School of Engineering and Environment - SEE

Shaping the future through Artificial Intelligent technologies to reduce vehicle accidents in Abu Dhabi

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2021

Acknowledgement

The completion of this research would not have been possible without the support from my supervisor Professor Bingunath Ingirige whose guidance was vital in determining the research outcome. I also appreciate the Traffic authorities in Abu Dhabi for their support and the access they provided me.

Special appreciation also goes to every person that I worked with in this study and related work. I particularly appreciate all the Traffic Engineering Department members for their time, advice, and guidance they accorded for me. Through their guidance, I was able to gain a better understanding of how to plan and execute scientific research effectively and how to present the outcome scientifically.

Among the people who supported me in my pursuit of this research are the members of my family. I greatly appreciate the help and the love that all my sibling and parents gave me during the research process. I also appreciate the willingness of my family members to relieve my regular family duties so that I could concentrate on my research. The prayers that you offered on behalf of me ensured the successful completion of this research. Thank you all.

Abstract

Traffic accidents (TAs) constitute one of the top killers in the United Arab Emirates (UAE). Without practical approaches to address the TAs in Abu Dhabi, the region is likely to experience continued economic losses and health burden to the affected families and country. This study identified interventions and solutions for mitigating TAs in Abu Dhabi. The study was guided by research questions that focused on the causes of accidents and how to mitigate TA. The study was based on descriptive observational methodology where quantitative data was collected using a detailed survey questionnaire (n= 300) that assessed various aspects relating to the driver's behaviour. The 2007 to 2017 MVC injuries baseline data were also analyzed. Data on TAs control strategies from existing studies were used to assess the artificial intelligent approaches in road safety management. The quantitative data analysis was carried out using SPSS software and Microsoft Excel software. The study findings showed that the most common traffic problems on Abu Dhabi's roads include driver-related factors, vehicular factors, and road condition-related factors. Risky overtaking, violation of the need to keep a safe distance and violation of speed limits were noted as the significant violations associated with the traffic problems on Abu Dhabi's roads. The baseline data analysis findings indicated that the three regions in Abu Dhabi registered a general reduction in TAs over the 10 years (2007 to 2017). However, the reduction in Al Ain was minimal over the study period. The study's findings relating to the forecasting of the accident trends showed that the Western region and Abu Dhabi would continue to experience a reduction in TAs in the future while the frequency of accidents in Al Ain will increase between 2017 and 2024. Most of the accidents in Abu Dhabi are associated with driver behaviour. The identified risky driver behaviours include the failure to keep adequate distance, maintain recommended speeds, and reckless driving. The study also noted the need to adopt artificial intelligent based interventions to limit the occurrence of accidents and enhance road safety. Based on the reported findings, management of the traffic problems need to focus on controlling risky driver behaviours. Road safety authorities in Abu Dhabi should adopt artificial intelligent approaches in the management of road safety.

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List of Acronyms

ACP..Artificial system, computational experiment, parallel execution

AI..Artificial intelligence

CMS..Changeable message signs

DAS..Driver assistance Systems

DBQ..Driver behaviour questionnaire

GIS..Geographic information system

GPS..Global positioning system

ICT..Information communication technology

ITS..Intelligent transport system

MVCs..Motor vehicle crashes

NGOs..Non-governmental organizations

NHTSA..National highway traffic safety administration

OECD.. Organisation for economic co-operation and development

RTAs..Road traffic accidents

SPSS..Statistical package for the social sciences

TAs..Traffic accidents

TMC..Road traffic management corporation

TP..Traffic police

UAE..United Arab Emirates

WHO..World Health Organization

1 Chapter One - Introduction

1.1 Background information

Traffic accidents (TAs) are among the top eight leading killers globally and equals the deaths caused by communicable diseases (WHO, 2009). The high cases of accidents result in high economic and health burden to the affected families and countries. According to World Health Organisation WHO (2013), deaths due to TA are just above a million across the globe, while cases of injuries are nearly fifty million. It is estimated that without the adoption of effective traffic management approaches, the TAs would be the 5th top killer by 2030 (WHO, 2009). The United Arab Emirates (UAE) experiences many deaths resulting from TAs (Klenk & Kovacks, 2003; Bener & Crundall, 2005). The country records fatalities and injuries higher than the international standards (WHO, 2015; Al Junaibi, 2016). In January 2017, a 69-car pileup on Abu Dhabi’s Al-Ain road resulted in 17 injuries and significant property damage whilst slowing and inhibiting traffic flows across several kilometres of roadway (Khaleej Times, 2016).

Various approaches have been considered for Tas management. One important approach is improved infrastructure (Antić et al., 2013; Meel et al., 2017; Pashkevich & Nowak, 2017). The introduction of express lanes and managed lanes have improved road safety (Kononov et al., 2012; Meel et al., 2017; Stanek, 2018). The addition of the cycle lanes has been indicated to be effective in reducing coalitions that can occur due to the motorist passing too close to the cyclist (Stewart & McHale, 2014). The infrastructural change that can be carried out to reduce the cases of accidents is erecting speed bumps (Antić et al., 2013). However, it should be noted that speed bumps, if not well utilized, can cause congestion and reduce road safety (Antić et al., 2013). The introduction of dedicated pedestrian lanes and road crossing bridges have also been associated with reduced accidents involving pedestrians (Miśkiewicz et al., 2017; Pashkevich & Nowak, 2017). However, concerns have been raised over the willingness of countries to adopt the highlighted infrastructural improvement due to the cost implication and their invasive nature (Elvis, 1999: Miśkiewicz et al., 2017).

From a global perspective, the focus of transportation is shifting from the construction of physical systems capacity to improving operational efficiency and integration (Queen et al., 2008). The new focus on the infrastructure sector is called Intelligent Transport System (ITS).

Artificial intelligence (AI) is believed to offer solutions to the problem of TAs (Szegedy et al., 2015; Jeon, Lee, & Sohn, 2018). The term AI refers to the creation of intelligent machines that have capabilities of the human brain and have the capacity to learn and solve problems (Agarwal et al., 2015). The IA systems operate by using existing knowledge and probability computations to capture the uncertainties between the real-life cause and effect scenarios (Agarwal et al., 2015). The use of AI in the transport system could offer advantages such as solving complex challenges involving massive datasets and reliable prediction of the traffic conditions and, therefore, the critical approaches to address the emerging traffic challenges (Agarwal et al., 2015). The AI systems also provide a means through which the pedestrian and the herd behaviour can be determined and, therefore, aid in developing the relevant structures to ensure safety. However, to fully harness the advantages associated with AI systems, there is a need to address various challenges such as the need for individuals with the required expertise, development of the quality standards for the use of AI systems, the formulation of policies to guide the implementation of AI (Agarwal et al., 2015).

The introduction of AI in the cities' transport system is regarded as an essential step in solving traffic problems (Żochowska and Karoń 2016). The AI-based transport system focuses on providing the motorist with information that enables them to drive safely and well-coordinated while making smart use of the existing transport facilities (Dimitrakopoulos and Demestichas 2010; Li et al., 2011). At the core of the use of AI in the transport system are the collection, synthesis and combination of traffic data alongside other control concepts that aim at providing solutions to complex transportation challenges (Wang 2010; Zhang et al., 2011). The devices that are used to implement AI in the transport sector include sensors, which can be mounted on the vehicles to alert the driver of possible danger ahead. Detectors, such as speed detectors, are also used (Katiyar et al., 2011). The navigation systems such as the global navigation satellite system also form an essential part of the ITS. Unlike the physical erection of new infrastructure such as the tunnels, which may cost millions of dollars, the erection of cameras and sensors is less costly (Elvis 1999; Miśkiewicz et al., 2017).

The success of AI in promoting safe driving has been demonstrated in various cities (Guerrero-ibanez et al., 2015). AI systems have been successful used in cities in Europe (Strom 2011; Festag 2014) and the US (Farooq et al., 2012). Some of the factors that lead to the variation in the development and effectiveness of the use of AI in different cities include the vehicular velocities, the types of vehicles, the driver behaviour such as lane discipline, and the city's population density (Faezipour et al., 2012; Fries et al., 2012; Al-Sultan et al., 2013; Guerrero-ibanez et al., 2015). Therefore, the AI adopted in UAE's transport system should suit the city's socio-economic and environmental characteristics. The Abu Dhabi Traffic Department has deployed various technologies in a bid to limit traffic congestion and accidents in the city. Al-Harthei et al. (2013) described the traffic patrol department has adopted an automated decision support system that helps the patrol officers effectively carry out patrol allocation. Although Al-Harthei et al. (2013) argued that the use of the Geographic Information System facilitates real-time routing of traffic patrol cars to specific geographic areas, the success of the Geographic Information System and other ITS options in Abu Dhabi is not well documented. The only available study that examines the effectiveness of ITS in addressing the traffic congestion and accidents in Abu Dhabi suggests that the use of technology in the region has led to increased adherence to traffic regulation (Al Junaibi, 2016). The study noted that the use of speed limit detectors leads to enhanced adherence. However, other warning options such as the variable messaging signs, have been shown to be less effective. The findings by Al Junaibi (2016) also suggested that advanced technologies are not reliable as the only platform through the road users is educated on accident prevention.

Abu Dhabi aims to achieve the target of zero fatalities by 2030 through increased enforcement, education and awareness, engineering improvements, emergency response, and evaluation (Al Junaibi, 2016). It is expected that the 5-pronged approach strategy will be achieved through the adoption of integrated systems and AI (Al Junaibi, 2016). Despite government interventions since 2011, the progress in Abu Dhabi has been constrained by an increase in the construction of road networks, dangerous driving behaviours, and complex traffic patterns (Ruiz, 2015). Due to these hurdles, additional research is needed to model and predict interventions that can improve upon fragmented network performance to enhance safe driving and systematically reduce the range of threats to and from drivers. It should also be noted that despite the reported benefits of AI, there is limited information regarding the use of the AI in the transport system in the UAE. The few researchers who have examined IA use in the country indicate that the technology help to reduce possible crashes (Al-Harthei et al., 2010, 2013). Al-Harthei et al. (2013) argued that the adoption of AI-based techniques could be helpful in improving the traffic flow and safety on the roads and highways of the Emirate of Abu Dhabi.

1.2 Problem Statement

Abu Dhabi is one of the biggest cities in UAE, known globally for its rapid growth (Hammoudi et al., 2014). However, the city faces the challenge of increased traffic congestion and accidents, which is partly attributed to increased vehicles in the region (Ministry of Interior Statistics, 2016). The TAs in Abu Dhabi account for 63 % of all injuries and are indicated to cost 2 % of the Gross National Product (Ameratunga, et al., 2006; Ochieng and Jama 2015). Despite the heavy investment on road safety as evident by the expenditure of USD 710,000 on road safety projects and an additional USD 940,000 on traffic awareness initiatives, the number of fatalities in Abu Dhabi continues to increase, with the 2016 cases (810 fatalities) being the highest since 2002 (Hammoudi et al., 2014; Road Safety UAE 2017). Considering that each TA related fatality costs about USD 2 million, the observed increase in the number of fatalities in the city causes economic setbacks in addition to human suffering (Hammoudi et al., 2014). Although the city has invested in the good road network, the challenge is associated with the drivers' behaviour and poor adherence to the road safety information. Human related factors such as aggressive driving, overspeeding, driving under the influence of drugs and the lack of road safety information cause many crashes (Alkheder, 2017). One of the options that offer a potentially practical approach to solving the causes of the TAs in the city is the adoption of traffic solutions such as the use of ITS. However, the effectiveness of ITS initiatives in Abu Dhabi is not well understood. Therefore, there is a need to further explore the option and its effectiveness in solving the challenge of TAs in the city to develop insights into how the solution can be applied to the rest of the cities in the UAE, which face similar traffic challenges as Abu Dhabi.

1.3 Research Aim and Objectives

1.3.1 *Aim*

The primary aim of this study is to conduct a critical analysis of traffic solutions, identifying case-based evidence of control deficiencies and monitoring limitations in Abu Dhabi in order to propose interventions and solutions for mitigating TAs and maximizing the efficiency of traffic flow patterns.

1.3.2 *Research Objectives*

Following are the key objectives, which facilitate the achievement of the main research aim:

- To establish the causes of TAs and congestion in Abu Dhabi. This objective was accomplished by using a survey involving selected police, drivers, and staff in the relevant department across the different sectors in Abu Dhabi.
- To identify the challenges facing Abu Dhabi concerning traffic, summarizing key technological, operational, systemic limitations and education of the drivers. This objective was achieved by using quantitative surveys involving police, drivers and staff in the department that compile statistics. The study targeted the data from published material and official and government data.
- To determine how AI systems can be used to solve traffic problems. This was accomplished through the desk research approach, which involved the retrieval and critical analysis of the existing data.
- To recommend an intelligent system approach for the UAE. This objective was accomplished through a desk research approach, which involved the retrieval and critical analysis of the existing data.

1.4 Research Questions (RQs)

Following are the key research questions identified for this study:

- What are the causes of traffic problems, including vehicular congestion and accidents on Abu Dhabi's roads?
- What are the best approaches, which can be used in Abu Dhabi to reduce car accidents?
- How has the use of AI systems been beneficial to TP in other countries, such as the UK and the USA, to reduce car accidents?
- How can AI systems be applied to solve these problems?

1.5 Assumptions

This study assumes that the traffic-related problems in Abu Dhabi are caused by:

- Human factors such as driving behaviour (related to the culture and the education)
- Roadway factors such as the construction of road networks (capacity of the roads, curves and junctions' problems).
- Vehicle factors.

1.6 Significance of the study

It is evident that Abu Dhabi experiences a high number of deaths due to TAs. The severity of the problem has led to Abu Dhabi embarking on a strategy that aims at reducing the number of fatalities to zero by 2030. This study aims to provide important insights into the current traffic situation in Abu Dhabi and the steps taken by the Abu Dhabi traffic department to ensure the attainment of its goal of zero fatalities by 2030. By assessing the causes of traffic problems including vehicular congestion and accidents on Abu Dhabi's roads, the study provides important information that the authorities can use in developing targeted interventions. The information regarding the causes of traffic problems is also important in creating awareness among the road users regarding the factors that they need to pay attention to when driving. The study's assessment of the best approaches that can be used in Abu Dhabi to reduce car accidents is also important in informing the relevant stakeholders about how to address the TAs in the region effectively. The outcome of the assessment documents the approaches that are sustainable and readily adopted by road users. It is crucial to ensure that the road users well perceive the strategies since the success of the interventions taken by the Abu Dhabi traffic department depends on how the road users, especially the drivers, understand and adopt them. Therefore, assessing how the drivers in Abu Dhabi feel about using AI systems in traffic management is important in determining the effectiveness of the adopted interventions and identifying the drivers' concerns that need to be addressed. The determination of the benefits of AI systems to TP in other countries, such as the UK and the USA, in reducing car accidents provides data that can be used to compare the performance and effectiveness of the TAs interventions adopted by Abu Dhabi. The findings relating to how the AI systems are applied to solve TAs in Abu Dhabi will also help provide insights into designing the AI systems to fit the dynamics that exist in Abu Dhabi.

2 Chapter Two - Literature review

This chapter discusses a comprehensive literature review on the road TAs (RTAs) worldwide, particularly in Abu Dhabi. For this purpose, different aspects of RTAs related studies such as predictive mathematical trends showing TAs of various countries, different causes of accidents and various approaches to the user to reduce the level of accidents. Also, the key challenges and barriers faced by the Abu Dhabi governments to implement new legislations and systems (i.e. ITS) on the road for undertaking safety measures. The primary purpose of conducting a comprehensive literature review is to add on various factors relating to the measures to overcome the RTAs problems faced by the Abu Dhabi government.

