on the eastern stretch of the city in the form of a chain, has a high traffic volume, and is considered to be the city's nourishing eastern artery. Therefore, it has a variety of traffic conflicts that pause a high likelihood for crashes.

It is clear that year 2016 had the most recorded crashes, followed by 2017. In terms of season, spring and summer seasons had the most recorded crashes, while Thursday, Saturday, and Sunday had the most recorded crashes per day. Moreover, the age group of (11-20) was most affected, and pedestrian injuries recorded the largest percentage in the zone (6). For instance, and as anticipated, Zone (6) recorded the highest percentage of intersection crashes as discussed before. Moreover, it also comprised the largest percentage of participants for both males and females, as well as the largest percentage of pedestrian accidents. The peak crash times were at 9:00, 10:00, 11:00, and 13:00, which coincide with the start of busy movements into and out of the city for various activities. The distribution of intersections in zones and the overall number of crashes are depicted in Table 4.4 a, and each zone in the Tulkarem City has its crash characteristics as presented in Table 4.4 b.

Table 4.4 a

Intersection crashes in Tulkarem City's zones

Zones	Intersections name	Number of crashes
1	Al-Masa Intersection Al-Hesba Intersection (new) Omar bin Abed Al-Aziz Intersection Helmy Hanoun Intersection Al-Qassam Mosque Intersection Irtah Girls School Intersection Al-Safeer Roundabout Al Balawi Intersection Al-Jallad Intersection	35
2	Far'un Street Intersection Al-Shobaki Intersection Al-Barghouti Intersection Al-Saffarini Mosque Intersection Al-Salam Roundabout French Bakery Intersection	70
3	City Center Intersection Jamal Abed Al-Naser Square Al-Hesba Intersection (old) Al Moqat'a Intersection Paris Street Intersection Al-Karaj Intersection	55
4	Al-Rawda Mosque Intersection Schools Area Intersection Cinema Al-Andalus Intersection Cinema Al-Fareed Intersection	40
5	Zanoubia Intersection Entrance Tulkarem-Camp Intersection Mohammed Al-Qasim Roundabout Mohammed Al-Qasim (Al-Maslakh) Intersection Muscat School Intersection	51
6	Nablus Street Intersections Al-Dama Intersection Al-Salam Intersection Hasouna Roundabout Iktaba Roundabout	141
7	Ahmed Yassin (Shweika) Roundabout Al-Jaruon Roundabout Al-Meja Roundabout Al-Alimi Roundabout Al-Younis Intersection Al-Sikka Street Intersections	36

Table 4.4 b

Comparison between intersection crashes per zone in Tulkarem City

Comparison Item	Zones (1)	(2)	(3)	(4)	(5)	(6)	(7)
% Crashes	8.17	16.35	12.85	9.34	11.91	32.94	8.41
Critical year	2016	2016	2016	2017	2016	2016	2017
Critical day	Thursday	Friday	Sunday	Sunday	Saturday	Sunday	Thursday
Critical month	June	January, April, and May	May	June	November	January	June
Critical season	Summer	Spring	Spring	Summer	Autumn	Summer	Spring
Critical hour	(14:00)	(11:00)	(14.00 & 16.00)	(10.00)	(13.00 & 17.00)	(9.00, 10.00, 11.00, & 13.00)	(12.00)
Critical age group	(11-15)	(16-20)	(16-20)	(11-20)	(11-15)	(16-20)	(11-15) & (21-25)
% Pedestrian crashes	5.97	13.43	20.89	11.94	7.46	35.82	4.47
Most frequent cause	Not giving right of way	Speeding & failure to maintain a safe stopping distance	Not giving right of way	Speeding	Speeding	Speeding	Not giving right of way
% Male	5.12	14.10	8.55	7.69	14.96	45.72	3.48
% Female	4.42	12.39	13.27	11.50	14.16	39.82	4.42

Due to the nature of zones with high vehicular and pedestrian volumes, such as the Zone 3 (City Center, Jamal Abed Al-Naser Square, and Paris Street), it occupied the third place 12.85% in terms of overall intersection crashes and the second place in pedestrian crashes with a rate of 20.89%. It should be noted that the majority of crashes in the area occurred between the hours of (14:00-16:00), which corresponds to the end of official working hours and the increase various activities, which would increase the probability of crashes, especially for pedestrians. On the other hand, Zone 2 was the second-highest in number of intersection crashes and the third in pedestrian crashes. Vehicles typically drive at a relatively high speed on all roads in that zone, which might explain the high number of pedestrian crashes. Additionally, these crashes could be attributed to the inadequate sidewalk space and facilities, particularly on Far'un Street.

4.5 Severity of Intersection Crashes in Tulkarem City

Several methods for crash severity are used; here is a presentation of some of these.

I. Rate method based on severity of crashes

The rating method based on the severity of the crash was applied at Tulkarem City intersections using the same mechanism as in the governorate level. As shown in Table 4-5, the intersections on Nablus Street were the most dangerous in the city, recorded the highest number of casualties and rates, followed by the Al-Sikka Street Intersections. The rate method based on crash severity is significant at 95% or higher.

Table 4.5

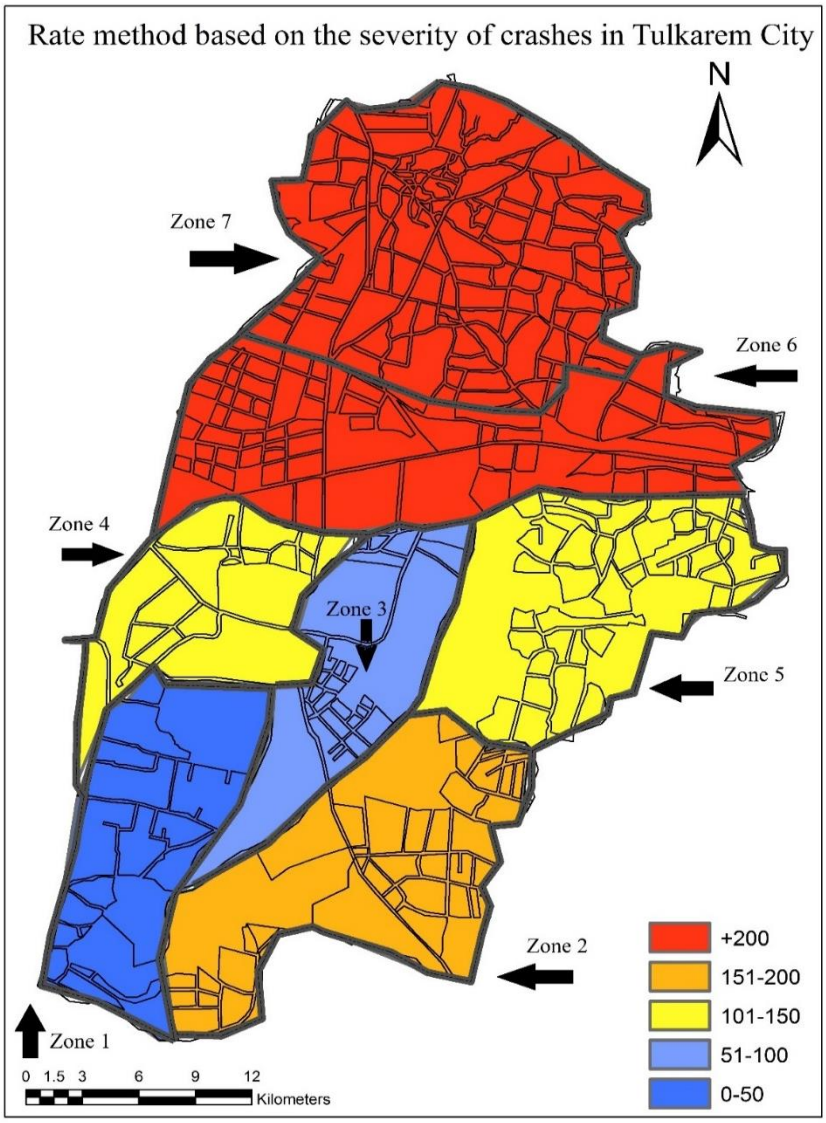
Rate method based on the severity of crashes in Tulkarem City

W: Weight			S: Sum			T: Total			R: Rank		
	Slight injuries			Medium injuries			Serious injuries				
Intersection Name	**No. of Injuries**	**W**	**S**	**No. of Injuries**	**W**	**S**	**No. of Injuries**	**W**	**S**	**T**	**R**
				Zone (1)							
Omar bin Abed Al-Aziz	6		6	1		2	0		0	8	24
Helmy Hanoun	7		7	1		2	0		0	9	23
Al-Qassam Mosque	0		0	3		6	0		0	6	26
Al-Safeer Roundabout	5	1	5	0	2	0	0	10	0	5	27
Al Balawi	5		5	1		2	2		20	7	25
Al-Masa	4		4	1		2	0		0	6	26
Al-Hesba (new)	0		0	2		4	0		0	4	28
Irtah Girls School	4		4	2		4	0		0	4	28
									Sum = 49		
				Zone (2)							
Far'un street	40		40	5		10	2		20	70	5
Al-Barghouti	0		0	1		2	0		0	2	29
Al-Saffarini Mosque	1		1	3		3	0		0	4	28
Al-Salam Roundabout	11	1	11	3	2	1	0	10	0	14	20
Al-Jallad	0		0	2		4	1		10	14	20
Al- French bakery	8		8	1		2	0		0	10	22
Al-Shobaki	5		5	2		4	0		0	9	23
Al-Sawana	4		4	3		6	2		20	30	15
									Sum = 153		
				Zone (3)							
City center	28		28	6		12	1		10	44	10
Jamal Abed Al-Naser Square	6		6	1		2	0		0	7	25
Al-Hesba (old)	1	1	1	0	2	0	0	10	0	1	30
Al Moqat'a	10		10	5		10	0		0	20	18
Paris Street	4		4	1		2	0		0	6	26
Al-Karaj	2		2	0		0	0		0	2	29
									Sum = 80		
				Zone (4)							
Schools Area	19		19	7		14	5		50	83	3
Cinema Al-Andalus	5	1	5	1	2	2	4	10	40	47	9
Al-Rawda Mosque	1		1	0		0	0		0	1	30
Cinema Al- Fareed	0		0	2		4	0		0	4	28
									Sum = 135		
				Zone (5)							
Zanoubia School	43		43	3		**6**	0		0	49	8
Entrance Tulkarem Camp	12		12	0		0	0		0	12	21
Mohammed Al-Qasim Roundabout	17	1	17	3	2	6	2	10	20	43	11
Mohammed Al-Qasim (Al-Maslakh)	11		11	4		8	1		10	29	16
Muscat School	2		2	0		0	0		0	2	29
									Sum = 135		
				Zone (6)							
Nablus Street	133		133	18		36	3		30	199	1
Al- Dama	22		22	4		8	2		20	50	7
Al-Salam	15	1	15	5	2	10	0	10	0	25	17
Hasouna Roundabout	10		10	2		4	2		20	34	14
Iktaba Roundabout	7		7	8		16	4		40	63	6
									Sum = 371		
				Zone (7)							
Ahmed Yassin (Shweika) Roundabout	10		10	4		8	0		0	18	19
Al-Jaruon Roundabout	5		5	4		8	6		60	73	4
Al-Meja Roundabout	4	1	4	3	2	6	3	10	30	40	12
Al-Alimi Roundabout	4		4	0		0	0		0	4	28
Al-Younis Intersection	14		14	6		12	1		10	36	13
Al-Sikka Street Intersections	8		8	3		6	8		80	94	2
									Sum = 265		

Based on the summation results of multiplying the number of injuries by the weight of each level of injury for each location in each zone, Figure 4-2 depicts the degree of severity for the zones in Tulkarem City. Due to the small number of intersections and the low degree of severity of these intersections, zone 1 was the least dangerous, with 49, while zones 6 and 7 were the most dangerous in Tulkarem City, with 371 and 265, respectively.

Figure 4.2

Crash rates based on the severity in Tulkarem City zones (total rates per zone)



II. Critical Rate of Crashes (CRC) method

According to the High Traffic Council (HTC, 2011), the CRC method compares the actual crash to a critical traffic crash rate value that cannot be exceeded, and if the calculated rate is higher than the critical value, that part of the intersection is classified as a high crash site. For the crash rate at intersections (number of crashes per million vehicles entering the intersection), if the crash ratio (crash rate/critical crash rate) is greater than 1.0, the intersection is classified as a high crash area (HTC, 2011).

The CRC method was applied to selected intersections in Tulkarem City due to the availability of traffic volume data for particular intersections and the lack of data for others.

According to the MOT (2010-2020), the number of registered and licensed vehicles in Tulkarem Governorate was obtained (50), identifying that the growth factor grew by almost (0.07) per year. Moreover, traffic volumes were estimated for the year 2021 based on the growth factor; see Figure G11 in Appendix G. Furthermore, during the period (2016-2018), data on traffic volumes were collected from prior studies on several city's intersections. Table 4-6 shows the critical rate of crashes at intersections in Tulkarem City.

Table 4.6

Critical rate of crashes at intersections in Tulkarem City

Intersection No.	Intersection Name	No. of Crashes	No. of Vehicles (Predicted) veh/day	Million Entering Vehicles (MEV)	Crash Rate (No. of Crashes/MEV)	Rank
1	Al-Younes Intersection	28	5386	14.2	2.0	6
2	Zanobia Intersection	17	5325	8.7	1.9	7
3	Entrance Tulkarem Camp	13	4800	7.4	1.8	8
4	Nablus Street Intersection	60	7169	22.9	2.6	3
5	Al-salam Intersection	23	6966	9.0	2.5	4
6	Al-Elami Intersection	13	6395	5.6	2.3	5
7	Omar bin Abdulaziz Intersection	9	5458	4.5	2.0	6
8	Jamal Abdulnaser Intersection	14	2700	14.2	1.0	10
9	Al- Jallad Intersection	16	3813	11.5	1.4	9
10	Schools Area Intersection	15	2300	17.9	0.8	11
11	Shwaikeh roundabout	15	6395	6.4	2.3	5
12	Hassounah Roundabout	19	6200	8.4	2.3	5
13	Central Business District (CBD)	25	10706	6.4	3.9	1
14	Dama Intersection	22	7300	8.3	2.7	2

As indicated in Table 4-8, the CBD had a crash rate of 3.9 crashes/MEV, which is high because of the small geographic area and corresponding high traffic volume, and was followed by the Nablus Street and Al-Dama intersections. The crash rates are significant at 95% or higher.

The HTC recommended using the CRC method because it is a basic and simple process that can be easily applied in Palestine to identify dangerous locations. Furthermore, the first method (rate method based on severity of crashes) has a large discrepancy in the weighting of all types of crashes, whilst the CRC method is biased in favor of fatal crashes because it gives greater weight to such crashes (HTC, 2011). For example, the schools' area in the CRC method had a ranking of 0.8, but ranked third in the first method. Since the effect of the fatal crashes is not critical at the city's level (no recorder fatal crashes), the CRC method could be used in this study.

In comparison, Green and Agent (2003) calculated crash rates in Kentucky, USA, indicating that there were 428 intersections in Kentucky that had crash rates equal one or more, compared to 12 in Tulkarem. There were also 36 intersections in Kentucky that had crash rates equal two or more and were considered dangerous, as opposed to 8 in Tulkarem. Due to the differences in traffic volumes, population counts, and number of intersections, this comparison may not be fair. In the same context, Al-Sahili and Khader (2016) calculated crash rates at intersections in Nablus City, where Al-Ghawi had the highest crash rate (1.7 crashes / mev), while Tulkarem's CBD area had the highest crash rate of (3.9 crashes / mev). This might be due to the relatively low traffic volumes in Tulkarem CBD area as compared to Nablus City.

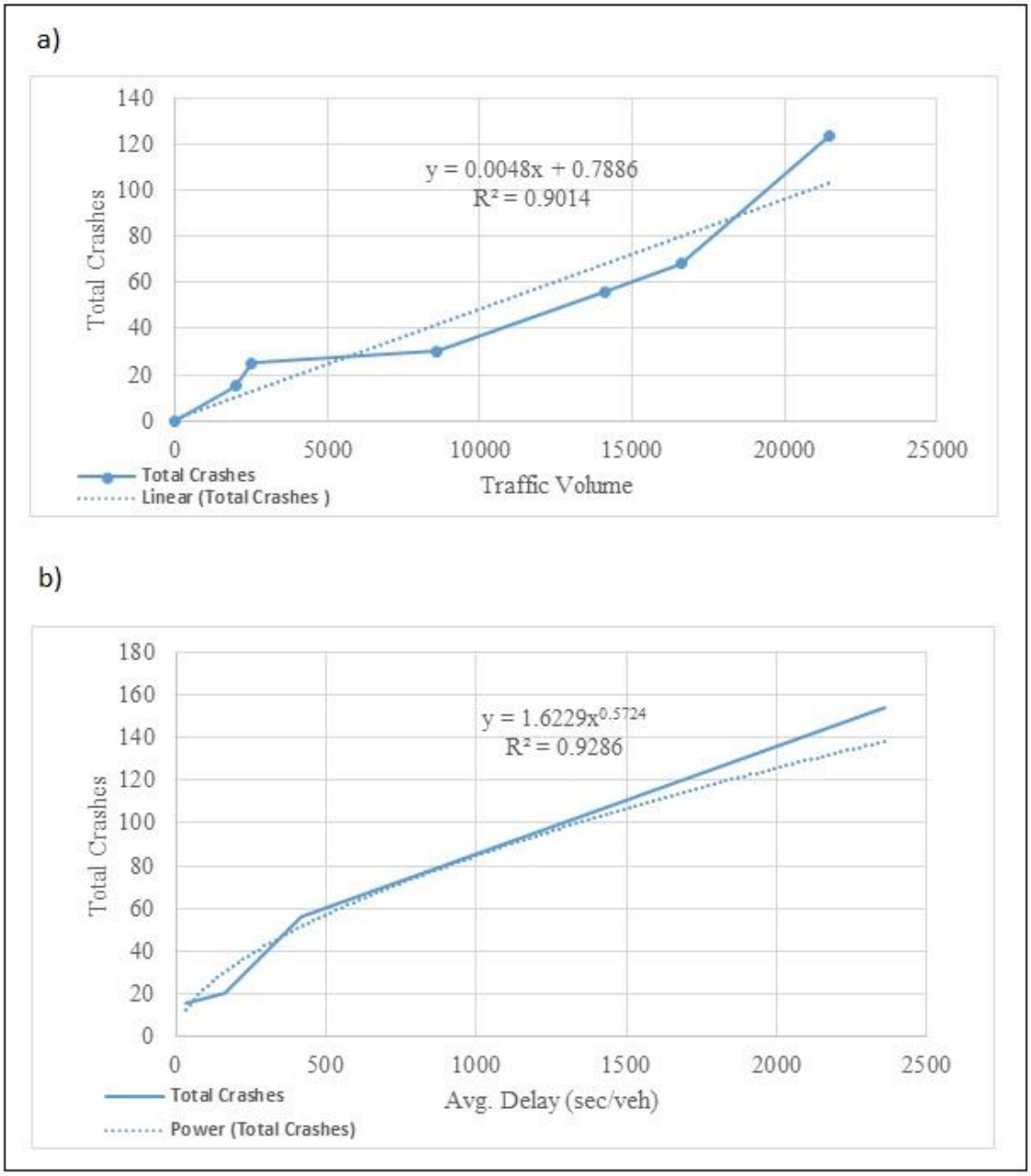
4.6 Relationships between Type of Intersection, Delays, and Crashes at Certain Intersections in Tulkarem City

This section explores the relationship between the type of intersection, delays, and the number of crashes at certain intersections (14 intersections) as shown in Table 4-9 in Appendix D.

The data collected revealed that as the number of vehicles and the average delay at intersections increase, crashes increase. Thus, when traffic congestion increases, crashes would increase. Figures 4.14 a, b depicts the relationship between traffic volumes and average delays versus the number of crashes. Traffic volume is significant at 95% or higher, while the average delay is not significant at 95%.

Figure 4.3

The relationship between traffic volume, Average Delay and the total number of crashes at certain intersections in Tulkarem City



The type of intersection and average delay were tested using a paired sample test, and the results showed that the statistical significance value was less than alpha (0.05), indicating that the groups were statistically different.

The level of service (LOS) was calculated at certain intersections using the Synchro software, and the results showed that the LOS (F) constituted the highest percentage of crashes at the intersections 57.00%, followed by the LOS (D) 28.00%, while the LOS (E)

witnessed 10.00%, which is illogical because the LOS (D) is higher in the total number of traffic crashes than the LOS (E); this explanation is due to the limited data available. Additionally, the LOS (C) witnessed 5.00%, as identified in Figure G12 in Appendix G.