2.1 Road Fatality and Traffic Congestion

British Medical Journal (1973) argues that the road fatalities in the UK were labelled as an epidemic. The road-related accidents have since then increased rapidly, with cases of accidents being reported around the world. A report by ICEBIKE (2017) shows that the real-time TAs statistics there were 838,896 people killed in TAs in 2016, while 23,678,521 people were injured in TAs, and the total cost incurred in 2016 on road-related accidents in the world reached a total of 350,442,111,618 US Dollars. The statistics show that the number of road-related accidents, casualties and injuries increase each year. For this purpose, more than 100 representatives from 70 Non-Governmental Organizations (NGOs) in 2009 came together in Brussels to meet and discuss the issues related to RTAs worldwide. The meeting ended up with the statement that there are 30 million fatalities and injuries claimed by TAs worldwide in 2009 and 150 road fatalities occur daily, which means 1.24 million people are affected globally per annum (Vanderschuren et al., 2017). Al-Rukaibi et al. (2020) sought to determine the cause of traffic crashes in Kuwait. The approach taken by the researchers involved the use of human capital design where the gross loss output method was used. Based on the analysis of annual reports that were obtained from 9 Kuwait authorities and ministries, Al-Rukaibi et al. (2020) reported that traffic accidents are associated with various types of losses. They noted that general crash-related cost contributed to the highest loss associated with traffic accidents and it represented 60.4 % of the total crashes cost. Al-Rukaibi et al. (2020) also noted that the cost of personal loss contributed to 35% of the total cash cost. Other costs associated with traffic accidents included the loss of productivity costs and delays.

Figure 2-1 below shows the statistics of the more than 182 countries traffic-related accidents, which World Health Organization issued (WHO, 2013). WHO (2013) report indicated that high number of fatalities and injuries due to RTAs in Africa is associated with poor infrastructure and lack of road facilities and legislation that is not strong enough to prevent people from making inappropriate driving. The European countries and North American countries are among the lowest fatality rates compared to other parts of the world. European countries and North America were accounts for the 17.0 % average road fatalities compared to other countries shown in the figure below. Besides the high rates, WHO (2013) reports also claimed that road fatalities decreased in 88 countries from the year 2007 to 2010. This was due to the development and commitment shown by the relevant countries for their road safety.

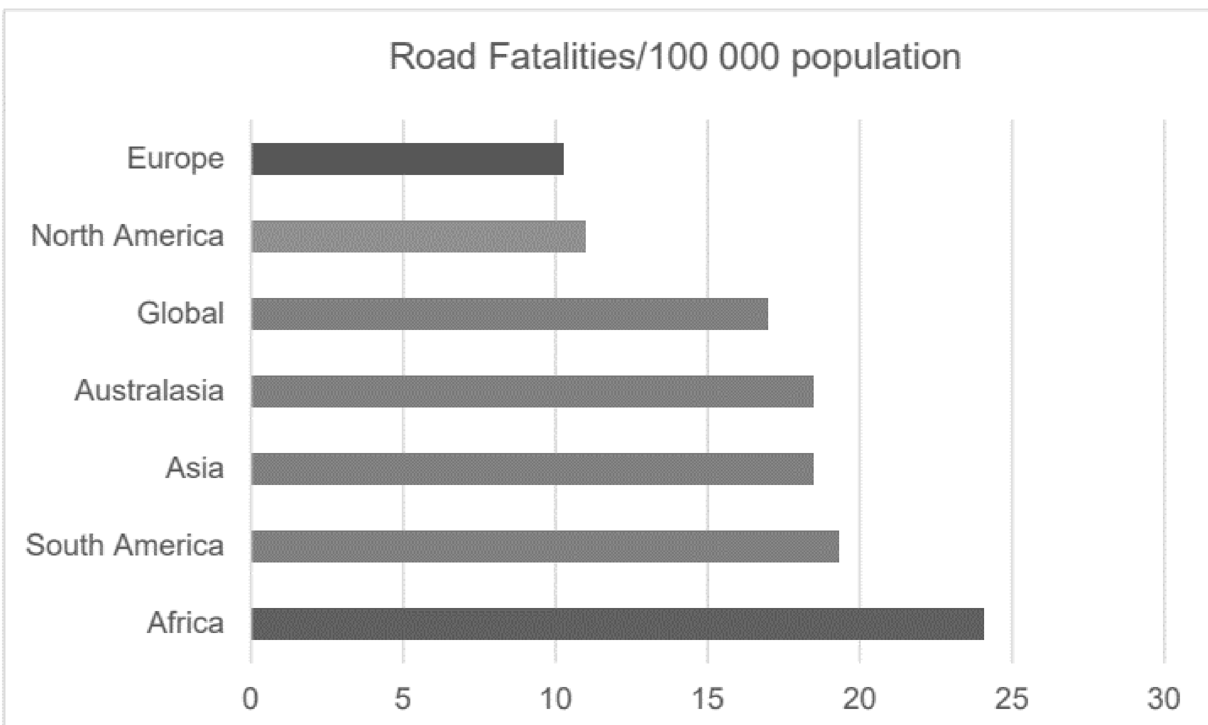


Figure 2-1: Road related Fatalities per 100, 000 Population

Source: (Adapted from: WHO, 2013)

Figure 2-2 below shows the statistics based on the people’s income level such as low, middle and high and provides an association with the road fatalities. The statistics show that those countries with a high number of deaths caused by roads accidents have very low income. However, when the income increases, the number of deaths caused by roads also decreases drastically. This suggests that the level of income could be linked with the rate of TAs. There is also another key element linked with high road fatalities: traffic congestion and lack of road infrastructure.

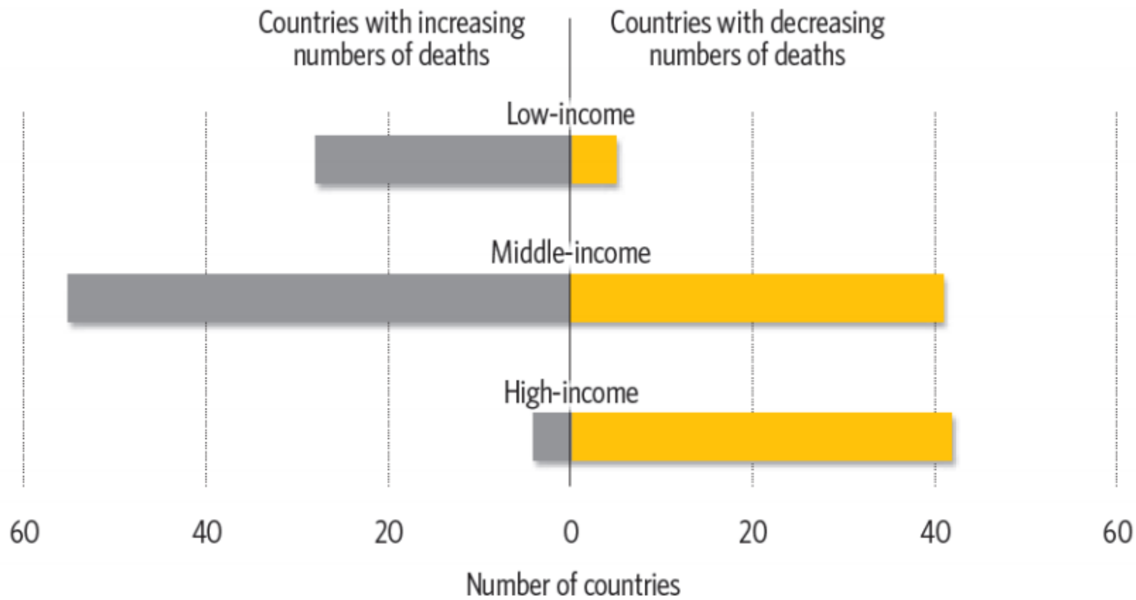


Figure 2-2: Road Fatalities Based on Low, Middle and High-Income Countries

Source: (Adapted from: WHO, 2013)

INRIX (2016) reported that traffic congestion results when the number of vehicles using the roads becomes more than road space capacity. Such trends are caused by factors like increasing population and improving the economy, which increases people's disposable income, making them purchase more vehicles. However, the study from Jamille et al. (2017) shows that the road space or infrastructure can be increased by converting spaces for roads to other uses or adding the capacity of roads, respectively. In addition, other activities like unplanned accidents and roadwork can decrease the supply temporarily. Increases in demand and reduced supply of roads lead to a large increase in over capacity and route delays. Significant utilization of road networks leads to "a tipping point" where any slight rise in and demand will significantly disproportional effect on the overall congestion (INRIX, 2016).

Despite acting as an indicator of a thriving economy, traffic congestion influences the efficient functioning of a city like Abu Dhabi. Increasing traffic levels inhibits or slows citizens' movement, lowers the available time to be spent on other key activities, and raises the frustration level among citizens. For businesses, increased traffic congestion increases the difficulty of transporting products across the city. In short, traffic congestion increases the extra time of travelling and leads to unpredictable times of arrivals. Al-Rukaibi et al. (2020), in their study that sought to determine the cost of traffic crashes in Kuwait, indicated that accidents result in costs beyond delays. The approach taken by the researchers involved the use of human capital design where the gross loss output method was used. Based on the analysis of annual reports that were obtained from 9 Kuwait authorities and ministries, Al-Rukaibi et al. (2020) reported that traffic accidents are associated with various types of losses. They noted that general crash-related cost contributed to the highest loss associated with traffic accidents and it represented 60.4 % of the total crashes cost. Al-Rukaibi et al. (2020) also noted that the cost of personal loss contributed to 35% of the total cash cost. Other costs associated with traffic accidents included the loss of productivity costs and delays.

The improving economic conditions in cities like London and Abu Dhabi also experience an increasing demand for transport facilities. Individuals travel to attend business and leisure activities, health and education-related undertakings, and purchase goods, services, or properties. Therefore, there is a general increase in travel demand. Besides, the economy's improvement offers citizens various alternatives of transport modes. Still, there is most importantly the ability to utilize and acquire private vehicles. Increasing employment accompanied by the reduction in petrol prices implies that more people and luggage are moved across these cities. If such increases in the demand for road capacity are not matched with an increase in the supply of road networks, the highways become highly congested.

Ochieng and Jama (2015) argued that the increasing traffic congestion due to the rapid growth of car ownership has made the transport department to design effective policies to increase the supply of road networks. The increasing car dependency in Abu Dhabi is linked to negative externalities such as environmental deterioration, increasing accidents, and reduced physical mobility. Car dependency in Abu Dhabi is increasing due to factors like lower fuel prices; zero tax policy making cars to be cheaper; the expanding infrastructure in the city; “personal factors like security, flexibility and speed; status and lifestyle of owning a car; and insufficient multi-modal transport in the city" (Ochieng & Jama, 2015, p. 148). The city has designed a comprehensive-modal transport network, which entails various attributes of mass transport.

Abu Dhabi needs to design various strategies to reduce traffic congestion and car dependency. Such initiatives include designing land-use policies that foster compact city structures while minimizing the total transportation level. The second factor is investing highly in mass transit like Bus Rapid Transit, metro, rail, tram, walking, cycling, and Light Rail Transit. Lastly, the adoption of effective travel management initiatives should be considered. For instance, London has successfully designed an integrative public transport network, including trams, underground train, cycle hire, and taxes (Ochieng & Jama, 2015, p. 149). Al-Tit et al. (2020) carried out a study that examined the factors that influence traffic safety in Saudi Arabia. The researchers based their study on data collected using questionnaires with 85 items that focused on road maintenance, traffic education, protective devices, road design, police campaign, and post-accident care. Al-Tit et al. (2020) collected 909 questionnaires that were obtained from Qassim university students. Their data analysis revealed that Saudi Arabia and specifically the Qassim region have a moderate level of traffic safety. The primary causes for traffic accidents that the researchers reported include excessive speeding, drivers not giving way, irregular stops, use of phones while driving, failure to comply with traffic signals, carelessness among drivers, and the failure to use seat belts.

Timmermans et al. (2019) noted in their study that assessed traffic accidents in Qatar that road traffic crashes are increasing, and there is a need to put in place implementation approaches, especially during times of the year when the risk of accidents is higher. Timmermans et al. (2019) based their conclusions on an exploratory study analysed through traffic crash data in Qatar for seven consecutive years between 2010 and 2016. The researchers obtained the data from the Traffic Department in the Ministry of Interior for the State of Qatar. Timmermans et al. (2019) observed an increase in the crashes associated with severe injuries in the region based on time series analysis. However, Timmermans et al. (2019) noted that the number of Accidents that result in fatalities reduced between 2010 and 2016. According to Timmermans et al. (2019), the crashes that result in severe injuries varied based on the different seasons, with winter and autumn recording the highest number of such crashes.

2.2 Trends of Road-Related Accidents around the World

This section presents the critical analysis on the RTAs worldwide to develop a comparison among USA, the United Kingdom (UK), South Africa, Kuwait, Lithuania, Saudi Arabia (SA), and Abu Dhabi. This comparison aims to understand who and what the major action plan in place in mentioned countries to prevent and the TAs to keep their citizen lives secure and provide the best possible infrastructure for their convenience.

The US was chosen because it is the leading world economy that has adopted various ways to address the high frequency of road accidents experienced in the country (Lombardi et al., 2017; Marshall, 2018; Yu et al., 2019). The US is one of the countries that have adopted artificial intelligence in traffic management (Ullah et al., 2020). The UK was also chosen for similar reasons as the US. The UK is experiencing increasing cases of traffic accidents (Andersson & Chapman, 2011; Hooper et al., 2014). The UK is also attempting new technologies that are based on artificial intelligence in the management of road accidents (Liebenau et al., 2009; Lai & Carsten, 2012). Lithuania was chosen to provide a contrast of the traffic accidents in Europe. Unlike the UK, Lithuania has a smaller population by has leading cases of TAs (Prentkovskis et al., 2010). Lithuania provides a good case study since the country had been registering a reduction in the number of traffic accidents (Yannis et al., 2014; Gonçalves et al., 2015). Therefore, the study of the traffic management system in Lithuania is likely to give hints on managing traffic accidents. South Africa is an emerging economy, just as is UAE. South Africa faces similar traffic issues as the UAE, such as increasing car owners and increasing traffic accidents (Chokotho et al., 2013). South Africa has also attempted the use of artificial intelligence to manage traffic and reduce road accidents. Both Kuwait and Saudi Arabia were chosen because they are located in the same region as UAE. The three countries are located in the Arabian Gulf (El Bcheraoui et al., 2015; Mansuri et al., 2015; Al-Eideh, 2016). Saudi Arabia is the largest country in the gulf while Kuwait is one of the smallest with a smaller population than UAE. The author's decision to choose the two countries (Kuwait and Saudi Arabia) was based on the need to get varied approaches used in the traffic management. Unlike Kuwait, Saudi Arabia as embraced artificial intelligence in the management of traffic accidents.

2.2.1 *Road TAs in the US*

In the US, car accidents are categorized under motor vehicle crashes to avoid the use of the word "accident' because it is inevitable (Jamille et al., 2017). The road injuries and fatalities in the US are grouped into seven categories shown in Table 2-1. The categorization is based on whether the accidents involve collision and causes of accidents. The categories also identify whether deaths occurred or not. TA are categorized into various groups as shown in the table below:

Table 2-1: Road fatalities and injuries categorized in various groups

Categories	Descriptions
First Category	Motor vehicle crashes include electrically and mechanically powered highway transport automobiles in motion except rails.
Second Category	Collision with fixed objects entails deaths occurring when motor vehicles strike fixed objects like abutment, guardrail, and impact attenuator.
Third Category	Collision with fixed objects entails deaths occurring when motor vehicles strike fixed objects like abutment, guardrail, and impact attenuator.
Fourth Category	Deaths occur because of the collision with pedestrian where individuals struck by automobiles off or on the highway despite the conditions of the incident.
Fifth Category	Non-collision deaths occur from the accident resulting from jack-knife or overturns.
sixth Category	Death, accidents occurring due to collision with pedal cyclists on highways, streets, parking lots, and private driveways.
Seventh Category	Lastly, accidents resulting from motor vehicles colliding with railroad trains

Source: (National Safety Council, 2015)

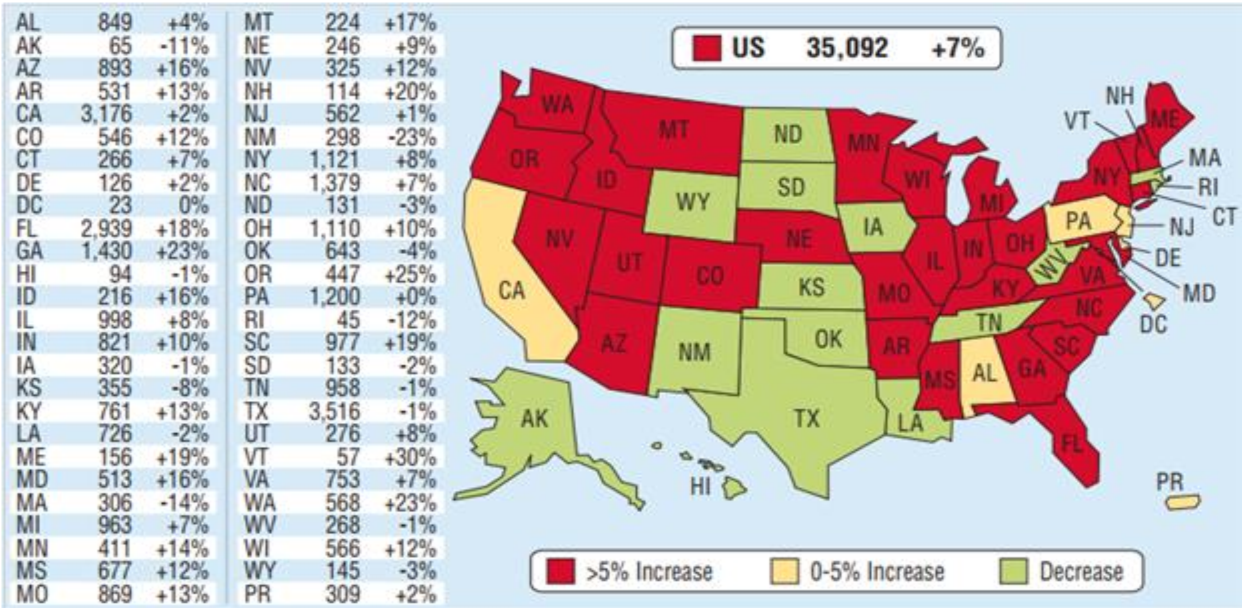
The National Highway Traffic Safety Administration NHTSA, (2016) that is shown in Table 2-2 suggests that the TAs in the US have been on the increase. Table 2-2 shows an increase in TAs by 17.9 % between the year 2011 (n= 5,338,000) and 2015 (n= 6,296,000). During the same time period, the number of fatalities increased from 32479 to 35485, representing an increase of 9.3 % (where the number of fatalities in 2011 is used as the reference value). The US NHTSA (2016) report shown in Table 2-2 therefore raises concern regarding the increase in road accidents and fatality rates.

Table 2-2: The number of TAs in the US between 2011 and 2015 (NHTSA, 2016)

Year	TAs	Fatalities	% Increase from the 2011 baseline value	
			Accidents	Fatalities
2011	5,338,000	32479	0	0
2012	5,615,000	33782	5.2	4
2013	5,687,000	32894	6.5	1.3
2014	6,064,000	32744	13.6	0.8
2015	6,296,000	35485	17.9	9.3

US Department of Transportation (2017) statistics show that in 2015 there were 35,092 fatalities occurred, which was 7 % increased as compared to previous years 2014 (32,744). Figure 2-3 below shows the statistics of the traffic-related fatalities in the USA in 2015 within the context of changes from 2014. The statistics revealed an overall 7 Percent of traffic-related incidents increased in 2015 compared to the incidents in 2014. It is also revealed from the results that the highest number of traffic-related incidents was found in Vermont and Oregon, where 30 % of the traffic-related incidents increased; while New Mexico and Massachusetts were among the lowest levels of percentage with 23 % and 14 % respectively the traffic-related fatalities in the USA.

The most recent data for TAs from NHTSA, National Safety Council, and OECD reports in the US covers from the 1920s to 2013. Therefore, there is a lack of data for 2014, 2015, and 2016 TAs. The following Table 2-3 and Figure 2-4 below shows eight years of accident fatalities in the US between 2005 and 2013. Table 2-3 and Figure 2-4 show that the number of deaths associated with TAs in 2005 (n = 32,624) was fewer than the 35500 deaths reported in 2013. As shown in Table 2-3, the number of deaths due to accidents seems to increase with the increase in the number of vehicles.



AL	849	+4%	MT	224	+17%
AK	65	-11%	NE	246	+9%
AZ	893	+16%	NV	325	+12%
AR	531	+13%	NH	114	+20%
CA	3,176	+2%	NJ	562	+1%
CO	546	+12%	NM	298	-23%
CT	266	+7%	NY	1,121	+8%
DE	126	+2%	NC	1,379	+7%
DC	23	0%	ND	131	-3%
FL	2,939	+18%	OH	1,110	+10%
GA	1,430	+23%	OK	643	-4%
HI	94	-1%	OR	447	+25%
ID	216	+16%	PA	1,200	+0%
IL	998	+8%	RI	45	-12%
IN	821	+10%	SC	977	+19%
IA	320	-1%	SD	133	-2%
KS	355	-8%	TN	958	-1%
KY	761	+13%	TX	3,516	-1%
LA	726	-2%	UT	276	+8%
ME	156	+19%	VT	57	+30%
MD	513	+16%	VA	753	+7%
MA	306	-14%	WA	568	+23%
MI	963	+7%	WV	268	-1%
MN	411	+14%	WI	566	+12%
MS	677	+12%	WY	145	-3%
MO	869	+13%	PR	309	+2%

NOTE: Puerto Rico is not included in the U.S. National Total.

Figure 2-3: Traffic Fatalities in the USA by State and Percentage changes occurs from 2014

Source: (US Department of Transportation, 2017)

Table 2-3: Eight years of accident fatalities in the US between 2005 and 2013

Year	Number of Deaths	No. of Vehicles (Millions)
2005	32,624	242
2006	34,785	245
2007	36,522	248
2008	35,255	250
2009	36,216	254
2010	35,332	250
2011	35,303	253
2012	36,415	253
2013	35,500	253

Source: National Safety Council (2015)

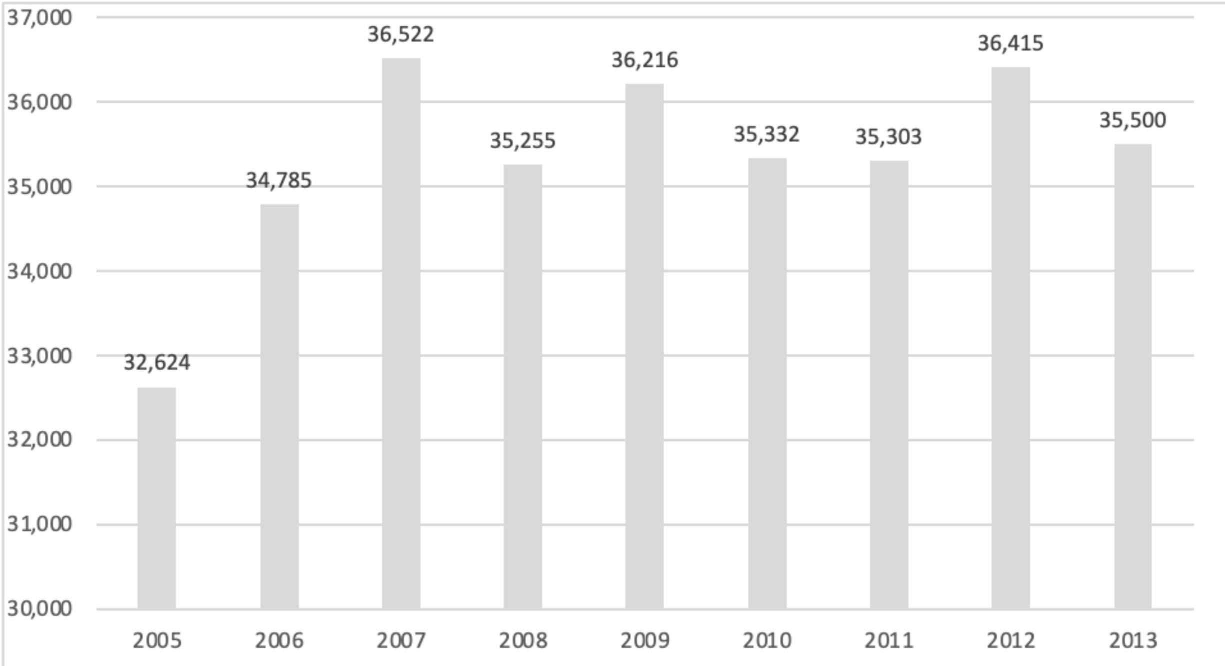


Figure 2-4: Eight years of accident fatalities in the US between 2005 and 2013

Source: National Safety Council (2015)

When comparing the years, there were decreases in the number of deaths 2 % between 2009 and 2010 and in 2012 and 2013. However, in the previous period between 2012 and 2011, there was an increase in the number of deaths 3 %. The report by National Safety Council (2015) shows that the US statistics show that motor vehicle injuries in this country decreased significantly by 96 % from 1912 to 2013. In 2013, the country recorded 4,300,000 incidents of motor vehicle injuries. The use of a safety belt was recorded as the highest cause of TAs, taking up to 87 % of the total TAs in 2013. As a result, the District of Columbia and forty-nine states passed a mandatory law for putting on the safety belt. Accordingly, vehicles designed passenger and child restraints and airbags, which significantly saved a number of lives from accidents. For motorcycles, lack of the helmet was considered as the most significant cause of accidental deaths (National Safety Council, 2015).

Many reasons have been identified in previous studies related to TAs around the world. Following are the major reason revealed by the American Association of State and Highway Transportation Officials (2010) study for the traffic-related accidents in the USA:

- **Aggressive driving:** aggressive driving can be in the form of blatant violation of traffic rules, verbal abuse, physical assault, changing lanes frequently, rude gestures and many more.

- **Driving fatigue:** The US National Traffic Safety Administration Report shows that the annual death rate due to driving fatigue in the US is over 100,000 cases. This mostly happened in the hours of 11 p.m. to 8 a.m., which is the peak time when the human body needs sleep.

- **Drunk driving:** Most of the TAs in US are caused by intoxicated drivers, which occur despite the increased legislation and fines, jail time and even revoked licence. Still drivers are driving their cars while heavy drunk.

- **Distracted Drivers:** About 25 to 50 % of all crashes related to the motor vehicle in the USA are linked with driver distraction. There are many causes of the distraction such as texting, rubbernecking, listening to music's, observing others on roads, driver fatigue, looking at sceneries, adjusting volume or radio, reading newspapers, looking at maps or books, and many more.

2.2.2 *Road TAs Statistics in the UK*

In the UK, car accidents are collected from the TP forces and entail all crashes involving motor vehicles and pedal cycles. The data acquired from the well-known database known as STATS19. Despite being considered the robust source of information, these statics are sometimes incomplete due to several reasons such as compiling errors, human errors, waiting for new reports, and others. Therefore, the data's underreporting makes the information unreliable in meeting certain users' needs (Department of Transport, 2015).

It is evident from Table 2-4 that there is a reduction in TAs in the UK (Department for Transport, 2016). The 8 year-long data (2009-2016) shown in Table 2-5 indicates that TAs documented by the UK's TP in 2016 (n= 136621) were the lowest since 2009. The observed reduction in the reported TAs from 2009 to 2016 represents a 16.5 % decline (where the number of reported accidents in 2009 is used as the baseline value, (Table 2-4). The only time where there has been an increase in TAs during the period between 2009 and 2016 is in 2014 where TAs increased from 138660 in the year 2013 to 146322 in 2014 (Table 2-4). The number of causalities also reduced during the reported time period (Department for Transport, 2016). Table 2-4 shows a reduction in the number of casualties from 2009 (n= 22146) to 2016 (n= 181384, Department for Transport, 2016). The observed reduction in the number of casualties represents 18.3 % (where the number of casualties in 2009 is used as the baseline value, (Table 2-4).

Table 2-4: TAs in the UK between 2008 and 2016 (Department for Transport, 2016)

Year	Number of reported accidents	Number of casualties	% Reduction from the 2009 baseline	
			Number of reported accidents	Number of casualties
2009	163554	222146	0	0
2010	154414	208648	5.6	6.1
2011	151474	203950	7.4	8.2
2012	145571	195723	10.9	11.9
2013	138660	183670	15.2	17.3
2014	146322	194477	10.5	12.5
2015	140058	186189	14.4	16.2
2016	136621	181384	16.5	18.3

Bad weather is also one of the contributors of TAs in the UK (Edwards, 1999; Andersson & Chapman, 2011; Hooper, Chapman, & Quinn, 2014). TAs has been indicated to be high in foggy weather (Edwards, 1999). The fog-relate increase in the risk of accidents is associated with reduced visibility, which leads to increase in collisions and crushes (Edwards, 1999). The UK also experiences long periods of rains, which leads to wet roads. Driving on wet roads is hazardous since there is reduced friction (Edwards, 1999). It has been observed that a third of the TAs in the UK occur as a result of the wet roads (Edwards, 1999; Andersson & Chapman, 2011; Hooper et al., 2014). The presence of snow on the UK roads also contributes to increased TAs

(Edwards, 1999; Andersson & Chapman, 2011). Other dangerous weather conditions include severe storms such as those that were experienced in October 1987 and January 1990 (Edwards, 1994; Edwards, 1999).

Accidents involving motorcyclists are high in the UK (Stone & Broughton, 2003; Parkin & Meyers, 2010; Pai, 2011; Walker, Garrard & Jowitt, 2014). High cases of motorcyclist collisions occur in the junctions as the motorists turn their vehicles to navigate the junction (Stone & Broughton, 2003). Accidents involving motorcyclists can also occur during overtaking (Pai, 2011). The failure of the motorists to keep an adequate distance from the motorcyclists when overtaking is a significant contributor to the accidents involving the motorcyclists (Parkin & Meyers, 2010). One of the approaches that have been suggested to be vital in reducing the accidents involving motorcyclists is adjusting the motorcyclists' appearance to warn and encourage the drivers to keep a safe distance from the motorcyclists when overtaking (Parkin & Meyers, 2010; Pai, 2011). However, a UK study that was conducted by Walker et al. (2014) revealed that motorcyclists' appearance could do little to influence the distance kept by the overtaking drivers. Based on the analysis of 5690 data points that involved motorcyclists with different outfits that indicated novice and experienced riders, the researchers noted that the overtaking distance only changed for the riders with police vests but remained unchanged for the riders having novice or experienced rider' outfits. The findings by Walker et al. (2014) therefore illustrate the need for alternative solutions that can help ensure that motorists can keep a safe distance from other road users.