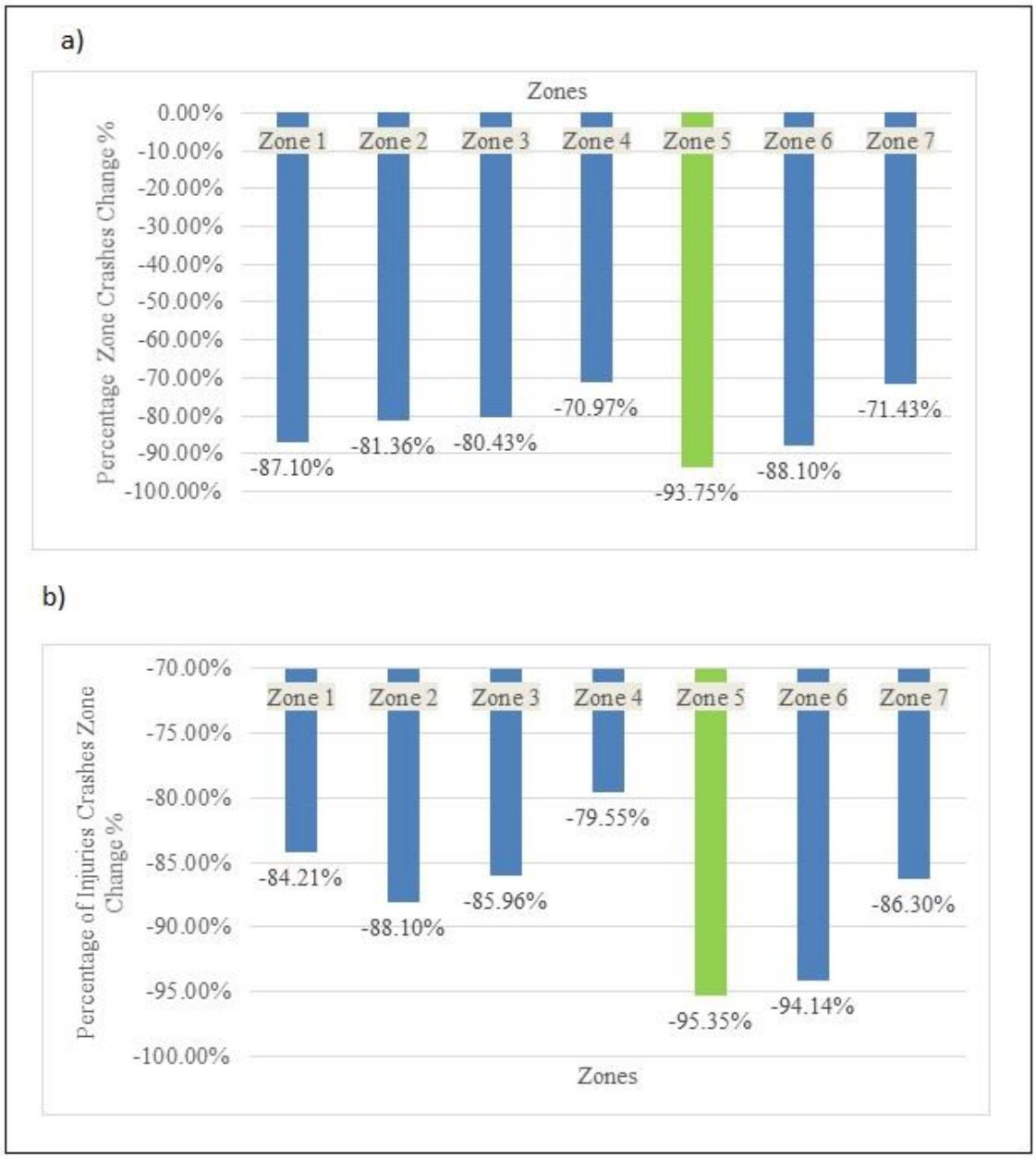
In general, it can be concluded that as delay increases, severity decreases since speed is low and drivers become more cautious. For this study, it should be noted that there were no intersections in Tulkarem City classified as LOS (A or B). LOS is significant at 95% or higher.

4.7 COVID -19 Impacts at Intersection Crashes in Tulkarem City

The severity of the rate of intersection crashes in Tulkarem City changed from red to yellow; a decrease in severity particularly in some zones, such as zones 6 and 7. Zone 5 had the greatest change in the number of intersection crashes and injuries, followed by zone 6 with percentages of (-93.75% and -88.10) in terms of crash frequency and (-95.35% and -94.14%) for injuries, respectively, as shown in Figures 4-15 a and 4-15 b. The main reason was the lack of economic activities in those zones during the period when citizens were allowed to move for only limited hours and when only some shops and commercial establishments were allowed to open; therefore, most citizens went to buy their supplies within those hours. Moreover, the effect of some closure decisions issued by the PCM, especially those stipulating the closures imposed between governorates, contributed to reducing crashes in zones 5 and 6, which explains the increase in the rate of decline in those zones, in contrast to the commercial zones located in zone 3.

Figure 4.4

Distribution of percentage change in intersection crashes and injuries in Tulkarem City by zone before and during the COVID-19 pandemic



During COVID-19, Tulkarem City had the most injuries 77.01%, while the other localities accounted for the remaining 22.99% of the total injuries; zone 6 had the most injuries 19.40% in the City, while during the period (2016–2019) Tulkarem City had 85.31% and zone 6 had the most injuries 36.75%. The severity of injuries in Tulkarem City decreased from red to light blue , and all other colors decreased to dark blue, which is an indication of the significant decrease in the number of injuries, as the rate of change

of injuries during the Covid-19 period reached to -83.46%.Zone 6 in the City had the lowest overall injuries, with a rate of decrease of -93.60 %, followed by zone 5 -92.40 %, since there was little traffic in those areas during peak demand periods during the COVID-19 pandemic. Figure 4.5 a to c illustrate the distribution of crashes and injuries in Tulkarem Governorate and City.

Figure 4.5 a

Distribution of intersection crashes in Tulkarem City by zone during the COVID-19 pandemic

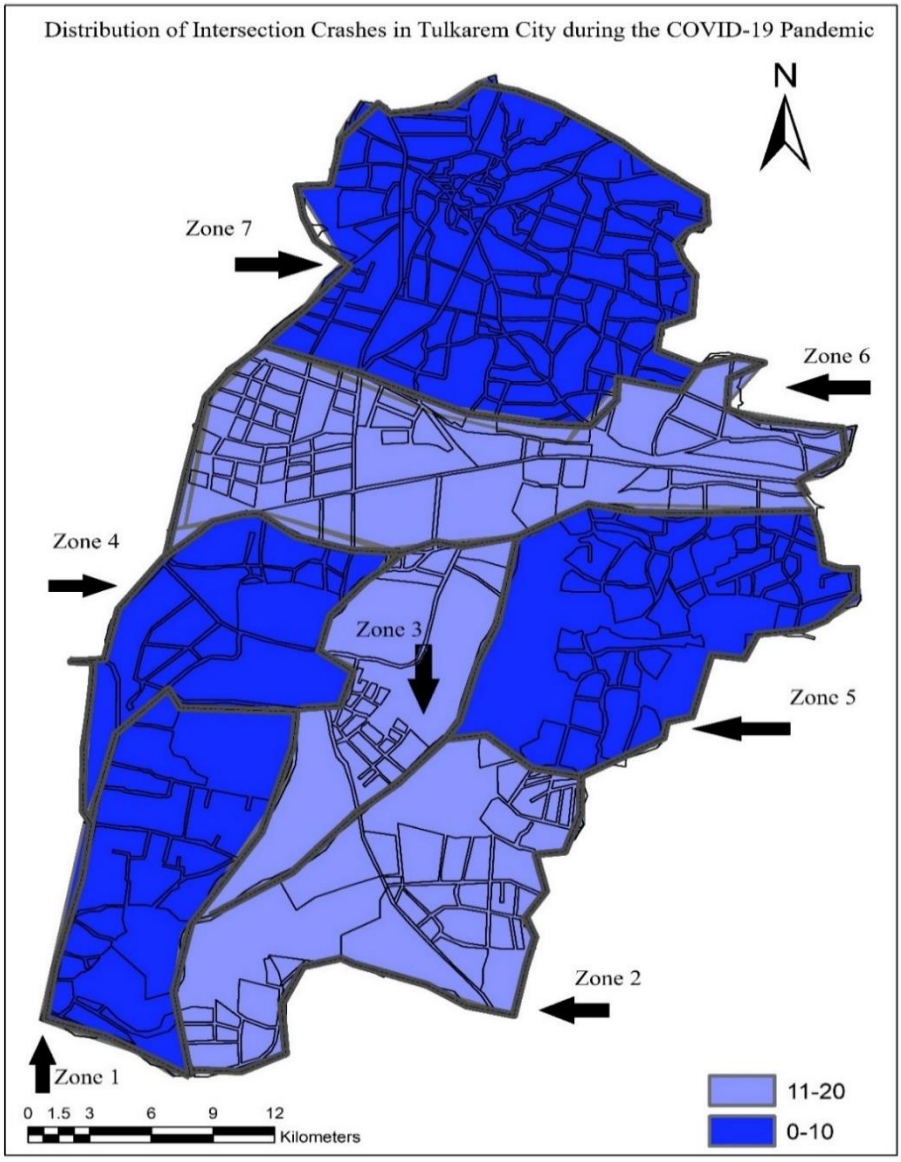


Figure 4.5 b

Spatial distribution of intersection crash injuries in Tulkarem Governorate by locality during the COVID-19 pandemic

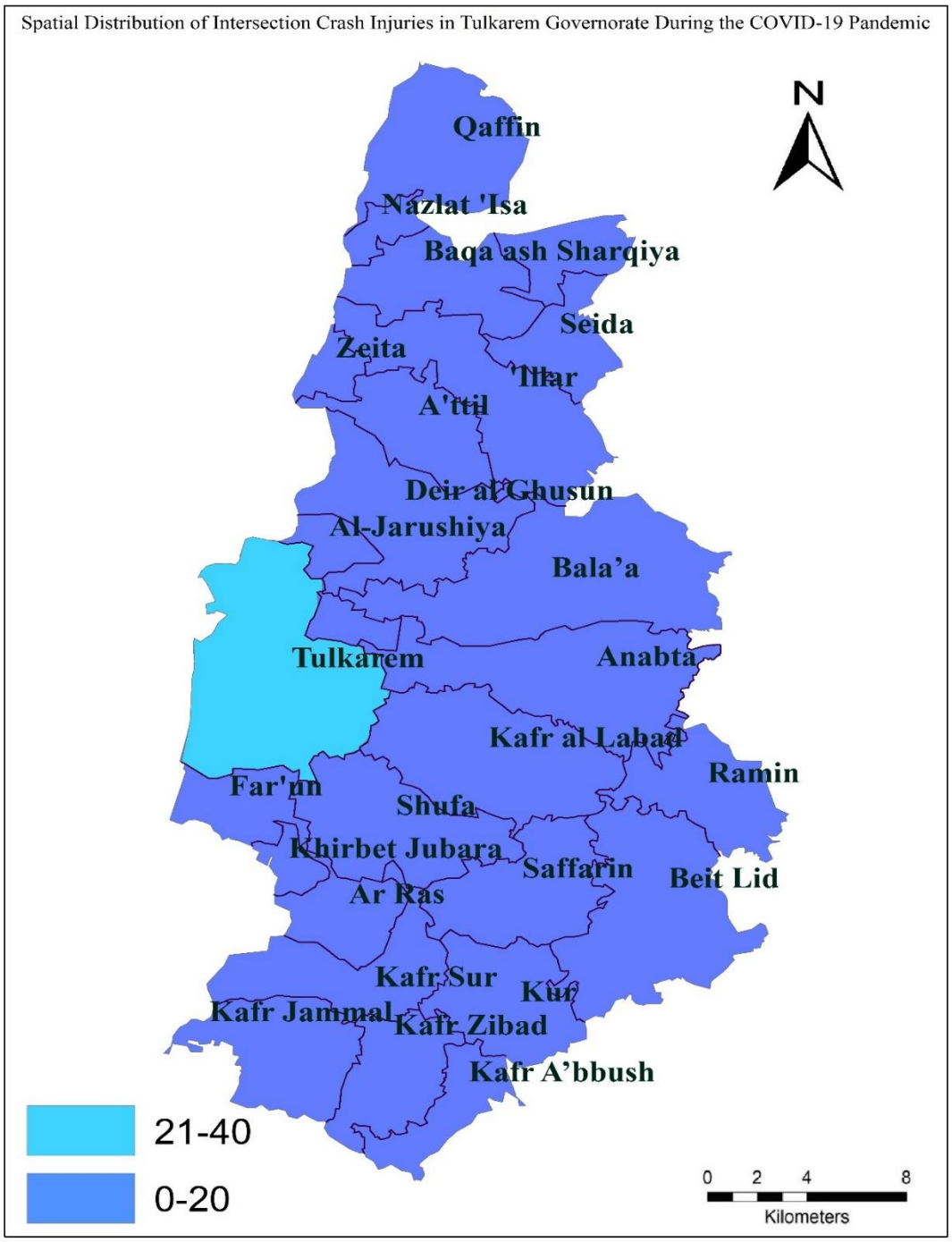
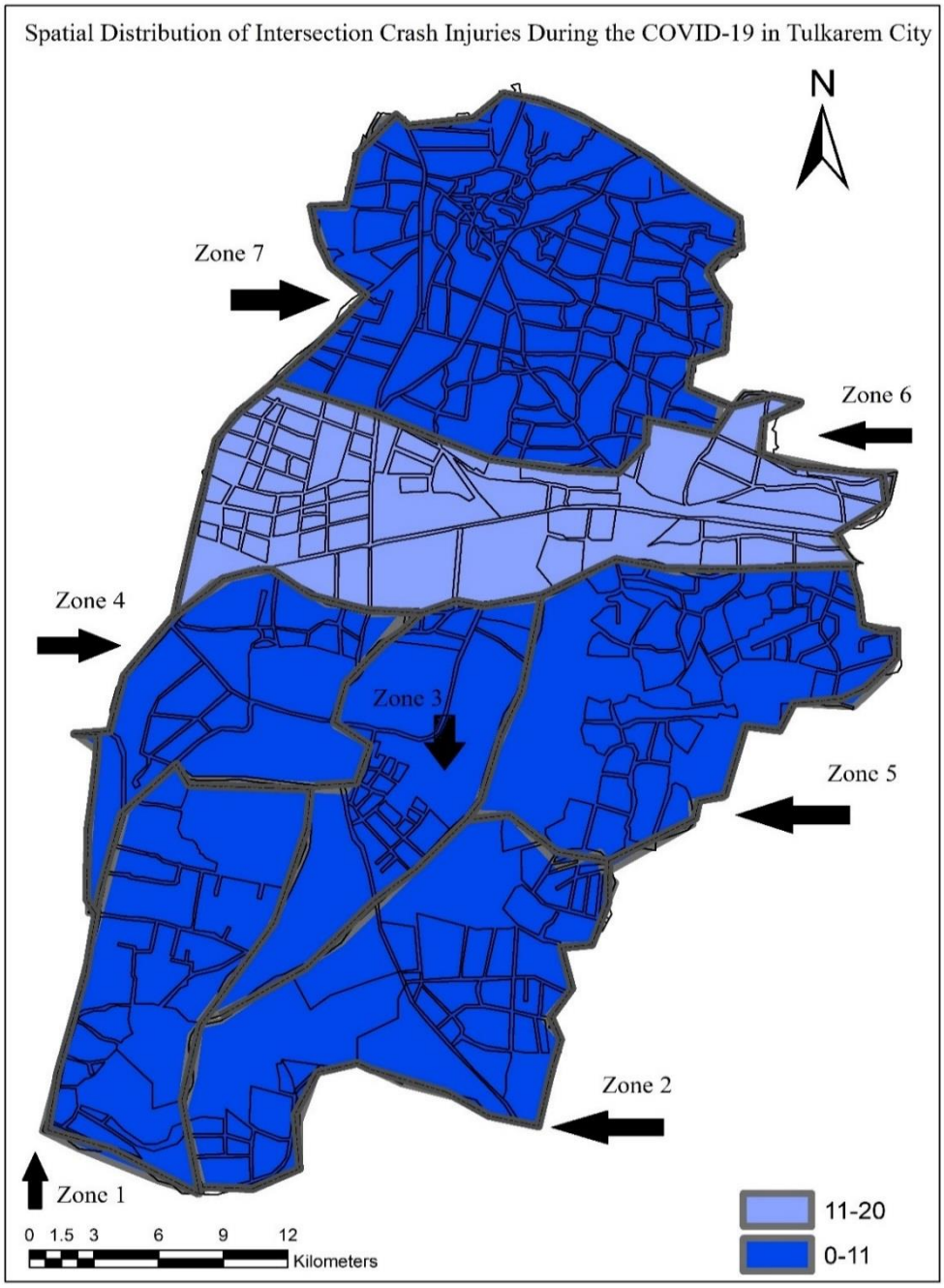


Figure 4.5 c

Spatial distribution of intersection crash injuries in Tulkarem City by locality during the COVID-19 pandemic



Chapter Five

Conclusions and Recommendations

5.1 General

The goal of this study is to investigate and assess intersection crashes in the Tulkarem Governorate. This study offers a wealth of details regarding intersection crash rates, types, severity, etc. in the Tulkarem Governorate for the period of (2016 - till July 2021). The relevant stakeholders might use the findings of this thesis to create the first steps in formualting a comprehensive action plan for reducing intersection crashes.

As a general observation, poor intersection quality (geometry, layout, control, etc.) and poor compliance to traffic rules among road users contributed to cities' high crash rates. In addition, pedestrians frequently cross the roadway at unmarked intersections without waiting for the pedestrian signal. Additionally, pedestrian amenities (such as markings, signs, walkways, etc.) are typically in poor shape and require upgrading.

5.2 Conclusions

A) Tulkarem Governorate Level

- The percentage of intersection crashes for Tulkarem Governorate for the 2016 - till July 2021 period was 24.42% of total crashes. Year 2016 had the highest number of intersection crashes. About 71% of crashes occurred at unsignalized intersections; 22% occurred at roundabout intersections and 6% at signalized intersections.
- Thursday, which is an active day for shopping, social, and leisure, was the day with the highest number of intersection crashes (17%), while Friday, which is a holiday with low traffic volume was the lowest (12%).
- Intersection crashes concentrated in the period of (10:00-16:00); 11:00 and 12:00 (noon time) recorded the highest frequency. This is an active period (10:00-16:00); it includes the active movement of people and the traffic volume is generally high. Students head home from their schools, employees leave their workplaces, and shopping activities are apparent as well. These contribute to increasing the number of crashes.

- The month of May recorded the highest frequency (10%) followed by April (9%). Spring and summer seasons recorded the highest frequency (28% and 26%, respectively) followed by autumn and winter (24% and 22%, respectively); not much differences among seasons. This is due to the high number of individuals and families' outdoor activities that take place throughout the spring and summer months, including school vacation; there is a high volume of road users. On the other hand, due to the prevalent cold and rainy weather, the autumn and winter seasons are less active.
- Males injured was higher than females (66%/34%). The age group of (16-20) was the most frequent for male victims (13%), while this was 6% for the females' same age group.
- "Not giving right of way" was the highest cause in all intersection crashes (30%), followed by speeding (27%). Private cars were the highest type of vehicles causing the crash, followed by public transportation vehicles.
- The percentage of crashes involving pedestrian formed approximately 16%, with "Failure to take safety measures for pedestrians" as the highest cause (30%), followed by speeding 27%. Similar percentages of pedestrian crashes were reported by the National Highway and Traffic Safety Administration in the USA.
- In terms of intersection crashes rate per 1,000 capita (of locality's population), Tulkarem City, Anabta, Bala'a, Deir el Ghusun, and A'ttil had the highest rates, in that order.
- Tulkarem City, Attil, and Balaa recorded the highest severity rating of localities in the Governorate, while Kur, Kafr Zibad, Kafr A'bbush, and 'Illar recorded the lowest severity rating among localities.
- As a general comparison with other studies, results of this thesis are somewhat similar to other studies conducted in similar regions (i.e., Jordan and Palestine); however, they are different with studies conducted in totally different regions such as the USA.

B) Tulkarem City Level

- The percentage of intersection crashes in Tulkarem City for the study period was 53% of total intersection crashes in Governorate.

- Similar to the Governorate results, 2016 had the highest number of intersection crashes (29%), while the period of (January-July 2021) had the lowest percentage (5%) due to the Covid-19 pandemic travel restrictions. Moreover, Thursday witnessed the highest number of intersection crashes (16%), while Wednesday and Friday were the lowest (13%).
- Spring season months recorded the highest frequency (27%) followed by summer (26%), autumn (25%), and winter (22%), with not much variation among seasons.
- The highest concentration of crashes was in the period of (12:00-20:00); 12:00 (noon time) and 13:00 recorded the highest frequency. During the peak traffic hour, Omar bin Abed Al-Aziz Intersection had the highest percentage of crashes (56%), followed by Paris Street Intersection (38%), while Al-Alimi Intersection had the lowest (8%). This can be attributed to the relatively low traffic volume at Al Alimi Intersection due to its location on the city's outskirts, which reduces the likelihood of crashes. In contrast, Omar bin Abdul Aziz Intersection connects the City Center with its southern, eastern, and western outskirts; thus witnessing high traffic volume and increasing the likelihood of crashes.
- The percentage of injured females in intersection crashes was much lower than males (29%), among which the highest number of female injuries occurred for an age group of (16-30). Males tend to drive more recklessly than females and at a faster speed, and females generally tend to adhere to traffic laws more than males. This also could generally be attributed to the lack of awareness among users, reckless driving, or poor safety measures on the road.
- No fatalities were recorded in the city during the study period, which could be attributed to slower driving speeds and traffic congestion, especially during rush hours, which may lessen the likelihood of severe injuries/fatal crashes.
- Pedestrian were involved in 15% of the total number of intersection crashes. “Failure to take safety measures for pedestrians” was the highest cause of crashes involving pedestrian.
- Based on the Critical Rate of Crashes (CRC) method, the CBD area had a crash rate of (3.9) crashes/MEV, which is high because of the small geographic area and corresponding high traffic volume, and was followed by Nablus Street and Al-Dama intersections.

- Related to the intersection's level of service (LOS), intersections with LOS (F) constituted the highest percentage of crashes (57%), followed by those with LOS (D) (28%), while intersections with LOS (E) witnessed (10%) and those with LOS (C) witnessed the least with only (5%).

C) During COVID-19 Pandemic

With the outbreak of the COVID-19 pandemic in Palestine, the government imposed several measures to control the spread of the virus for the period of March 2020 to July 2021, which affected travel patterns. Due the difference in government's measures, the pandemic period was divided into two periods; March - December 2020 and January - July 2021. Comparisons were made between the crashes for the period of 2016-2019 (pre-pandemic) with crashes during the two pandemic periods.

- As a general conclusion, measures taken by Palestinian Council of Ministers during the pandemic reduced the number of crashes; however, severity level was almost the same.
- Number of intersection crashes in Tulkarem Governorate decreased by an average of 81% during the pandemic due to the imposed measures.
- Thursday witnessed the highest number of crashes before and during the pandemic, while Friday had the least before the pandemic. On the other hand, the least number of crashes occurred on Saturdays in the first period and on Wednesdays in the second period.
- The period of 10:00-14:00 was the most prevalent in intersection crashes during the pandemic period, and this is in line with the opening of some sectors and facilities by the governmental decisions.
- During the two pandemic periods, males constituted the majority of victims (67%), and the age group of 21–30 were the most affected by these crashes. When compared to the years before the pandemic, younger age groups were the most affected.
- During the two periods of the pandemic, pedestrian crashes constituted 19% of the total crashes in the governorate. Approximately, 64% of crashes involved injuries; 86% minor and 14% medium to severe; these percentages were close to the period before the pandemic.

- Tulkarem City had the highest number of intersection crashes in the governorate during the pandemic periods (41%), while it was 53% before the pandemic. The rate of crashes involving pedestrians per 1,000 people was also the highest in Tulkarem City, a decrease by 87% compared to before the pandemic, followed by the town of Anabta; decrease by 64%. The localities that witnessed relatively higher frequency of crashes were Deir al Ghusun, Attil, and Qaffin in the north, and Furoun in the south.
- The average percentage change (reduction) was lowest in spring (-82%), while summer and autumn recorded the largest decrease (-95% and 93%).
- In Tulkarem City, the severity of the rate of intersection crashes reduced.
- In terms of the intersection crash rate per locality's area (square kilometer) during COVID-19, Zeita recorded 6.67 crashes/km^2, the highest in the governorate, followed by Qaffin with 4.00 crashes/km2, and Tulkarem City with 1.88 crashes/km^2.
- In terms of the intersection crash rate per 1,000 capita (of the locality's population) during COVID-19, Tulkarem City, Anabta, Bala'a, Deir el Ghusun, and A'ttil had the highest rates in that order, and this arrangement is consistent with the pre-pandemic period.

5.3 Recommendations

Decision-makers and interested parties should follow up on the findings of the intersection crash analysis in Tulkarem Governorate and benefit from its outcomes. This study serves as a guide for future investigations of the Palestinian traffic safety program. The following specific recommendations are offered:

- It is strongly advised to create a method for documenting crash data that transitions from manual to electronic use of electronic tablets or cellphones and to use technology to improve accuracy and eliminate errors in data recording. This helps provide more information and a more thorough examination by, for example, revealing the ages of the drivers, type of collisions, and information about Property Damage Only (PDO).
- Stepping up awareness efforts on traffic laws directed at all road users, particularly school children, under the supervision of the institutions in charge.

- Increasing the human power of the traffic police to improve their control over traffic laws in order to improve the safety level.
- Due to the lack of traffic volumes studies at intersections, it is recommended to conduct traffic counts at all major intersections in Tulkarem Governorate so that crash rate analysis become more accurate.
- Due to the high percentage of crashes at un-signalized intersections, it is recommended to conduct a study to assess the most appropriate traffic control type (roundabout, signalization, etc.) so as to properly control traffic conflicts.
- Due to the poor pedestrians' facilities throughout the study area, particularly the CBD area of Tulkarem City, new road planning and traffic regulations are highly recommended.
- This thesis offers comprehensive results on the impacts of collisions at intersections in Tulkarem Governorate, which can be expanded to be thorough and valuable for other Palestinian governorates. Therefore, future research could be directed to conducting more thorough research on the subject throughout Palestine. This also should be supported by developing medium and long-term plans to improve traffic safety conditions in Tulkarem Governorate and Palestine.
- Due to the high frequency of crashes and injuries in the North and Central localities of Tulkarem Governorate, one can perform a study on the economic and social repercussions that could have an impact on crashes generally. Moreover, in the city, one can make a research about the effect of land use classifications on crashes, and developing of ARIMA model to predict crashes in the future.

List of Abbreviations

Abbreviation	Meaning
PCBS	Palestinian Central Bureau of Statistics
MOT	Ministry of Transportation
MTA	Ministry of Tourism & Antiquities
WHO	World Health Organization
NHTSA	National Highway Traffic Safety Administration
ADT	Average Daily Traffic
AADT	Average Annual Daily Traffic
CRF	Critical Rate Factor
GLM	Generalized Linear Model
EU	European Union
UAE	United Arab Emirates
LOS	level of Service
JTI	Jordan Traffic Institute
FARS	Fatality Analysis Reporting System
FHWA	Federal Highway Administration
ARIMA	Autoregressive Integrated Moving Average
GNP	Gross National Product
PT	Public Transportation
JPSD	Jordanian Public Security Directorate
GDPP	General Directorate of Palestinian Police
SPSS	Statistical Package for the Social Sciences
ANOVA	Analysis of Variance
COVID-19	Coronavirus Disease-19
KSI	Killed or Seriously Injured
HTC	High Traffic Council
MPWH	Ministry of Public Works and Housing
MEV	Million Entering Vehicles
CBD	Central Business District
PCM	Palestinian Council of Ministers
ITF	International Transport Forum

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Appendices

Appendix A

Collected Data

A1: A Sample Collected Data 2016

Day	Time of Crashes	City/Village	Location	Type of Crashes	Cause of Crashes	Details	No. of Injuries	No.of Deaths	Type of Injuries
January									
ednesday	11:30	Faruan	Faruan Intersection	Two vehicles collided	Not giving Right of Way	2 Private car	1	0	Slight
Friday	17:15	Sida	Sida Intersection	Taxi collided a private car	Not giving Right of Way	Private car + Taxi	2	0	Slight
Friday	5:00	Al-Kafreat	Al-Kafreat Intersection	Taxi collided a private car	Not giving Right of Way	Private car + Taxi	5	0	Slight
ednesday	13:30	Al-Kafreat	Al-Kafreat Intersection	Two vehicles collided	Not giving Right of Way	2 Private car	1	0	Slight
Sunday	12:15	Tulkarem	Paris Street Intersection	Two vehicles collided	Not giving Right of Way	2 Private car	0	0	-
Monday	14:15	Faruan	Faruan Intersection	Two vehicles collided	Deviation from the lane to the left	Taxi + Private car	1	0	Slight
Sunday	8:25	Tulkarem	Nablus Street Intersection	Two vehicles collided	Not giving Right of Way	2 Private car	0	0	-
Monday	13:15	Tulkarem	Nablus Street Intersection	Three vehicles collided	Speeding	3 Private car	5	0	Slight
Friday	11:40	Tulkarem	Al-Salam Roundabout	Two vehicles collided	Not giving Right of Way	2 Private car	1	0	Slight
ednesday	16:30	Tulkarem	Nablus Street Intersection	Taxi collided a private car	Speeding	Taxi + Private car	1	0	Slight
Monday	17:25	Tulkarem	Schools Area	Two vehicles collided	Reckless driving	2 Private car	3	0	Medium
Tuesday	15:30	Alar	Alar-Ateel-Eastern Baqa Intersection	Vehicle collided a pedestrian	Failure to take safety measures for pedstrianes	Pedstriane +Private car	1	0	Slight
Friday	13:10	Tulkarem	Mohammed Al-Qasim Roundabout	Vehicle collided a pedestrian	Failure to take safety measures for pedstrianes	Pedstriane +Private car	4	0	1 Hard + 3 Medium
Tuesday	21:15	Tulkarem	Jamal Abdel Nasser Square	Two vehicles collided	Reversing	2 Private car	0	0	-
Saturday	20:00	Anbta	Bazaria - Anabta Intersection	Two vehicles collided	Not giving Right of Way	2 Private car	0	-	-
Thursday	9:15	Balla	Balla Intersection	Bus collided a private car	Wrong deviation	Bus + Private car	4	0	Slight
Friday	9:00	Zeta	Zeta Intersection	Vehicle collided a pedestrian	Not giving Right of Way	Pedstriane +Private car	1	0	Slight

Appendix B

SPSS Tables

Table B1

ANOVA test at intersections in Governorate per year

Year of Crash	Sum of squares	df	Mean square	F	Sig.
Between groups	254.311	21	12.110		
Within groups	1607.939	790	2.035	5.950	.000
Total	1862.250	811			

Table B2

ANOVA test at intersections in Governorate per day

Day of Crash	Sum of squares	df	Mean square	F	Sig.
Between groups	15.971	5	3.194		
Within groups	3214.999	806	3.989	.801	.549
Total	3230.969	811			

Table B3

ANOVA test at intersections in Governorate by time of crash

Time of Crash	Sum of squares	df	Mean square	F	Sig.
Between groups	2499.556	23	108.676		
Within groups	1873.667	120	15.614	6.960	.000
Total	4373.222	143			

Table B4

ANOVA test at intersections in Governorate by season and month of the year

Months	Sum of squares	df	Mean square	F	Sig.
Between groups	28.178	10	2.818		
Within groups	8967.757	801	11.196	.252	.990
Total	8995.935	811			
		Season			
Between groups	2.317	1	2.317		
Within groups	810.129	689	1.176	1.970	0.161
Total	812.446	690			

Table B5

Paired samples test at intersections in Governorate by age of injuries with gender of injuries

Gender of injuries		Paired differences							
		Mean	Std. deviation	Std. error mean	95% confidence Lower	Upper	t	df	Sig. (2-tailed)
Pair 1	Age of injuries - Gender of injuries	25.59	14.12	0.52	23.56	25.61	46.94	726	0.000

Table B6

Comparison of the descriptive statistical differences of the most important variables before and during Covid-19 at intersections in Tulkarem Governorate.

During COVID-19 (2020-July 2021)							
Variable	Month	Age	Day	Time	Type of Crash	Type of Injury	Injuries by Gender
N	132	87	132	132	132	87	87
Mean	May	25	Tuesday	11:00	Two-vehicle collision	Slight	Male
F critical	7.64	0.081	0.273	0.142	0.007	0.38	0.643
Sig (using alpha = 0.05)	0.007	0.777	0.602	0.707	0.935	0.539	0.888
Significant or not	Significant	Not significant	Not significant	Not significant	Not significant	Not significant	Not significant
Pre COVID-19 (2016-2019)							
Variable	Month	Age	Day	Time	Type of Crashes	Type of Injuries	Injuries by Gender
N	678	708	678	678	678	708	708
Mean	June	26	Thursday	11:00	Two-vehicle collision	Slight	Male
F critical	0.0406	0.785	0.528	2.013	1.05	0.38	1.537
Sig (using alpha = 0.05)	0.987	0.376	0.663	0.111	0.366	0.539	0.004
Significant or not	Not significant	Not significant	Not significant	Not significant	Not significant	Not significant	Significant

Table B7

Pedestrian crash summaries at intersections in Tulkarem City

Pedestrian crash summaries in Tulkarem City		
Comparison Item	Critical term	Significant or not at 95% or higher
Year	2016	Significant
Month	May	Not significant
Season	Spring	Significant
Hour	13:00-14:00	Significant
Age Group	(16-20) Male (11-15) Female	Significant
Day	Thursday	Not significant
Male/Female percentage	46.32%/53.68%	Significant
Cause	Failure to take safety measures when crossing the intersection	Significant

Appendix C

Tables of all Data Collection and Analysis of Tulkarem Governorate Crashes

Table C1

Relationship between Palestinian Council of Ministers' decisions and the number of crashes at intersections in Tulkarem Governorate (March–December 2020)

First Period of the Pandemic (March to December 2020)				
PCM Decisions by Month	Month	Total Number of Crashes	Critical Day	Critical Hour
Traffic between governorates was restricted Closing all educational facilities Preventing movement of citizens from towns, villages, and camps to urban centers Movement was prohibited from 18:00 pm till 06:00 am	March	8	Thursday	18:00
Traffic between governorates was restricted All educational facilities were closed Some shops, bakeries, and gas stations were allowed to open from 10:00 am till 17:00 pm but closed on Friday Movement was prohibited from 18:00 pm till 6:00 am	April	7	Thursday	16:00
Preventing movement of citizens from towns, villages, and camps to urban centers Some shops were allowed to open from 10:00 am till 18:30 pm but closed on Friday Movement was prohibited from 19:30 pm on Friday till 12:00 am on Monday All educational facilities were closed	May	6	Monday & Wednesday	17:00
Preventing movement of citizens from towns, villages, and camps to urban centers Some shops were allowed to open from 10:00 am till 18:30 pm but closed on Friday Movement was prohibited from 19:30 pm on Friday till 12:00 am on Monday	June	5	Tuesday	11:00

All educational facilities were closed All governorates were closed for two weeks Movement was prohibited from 20:00 pm till 06:00 am Movement was prohibited on Thursday from 20:00 pm till 06:00 am on Sunday	July	6	Thursday	18:00
Shops were allowed to open and movement of transportation was allowed from 10:00 am till 20:00 pm All educational facilities were closed Traffic between governorates was restricted	August	7	Sunday	21:00
Shops were allowed to open and movement of transportation was allowed from 10:00 am till 20:00 pm All educational facilities were closed Traffic between governorates was restricted	September	4	Thursday	15:00
Shops were allowed to open and movement of transportation was allowed from 10:00 am till 20:00 pm All educational facilities were closed Traffic between governorates was allowed from 7:00 am till 12:00 am	October	2	Thursday & Sunday	16:00 & 11:00
Shops were allowed to open and movement of transportation was allowed from 7:00 am till 12:00 am All educational facilities were closed Traffic between governorates was allowed from 7:00 am till 12:00 am	November	2	Wednesday	12:00 & 17:00
Shops were allowed to open and movement of transportation was allowed from 7:00 am till 12:00 am All educational facilities were closed	December	1	Wednesday	12:00

Table C2

Relationship between Palestinian Council of Ministers' decisions and crashes at intersections in Tulkarem Governorate (January–July 2021).

Second Period of the Pandemic (January 2021 to July 2021)				
PCM Decisions by Month	**Month**	**Total Number of Crashes**	**Critical Day**	**Critical Hour**
Regular school hours for some classes and continued closure of institutes and universities Movement was prohibited from 19:30 pm till 6:00 am	January	6	Sunday	11:00
Movement was prohibited from 19:00 pm on Thursday till 6:00 am on Sunday Movement was prohibited from 19:30 pm till 6:00 am Traffic between governorates was restricted from Tuesday at 19:00 pm All educational facilities were closed	February	7	Monday	21:00
Movement was prohibited from 19:00 pm on Thursday till 6:00 am on Sunday Some shops were allowed to open from 10:00 am till 18:30 pm and closed on Friday	March	8	Friday	19:00
The same decisions were continued All commercial sectors were open till 20:00 pm	April	8	Thursday	19:00
Regular school hours for some classes and continued closure of institutes and universities Transportation was allowed from 7:00 am till 19:00 pm Some commercial sectors were open till 8:00 pm	May	9	Tuesday	16:00
Transportation was allowed from 7:00 am till 19:00 pm Regular school hours for some classes and continued closure of institutes and universities Most of the commercial sectors were closed	June	8	Thursday	20:00
Traffic between governorates was restricted All educational facilities were closed	July	8	Wednesday	18:00

Appendix D

Tables of all Data Collection and Analysis of Tulkarem City Crashes

Table D1

Number of pedestrian injuries and severity level at intersections in Tulkarem City

Year	Slight	Medium	Severe	Fatal
2016	14	7	1	0
2017	13	3	0	0
2018	12	1	1	0
2019	5	3	0	0
2020	5	0	0	0
Till July 2021	5	0	0	0
Total Injuries	54	14	2	0

Table D2

Profile of KSI crashes in Tulkarem City

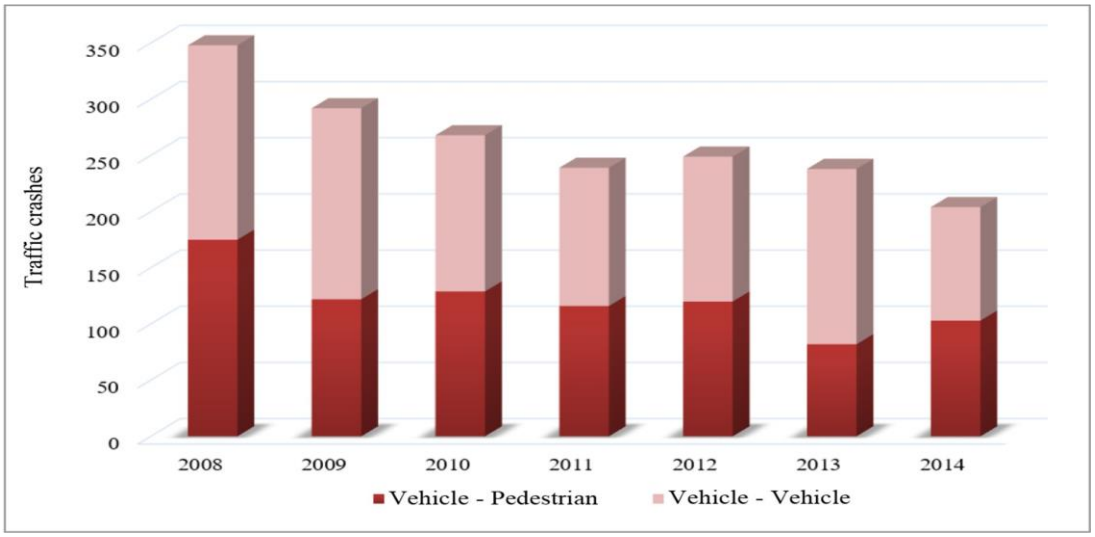
Item	Value	Percentage
Critical year	2018	(45.45)%
Critical day	Sunday	(54.54)%
Critical month	April	(36.36)%
Critical season	Spring	(54.45)%
Critical time	10.00 Am	(36.36)%
Critical victim’s age	(16-20)	(36.36)%
Critical zone	Zone (4)	(36.36)%
Male/Female percentage	-	60.00/40.00%

Appendix E

Figures Related to Literature Review

Figure E1

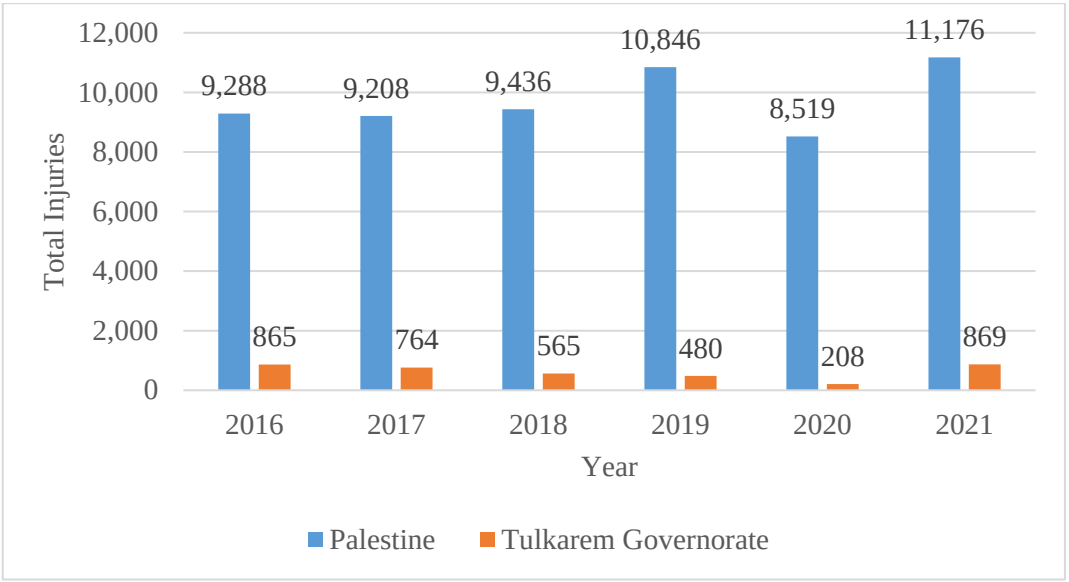
Traffic crashes in Bucharest (2008–2014)



[Source: Raicu et al., 2014]

Figure E2

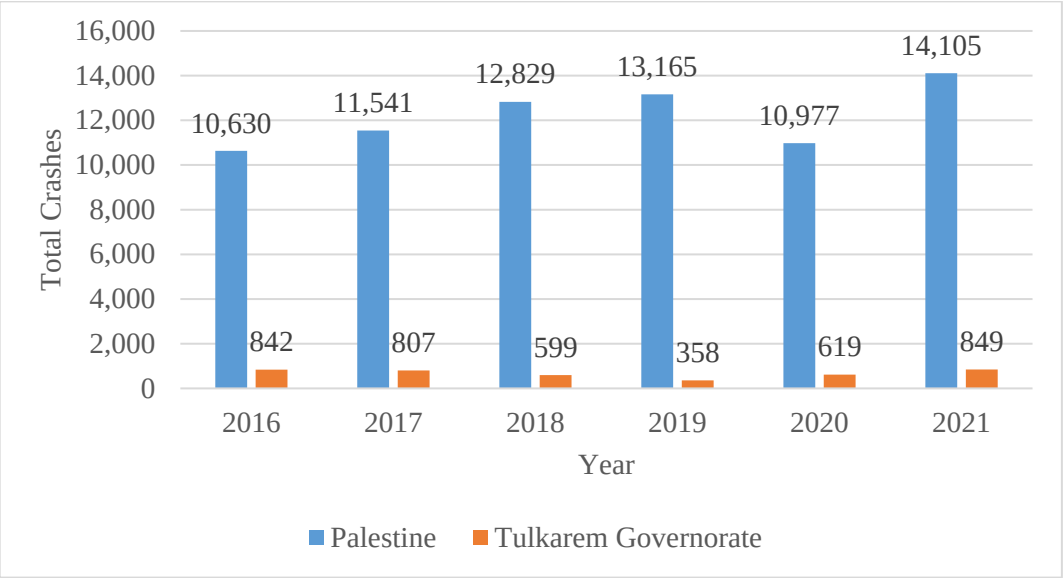
Number of injuries per year in Palestine and Tulkarem Governorate



[Source: Palestinian Police Annual Reports (2016-2021)].