The reduction of deaths due to TAs is one the major public health goals in the UK. One of the approaches adopted by the UK government in addressing TAs in the country is ITS (Liebenau et al., 2009; Lai & Carsten, 2012). The use of ITS in the region has led to the reduction in TAs and the related causalities. The reduction in TAs due to ITS adoption is associated with the increased adherence to the traffic rules and safe driving speeds (Lai & Carsten, 2012). The reduction in the number of TAs resulting from the adoption of ITS in the UK is an indicator of the importance of the integration of advanced technologies in the management of traffic safety (Liebenau et al., 2009).

2.2.3 *Road TAs in Lithuania*

TAs are the 5th cause of death in the European nations (Eksler et al., 2008; Yannis et al., 2014; Gonçalves et al., 2015). By 2014, deaths attributed to TAs in the region was indicated to be 6 people per 100, 000 of the population (Gonçalves et al., 2015; Bauer et al., 2016). Lithuania is a European country with the leading cases of TAs (Prentkovskis et al., 2010). However, there has been a steady declines in the number of fatalities due to TAs since 2006 in which about 760 number of fatalities was reported, which is more than twice the number of fatalities (241) reported in 2015 (Lithuania Statistics Department 2016). As shown in Table 2-5, the number of TAs has remained steady between 2014 and 2016, with the statistics released by Lithuania's Police Department under the Ministry of the Interior showing the number of TAs in 2014 to be 3225 and 3212 in 2016 (Lithuania Statistics Department 2016). However, the number of fatalities has reduced from 267 in 2014 to 192 in 2016 (Table 2-5).

Table 2-5: TAs and fatalities in Lithuania between 2014 and 2016

Year	Number of TAs	Number of fatalities
2014	3225	267
2015	3033	242
2016	3213	192

Source: (Lithuania Statistics Department 2016)

According to Lunevicius et al. (2010), individuals who are aged between 5 and 29 years are the most affected by the TAs in Lithuania. Strukcinskiene (2008) also noted a 34.5 % increase in the number affected individuals aged between 15 to 19 years old. Most of the TAs in Lithuania involve vehicle-vehicle collision. Prentkovskis et al. (2010) noted that by 2009, 33.4 % of TAs involved vehicle collisions with drivers being the main TA perpetrators. Lithuanian Road administration (2017) indicates that 11% of the TAs are due to the collision involving other obstacles.

In Lithuania, the cases of TAs that involve the pedestrians come second only to the vehicle collision accidents. The data presented by Lithuanian Road administration (2017) indicate that by 2016 the TAs involving pedestrians accounted for 31.1 % of the TAs in the country. The 2016 statistics shows a shift from the early 2000 statistics, which showed that crashes involving pedestrians accounted for the highest proportion of TAs in Lithuania. Other forms of TAs in the country include overturning and grounding on an obstacle, which account for 9.66 % and 2.5 % of the TAs (Lithuanian Road administration 2017).

The causes of TAs in Lithuania are the same as those reported in the UAE. In Lithuania, TAs such pedestrian crashes, and vehicle collision are mainly caused by over speeding. The study conducted by Abbondati et al. (2017), which examined the number of TAs after and before the installation of speed control cameras in the country, reported a 19 % decline in number of crashes following the installation of speed control cameras. The observed decline in a number of crashes suggests the significant contribution of overspeeding to the reported cases of accidents. Poor weather conditions also cause various accidents in Lithuania. However, the most dangerous condition in Lithuania is snowstorms and mist (Čižiūnienė and Matijošius 2015). According to Čižiūnienė and Matijošius (2015), bad weather causes an increase in the number of TAs by increasing the risk of slips. The researchers observed that in the month of autumn, where there is high precipitation, drivers experience poor road visibility, and the roads become slippery. Čižiūnienė and Matijošius (2015) noted that the most affected drivers are those who lack sufficient information about the roads they are using. The researchers also noted that the crashes due to bad weather occur mainly during the night since the visibility and road awareness is further reduced. According to Čižiūnienė and Matijošius (2015), 74 % of all the accidents in Lithuania occur during the night. According to the Lithuanian Road administration (2017), most of the accidents (65.15%) are caused by drivers, while pedestrians cause 7.14 % of the TAs (Table 2-6). Cyclists cause 3.72 % of the reported accidents, as shown in Table 2-6.

In Lithuania, accidents are mainly caused by drivers who display aggression, impulsiveness, and neuroticism (lavinskienė et al., 2015). In a study, which involved the analysis of personality traits of the traffic offenders (n= 688), Lavinskienė et al. (2015) noted that drivers with high risk profiles are likely to commit traffic offense that lead to accidents. The researchers observed that speeding and violation of other traffic rules were common among the drivers with high-risk personalities such as aggression, and impulsivity. Endriulaitienė et al. (2014) noted that aggressiveness among drivers is the most frequent determinant of risky driving behaviour that often leads to TAs.

Table 2-6: The causes of TAs in Lithuania between 2010 and 2016

Year	Causes of TAs (%)			
	Drivers	Pedestrians	Cyclists	Others
2010	68.0	15.0	7.0	10.0
2011	70.5	11.2	7.2	11.1
2012	71.5	11.3	6.1	11.1
2013	66.6	9.7	5.8	17.9
2014	68.94	9.09	5.68	16.28
2015	70.14	8.7	4.58	16.58
2016	65.15	7.14	3.72	23.99

Source: (Lithuania Statistics Department 2016)

The drivers with high-risk profiles are predominantly male, while most female drivers were observed to have low-risk profiles such as agreeableness and openness (lavinskienė et al., 2015). Sleepiness among Lithuanian motorists also contributes to TAs in the country (Gonçalves et al., 2015). According to Gonçalves et al. (2015), 5 % of the TAs are caused by drivers who fall asleep. Prentkovskis et al. (2010) also indicate that the driver's inexperience and/or aggressiveness can sometimes lead to them driving too close to the leading vehicle. Prentkovskis et al. (2010) argue that such driving behaviour is associated with a high risk of crashes even in situations where the driver applies emergency breaks.

2.2.4 *RTAs in Saudi Arabia*

Saudi Arabia (SA) is located in the Middle Easter country and also a neighbour country of Abu Dhabi. The number of deaths that occur due to TAs accounts for 4.7 % of all mortality in SA (Mansuri et al., 2015; El Bcheraoui et al., 2015). A study conducted in SA for their road-related accidents in 2012 shows that there were 41,086 crashes recorded in the Kingdom, which resulting 7,638 deaths (Al-Turki, 2014). SA is considered one of the highest rate of the road-related accidents with the rate of 25.33 per 100,000 of the whole population (Mansuri et al., 2015). If the road traffic fatality compared with the UK and Australia, the SA accounts for 4.7 % while it remains 1.7 % in the UK and Australia. It is also more severe accidents to death ratio is 32:1 versus 283:1 in the USA; therefore, the road and safety experts also predicted that if the current ratio in SA continues, there is highly likely the TAs can reach to four million by the year 2030 (Al-Turki, 2014). The observed mortality reflects the upward trend in the cases of TAs since the year 2000. Based on the data from the TP department, Barrimah et al. (2012) observed that there has been a steady rise in the number of deaths due to TAs in SA from 2005 where there were 14 deaths per 100000 people to 16 deaths per 100000 people in 2010. According to Bendak (2011), more than 6450 deaths due to TAs and additional 36400 injuries are reported in SA every year. The most affected age group are the individuals aged between 19 to 30 years, making up 47 % of the motorists involved in TAs in the country. According to Barrimah et al. (2012), the rate of TAs among male drivers is higher than female drivers. Barrimah et al. (2012) based their observation on data analysis on victims of TAs obtained from the TP department and from the hospital's emergency hospital data in the Qassim region of SA. Mansuri et al. (2015) identified several causes of road-related accidents and categorized them into three major categories: Table 2-7. The causes of accidents include driver-related causes, road-related causes and the causes associated with the vehicle (Table 2-7).

Table 2-7: Causes of RTA in SA (Adapted from: Mansuri et al., 2015)

Driver	Road	Car
• Distracted driving • Excessive speed • Violations of signals at intersections • Fatigue during driving • Wrong side driving • Break suddenly • Improper turns • Bad habits and careless driving • Not often use seat belt • Poor eyesight • Hypoglycaemia • Presence of drugs • New driver	• A large increase in the number of vehicles and expansion of roads between cities • Large national development projects for supporting kingdom infrastructure • Bad weather • Animal crossing • Deadly curves • Potholes	• Tire blowouts • Leakage of fluid and gas • Poor car services • Wrong wheel suspensions • Bad lights at night time

Source: Mansuri et al. (2015)

Causes of TAs in SA vary (Al-Naami et al., 2010; Prentkovskis et al., 2010; Bendak, 2011; Barrimah et al., 2012). According to Barrimah et al. (2012), one of the primary cause of TAs in the country is high speeding. The researchers noted that 43.1 % of the accidents are caused by driving beyond the stipulated speed limit. Barrimah et al. (2012) also observed that lack of caution and wrong turning, inappropriate stopping, violation of traffic rules and driving under the influence of drugs are responsible for 14.7 %, 14.52 %, 13.7 %, 1.8 % and 0.01 % of the cases of TAs respectively. Bendak (2011) observed that reckless driving is the leading cause of TAs in the country. In his assessment, which involved the analysis of motor vehicles (n= 25919) at the intersections (n= 18) in different cities in SA, Bendak (2011) observed that a considerable number of motorists (5.9 %) crossed the intersection on red traffic lights. Al-Naami et al. (2010) also made similar observations regarding the causes of TAs in the country. Al-Naami et al. (2010) also noted that the percentage of TAs that are attributed to overspeeding is slightly higher (65.0 %) compared to the percentage observed by Barrimah et al. (2012). Al-Naami et al. (2010) also noted that the violation of traffic rules is responsible for over 50 % of the TAs. The researchers, however, noted the drivers' errors are the highest causes of TAs and are responsible for 80 % of all reported accidents. Violation of the traffic rules is a risky traffic offence since it often leads to head-on collisions associated with fatal consequences (Prentkovskis et al., 2010). Some of the primary driver’s errors that lead to accidents include improper stops and turns, vehicle condition and poor interpretation of traffic signs and warnings (Al-Naami et al., 2010). The researchers also highlighted stress and exhaustion among the drivers as one of the major cause of TAs in the country. BaHammam et al. (2014) highlight sleep-driving as one of the rising concerns in SA and a possible future cause of major TAs. The researchers based their observation on 1,219 male drivers with a mean age of 32.4 ± 11.7 years. BaHammam et al. (2014) reported that about 33.1 % of the respondents had experienced at least one near-miss accident due to sleep-driving. The researchers noted that sleep-driving causes 11.6 % of the TAs in the country. Based on the discussed evidence, it is evident that driver’s mistakes such as overspeeding, violation of traffic rules, stress and exhaustion are the major cause of accidents in SA. However, it is also important to note that poor weather can also reduce visibility, which leads to increased chances of crashes and collisions (Mansuri et al., 2015). According to Alshammari et al. (2017), most of the TAs in SA occurs during very sunny conditions (63.9 %) and during rainy conditions (13.5 %). Alshammari et al. (2017) based their observation on a cross-sectional study that involved the analysis of data collected from 407 drivers. According to Alshammari et al. (2017), the high cases of TAs during sunny weather is associated with increased stress and compromised driver performance at high environmental temperatures.

Issa (2016) provides an extensive study on the effect of driver's characteristics on the likelihood of TAs in SA. According to the researchers, the drivers who are poorly educated on road safety protocols and who have limited knowledge regarding the road safety issues in the country are more likely to be involved in TAs. Issa (2016) based their results on a questionnaire based-survey that targeted drivers in Tabuk City of SA. The researchers observed that drivers' experience is an essential contributor to the likelihood of TAs in SA. Issa (2016) observed that the drivers who have less experience, such as those who have recently obtained their driving licence, have a high likelihood of being involved in accidents. Ratrout et al. (2017) in the study, which aimed at characterizing the behaviour of crash-prone drivers in SA, noted that the driver's experience and knowledge of traffic rules are essential in reducing the cases of TAs. Hasan et al. (2014) carried out a study among 300 drivers selected from Jeddah. The researchers noted that racing another driver is a common behaviour among motorists. Hasan et al. (2014) also noted that most of the drivers deliberately ignore the traffic rules while some, due to time pressure, are forced to ignore the traffic regulations. These findings suggest that driver's behaviour is the main determinant of TAs in SA. The negative behaviours among the drivers, such as the failure to obey the traffic rules, are the main causes of TAs in the region (Issa 2016; Ratrout et al., 2017).

2.2.5 *TAs in Kuwait*

Kuwait is the leading country with the highest TA cases per population in the Gulf Cooperation Council region. The country has a poor road safety record despite the high standard of its road network (Hajeeh 2012). Al-Eideh (2016) indicates that Kuwait has experienced a sustained increase in the number of TAs. In a study that involved analysing the official statistics of TAs in the country, Al-Eideh (2016) noted that the number of TAs in 2012 and 2013 was the highest since 2002 (Table 2-8). As shown in Table 2-8, the increase in TAs has coincided with increased vehicles in the country. The number of deaths that occur due to TAs in the country has also increased with the increase in TAs, with the year 2011, 2012 and 2013 having the highest deaths due to the accidents, as shown in Table 2-8.

Table 2-8: The number of TAs in Kuwait between the year 2002 and 2013

Year	Vehicles count	TAs	Number of Deaths
2002	947382	37650	315
2003	954978	45376	372
2004	1042617	54878	400
2005	1134042	56235	451
2006	1215745	60410	460
2007	1293308	63323	447
2008	1353390	56660	410
2009	1414925	61298	407
2010	1477769	65861	374
2011	1554737	75194	493
2012	1644314	86542	454
2013	1748424	89527	445

Source: (Al-Eideh 2016)

Al-Eideh (2016) predicted that the cases of TAs in Kuwait would continue to increase. Based on the probabilistic models that Al-Eideh (2016) developed for the accidents rates from the year 2014 to 2020, the number of TAs in the year 2020 is expected to be the highest. As shown in Table 2-9 Kuwait is expected to record 113918 in 2020, resulting in 448 deaths. The number of vehicles and the cases of violation of the traffic rules is also expected to increase as shown in Table 2-9.

Table 2-9: The projected cases of TAs and associated factors

Year	Total number of Vehicles	Total TAs	Total number of deaths	Total number of violations
2014	1816218	90154	462	3962052
2015	1889562	94115	461	4097226
2016	1962907	98075	460	4232401
2017	2036252	102036	458	4367575
2018	2109597	105997	455	4502749
2019	2182941	109957	452	4637924
2020	2256286	113918	448	4773098

Source: (Al-Eideh 2016)

The increase in the violation of the traffic rules, as shown in Figure 2-5, could be one of the reasons for the increase in the cases of TAs in the country. As shown in the Figure 2-5, there was a gradual increase in the number of violations of traffic rules between 2002 and 2013. The highest number of violations were registered in 2010.

The violation of traffic rules in Kuwait varies. Some of the frequently reported violations are overspeeding and the failure to observe traffic lights. According to Raman et al. (2014), there are frequent cases of overspeeding among the Kuwaitis and non-local Arabs drivers. Raman et al. (2014) made their observations in a cross-sectional survey study, which involved analysing the data on driving behaviour among 754 individuals with valid driving licence. The causes of the high TAs in Kuwait are mainly bad weather and reckless driving (Raman et al., 2014). Raman et al. (2014) noted that overspeeding was significantly related to the high cases of TAs According to their study, 31.9 % of the drivers frequently exceed the speed limit.

The behaviour of the driver also contributes significantly to the TAs in Kuwait. A study that was carried out by Koushki and Bustan (2006) showed that the drivers who have high-risk behaviour such as the failure to use seat belts and those who do not maintain the required distance between themselves and the lead vehicle are more prone to accidents.

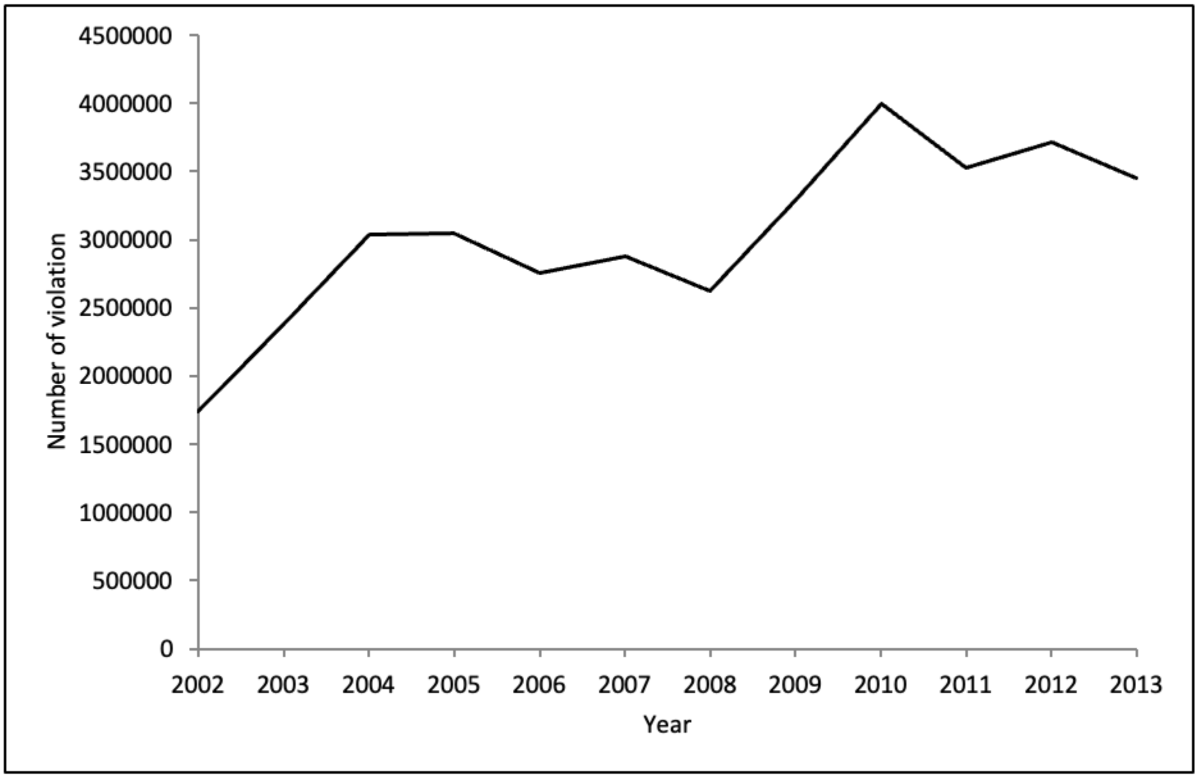


Figure 2-5: The increase in the number of traffic rule violation in Kuwait

Source: (Al-Eideh 2016)

Koushki and Bustan (2006) based their observations on a study that examined the lifestyles of 1467 drivers by considering their values, attitudes and actions. The researchers noted that the high-risk drivers were satisfied with their lives despite the high risk of accidents that they subject to themselves. Raman et al. (2014) also observed the frequent neglect of seat-belt use among drivers in Kuwait. The researchers also noted that most of the drivers (51.1 %) always use their phones while driving, while 32.4 % of them text while driving. Texting is associated with the increase in TAs since it reduces the drivers' reaction time (Backer-Grøndahl & Sagberg, 2011).

The fatalities due to TAs vary across different age groups. According to the findings obtained by Hajeeh (2012), the most affected individuals are those aged between 21 to 30 years (Figure 2-6). The second most affected group of individuals are those aged between 31 to 40 years. As shown in Figure 2-6, individuals aged below the age of 10 and those aged above 51 years are the least affected.

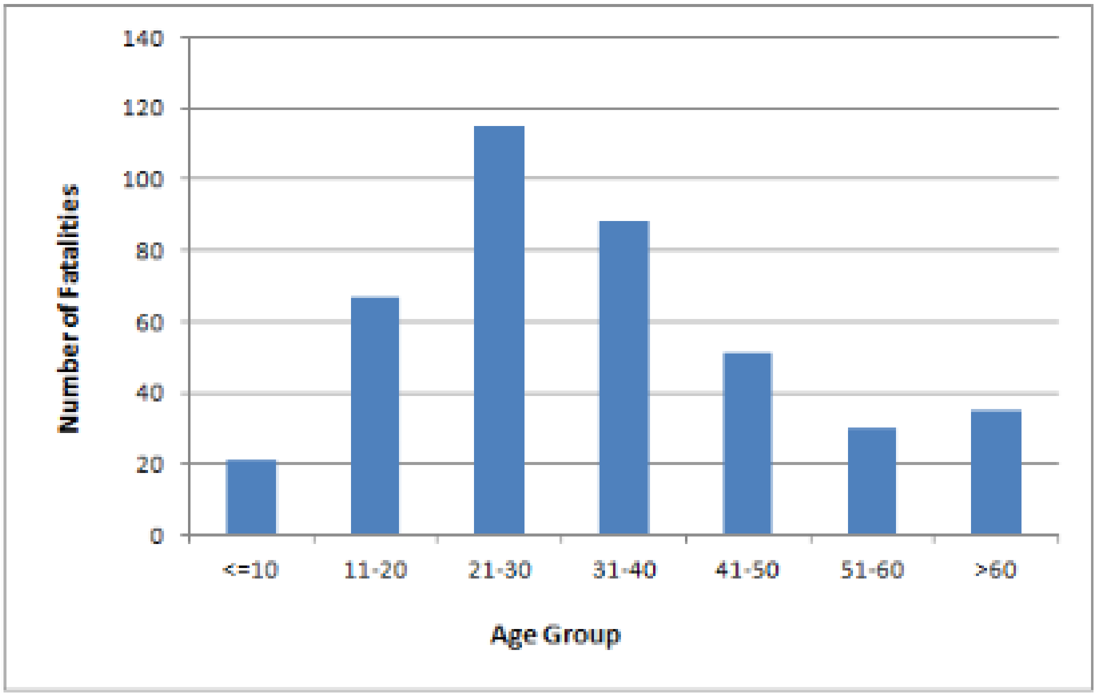


Figure 2-6: The number of deaths due to TA across the different age groups

Source: (Hajeeh 2012)

The study carried out by Koushki and Ali (2003) suggests that pedestrian accidents in Kuwait are frequent. Koushki and Ali (2003) based their observation on the data analysis obtained from Kuwait's Ministry of Interior, General Traffic Department. The researchers analysed 442 pedestrian accident records. Koushki and Ali (2003) observed that many pedestrian accidents involved males, while the most affected age group are the individuals aged below 25 years. According to Koushki and Ali (2003), most of pedestrian accidents occur during the night. The researchers noted that 70.8 % of the accidents occur at the street intersections, with fewer cases (12.4 %) occurring in the parking areas. The causes of pedestrian accidents in Kuwait vary with reckless driving being observed to account for 44.7 % of the cases as reported by Koushki and Ali (2003) in Table 2-10. Driving at high speed is the second most frequent cause of pedestrian accidents. At the same time, illegal crossing and the other pedestrian mistakes account for 8.8 % and 12.6 % of the accidents (Table 2-10).

Table 2-10: The cause of TAs involving pedestrians

Cause	Frequency	Percentage
High Speed	71	16.0
Reckless/Careless Driving	198	44.7
Use of Mobile by the driver / pedestrian	29	6.5
Illegal Crossing	39	8.8
Pedestrian Fault	56	12.6
Darkness	18	4.1
Other	32	7.3

Source: (Koushki and Ali 2003)

2.2.6 *TAs in South Africa*

South Africa is one of the most developed countries in Africa, and it is located in the Sub Saharan part of the content. The country is a home to about 55.91 million people. Its transport system supports the country's thriving economy. Despite the efforts of the South African government to develop the road network, cases of traffic safety continue to be a major issue in the country (Chokotho et al., 2013). TAs in South Africa is considered as a crisis (Vanderschuren 2008). It is estimated that about 10 000 individuals have lost their lives due to TAs in the country, while about 150,000 suffer injuries as a result of about half a million cases of reported accidents annually. As indicated by the data collected by the ArriveAlive initiative, the number of fatalities have increased since 1990 with the findings presented in Table 2-11 indicating an increase of 26.1 % in the number of fatalities. It is also evident that the number of fatal crushes increased by 27.2 % in 2016 from the number of 9174 fatal crushes in 1990. However, the number of deaths per 100,000 population and the deaths per 10000 registered vehicles, reduced by 16.8 % and 59.5 % from the 1990 figure of 30.3 and 24.2 respectively (Table 2-11).

Table 2-11: Trend in the number fatalities, and the crashes between 1990 and 2016 (ArriveAlive 2015).

Safety parameter						1990 % change over			
	1990	2000	2010	2015	2016	2000	2010	2015	2016
Fatalities	11157	8494	13967	12944	14071	-23.8	25.1	16.0	26.1
Fatal crashes	9174	6679	10837	10613	11676	-27.1	18.1	15.6	27.2
Deaths per 100 000 population	30.3	19	27.4	23.6	25.2	-37.2	-9.5	-22.1	-16.8
Deaths per 10 000 registered vehicles	24.2	14	15.3	11.1	9.8	-42.1	-36.7	-54.1	-59.5

The data on the number of registered vehicles between the year 1990 and 2016 is presented in Figure 2-7. The findings show there has been a near three times increase in the number of registered vehicles from the initial figure of 4616 in 1990 to 11964 in 2016. As shown in Figure 2-7, increased registered vehicles correspond with high fatalities. Therefore, this suggests that the observed increase in the number of crashes could be linked to the increase in the number of vehicles on the South African roads. Venkataraman et al. (2013) suggested that increased vehicles counts without the expansion of the infrastructure result in congestion and a subsequent increase in the risk of crashes.

The TAs in the country are categorized into four groups based on the degree of fatality. The fatal accidents characterized by the loss of human life are the least common and represent 1.3 % of all the accidents that occur. The major accidents, which are characterized by major injuries, are the second least frequent accidents and represent 4.8 % of all the accidents that occur in the country. The minor accidents that cause minor injuries to the individuals account for 15.9 % of all the accidents and they are the second most frequent form of accidents. As shown in Figure 2-8, the most frequent form of accidents is the ones that result in damage but no injuries or death.

The TAs in South Africa is associated with various costs. According to the findings presented by the TMC (2016), the highest cost as a result of road crashes is associated with human casualties, which account for 69.3 % of the entire cost of crashes (Table 2-12).

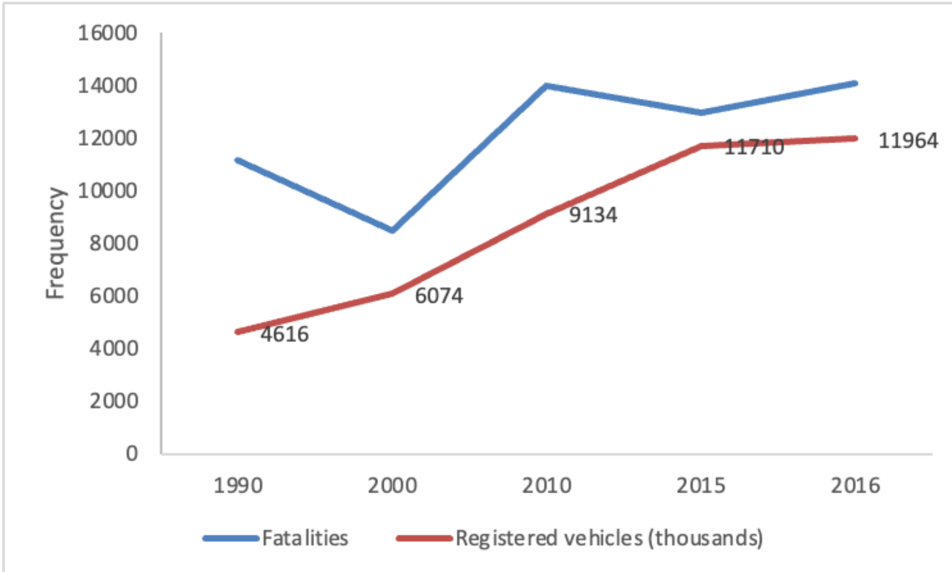


Figure 2-7: The rise in the number of fatalities with increased registered vehicles (ArriveAlive 2015).

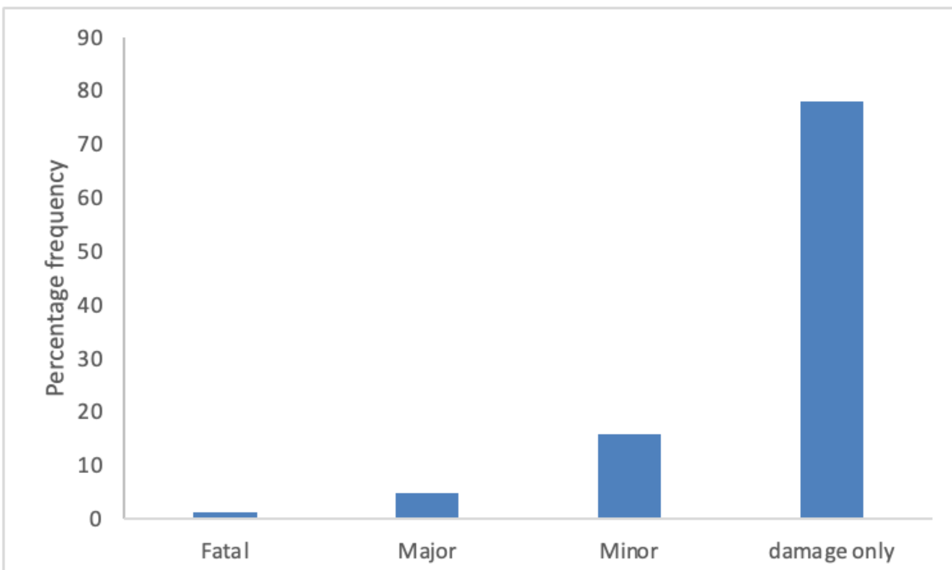


Figure 2-8: Types of Road traffic crashes in South Africa (N=832433) (Road Traffic Management Corporation, (TMC) 2016)

Human fatalities result in a loss that amounts to $4608.23, while the major, minor and damage only accidents result in losses that cost of up to $1958.73, $1149.13, and $107.28 respectively. The second highest category of costs is the incident costs, which account for 15.8 % of the entire costs. As indicated in Table 2-12, the incident cost resulting from the fatal accidents results in $159.42 but the highest incident cost is associated with the accidents that cause damage only where the cost can be as high as $1005.11. The incident cost resulting from minor and major accidents is $216.46 and $403.92, respectively (Table 2-12). The other category of the cost associated with the TAs in the country is the vehicle repair costs, which account for 14.9 % of the TA costs. The damages only accidents are the highest contributors to vehicle repair cost while the fatal accidents and the major accidents are the least and the second lowest contributors to the vehicle repair cost.