Figure E3

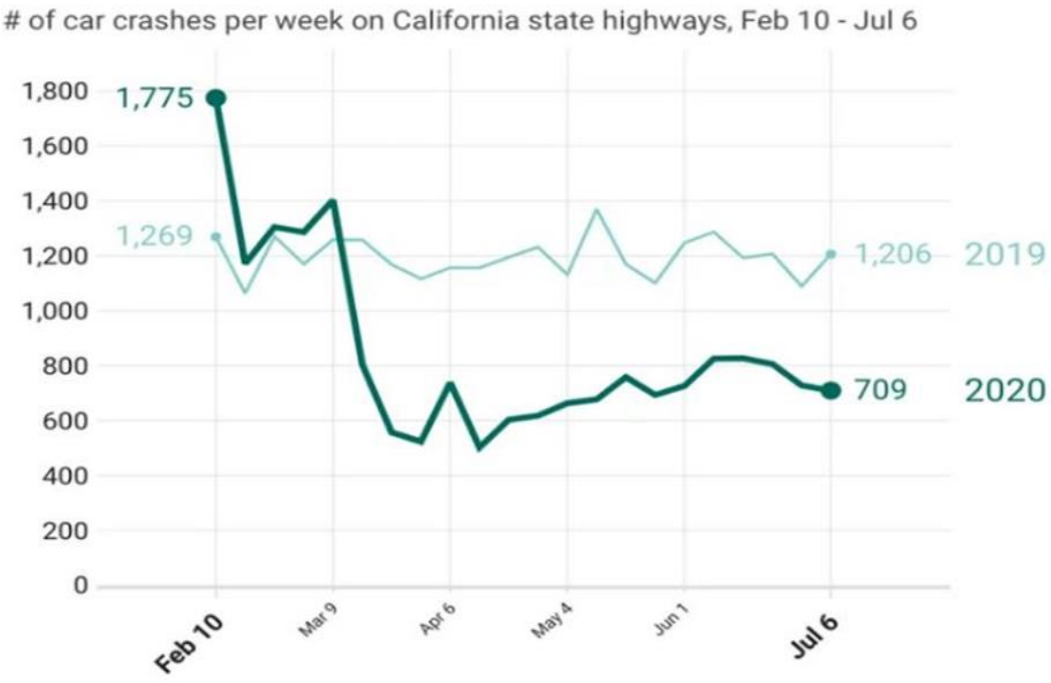
Number of crashes per year in Palestine and Tulkarem Governorate



[Source: Palestinian Police Annual Reports (2016-2021)]

Figure E4

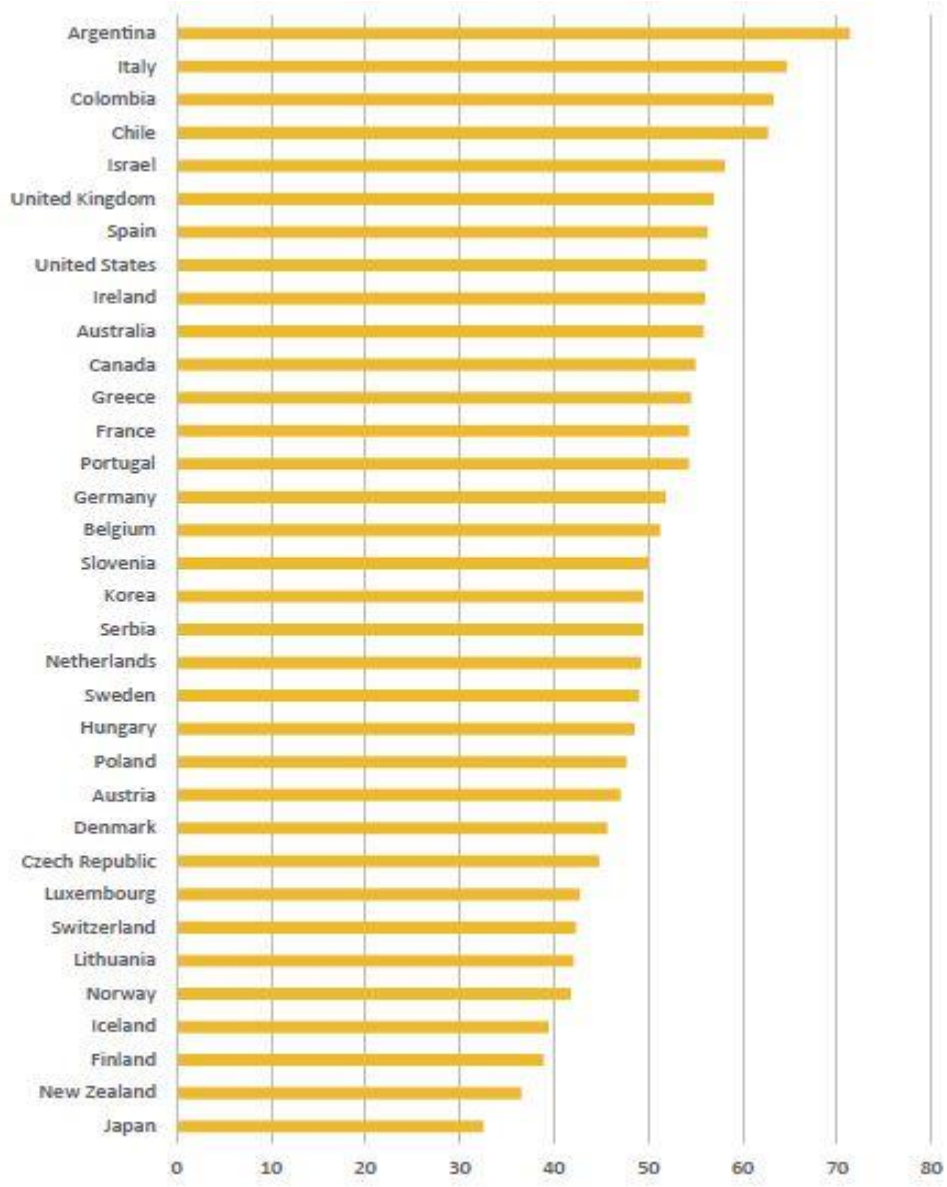
Number of crashes per week in California, Feb 10–July 6 2020



[Source: California Personal Injury Lawyer, 2020]

Figure E5

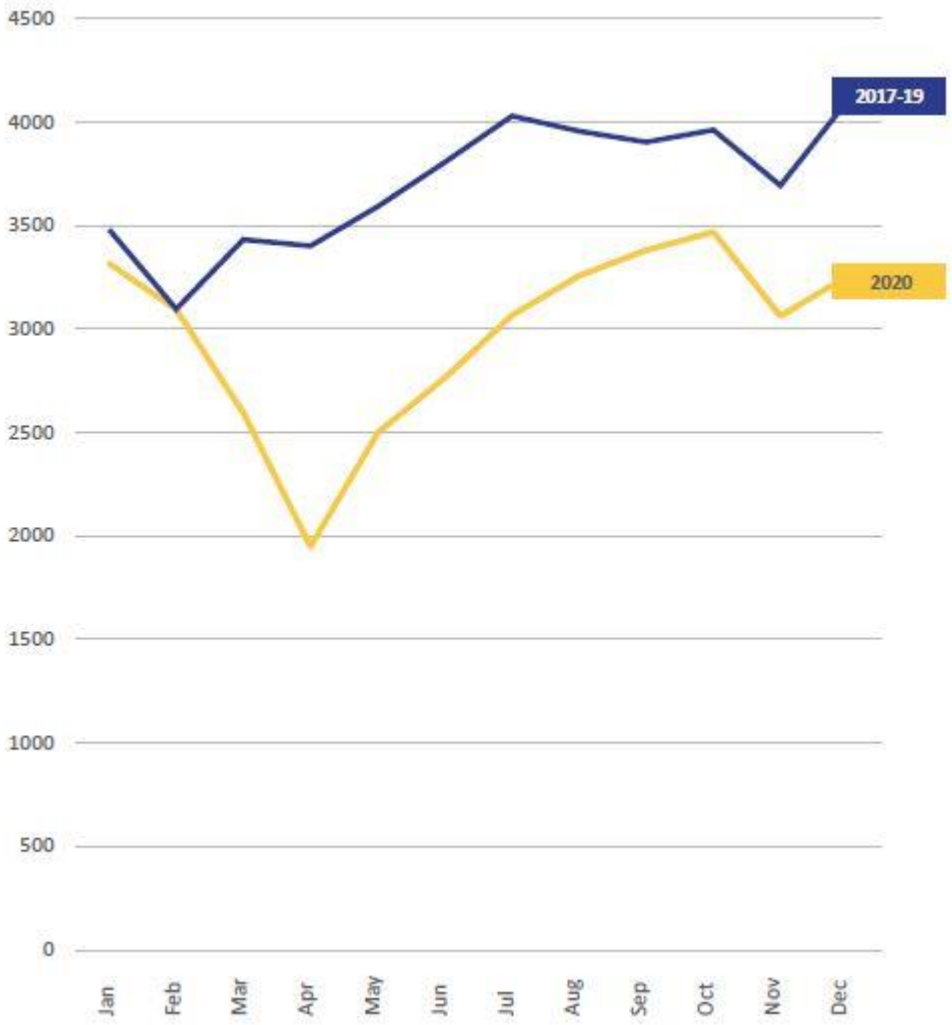
Restrictiveness of government responses to the Covid-19 pandemic



[Source: International Transport Forum, 2021]

Figure E6

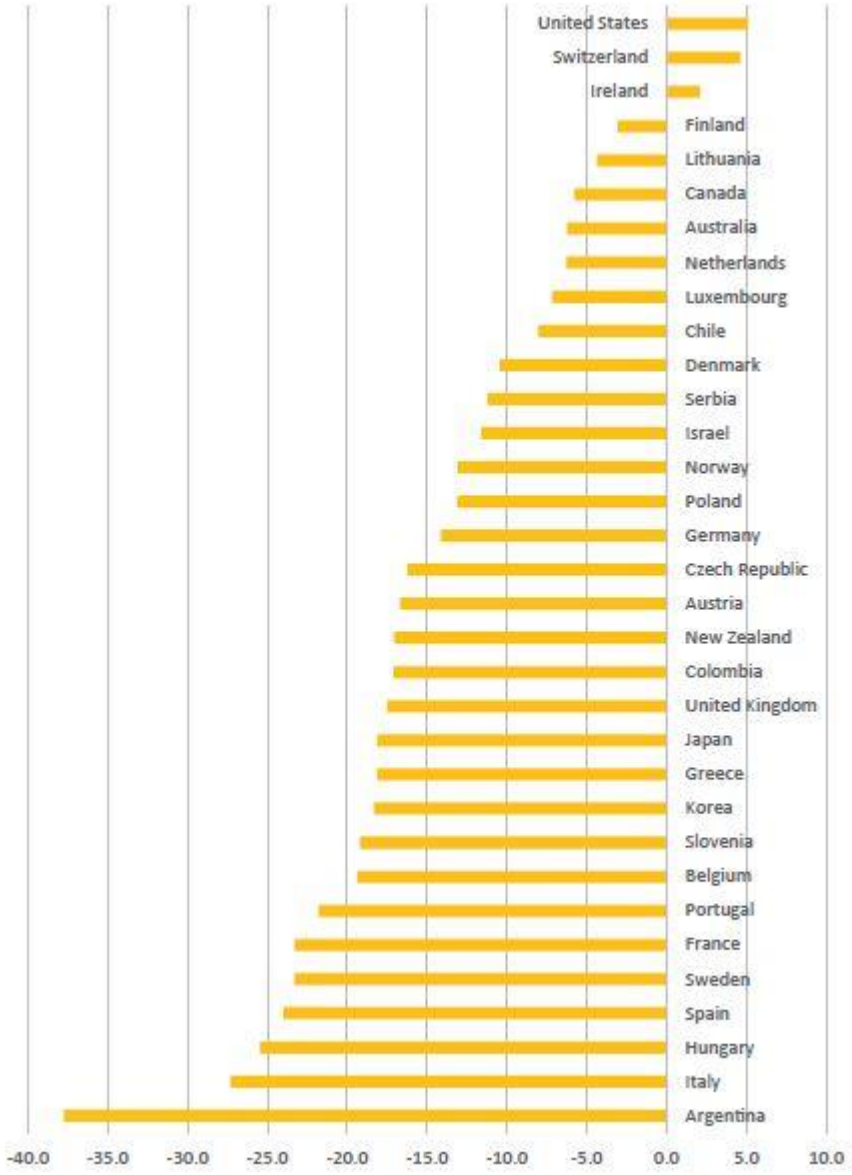
Overall trend for road deaths in 2020



[Source: International Transport Forum, 2021]

Figure E7

Comparing road traffic fatality percentages before and during the COVID-19 pandemic



[Source: International Transport Forum, 2021]

Appendix F

Figures of Data Collection and Analysis of Tulkarem Governorate Crashes

Figure F1

Total intersection crashes in Tulkarem Governorate by year

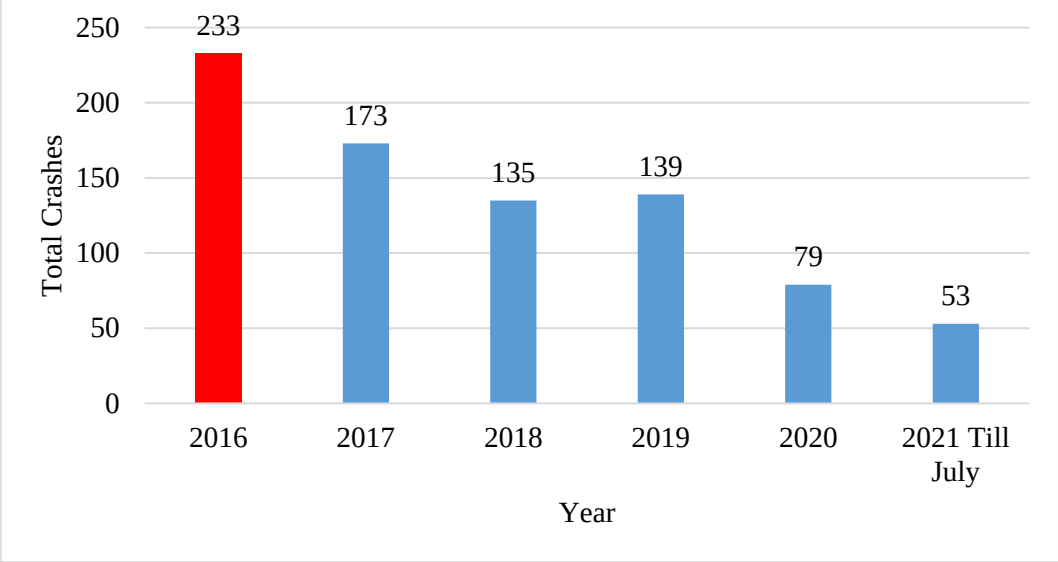


Figure F2

Distribution of intersection crashes in Tulkarem Governorate by day

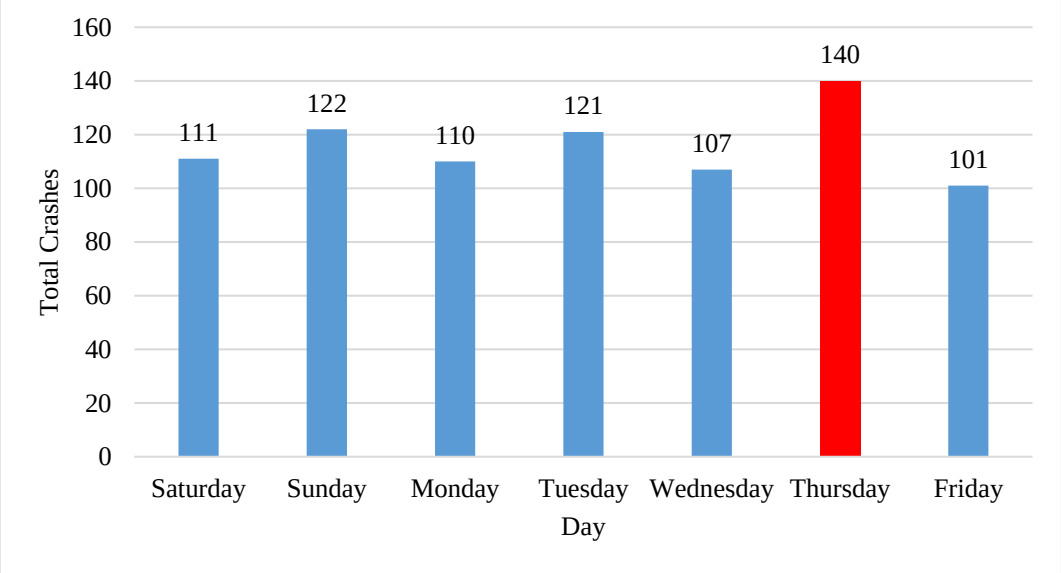


Figure F3

Distribution of intersection crashes in Tulkarem Governorate by hour

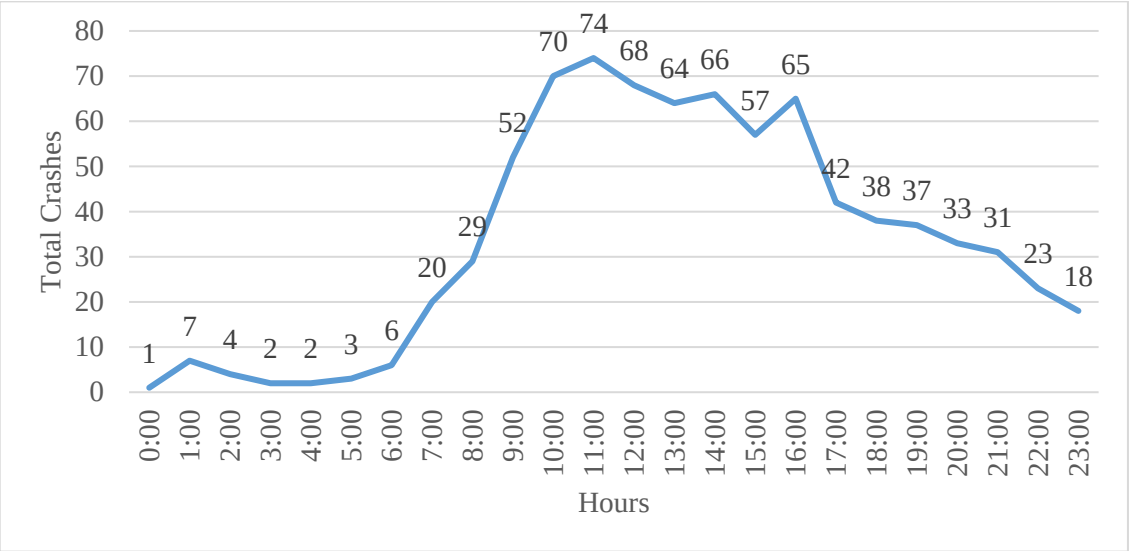


Figure F4

Distribution of intersection crashes in Tulkarem Governorate by month

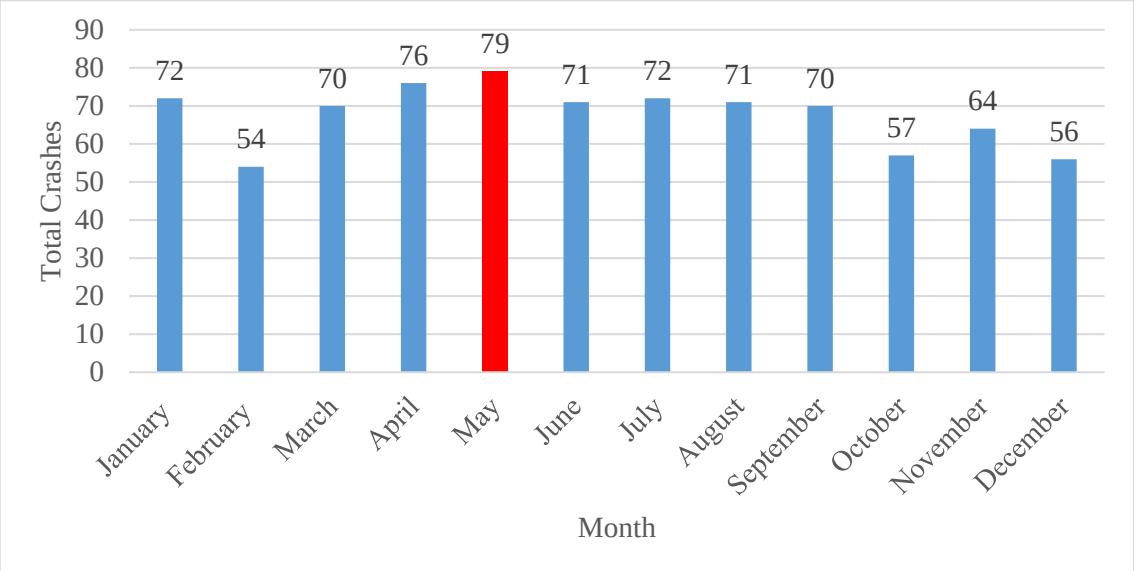


Figure F5

Distribution of intersection crashes in Tulkarem Governorate by season

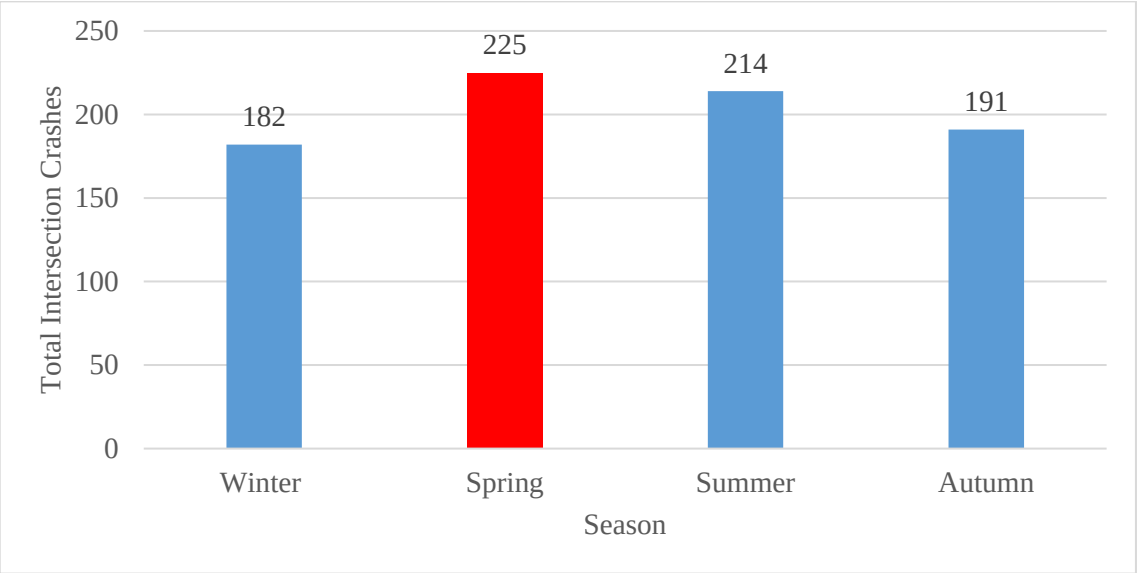


Figure F6

Severity of intersection crashes in Tulkarem Governorate

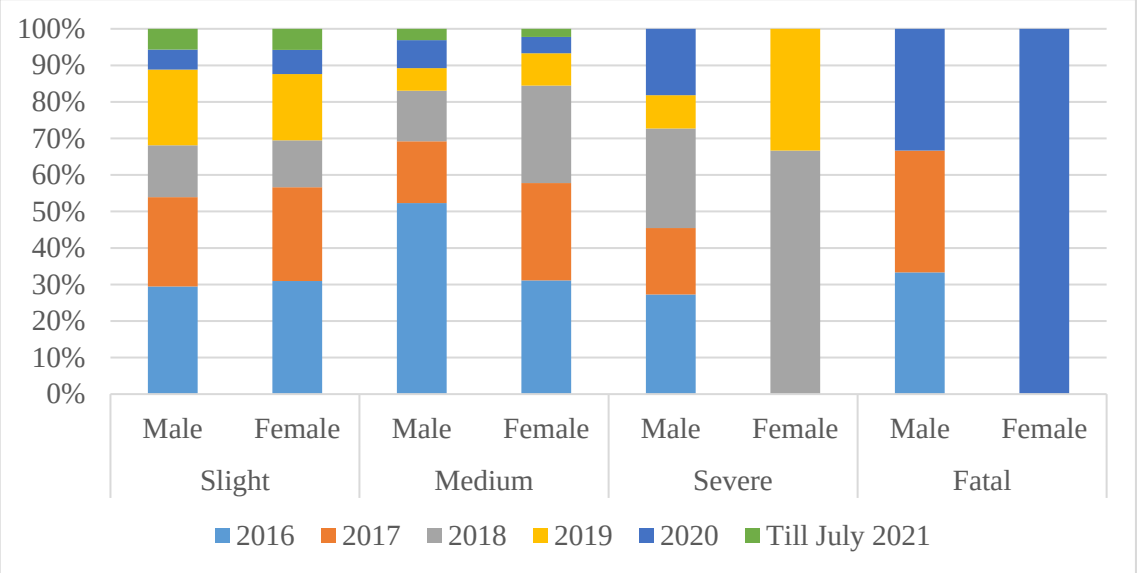


Figure F7

Distribution of intersection crashes in Tulkarem Governorate by age

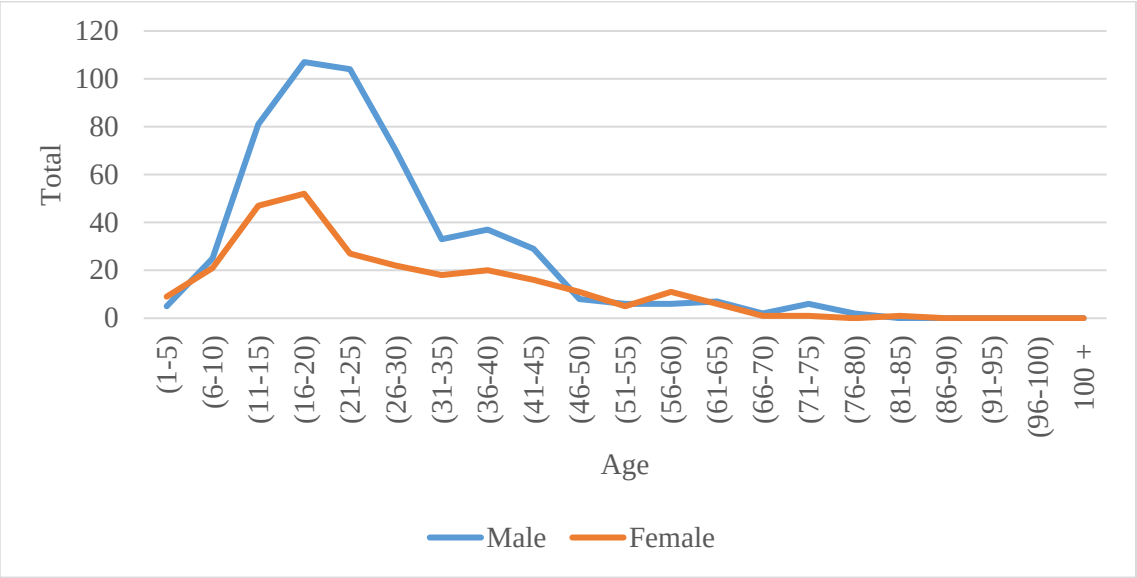


Figure F8

Distribution the percentage of intersection crashes in Tulkarem Governorate by type of crash