Table 12: The cost (US dollars) of Road traffic crashes in South Africa (TMC 2016)

Category	Fatal	Major	Minor	Damage only	Total	%
Human Casualty Costs	4608.22	1958.72	1149.13	107.28	7823.37	69.3
Vehicle Repair Costs	17.22	63.91	229.25	1374.20	1684.75	14.9
Incident Costs	159.42	403.92	216.46	1005.11	1785.00	15.8
Total Cost	4784.95	2426.56	1594.93	2486.68	11293.12	

The data on TAs across the different demographics show that pedestrians' accidents are the most frequently reported (Figure 2-9). According to the ArriveAlive (2016) statistics, 38 % of all fatal crashes involve pedestrians and mainly include the drunk, reckless, and distracted pedestrians, who disobey the traffic regulations such as the traffic lights, and the pedestrians who are the victims of reckless driving. The second highest cases of accidents involve the passengers, who mainly board overloaded vehicles or board the goods vehicle. According to the findings presented in Figure 2-9, about 33 % of the fatal accidents involve passengers. The cyclists are involved in 32 % of the fatal accidents, while 26 % of the fatal accidents involve drivers. Therefore, it is evident that the different road users in South Africa contribute to the increasing number of crashes and fatalities in the country.

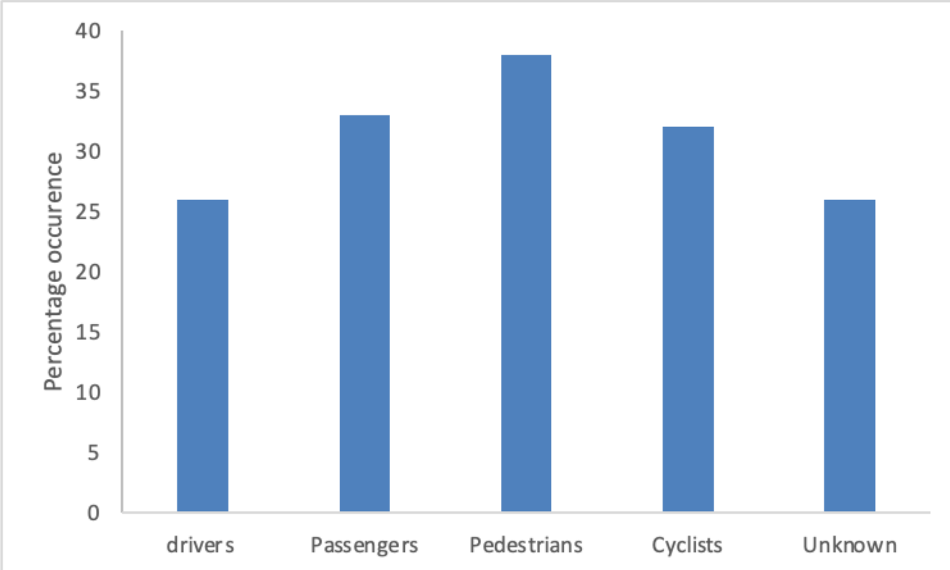


Figure 2-9: The involvement of the different road users in fatal accidents in South Africa

The causes of TAs in South Africa can be categorized into three categories: the human-related causes of accidents, vehicle-related causes of accidents and road & related environmental causes of accidents (Table 2-13). The causes across the different categories can contribute to the occurrence of an accident incident such a drink driving that results in overspeeding and risky turning on a sharp bend. Among the human-related causes of accidents, overspeeding is the highest cause of accidents, while jaywalking is the second most recorded cause of road accidents. The findings presented in Table 2-13 also show that the human-related causes of accidents such as risky overtaking, violation of the traffic rules and risky turning are responsible for 7.33 %, 3.12 % and 3.23 % of the TAs. Among the vehicle-related causes of accidents, the bursting of tyres is reported in 36.3 % of the accidents, while faulty brakes are indicated to contribute to 25.04 % of the accidents. Other vehicle-related causes of accidents such as faulty steering and the lights related faults are reported in 24.15 % and 2.07 % of the documented accidents. The major road & environmental-related causes of accidents include the presence of sharp bends, which have been reported in 27.99 % of the accidents. The other road & environment-related causes of accidents include poor road conditions such as slippery road, poorly maintained road, and diminished visibility, such as during poor weather (Table 2-13).

Table 2-13: Causes of TAs in South Africa (ArriveAlive 2015)

Causes of TAs	
Human related causes of accidents	**% of Group**
Over speeding	36.4
Jay walking	31.74
Risky Overtaking	7.33
Risky turning	3.23
Violation of the traffic rules	3.12
Vehicle related causes of accidents	**% of Group**
Tyre bursting	36.3
Faulty brakes	25.04
Faulty steering	24.15
Lights related faults	2.07
Road & Environment related causes of accidents	**% of Grou**p
Sharp bend	27.99
Poor road conditions	20.4
Diminished visibility	15.01

Various efforts have been put in place towards solving the issue of TAs in South Africa. One of the approaches is through the creation of awareness regarding road safety. The awareness program focuses on educating the road users about the road signs and regulations and how to interpret and adhere to the guidelines (Chokotho et al., 2013). The country has also put in place stricter rules and penalties against traffic offenders. In order to man and ensure adherence to the set rules, South Africa has increased the number of TPs on the major roads and cities. Despite the reports of the use of technology to address the traffic safety issues in South Africa, there is limited evidence of its effectiveness in reducing TAs (Vanderschuren 2008).

2.3 Road TAs in Abu Dhabi

The UAE is among the five leading countries in the gulf with the highest TAs casualties (Mohammed, 2015). According to Mohammed, (2015), the deaths that occur due to TAs account for 21 % of all deaths in the country. Abu Dhabi is the major city in the UAE with a population of about 1.145 million (CIA, 2016) and the TAs statistics shows from 2016 that the ratio is 24.1 %. There are many major economic activities linked with this city in the Gulf region, and considered one of the wealthiest cities around the world. The transportation systems is also developed, and there was estimated at 1 million vehicles and pieces of heavy equipment in Abu Dhabi, and the length of the roads is around 2 km (Ministry of Interior Statistics, 2016).

Hammoudi et al. (2014) stated that on RTAs in Abu Dhabi showed a number of factors that cause motor crashes. Such factors include driving under the influence of drugs and alcohol, aggressive driving or overspeeding, and lack of road safety information. The survey also showed that Abu Dhabi records the highest TAs in the UAE region compared to other places like Al Ain. This is because the region has a relatively larger number of motor vehicles and the highest population density than other UAE regions (Hammoudi et al. (2014). According to Ochieng and Jama (2015), TAs in Abu Dhabi accounted for about 63 % of all injuries. However, the statistics provided by Mohammed (2015) indicate that TAs in the country is on the decline. As shown in Table 2-14, TAs in the year 2013 (n= 5124) is lower than TAs in 2011 (n= 6454). Mohammed (2015) also showed that the decline in TAs results in a reduction in the cases of deaths and injuries associated with the TAs (Table 2-14).

Table 2-14: Summary of the TAs and the deaths in the Abu Dhabi (Mohammed, 2015)

Year	TAs	Number of injuries	Number of deaths
2011	6454	7808	727
2012	6700	7586	628
2013	5124	7743	651

The number of deaths due to TAs is high in the UAE compared to other countries in the Middle East (Christensen-Rand et al., 2006). As shown in the Table 2-15, the number of deaths per 100, 000 populations in the UAE (n= 29) is more than twice the reported case in the Yemen (n= 8), Egypt (n= 13), Iraq (n= 8), Syria (n= 10), Bahrain (n= 12). The data presented by Christensen-Rand et al. (2006) also shows that the number of deaths due to TAs in UAE is higher than the cases reported in Kuwait (n= 18), Oman (n= 25), Qatar (n= 19) and SA (n= 21) as shown in Table 2-15.

Table 2-15: The comparison of TAs in UAE to other countries in the Middle East (Christensen-Rand et al., 2006)

Country	Deaths per 100, 000 population
Yemen	8
Egypt	13
Iraq	8
Jordan	15
Syria	10
Oman	25
Bahrain	12
Kuwait	18
Qatar	19
SA	21
UAE	29

According to the study carried out by Mohammed (2015), the observed high cases of TAs in UAE and resulting fatalities are associated with various causes. As shown in Table 2-16, the causes of the TAs in the country vary from direct violation of the traffic rules to lack of respect for other road users. The sudden change of lane is the highest cause of accidents in the UAE, accounting for 589 accidents and 113 fatalities in the country. Table 2-16 also shows that misjudgements of the road users and the failure to keep safe driving distance account for 406 and

350 cases of accidents, respectively. The other causes of the accidents in the country include negligence (n= 265), lack of adherence to speed limits (n= 258) and poor use of the junctions (n= 232).

Table 2-16: The causes of TAs in UAE (Mohammed, 2015)

Causes	TAs	Number accident casualties	Number of injuries
Sudden lane changes	589	113	914
Misjudgements of road users	406	48	402
Lack of safe driving distance	350	41	576
Negligence	265	39	303
Lack of adherence to speed limits	258	62	390
Poor use of junctions	232	19	353

The observation made by Mohammed, (2015) agree with the findings of an earlier study that was carried out by Bener, Özkan & Lajunen (2008), which highlighted human-related errors such as violation of traffic rules such as over speeding, lack of adherence to the traffic lights at the junction, and hostility towards other road users. Bener et al. (2008) also noted that errors such as the failure to spot objects when reversing, underestimation of the oncoming vehicle during overtaking, and the failure to accurately spot the presence and/or the position of other road users such as pedestrians. The observed causes of the TAs suggest that human errors and action are the key contributors of the rise in the causes of TAs in the UAE (Mohammed, 2015). Other human-related factors such as the driver's mental state have also been shown to be critical contributors of increased TAs in the country (Bener et al., 2001). Based on the cross-sectional study that involved 1985 drivers, Bener et al. (2001) noted that drivers who suffer from migraines are at a high risk of being involved in TAs. According to Bener et al. (2001), a significantly high number of licensed drivers with migraines are likely to engage in careless driving leading to TAs compared to the licensed drivers without migraines ($p < 0.002$). However, less number of licensed drivers with migraines exceeds the speed limit. The fact that human-related factors are the leading causes of TAs in the UAE suggests that the intervention strategies should reduce the occurrence of human-related causes of accidents. The enforcement of strict rules and penalties is one of the ways through which the UAE authorities aim at reducing TAs (Parkes et al., 2010). However, the recent adoption of the advanced technology-based ITS in addressing the high cases of preventable TAs and the resulting fatalities is seen as a step in the right direction (Al Junaibi, 2016).

2.4 Causes of TAs

Based on the review of the literature, the causes of TAs can be classified into three main components such as road, vehicle, and driver (WHO, 2009). Aspects related to the drivers' behaviour emerge as one of the leading causes of TAs (Arien et al., 2013; Lavinskienė et al., 2015; Mansuri et al., 2015; Issa, 2016; Ratrout et al. (2017). Prentkovskis et al. (2010) noted that 33.4 % of TAs are associated with drivers' behaviour. Driving under the influence of alcohol is one of the causes of accidents attributed to driver's behaviour. Various researchers highlighted driver drunkenness as a significant contributor to the increase in TAs (Arien et al., 2013; Lavinskienė et al., 2015; Mansuri et al., 2015). Endriulaitienė et al. (2014) noted that aggression the most frequent determinant of risky driving behaviour that often leads to TAs.

Other driver behaviours such as improper stops and turns and poor interpretation of traffic signs and warnings also increase the risk of TAs (Al-Naami et al., 2010). Issa (2016) noted that poorly educated drivers who have limited knowledge regarding road safety issues are more likely to be involved in TAs. Ratrout et al. (2017) noted that a driver's knowledge of traffic rules determines the risk of TAs. Hasan et al. (2014) however noted that the drivers with a good understanding and knowledge of traffic rules deliberately ignore the traffic rules. Speeding is the other driver behaviour associated with an increased risk of accidents (BaHammam et al., 2014; Al-Tit et al., 2020). Failure of drivers to keep a safe distance, especially when overtaking, is also identified as one of the major causes of TAs (Parkin & Meyers, 2010; Pai, 2011; Walker et al., 2014). Evidence also indicates that TAs occurs as a result of distracted driving. Various factors contribute to distracted attention among drivers, with one of them being the use of mobile phones, such as texting while driving (Backer-Grøndahl & Sagberg, 2011). Evidence suggests that 25 to 50 % of all crashes are linked with driver distraction. Gonçalves et al. (2015) noted that sleepiness results in impaired attention resulting in TAs.

The road infrastructure also contributes to the increase in the risk of TAs. Evidence suggests that without effective planning, the road infrastructure can lead to traffic congestions and TAs (Wang et al., 2013). According to Čižiūnienė and Matijošius (2015), poor road visibility and the slippery roads contributes to increased cases of TAs. Evidence also indicates that bad weather contributes to the increase in TAs (Mansuri et al., 2015). Severe storms have been associated with an increased risk of TAs (Edwards, 1994; Edwards, 1999). Snowstorms, rains, and mist also contribute to an increased risk of TAs (Čižiūnienė and Matijošius 2015; Alshammari et al., 2017).

There are different causes of TAs as discussed in Table 2-17 below. The causes include driver-related causes such as driver behaviour and attitude. Table 2-17 also suggest that accidents can be caused by the factors associated with the road infrastructure.

Summary of the comparison of TAs in UAE and other countries

This section summarizes the comparison between TAs and the associated fatalities in UAE and the countries in Europe (UK and Lithuania), US, and the Middle East (SA and Kuwait). As shown in Table 2-18, TAs in the UAE are lower than the other four countries considered in this review. The findings presented in Table 2-18 shows that the number of accidents per population in the UAE is 0.1 %, which is lower compared to the where the number of % accidents per population in the US (1.8 %), Kuwait (2.5 %) and UK (0.2 %) in the year2013. Although TAs in SA is higher (n= 37,530, for the year 2013) than that of the UAE (n= 5124, for 2013), the % accidents per population for both countries is 0.1 % (Table 2-18).

Table 2-17: The Causes of TAs

Causes	Description
The impact of alcohol driving	The impact of Alcohol is considered a significant cause behind the RTAs each year (Arien et al., 2013).
The effect of drivers behaviour and attitude	According to WHO (2009), TAs consist of three main components: road, vehicle, and driver.
Distracted driving	A distraction can be caused by drivers diverting their attention from the driving and focusing on their activities (National Safety Council, 2015).
The consequences of speeding	Speeding is argued to be the major causative factor for accident injuries, deaths, and damage to properties (Ayuso et al., 2010).
Road infrastructure	Roads are planned to specific criteria such as traffic congestions, environment, travel time and travel cost (Wang et al., 2013).

Table 2-18: The comparison of the TAs in the UAE and other countries

Year	US (NHTSA, 2016)		UK (Department for Transport, 2016)		SA (Al-Turki, 2014)		Kuwait (Al-Eideh 2016)		UAE (Mohammed, 2015)	
	TAs	% Accidents adjusted based on population[1]	TAs	% Accidents adjusted based on population[1]	TAs	% Accidents adjusted based on population[1]	TAs	% Accidents adjusted based on population[1]	TAs	% Accidents adjusted based on population[1]
2011	5,338,000	1.7	151474	0.2	39,000	0.1	75194	2.4	6454	0.1
2012	5,615,000	1.8	145571	0.2	41,086	0.1	86542	2.5	6700	0.1
2013	5,687,000	1.8	138660	0.2	37,530	0.1	89527	2.5	5124	0.1

1 the yearly population of each of the country is based on the statistic documented by the World (https://data.worldbank.org/indicator/SP.POP.TOTL)

The comparison of the number of fatalities due to traffic TAs in UAE and the other three countries (US, Kuwait and SA) shows that the proportion of fatalities per reported accidents in SA and UAE are higher compared to the proportion of fatalities per reported accidents in Kuwait and the US (Table 2-19). As shown in Table 2-17, the proportion of fatalities per reported accidents in the UAE by 2013 was 12.7 %, which is higher than that of the US (0.5 %) and Kuwait (0.5 %). Table 2-20 also indicates an increase in the proportion of fatalities per reported accidents in UAE between 2011 and 2013, while countries such as the US and Kuwait have experienced a reduction. The observed high number of fatalities in the UAE despite the relatively low number of accidents constitutes this study's research interest.