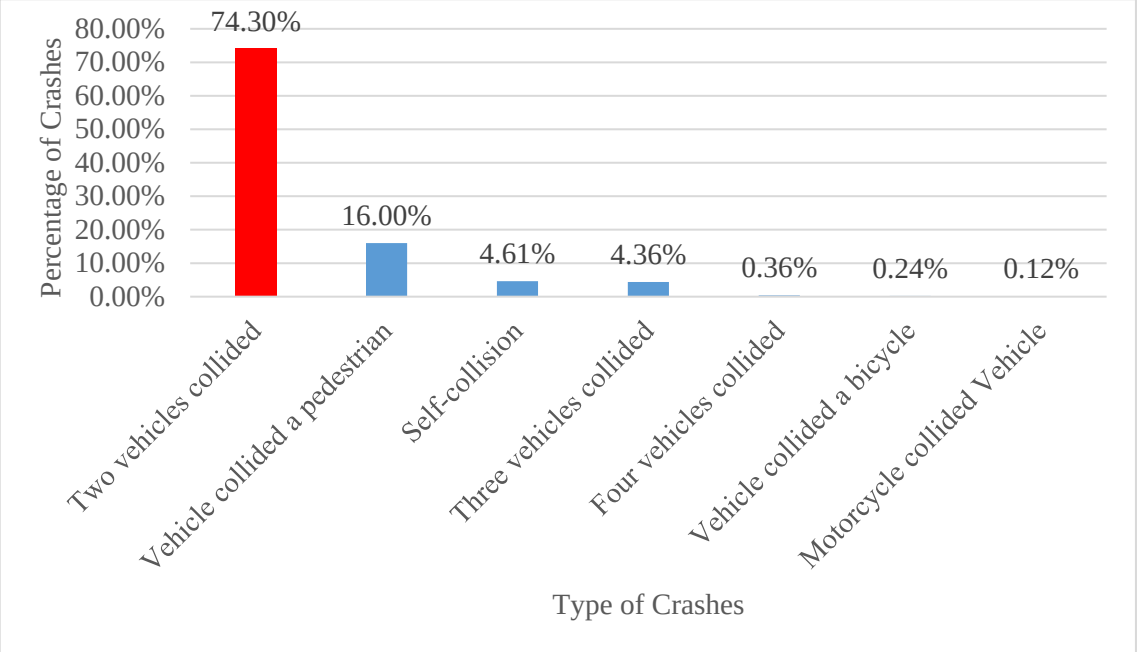


Figure F9

Distribution the percentage of intersection crashes in Tulkarem Governorate by details of crash

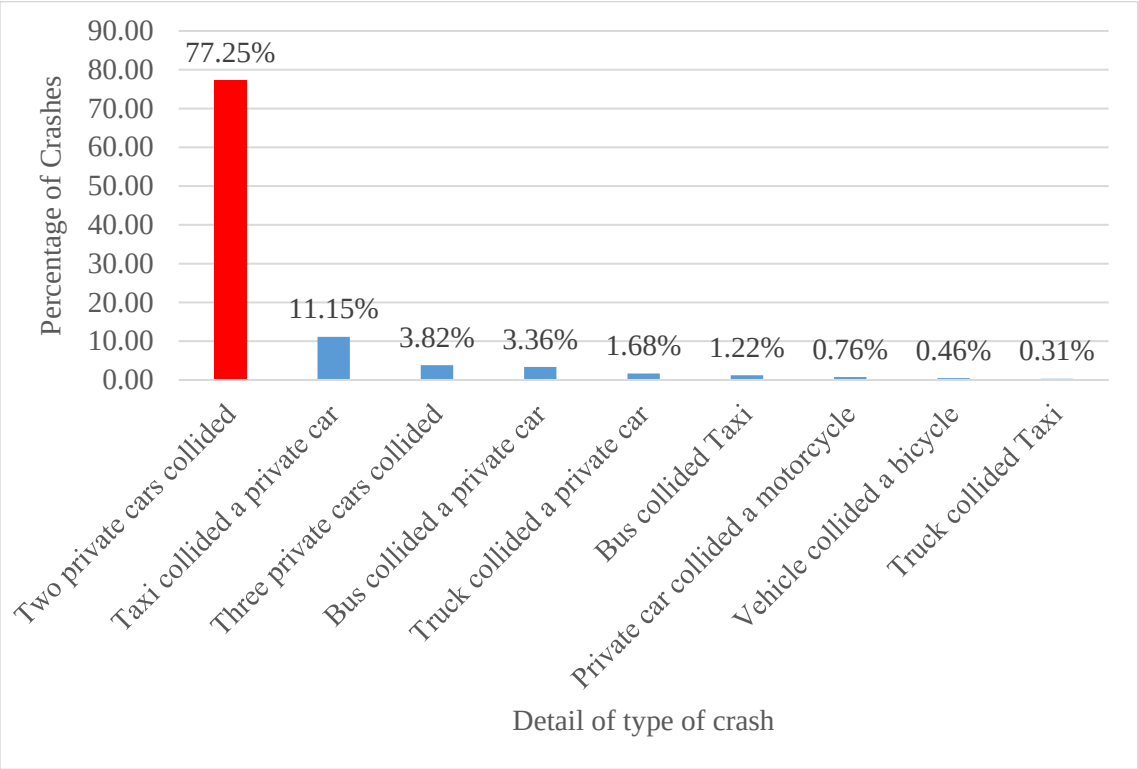


Figure F10

Analysis of intersection crashes in Tulkarem Governorate by cause of crash

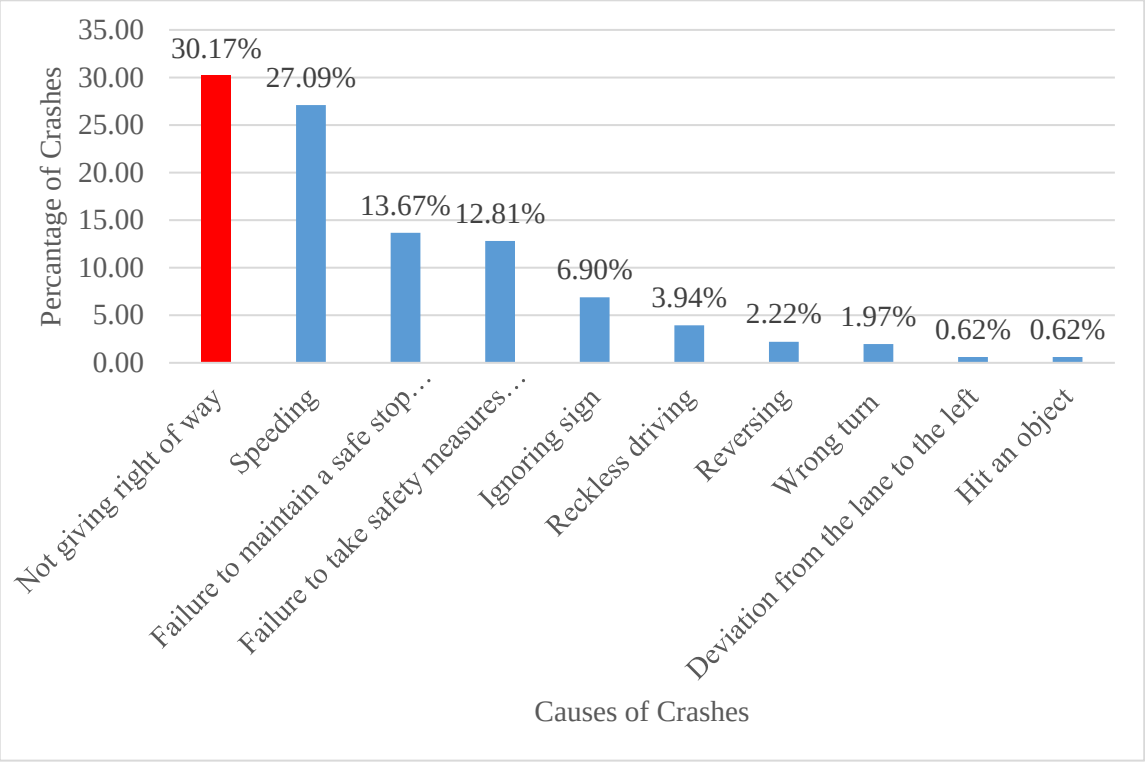


Figure F11

Total crashes involving pedestrians at intersections in Tulkarem Governorate by year

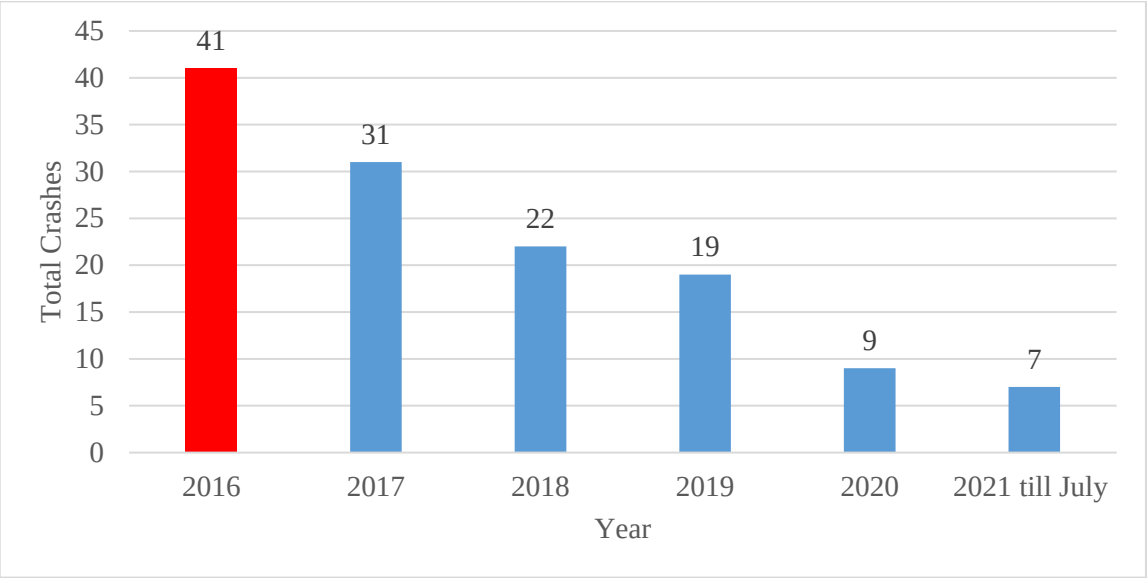


Figure F12

Distribution of crashes involving pedestrians at intersections in Tulkarem Governorate by day

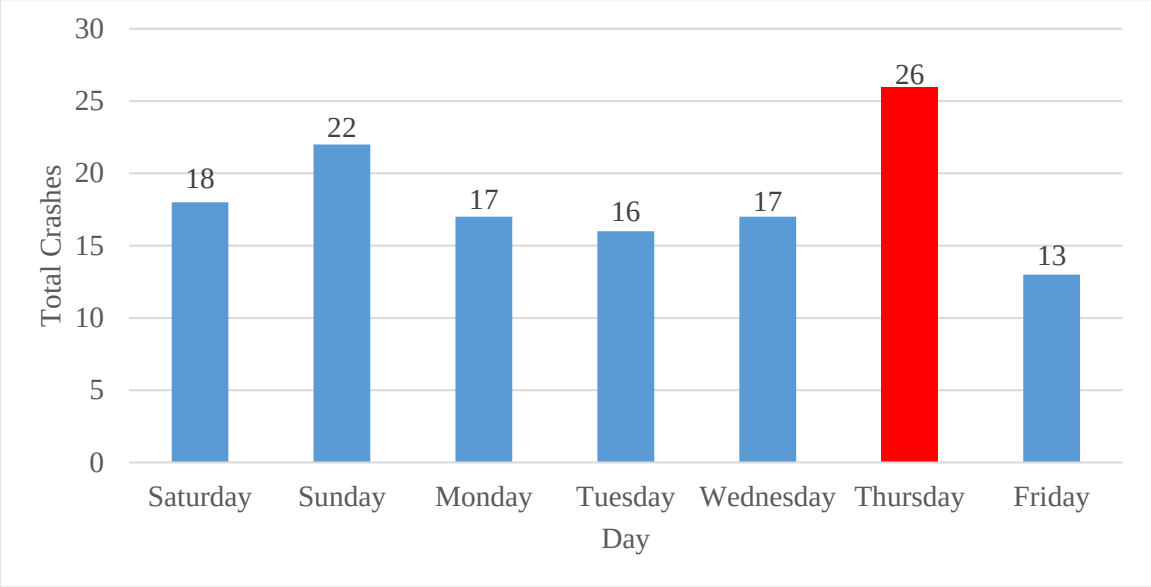


Figure F13

Distribution of crashes involving pedestrians in Tulkarem Governorate by hour

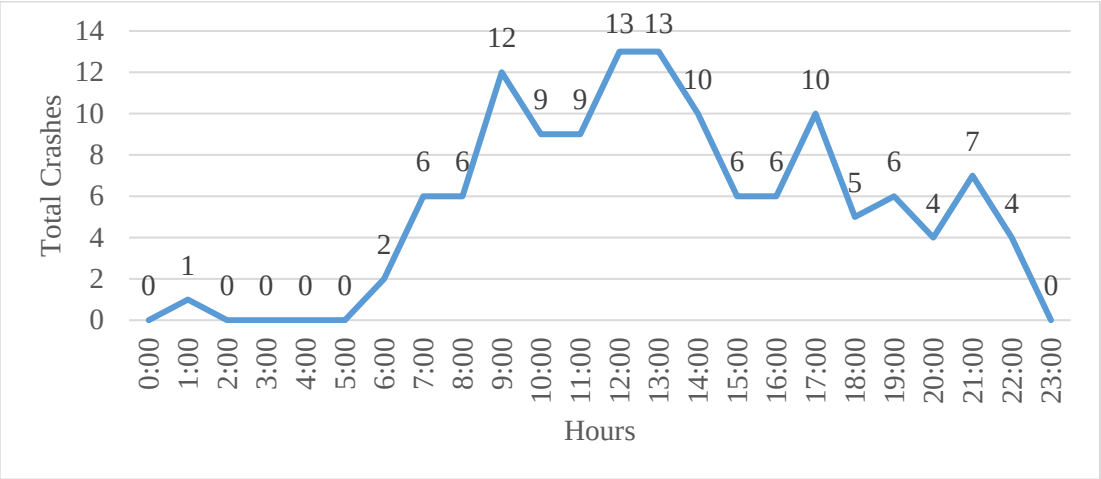


Figure F14

Distribution of crashes involving pedestrians in Tulkarem Governorate by month

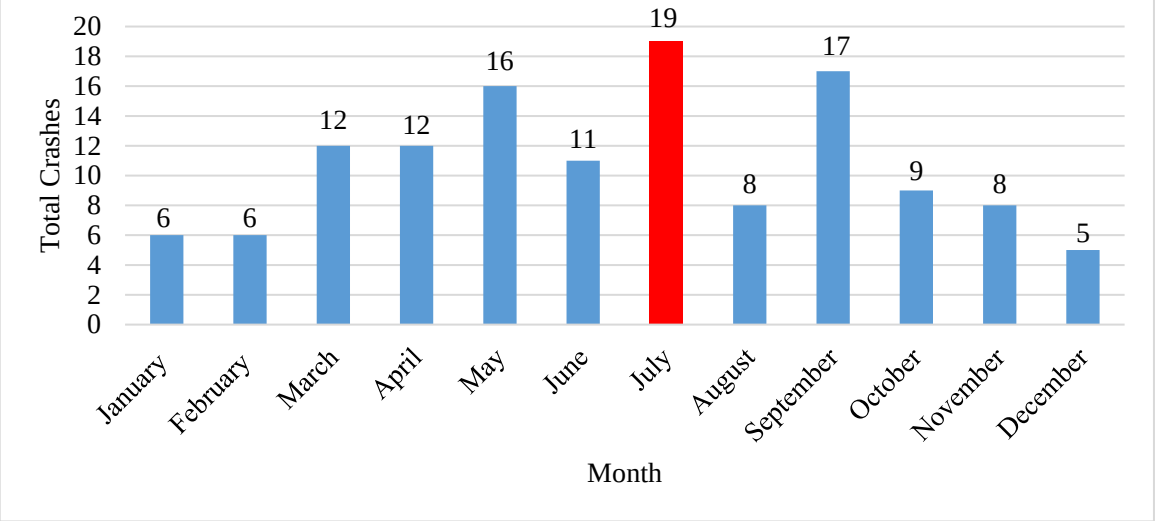


Figure F15

Distribution of crashes involving pedestrians at intersections in Tulkarem Governorate by age

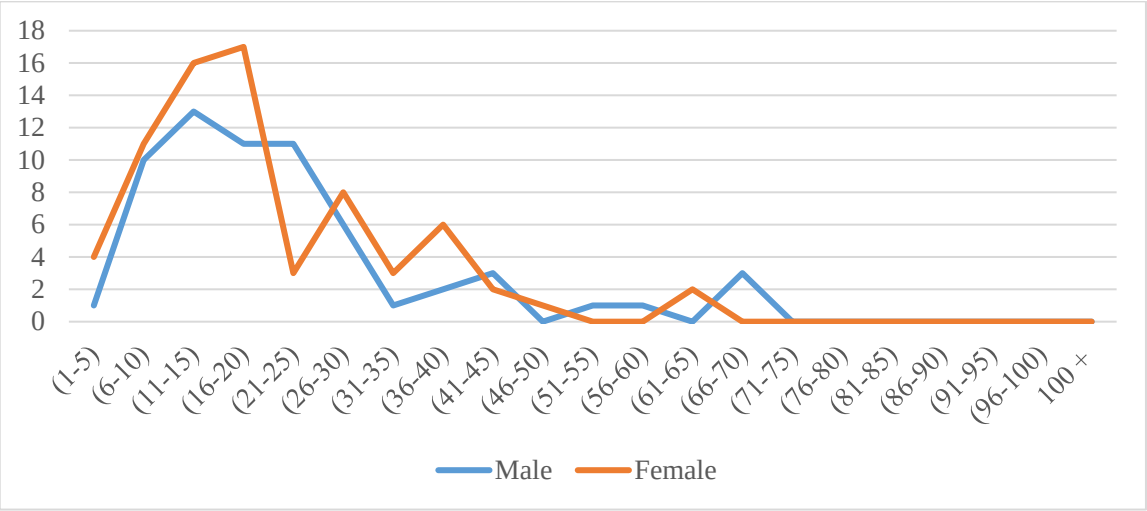


Figure F16

Severity of crashes involving pedestrians at intersections in Tulkarem Governorate

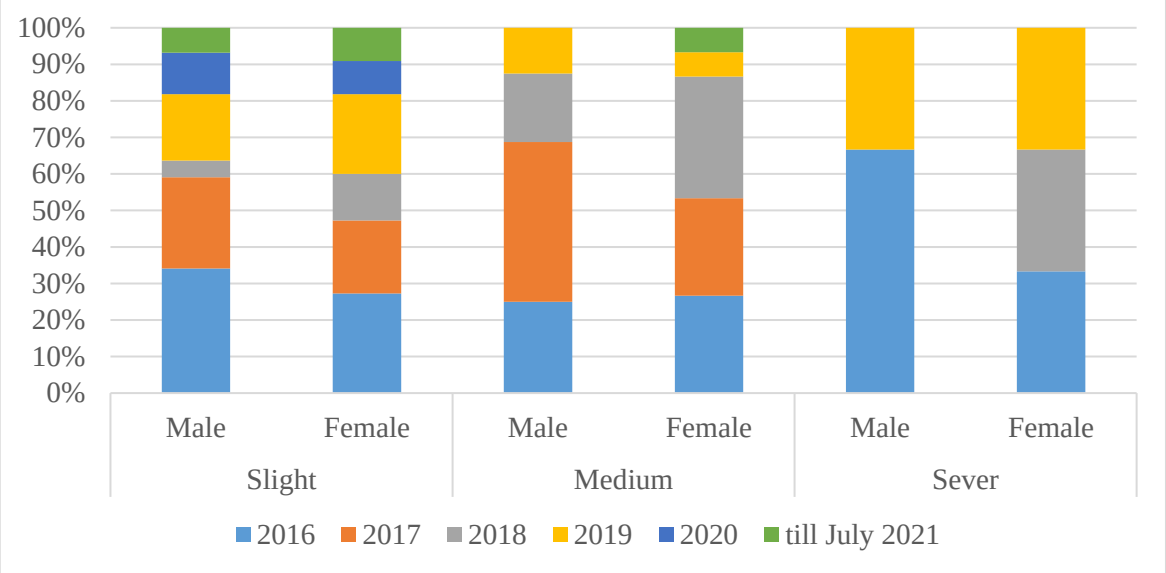


Figure F17

Analysis of crashes involving pedestrians at intersections in Tulkarem Governorate by cause of crash

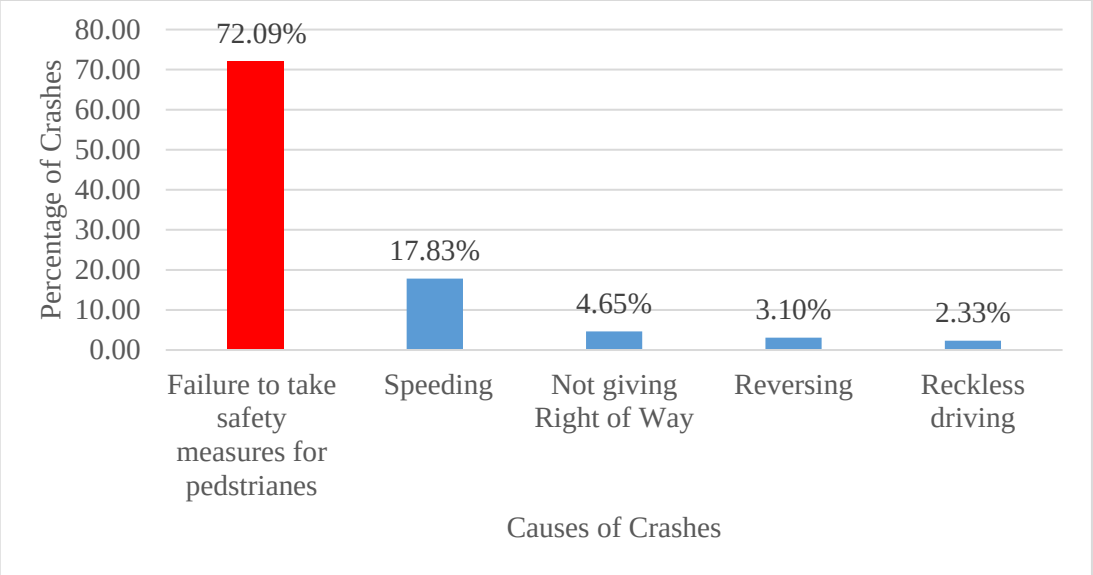


Figure F18

Type of Pedestrian Crashes at intersections in Tulkarem Governorate

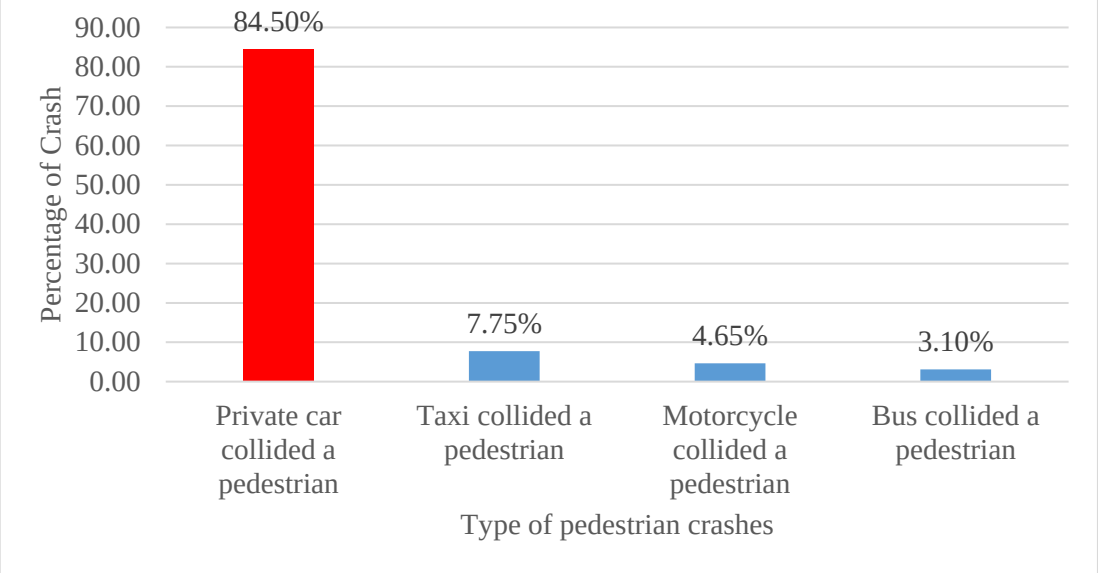


Figure F19

KSI at intersections in Tulkarem Governorate by day

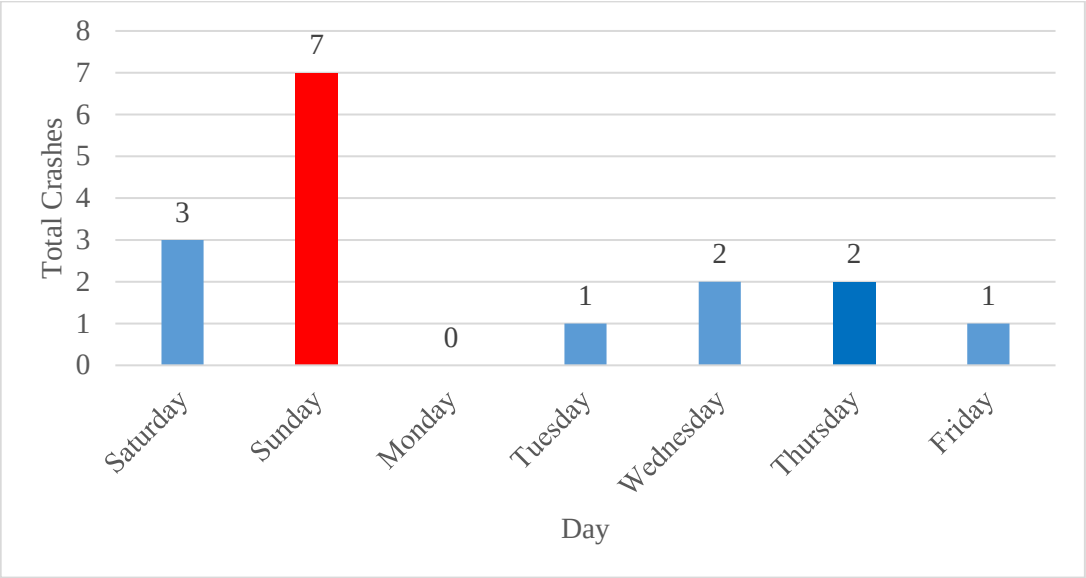


Figure F20

KSI at intersections in Tulkarem Governorate by hour

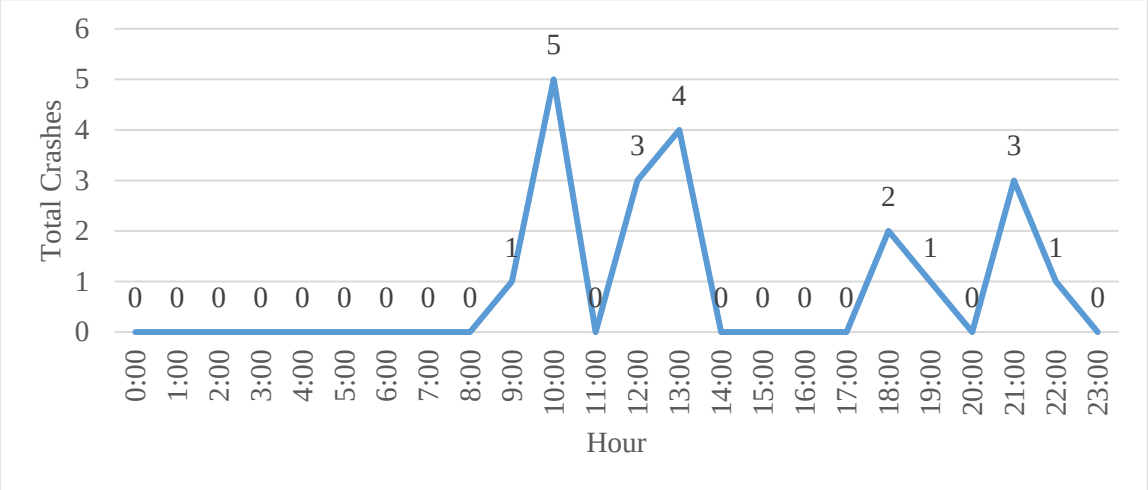


Figure F21

KSI at intersections in Tulkarem Governorate by month

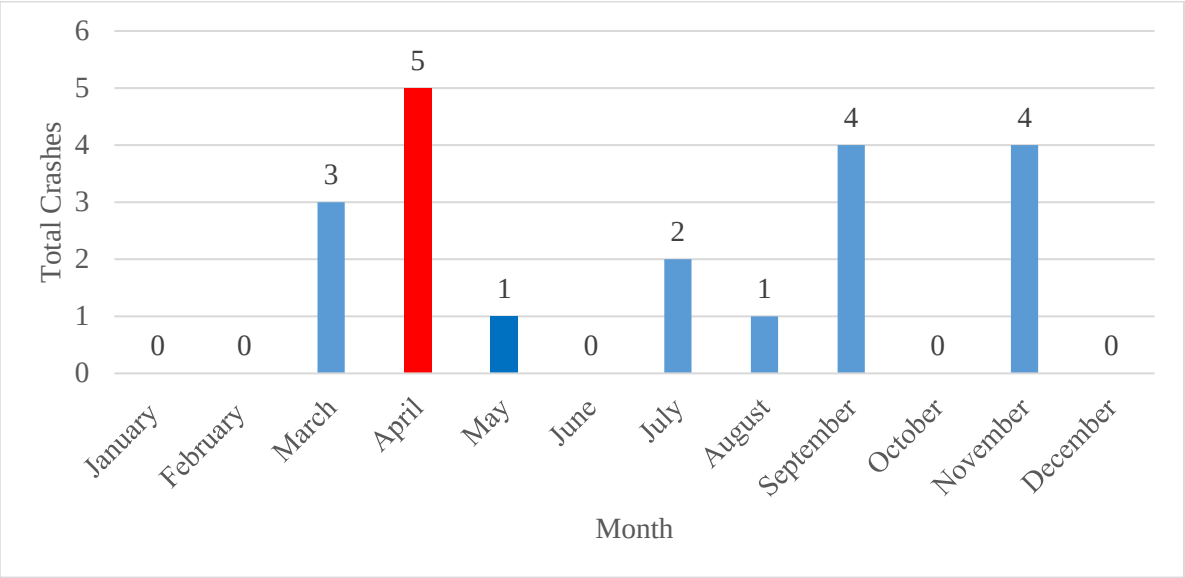


Figure F22

KSI at intersections in Tulkarem Governorate by age

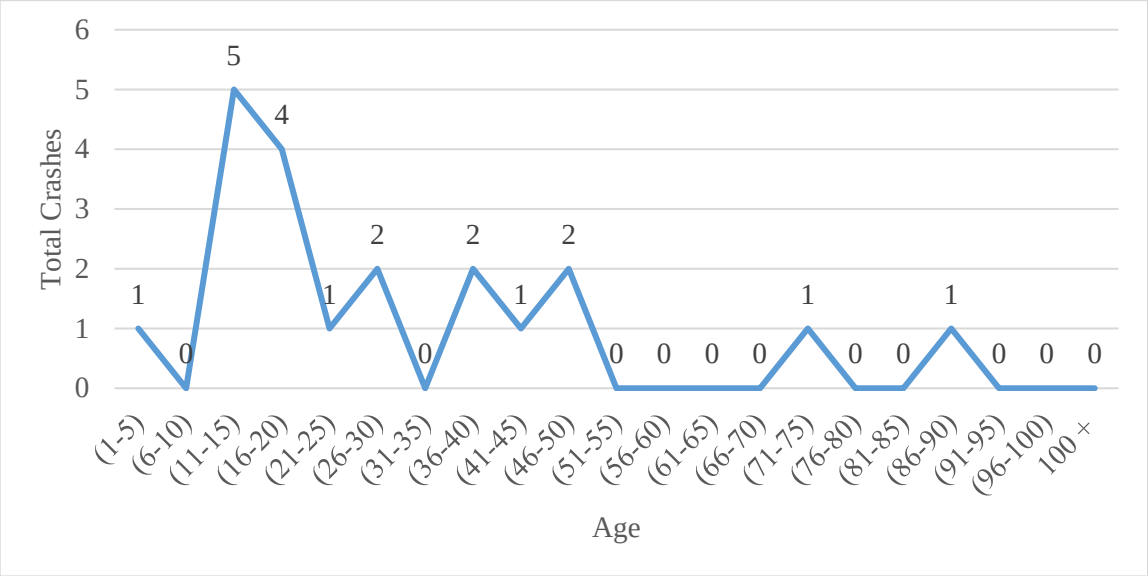


Figure F23

Spatial distribution of crash severity rating scores at intersections in Tulkarem Governorate

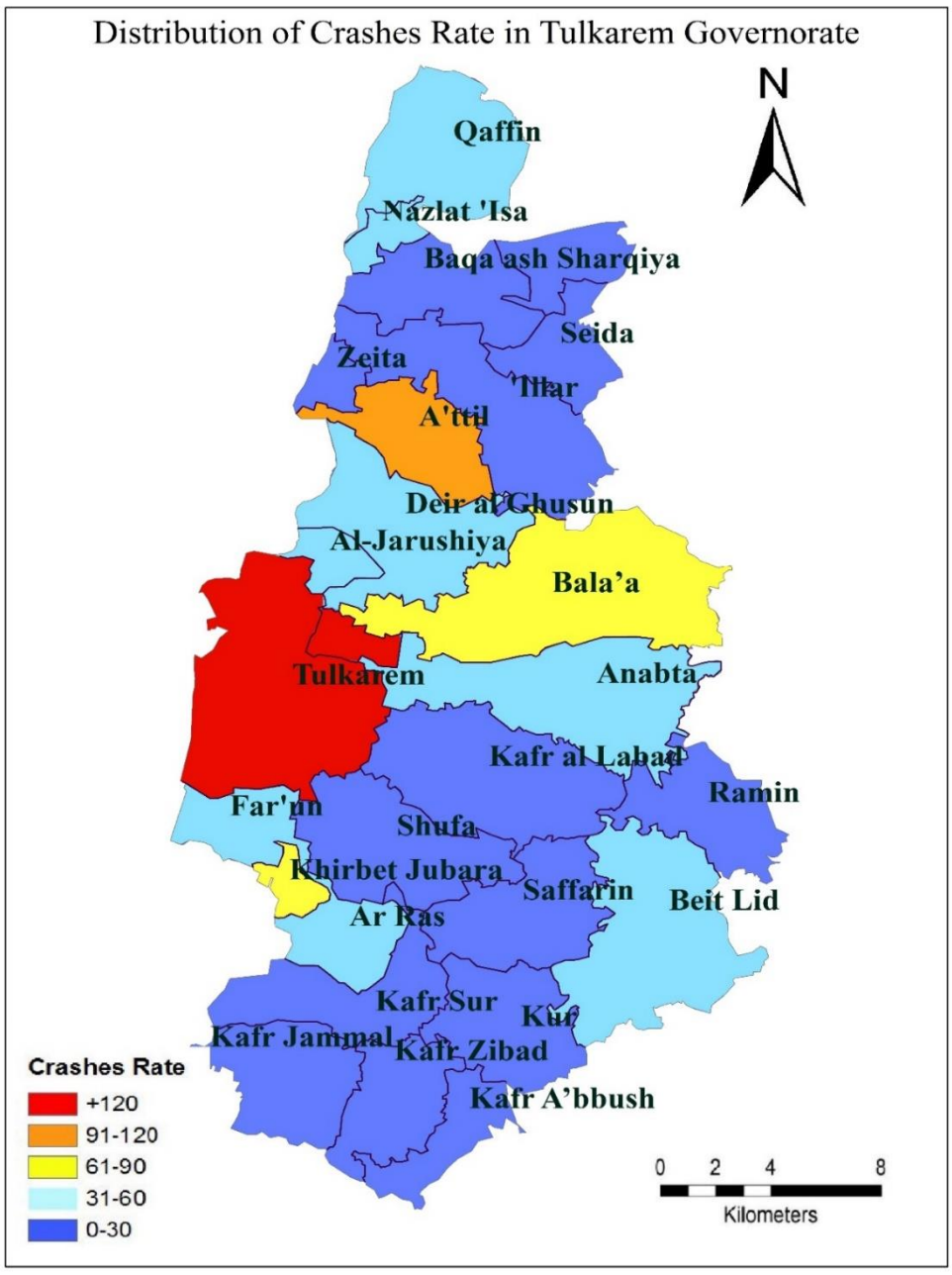


Figure F24

Percentage change in number of crashes before the first period of the COVID-19 pandemic compared to 2020 and till July 2021

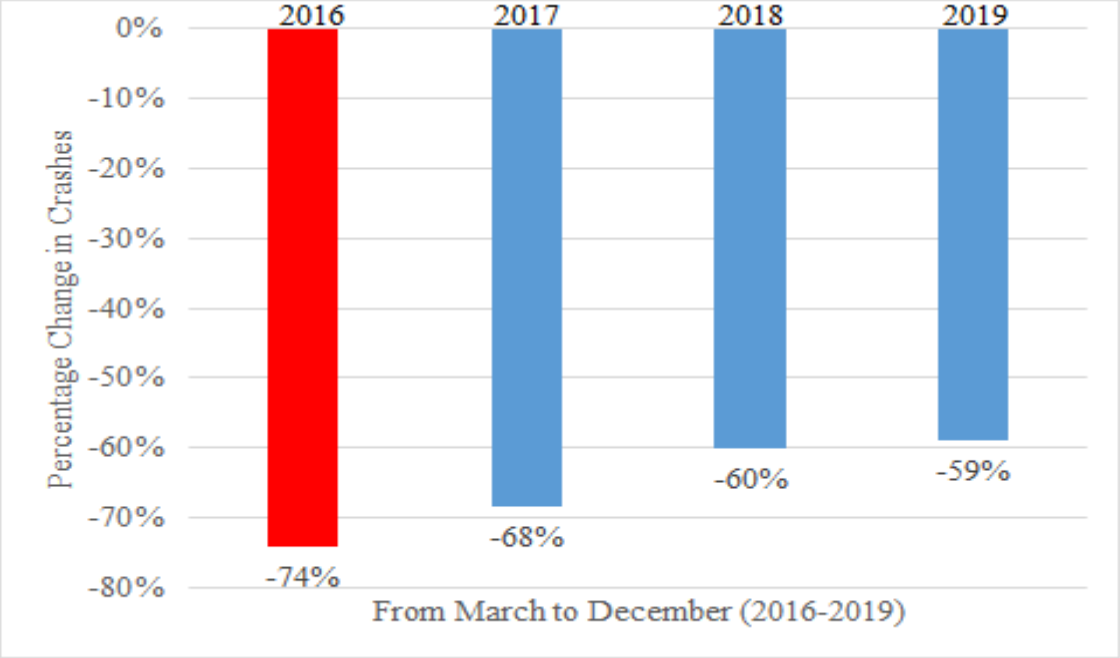


Figure F25

Distribution of intersection crashes in Tulkarem Governorate by day for the first period of the COVID-19 pandemic

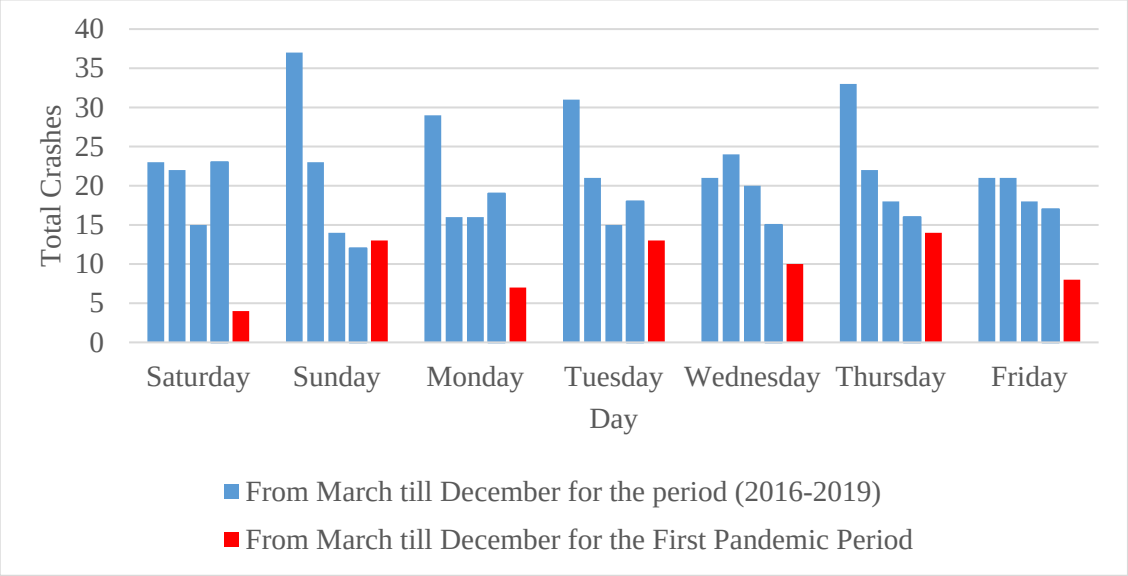


Figure F26

Distribution of intersection crashes in Tulkarem Governorate on an hourly basis during the first period of the COVID-19 pandemic