Table 2-19: The comparison of the proportion of fatalities per reported accidents in UAE and other countries

Year	US (NHTSA, 2016)		Kuwait (Al-Eideh 2016)		SA (Al-Turki, 2014)		UAE (Mohammed, 2015)	
	Number of fatalities	Number of fatalities per reported accidents	Number of fatalities	Number of fatalities per reported accidents	Number of fatalities	Number of fatalities per reported accidents	Number of fatalities	Number of fatalities per reported accidents
2011	32479	0.6	493	0.7	7,153	18.3	727	11.3
2012	33782	0.6	454	0.5	7,638	18.6	628	9.4
2013	32894	0.5	445	0.5	7,661	20.4	651	12.7

2.5 Possible Solutions for Avoiding TAs in Abu Dhabi

There are different solutions to avoid TAs, as discussed in Table 2-20 below. The reported solutions include addressing driver-related behaviour such as driving under the influence of alcohol, use of phones while driving and controlling speeding. Table 2-20 also identified the management of traffic network and patterns. (For more details, see Appendix B):

Table 2-20: Possible Solutions for TAs

Causes	Description
Ban on the Use of Handheld Devices during Driving	Handheld devices such as smartphones, tablets, etc. need to be unauthorized while driving (Ayuso et al., 2010).
Driving Under Influence of Alcohol	Alcohol is harmful to the drivers it weakens the driver’s ability to driver and concentrates on the road (Hassan et al., 2012).
Use of Safety Belt	Safety belts can help to lower fatal injury during the TAs (Hammoudi et al., 2014).
Airbags and Helmets	Combining shoulder or lap belts with air bags provides the best protection mechanism for vehicle occupants during the accident (Hatfield and Murphy, 2007).
Control Speeding	There are three ways of controlling speed such as narrowing, horizontal speed control, and vertical speed control (Abdelfatah et al., 2015)
Control Measures in Abu Dhabi	The UAE government has taken several measures to make sure the control and reduce TAs in Abu Dhabi (Ministry of Interior Statistics, 2016).
Managing Traffic Network	Road intersections forms the most critical attributes in determining the performance of road networks in cities. This makes traffic signals act as critical devices for controlling traffic in such intersections (Davara and Pandya, 2016).
Optimization of Traffic Patterns	The optimisation of traffic patterns through monitoring, network architecture, and control systems (e.g. lights, routes, access) are also essential for the reducing RTAs (Manner and Wunsch-Ziegler, 2013) in Abdu Dhabi.
Optimization of Road Networks	Road optimization entails the efficient use of available road infrastructure in order to accommodate the increasing demand of road use (Scellato et al., 2010). This requires the design of effective approaches to deal with the complex congestion networks in cities like Abu Dhabi.

2.6 Construction of Road Networks

The following Table 2-21 shows the previous studies contributions within the context of the construction of road networks and TAs. The first contribution relates to accidents caused by road congestion—the second contribution. The second contribution relates to the claims that congestion reduces the number of Tas. While the third contribution highlights the role of technology in reducing TAs (For more details, see Appendix C).

Table 2-21: Study Contributions toward TAs

Study Contributions	Findings
First Study Contribution	Road congestion is constantly increasing which causes TAs (Zhu and Roy, 2003; Xia, 2009; Johansson et al., 2011).
Second Study Contribution	This study group claims the congestion actually reduce the number of TAs because vehicle operate at slower speed (Bando et al., 1995).
Third Study Contribution	This study group claims that new technology (i.e. navigations, etc.) helps to reduce the TAs because it can provide more alternative paths or routes to destinations (Casas and Codina, 2005; Deakin and Frick, 2009; Salmon and Stanton, 2009; Velaga, 2009).

2.7 Intelligent Transport System

The following Table 2-22 shows some important ITS for monitoring and controlling road traffics. Table 2-22 indicates that ITS could be used to analyze different crashes, monitor and control traffic. The ITS identified in Table 2-22 include Geographical Information System, Real-Time Systems, Wireless Sensor Networks and AI (For more details, see Appendix D).

Table 2-22: List of ITS for Monitoring and Controlling Road Traffics

ITS	Descriptions
Geographical Information System	Several applications such as ArcInfo and ArcView can be used in the automation process of building the traffic topology network (Svitekin, 2006; Stanojevic et al., 2013). Other researchers stressed that GIS could be used to solve many traffic solutions claim that GIS systems can analyse different crashes on different lanes using a lane-by-lane basis on roads characterized by different lanes (Helfert et al., 2016).
AI	AI is being used at various fields, including traffic management, which can respond to the demands, optimize different online timing plans, and implement real-time control (Williams, 2008; Neider et al., 2010).
Real-Time Systems	These systems as aforementioned collect data in the real-time and analyse it using different types of approaches to monitor and control traffic (Cobo et al., 2014).
Wireless Sensor Networks	Wireless sensor networks control the flow of traffic using wireless sensors (Tay and Huang 2013).
CCTV	These can be installed at different hotspots in cities that are prone to traffic congestion (Queen and Albers, 2008).

2.8 The utilisation of high tech in the future cars to avoid driver mistakes

Various onboard technologies that provide effective assistance to the driver have been developed (Enzweiler and Gavrila 2009; Raju et al., 2014; Jaint et al., 2017). The technologies range from the safety mechanism, navigation aids, and other sensor technologies that increase the drivers' awareness of their surroundings and the road ahead. Some of the mistakes that often lead to accidents involve non-motorized road users such as pedestrians and cyclists (Olszewski et al., 2015; Hoxha et al., 2017). The accidents involving non-motorized road users are mainly caused by the inability of the drivers to detect oncoming dangers in a reasonable time (Bagheri et al., 2014). Sensor-based technologies and computer vision algorithms have been developed to solve the challenges associated with detecting pedestrian location and movement (Del Rosario et al., 2015; Acevedo-Avila et al., 2016; Heimberger et al., 2017). The technologies help in engaging automatic breaking or assist in autonomous manoeuvring to avoid accidents (Madni et al., 2018). The sensors that are used in the detection of pedestrians include radars, lasers scanners and infrared scanners (Bagheri et al., 2014). Sensors, which are capable of detecting the location of the pedestrians, have been developed. The sensors are mounted on the vehicles, and they alert the driver in case of an imminent danger involving a pedestrian (Enzweiler and Gavrila 2009; Guo et al., 2012). As demonstrated by Guo et al. (2012), the pedestrian detection technologies such as sensors operate through a two-step detection approach, with the first step involving identifying potential pedestrians. The approaches that can identify the candidate pedestrian include the AdaBoost algorithm and cascading method (Guo et al., 2012). The second step in the sensor-based detection of the pedestrians is the confirmatory step, where the sensors determine whether the candidate is a pedestrian. The approaches used in the confirmatory stage involve the elimination of the identified candidates that do not fit the description of a pedestrian, based on physical characteristics such as posture (Gavrila 2009). Examples of the confirmatory approaches used by sensors include support vector machine (Guo et al., 2012). However, Dollar et al. (2012) noted the anomaly in the pedestrians' detection technologies in their study that involved the assessment of 16 pre-trained high tech detectors. The researchers observed that the detectors have very low resolution and semi-occluded pedestrians. Gandhi and Trivedi (2007) also argued that the use of sensors is limited by poor visibility, especially in bad weather.

Radio communications technology is one of the recent technologies that solve pedestrian detection problems such as poor detection due to low visibility or close proximity to the pedestrian (Amin et al., 2016.). The radio communications technology provides drivers with an extended view, which is very important in detecting and preventing accidents in a situation where the danger is in the non-line-of-sight concerning the mounted sensor (Qi et al., 2006).

Recent developments have facilitated the use of WIFI communication technology in the detection of the pedestrian. The use of WIFI is accomplished through the communication between WIFI devices. WIFI-direct is an example of a wireless standard that allows the devices such as smartphones that have installed WIFI-direct to communicate. Therefore, the driver is able to detect the pedestrians through the detection of a WIFI signal from the pedestrian’s phone. However, the use of WIFI is challenged by the possible interference from other networks (Bagheri et al., 2014). According to Bagheri et al. (2014), the vehicle to pedestrian communication technologies are more effective in detecting the presence of pedestrians. Bagheri et al. (2014) suggest that the use of a multi-level approach, which utilises cellular technologies such as LTE is associated with greater adoption and reduced cost.

Cloud computing technologies have also been demonstrated as safety-enhancing technologies. The cloud computing option called VANET-Cloud, which has been proposed by Bitam Mellouk and Zeadally (2015) is one of the high-tech approaches that can be used in future cars in the prevention of accidents. According to Bitam et al. (2015), the VANET-Cloud technology function allows the onboard computer devices to communicate with the traditional cloud computing systems. The proposed VANET-Cloud technology is advantageous since it cuts on costs by utilising the already installed computer systems in the vehicles. The VANET-Cloud technology proposed by Bitam et al. (2015) is an improvement of the Vehicular Cloud that was earlier suggested Olariu et al. (2013). Some of the weaknesses of the earlier proposed Vehicular Cloud are the inability to use the traditional cloud resources and the inability to keep the system always switched on. Another technology related to the VANET-Cloud is the CROWN system proposed by Mershad and Artail (2013). The CROWN system depends on the roadside units to acquire the required cloud services and does not use the on-board computers, as is the case with the VANET-Cloud. Other cloud-based technologies that have the potential to improve navigation and reduce accidents in the future cars include the service paradigm called sensor as a service proposed by Zingirian and Valenti (2012) and the vehicular cloud networks, which include vehicular clouds, vehicles using clouds, and hybrid clouds (Hussain et al., 2012). One of the other key cloud-based technologies set to enhance road safety among drivers of future cars is the cloud-assisted systems for autonomous driving, such as the Carcel system. The use of the Carcel system, which uses the signals collected from the autonomous vehicle sensors and the roadside objects to avoid possible accidents involving pedestrians and other motorists, is associated with enhanced road safety. The VANET-Cloud system proposed by Mellouk and Zeadally (2015) is, however, the only cloud-based computing technology that can allow vehicular drivers to use the system in mobile and stationary nodes. The VANET-Cloud system has the capacity to improve the drivers' awareness of the possible collisions and how to avoid them while enhancing traffic management.

Although the vehicle to vehicle and the vehicle to pedestrian communication improves the detection of imminent danger, the ability of the drivers to react quickly and appropriately to an impending danger is key in the prevention of accidents (Jurecki and Stańczyk 2014). However, tension and inexperience can result in the inability of the drivers to act as required (Da Silva et al., 2014). Semi autonomous vehicles have been developed to limit drivers' mistakes in responding to the feedback from the vehicle to vehicle and the vehicle to passage communication. The semi autonomous vehicle technology consists of high-tech sensor, camera module, and raspberry pi (Raju et al., 2014). Raju et al. (2014) noted that the semi autonomous vehicles are capable of seizing the control of the vehicle upon the detection of the imminent danger and help the driver in avoiding the danger, after which the driver regains complete control over the vehicle. The semi-autonomous vehicle technology also limits the occurrence of accidents in highways by enhancing the adherence of the driver to the traffic rules. According to Raju et al. (2014), the semi-autonomous vehicle technology puts the vehicle to a stop in response to the traffic rules such as the red-light display. The technology is, however yet to implemented in mass production vehicles.

Advanced technologies that are aimed at improving anti-lock braking and the traction control system in future cars also offer the potential to enhance the prevention of accidents (Ivanov et al., 2015). By preventing the locking of wheels during braking, the anti-lock braking technologies enhance the braking performance and maintain the vehicle's stability during an abrupt stop. The traction control provides wheel skidding, enhancing the optimal acceleration and increasing vehicle safety by reducing instability (Ivanov et al., 2015). One of the advanced technologies in traction control is the super-twisting algorithm proposed by Kuntanapreeda (2015). The super-twisting algorithm is set to enhance traction control by facilitating the achievement of an appropriate wheel slip ratio, which increases the ability of the vehicles to handle the unexpected alteration in the tire-road frictions (Kuntanapreeda 2015). Senapati et al. (2017) described an intelligent braking technology, which enhances collision prevention by incorporating the steering and braking assistance system. Senapati et al. (2017) proposal is based on a self-regulated fuzzy control algorithm. The technology incorporates a short-range radar system that helps in the detection of the obstacles that are in front of the vehicle and based on the approximate collision time, the intelligent braking system is activated. In addition to engaging the intelligent braking option, the technology proposed by Senapati et al. (2017) also engages the steering control based on assessing the moving object. The system is set to prevent collisions by limiting the accidents caused by poor decision making due to panic by the driver.

The other technologies involve the high/low beam adjustment assistance, which aims at preventing accidents caused by dazzling lights from approaching vehicles. One of the proposed technologies includes the intelligent auto-dipping system proposed by Jaint et al., 2017. The technology automatically dips the beams of the host vehicle upon the detection of the head beams of the oncoming vehicles. The proposed intelligent auto-dipping system utilizes the real-time processing feedback of the signals from the oncoming vehicle by the USB web cam and Raspberry Pi to make the required adjustment to the beam (Jaint et al., 2017).

Adaptive cruise control technologies also have the ability to enhance vehicle safety by keeping a safe distance between vehicles. Dey et al. (2016) proposed the cooperative adaptive cruise control systems autonomously maintain small headway between vehicles that are moving at harmonised speed. The cooperative adaptive cruise control systems improve the already existing adaptive cruise control, which enables the vehicles to drive within a safe distance from a leading vehicle (Vahidi and Eskandarian 2003). Unlike adaptive cruise control, the cooperative adaptive cruise control systems form a platoon, which is facilitated by communication between vehicles. The adoption of cooperative adaptive cruise control systems is set to limit collision by eliminating traffic stream and the human errors that occur due to the difference in the driving behaviour and errors in a motorway driving.

Various technologies have been developed to tackle the accidents that occur due to the challenges associated with driving during the night, with the significant development being cameras to track pedestrians' presence and alert the driver of possible danger (Satzoda and Trivedi 2016). According to Kwak et al. (2017), far-infrared cameras can track the pedestrians during the night without being affected by the variation in the illumination since the cameras detect the pedestrians based on the changes in the thermal energy (Kwak et al., 2017). The vehicle detection using Active-learning during nighttime technology proposed by Satzoda and Trivedi (2016) has the ability to enhance the ability of a motorist to detect other motorists during the dark without the influence by the variation in the ambient light conditions. The technology can detect the breaking and turning light signals of close motorists to an accuracy level of 98 % (Satzoda and Trivedi 2016).