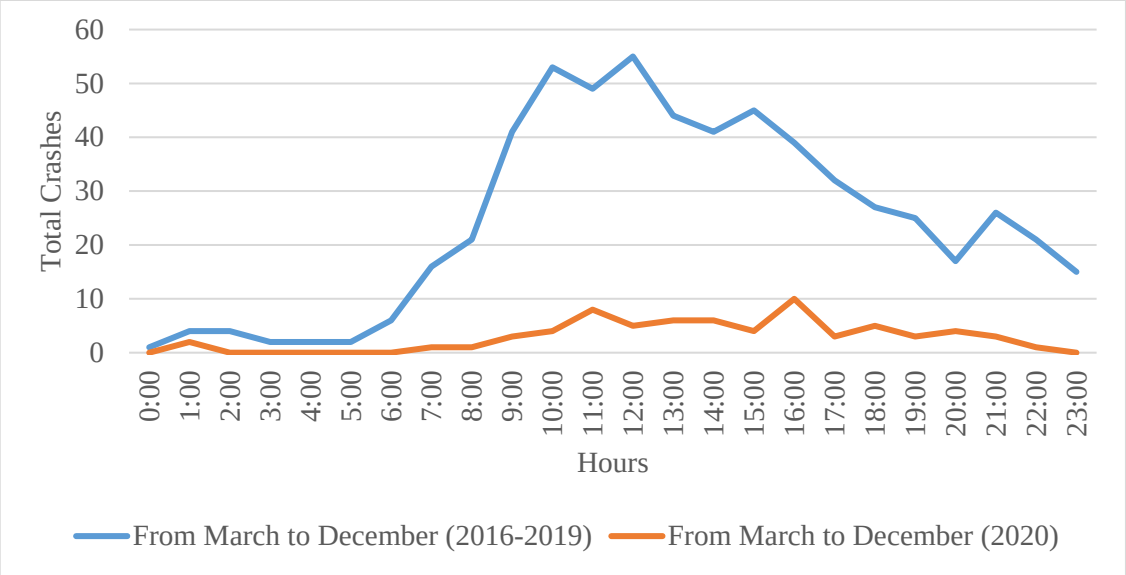


Figure F27

Distribution of intersection crashes in Tulkarem Governorate on a monthly basis before and during the first period of the COVID-19 pandemic

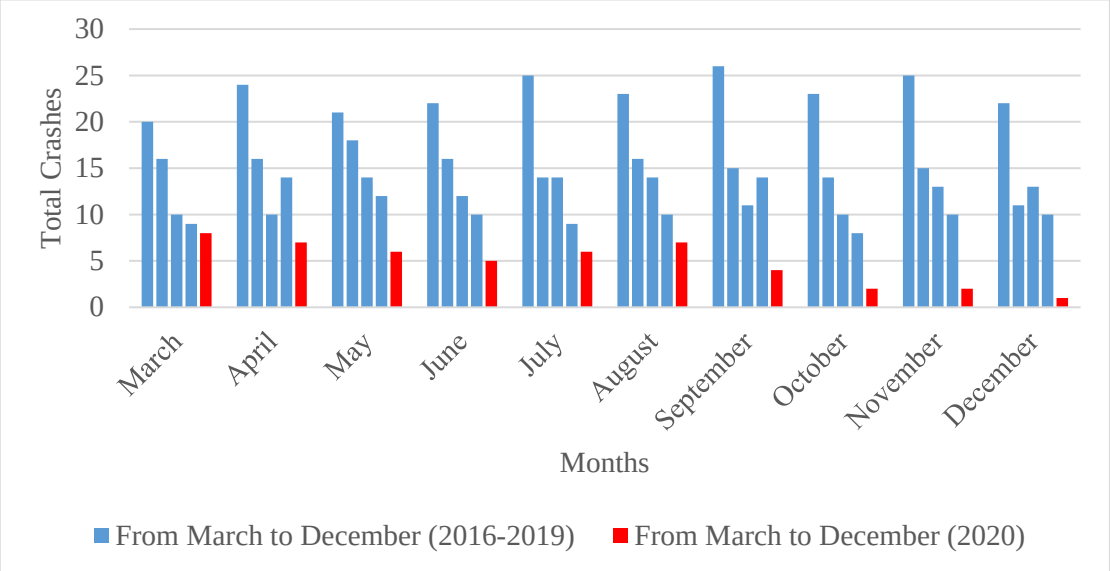


Figure F28

Percentage change in the number of crashes before the second period of COVID-19 pandemic compared to 2020

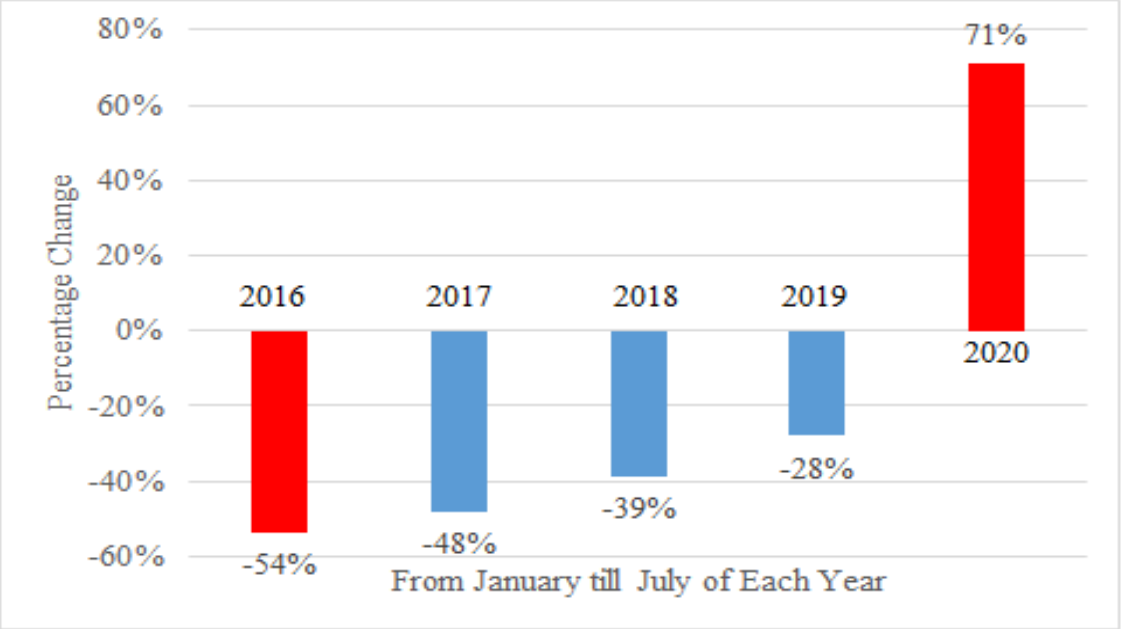


Figure F29

Distribution of intersection crashes in Tulkarem Governorate on a monthly basis before and during the second period of the COVID-19 pandemic

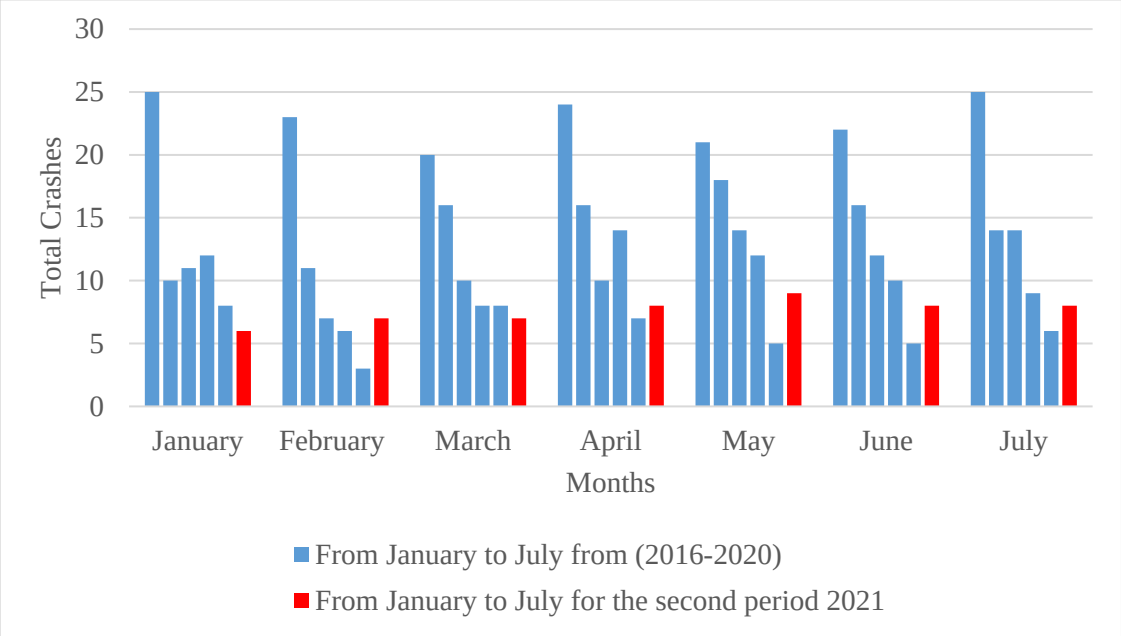


Figure F30

Distribution of intersection crashes in Tulkarem Governorate by day for the second period of the COVID-19 pandemic

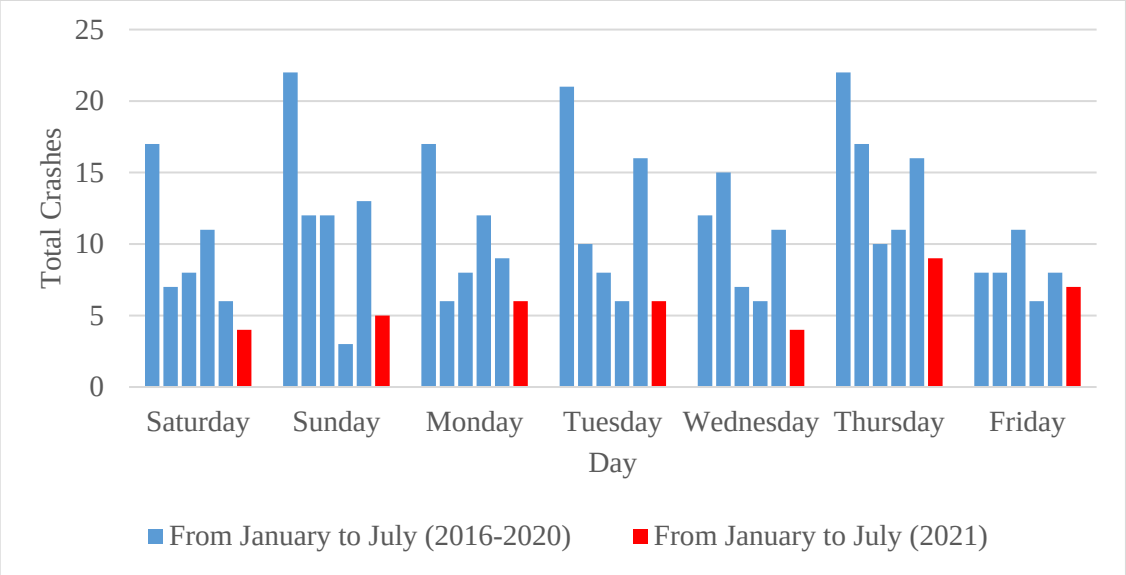
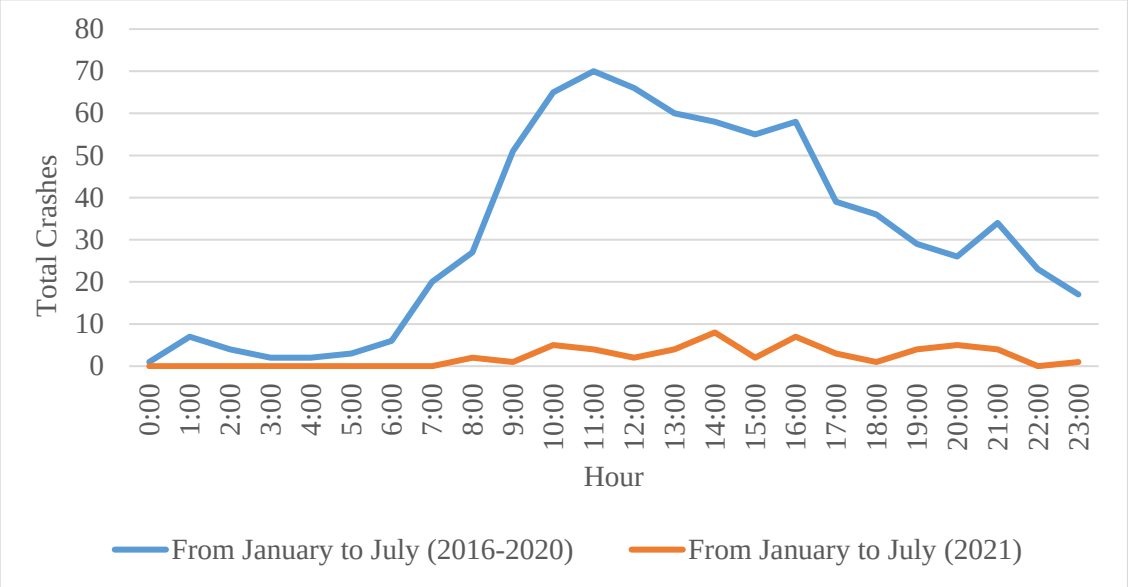


Figure F31

Distribution of intersection crashes in Tulkarem Governorate by hour for the second period of the COVID-19 pandemic

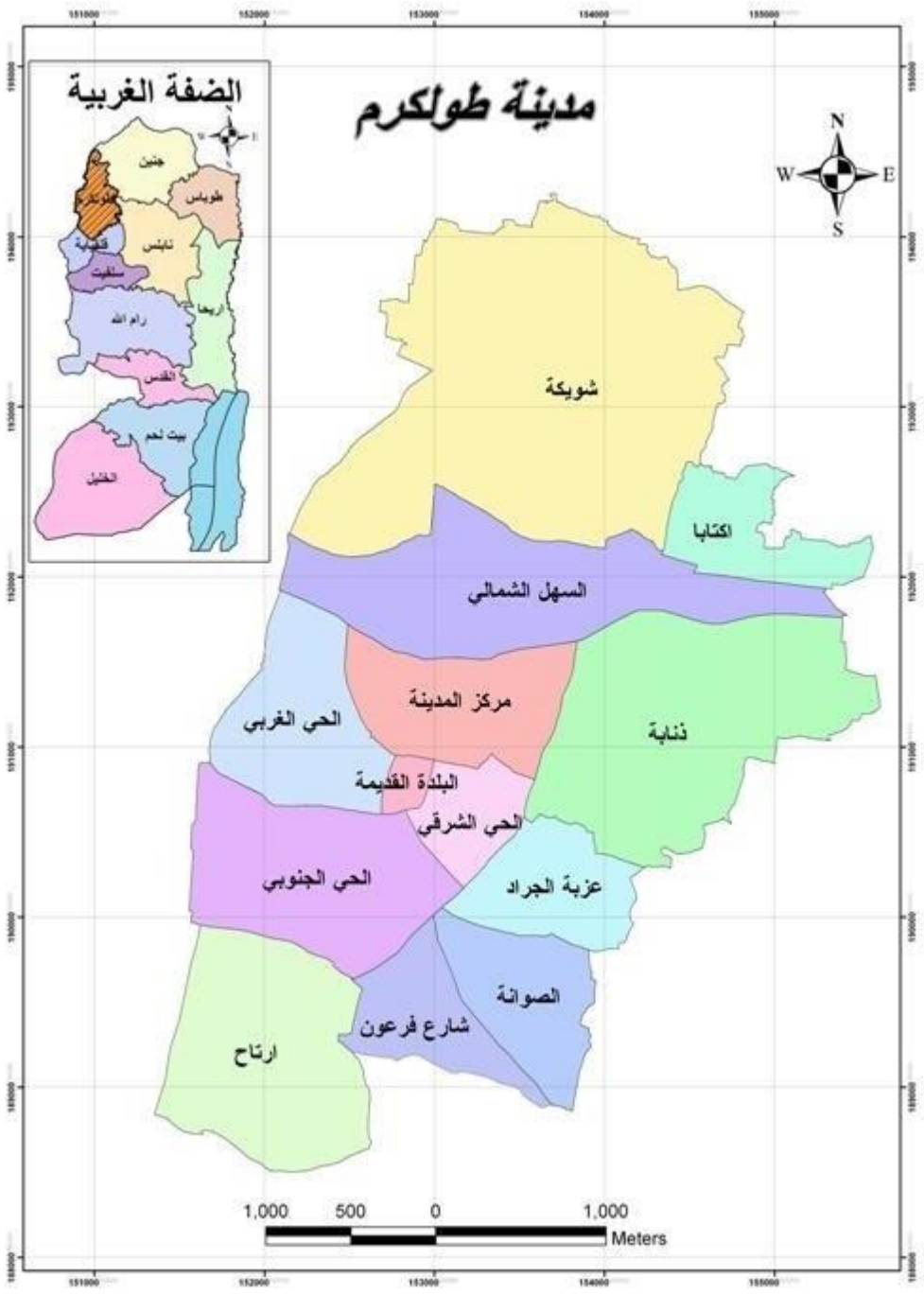


Appendix G

Figures of Data Collection and Analysis of Tulkarem City Crashes

Figure G1

Tulkarem City map and its neighborhoods



[Source: Tulkarem Municipality]

Figure G2

Distribution percentage of intersection crashes in Tulkarem City by year

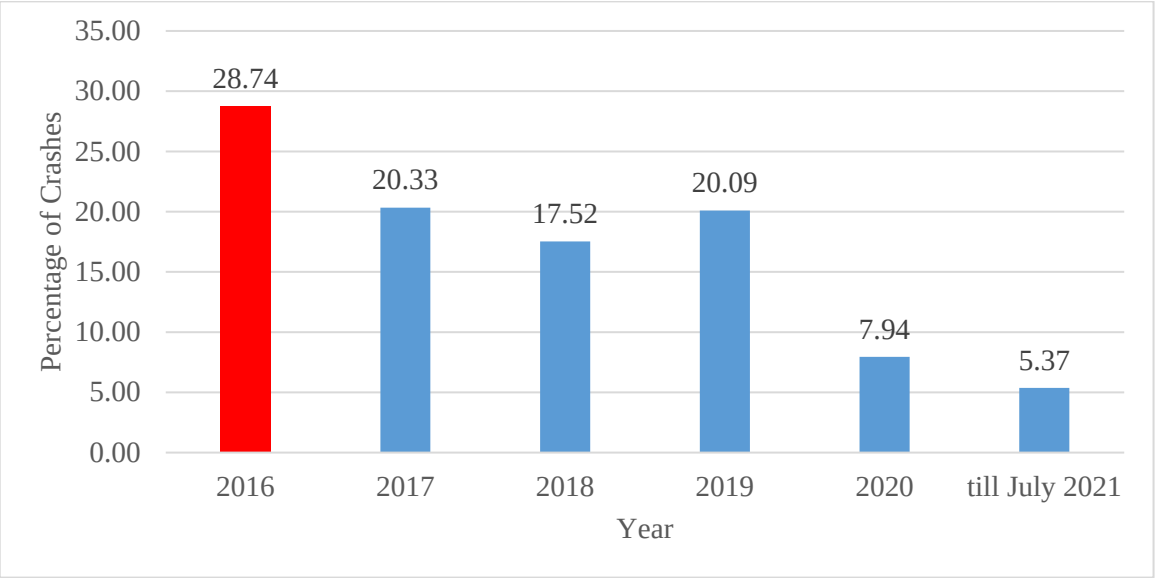


Figure G3

Distribution of intersection crashes in Tulkarem City by day

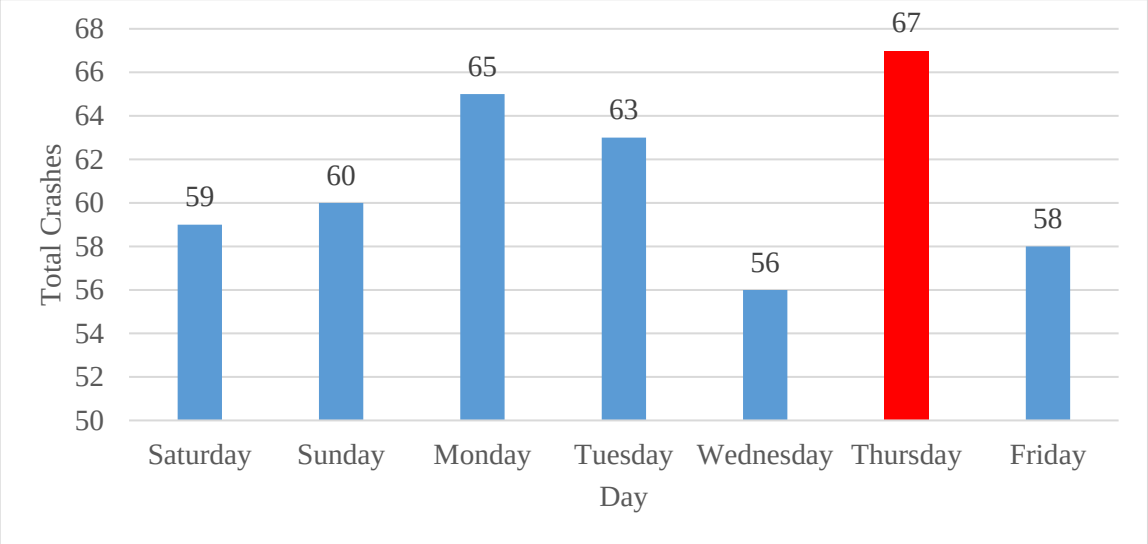


Figure G4

Distribution of intersection crashes in Tulkarem City on an hourly basis

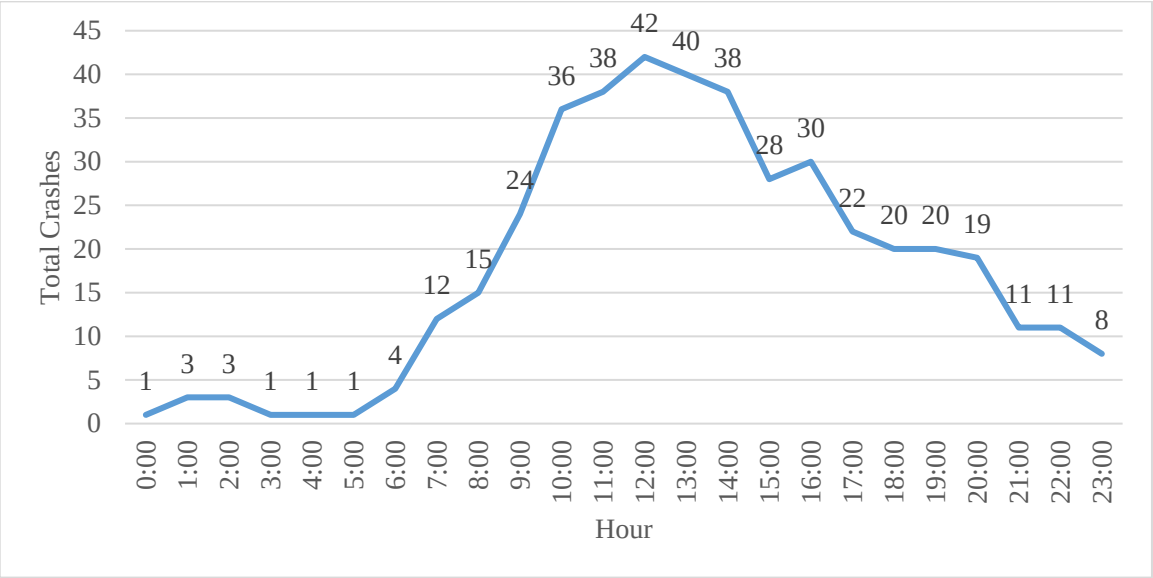


Figure G5

Distribution of intersection crashes in Tulkarem City by month

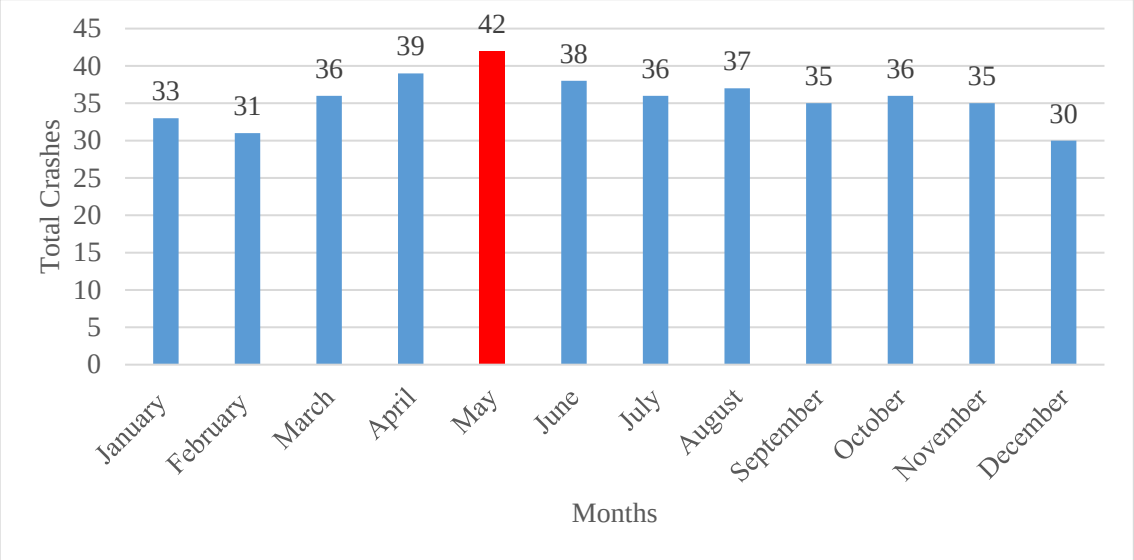


Figure G6

Distribution of the causes of crashes at intersections in Tulkarem City

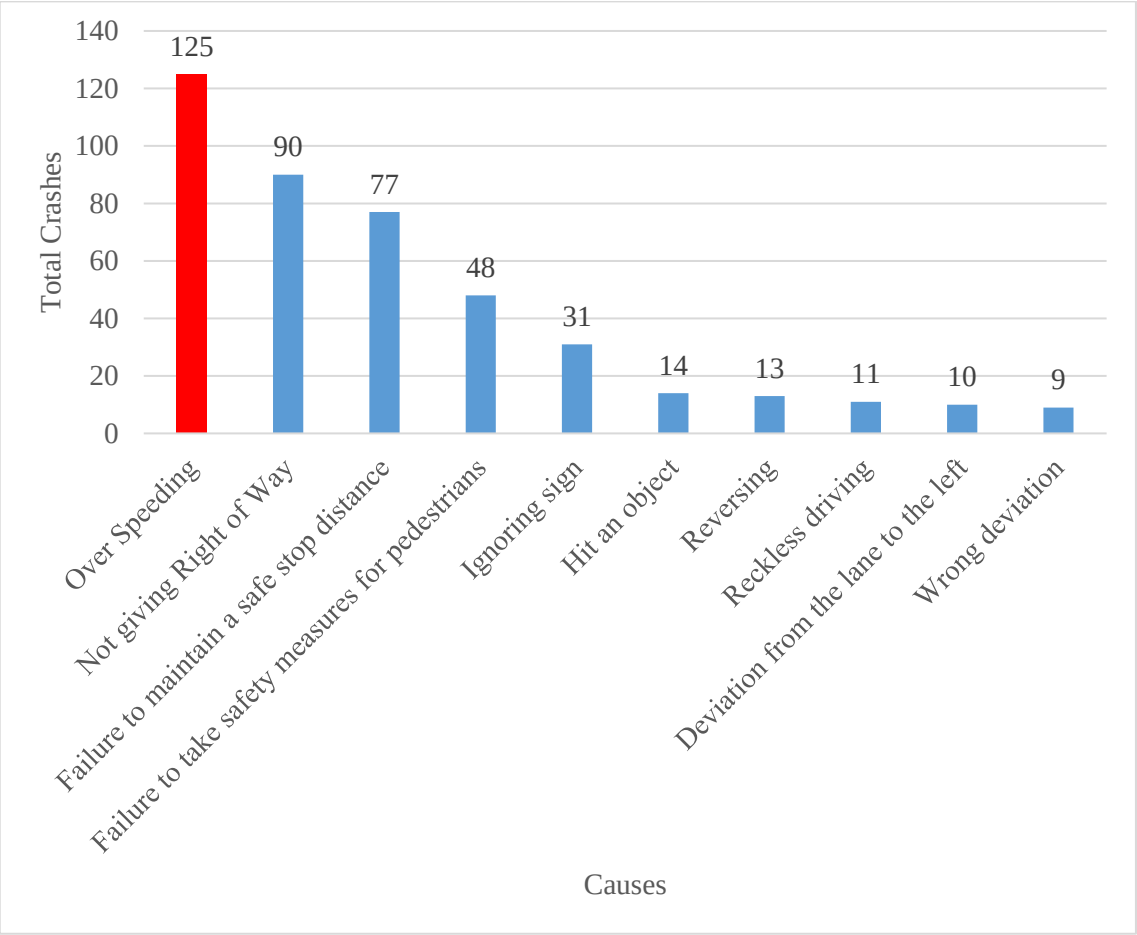


Figure G7

Distribution of the percentage of crash types at intersections in Tulkarem City

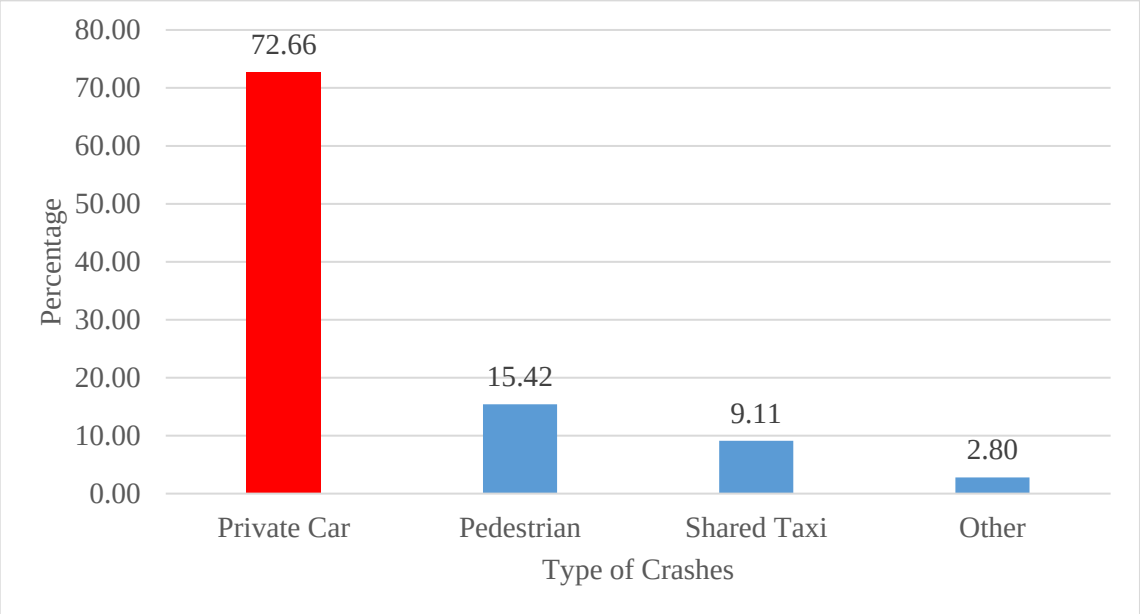


Figure G8

Intersection crash severity and victim's gender in Tulkarem City

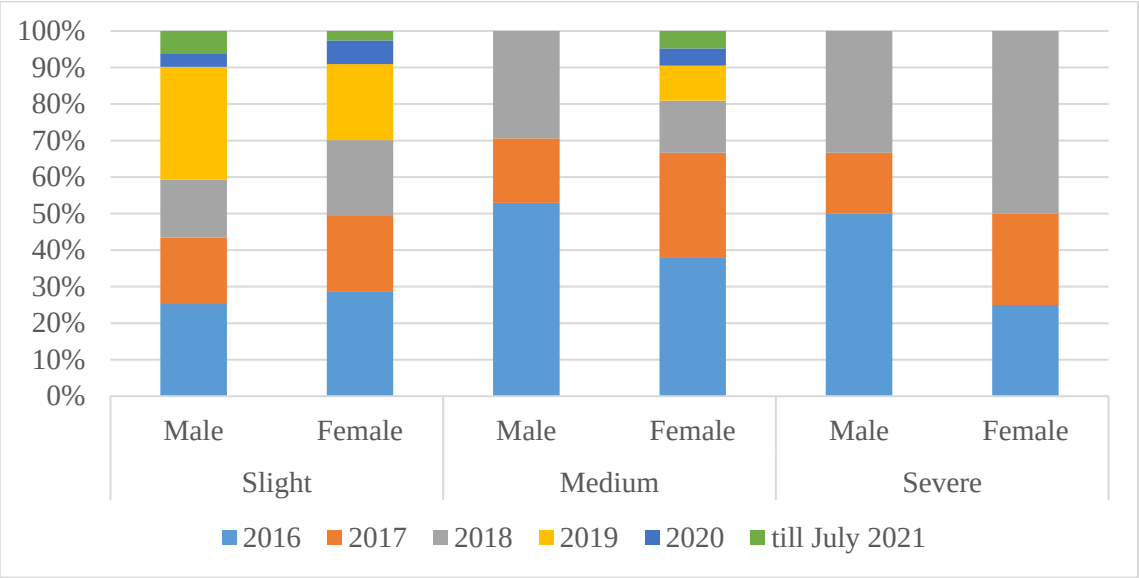


Figure G9

Distribution of intersection crashes in Tulkarem City by victim's age

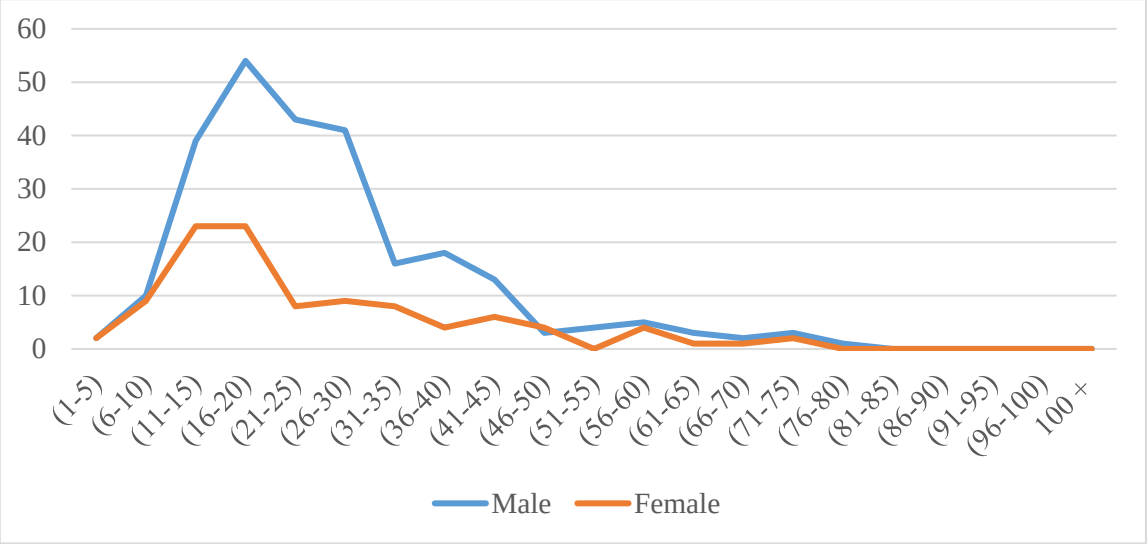


Figure G10

Severity of crashes involving pedestrians at intersections in Tulkarem City

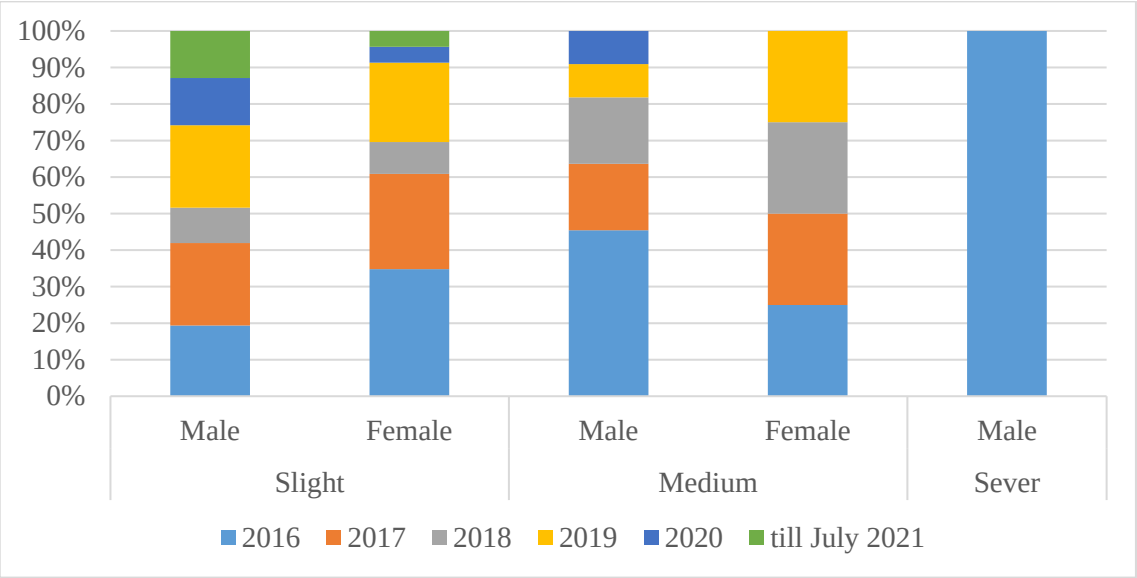


Figure G11

Number of registered vehicles in Tulkarem Governorate per year

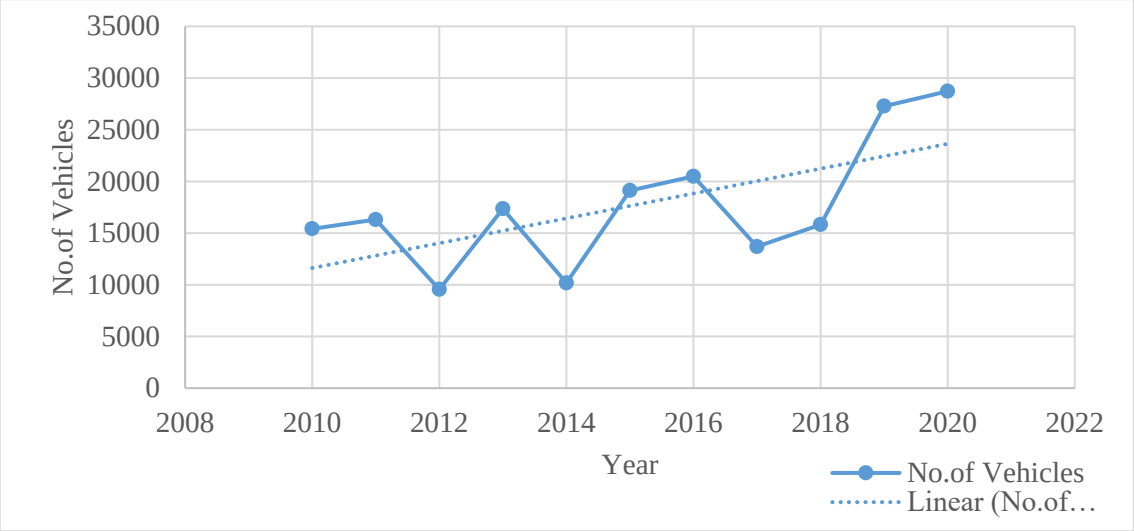
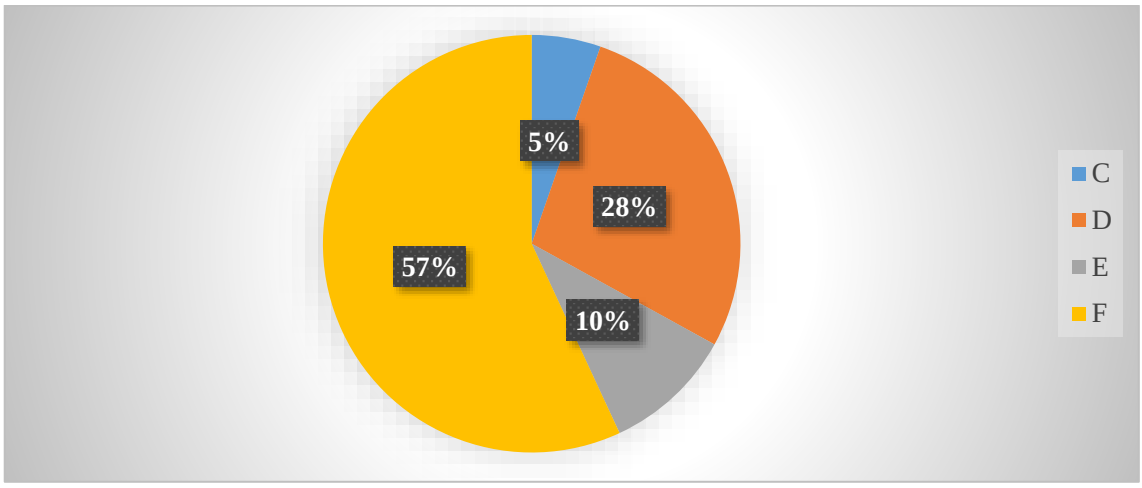


Figure G12

The relationship between LOS and the percentage of crashes at certain intersections in Tulkarem City



جـامعـــة النجاح الوطنية

كليـــة الدراســـات العليـــا

السلامة المرورية على التقاطعات في فلسطين : محافظة طولكرم كحالة دراسية

إعداد

محمد وائل عبد الفتاح الطيبي

إشراف

د. خالد الساحلي

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

2022

السلامة المرورية على التقاطعات في فلسطين: محافظة طولكرم كحالة دراسية

اعداد

محمد وائل عبد الفتاح الطيبي

إشراف

الدكتور خالد الساحلي

الملخص

خلفية الدراسة: يوجد عدد محدود من الدراسات في فلسطين حول السلامة المرورية على التقاطعات. الهدف الرئيسي من هذا البحث هو عرض وتحليل ملف شامل لحوادث الطرق عند التقاطعات في محافظة طولكرم، والتي تعد بمثابة حالة دراسية للضفة الغربية (الضفة الغربية) و تم الحصول على حوادث المرور للفترة من 2016 إلى يوليو 2021 لمحافظة طولكرم من إدارة شرطة المرور.

أهداف الدراسة: الهدف الرئيسي من هذا البحث هو رسم ملف شامل لحوادث الطرق عند التقاطعات في محافظة طولكرم.

منهجية الدراسة: تم استخدام طريقتين مختلفتين لتحديد أكثر التقاطعات خطورة في المحافظة: الطريقة الأولى من خلال حساب شدة الإصابات عند التقاطعات والطريقة الثانية من خلال حساب معدل الاصطدام حسب الأحجام المرورية على بعض التقاطعات وأجريت التحليلات على ثلاثة مستويات وهي: محافظة طولكرم، مدينة طولكرم، وتأثير جائحة كوفيد – 19 على حوادث التقاطعات.

نتائج الدراسة: أظهرت النتائج أن مدينة طولكرم والمنطقة (6) في المدينة كانت من أكثر المواقع خطورة. كما أشارت النتائج إلى أن يوم الخميس شهد أعلى عدد من حوادث التقاطعات لجميع المستويات. سجلت الفترة 16:00– 10:00 أكبر عدد من الحوادث على مستوى المحافظة ، بينما كانت الفترة من10:00– 20:00 هي الأعلى في مدينة طولكرم ، وأثناء الوباء كانت الفترة 10:00– 14:00كان الأعلى. سجل فصل الربيع أعلى معدل تكرار على جميع المستويات ، يليه الصيف والخريف والشتاء. وكانت نسبة إصابة

الذكور أعلى من نسبة الإناث على كافة المستويات. كان "عدم إعطاء حق المرور" هو السبب الأعلى في جميع حوادث التقاطعات في المحافظة ، بينما كانت "السرعة الزائدة" هي السبب الأعلى في المدينة. وشكل عدد حوادث إصابات المشاة 15.88٪ من إجمالي عدد حوادث التقاطعات. على مستوى محافظة طولكرم وكانت معظم الإصابات في الفئة العمرية 11 – 30 سنة في المحافظة والمدينة.

الإستنتاجات :أشارت النتائج إلى أن غالبية الحوادث نتجت عن سلوك مستخدمي الطريق؛ لذلك، يُنصح بشدة بإطلاق حملات توعية وطنية حول قوانين المرور تستهدف جميع مستخدمي الطريق (السائقين والركاب والمشاة)، أضف على ذلك هناك قضية أخرى مهمة وعاجلة، وهي إنشاء برنامج وطني للسلامة المرورية.

الكلمات المفتاحية: التقاطعات، السلامة المرورية، كوفيد –19، طولكرم، حوادث، مشاة، فلسطين.