Various novel technologies have also been developed to prevent accidents during abnormal driving conditions such as speeding when manoeuvring sharp turns. One of the technologies is the use of a 3-axis gyroscope in enhancing the electronic stability control (Balachandran et al., 2016). Schnelle et al. (2017) have also proposed an electronic stability control technology that involves the compensatory and anticipatory components, which can help to keep the vehicle within the driver's desired path at different speeds. According to Schnelle et al. (2017), the technology offers an accurate steering wheel fit compared to the conventional geometric centreline. The other abnormal driving condition that results in accidents is driver's fatigue (Alonso et al., 2016). Novel technologies that detect driver's fatigue using steering wheel angles and automatically engage autonomous driving in case of fatigue have been developed (Azim et al., 2014; Lawoyin et al., 2015; Man and Hui-ling 2015). Li et al. (2017) proposed an online technology capable of detecting driver's drowsiness using the data collected from the cameras mounted on the vehicle. Li et al. (2017) demonstrated that the system has an accuracy of 78.01 %. The technologies that assist the driver during a few minutes or seconds before the accidents have also been developed and promise to reduce cases of accidents and possible fatalities. According to Sternlund et al. (2017), lane departure warning and lane-keeping aid technologies have the potential to lower the crash potential and possible injuries.

2.9 Use of AI in the management of road safety

According to Abduljabbar et al. (2019), AI has been used in the transportation sector to solve challenges such as the excessive emission of carbon dioxide, increasing road users, and road safety management (Abduljabbar et al., 2019). The broad definition of the term AI is the computer science that executes different roles; in the same way, human brains work (Abduljabbar et al., 2019). The development of AI can be traced back to 1956 to the failed work that was carried out by John McCarthy (Sadek, 2007). The exponential development of AI occurred between 1960 and 1970 following the exploration of the knowledge-based system, which uses human knowledge and pre-determined rules to give advice (Sadek, 2007). During the 10 year period (1960 to 1970), researchers also assessed the various aspects of AI using artificial neural network systems (Sadek, 2007). Unlike the knowledge-based system, the artificial neural network systems closely mimic the human brain, and it is made up of multiple layers of neuron connections. An example of the artificial neural network systems is the Feedforward Neural Network, which is made up of a unidirectional data movement system that includes the input, hidden and output layers.

The artificial neural network systems were mainly used in various fields such as health, manufacturing industries, and law (Abduljabbar et al., 2019). Despite the potential use of artificial neural network systems, AI was not immediately adopted until the 1980s, when the actual experimentation of the significance of AI begun (Abduljabbar et al., 2019). The information that was derived from the backpropagation algorithms that were assessed in the 1980s and mainly focused on the training of the artificial neural network systems to reduce prediction errors led to the concept of machine learning (Abduljabbar et al., 2019). The development of the concept of machine learning has enabled the coding of computers to have the human mind capabilities. Such abilities allow the computers to use access the big data and use the relevant feature of the data to address specific problems (Abduljabbar et al., 2019).

The examples of machine learning techniques include the Convolutional Neural Network, which is primarily used in image processing (Jin et al., 2017). The other technique is the Recurrent Neural Network, which is well suited for text and language processing (Zhang et al., 2017). The Convolutional Neural Network and the Recurrent Neural Network have several hidden layers, and the two networks are often termed deep learning techniques (Abduljabbar et al., 2019).

There are types of AI techniques that can be used to improve safe driving. One such technique is the genetic algorithm, which seeks to provide the best solution to a given traffic problem by selecting the best solutions from a population of solutions using a fitness algorithm (Koza 1998; Halim et al., 2016). However, the genetic program breeds computer programs in a tree-like manner and helps in the prediction of crashes in real-time (Xu et al., 2012). The genetic program based systems are also crucial in the prediction of the traffic and weather conditions and the provision of the best solution to address the traffic problems (Xu et al., 2012). For the case of crashes, the random forest models that use regression trees are used to identify the best option from the genetic program. Damousis et al. (2007) also indicated that the genetic program could be used to train other computer models used in predicting crashes.

The other AI techniques are based on the conditional random field, which is used to collect data such as speed, acceleration, lane position, and the distance from the incoming vehicle. The conditional random field is also used in developing systems capable of predicting unsafe driving conditions (Wang et al., 2010). The principal component analysis is the AI technique that can predict the likelihood of crashes. Systems built based on principal component analysis include the crash prediction application that uses the various description of the driver in the prediction of accidents (Singh & Dongre, 2012). Fuzzy logic is the other AI technique, which represents the decisions using the natural language. The Fuzzy logic facilitates computer-based thinking to resemble that of humans. Other techniques include the temporal difference learning technique and the support vector machine technique (Li et al., 2008; Halim et al., 2016). Figure 2-10 provides a summary of the AI techniques that are used in the prevention of road crashes and unsafe driving.

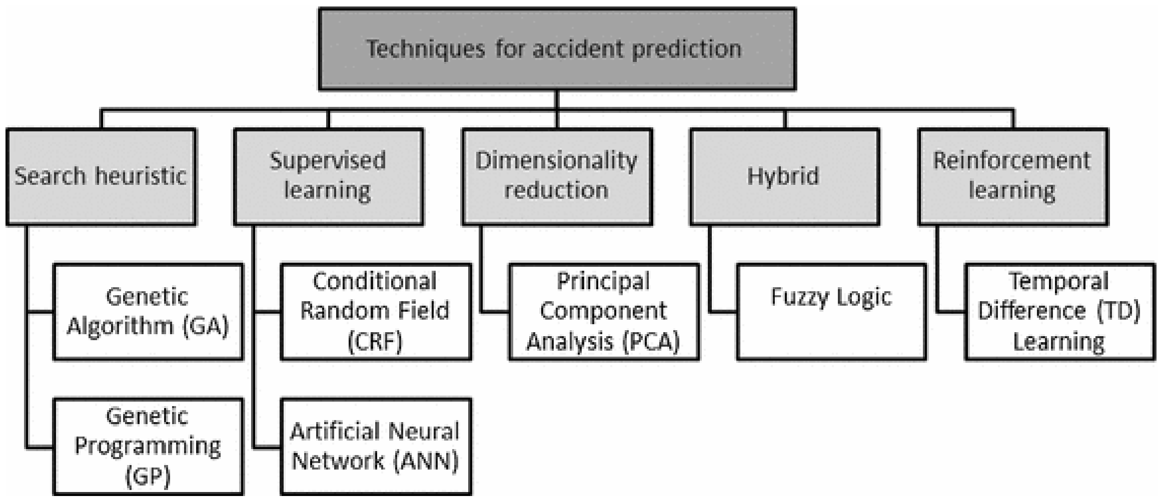


Figure 2-10: Description of the AI techniques that are used in enhancing road safety (Halim et al., 2016)

2.9.1 *Importance of the AI systems in traffic control*

Abu Dhabi has invested in strategies that are aimed at addressing traffic accidents. One of such initiatives is the expansion of the road network to address congestion (Davara & Pandya, 2016). However, the reduced congestion due to the expanded road network has not yielded the desired road safety outcomes (Mohammed, 2015). The number of vehicles increased and threatens to cause congestion, and the number of accidents that result in high fatalities continues to be reported (Mohammed, 2015). Given the intricate road network and a high number of vehicles in Abu Dhabi, automatic systems such as AI systems are likely to solve the road safety issue.

One of the important of the AI systems such as neural networks is computer-controlled vehicles. The unmanned vehicles are essential in enhancing road safety since they help to reduce the errors that occur due to human intervention. According to Tullio et al. (2017), unmanned vehicles eliminate human error in driving, which leads to increased highway safety and reduced congestion. The increased road safety due to the adoption of unmanned vehicles is because they are less susceptible to environmental stimuli, unlike human drivers. Hence the driving pattern is easily predictable and controlled (Tullio et al., 2017). The road safety features that can easily be controlled while using unmanned vehicles include the driving distance, acceleration and deceleration profiles, lane positioning, and vehicle headways (Tullio et al., 2017).

The main component of unmanned vehicles that help to reduce accidents is the vehicle safety integration system. The feature is made up of a series of digital cameras and sensors that help collect information from several vehicle angles. The sensors such as the short-range and long-range systems help vehicle communication and access information from maps, road condition messages, and emergency reports. The collected information is then processed by the computer that is fitted onto the vehicle, and the output used to make the driving decisions (Tullio et al., 2017). Some of the decisions that are made include lane departure, forward collision alerts and action to prevent accidents (Tullio et al., 2017). The advances in the AI such as the introduction of the vision-based DAS, which enhances the image processing by the computer system that is fitted to the unmanned has enhanced that ability of the vehicles to computerise real-time decisions, which is critical in the prevention of the occurrence of accidents (Tullio et al., 2017).

The other application of AI in addressing the road safety issues is through driver behaviour modelling (Lin et al., 2005). The drivers' behaviour, such as the handling behaviour, can be modelled using mental workload and the performance features (Lin et al., 2005). The modelling seeks to describe the behaviour of the driver when interacting with the vehicle and during the interaction with the environment (Lin et al., 2005). The use of AI in the modelling of the driver behaviour ensures the optimization of the roles of the driver, which includes supervision, control, actuation and detection of danger (Lin et al., 2005). The driver’s behaviour is important since most of the TAs in various countries are caused by human errors. The AI features that have been used in the modelling of driver behaviour include sophisticated artificial neural network architectures (Lin et al., 2005).

AI is also important in predicting the problems on the roads caused by weather or abrasion (Lendel & Štencl, 2010). The artificial intelligent systems that can be used to prevent accidents that are likely to be caused by bad weather include the traveller information systems and the Advanced Traveler Information Systems (Lendel & Štencl, 2010). The systems can collect information and warn the drivers of the bad weather and advise on the required speed in the various weather conditions (Lendel & Štencl, 2010).

2.10 Synthesis of the literature

It is evident from the assessed studies that road-related accidents continue to be reported across the different countries globally (Hooper et al., 2014; Yannis et al., 2014; El Bcheraoui et al., 2015; Jamille et al., 2017). Increased urbanization and traffic congestion in the major cities increases the risk of the rise in road fatalities. The deaths and injuries associated with traffic accidents are responsible for the high economic losses in the affected countries (Ministry of Interior Statistics, 2016). The evidence from the assessed literature shows that the major cities in the UAE such as the Abu Dhabi face serious road safety challenge (Al-Remeithi 2015; Al Junaibi, 2016). The few studies that have assessed TAs in Abu Dhabi point to the need to address the TAs to ensure continued economic growth and prosperity of the city and the country at large. To further understand the TAs and consider the challenge associated with TAs, the researcher assessed the situation in countries across the world that have similar road safety challenges as UAE.

The assessment of the trends of road-related accidents worldwide has shown that Abu Dhabi is not the only country with high cases of the TAs (Yannis et al., 2014; El Bcheraoui et al., 2015; Jamille et al., 2017). In the US, the deaths that occur due to TAs have been noted to have increased by 9.3 % between 2011 and 2015 (NHTSA 2016). Although the TA report from the UK shows a general slight reduction in TAs, it should be noted that there has been an increase in the reported TAs in the recent years such as in 2014 (Department of Transport, 2015). Evidence also shows that the number of road fatalities in the UK increased by 18.3 % between 2009 and 2016 (Department for Transport, 2016). Lithuania also has high TAs and is considered to have the 5th cause of death in the European nations (Gonçalves et al., 2015). Although the assessed literature indicates a steady decline in the number of TAs in Lithuania, the stagnation observed between 2014 and 2016 raises questions over the future road safety trends in the country (Lithuania Statistics Department 2016). The assessed literature also indicated that Saudi Arabia is one of the Asian countries that have high cases of TAs, and it is predicted to worsen (Al-Naami et al., 2010; Prentkovskis et al., 2010; Bendak 2011; Barrimah et al., 2012; BaHammam et al., 2014; Mansuri et al., 2015; Alshammari et al., 2017). The evidence further suggests that the TAs in Saudi Arabia may be higher than in countries such as the UK (Al-Turki, 2014; Mansuri et al., 2015). However, Kuwait is the leading country with the highest TA (Hajeeh 2012; Al-Eideh, 2016). South Africa, one of the most developed countries in the African continent, also faces serious traffic safety challenge (Vanderschuren 2008; Chokotho et al., 2013). Therefore, it is evident that the highlighted countries have a common problem and the governments of the respective countries need to put in place sufficient strategies to address the challenge.

Across all the highlighted countries, evidence suggests that human errors and violation of the traffic rules are the main reasons for the reported cases of Tas (Koushki & Ali, 2003; Al-Naami et al., 2010, Backer-Grøndahl & Sagberg 2011; Al-Eideh, 2016). The limited studies that assess the TAs in Abu Dhabi however did not allow the conclusive determination of the cause of TAs in the region (Hammoudi et al., 2014; Mohammed, 2015; Ochieng & Jama, 2015). Common road safety challenges across the highlighted countries make it appropriate to evaluate the approaches that the respective governments and the road safety authorities in such countries use in addressing the road safety issue. Of importance to this study is the AI approaches that are used to address the road safety issue. The literature assessment suggests that some of the highlighted countries have adopted various forms of AI to varying degrees (Mohammed, 2015; Tullio et al., 2017; Abduljabbar et al., 2019). However, the use and the effectiveness of IA initiatives in Abu Dhabi is not well understood. It is possible that if similar road safety problems cause the road accidents in Abu Dhabi as in the highlighted countries, one can use the findings regarding the AI utilization in such countries to recommend the adoption of such technologies in Abu Dhabi.

2.11 Research gap

The assessment of the evidence presented by the existing literature indicates that UAE has high number of accidents. The researchers that have studied the TAs in UAE have mainly compared the rate of accidents in the country to her neighbours and countries in the West. The existing studies have also focused on congestion in the country, focusing on the cities such as the Abu Dhabi.

It should also be noted that the TP department in Abu Dhabi has kept a record of the accidents in the area. The record provides, daily occurrence of accidents in the city, the causes, and where the accident occurred and the description of the car, driver and the condition of the road and the weather. Although various researchers have analysed the trends of TAs using the data for the TP department, there are limited studies that provide the recent trends of TAs and the causes in Abu Dhabi. It should also be noted that there are not studies that provide a projection of future trends of TAs and the causes in Abu Dhabi.

The assessed literature has also shown the importance of technologies such as AI in the management of the road safety. However, most of the existing studies are based on data from Western countries. Limited work has been done to demonstrate the importance of AI in addressing the road safety challenges that are unique to Abu Dhabi. Therefore, there is a need for further research into the area to develop more insights into how technology is used in the management of traffic in the UAE and the efforts that should be put in place to enhance its adoption.

2.12 Chapter summary

Based on the reviewed studies, it is evident that TAs present a major challenge in the UAE. The literature showed the number of accidents and deaths due to TAs in the UAE is higher than in other countries, this leads us to study why this rate is high and what could be the solutions. It has been observed that TAs are the second leading cause of deaths in the country, which illustrates the need to adopt appropriate strategies to address the problem. The review has also shown that despite the recent reduction in TAs, the number of deaths per accidents country still increases. A comparison with the developed countries such as the US shows that UAE registers a higher number of deaths per accidents. In contrast, the comparison with the countries in the Middle East such as Bahrain, Oman, Qatar, and Jordan reveals that UAE has a higher proportion of deaths per 100, 000 populations as a result TAs, which clearly shows the severity of the problem in the country. The challenge of TAs in the UAE is associated with the congestion the country's roads.

It is difficult to use congestion as the only factor contributing to TAs in most roads, but congestion offers insights into the severity and presence of certain car crashes. Therefore, congestion can influence different types of TAs thus; there is a connection between traffic volumes and accidents. The authors analysed the different flow parameters and discovered that eight traffic flow factors that to explain the relationship between the safety and condition of traffic flow. These included congestion in the interior and left lanes, the synchronised lane conditions, the volume level, the right lane perturbation, volume variation across different lanes, and the systematic volume change. Other factors included the conforming curb lanes, the synchronized interior lanes, and the flow in the left. Due to increasing traffic congestion in Abu Dhabi, the traffic controllers and transport planners can integrate various approaches to enhance the utilization of the existing road capacity. For instance, integrating adaptive control systems like SCOOT and SCAT approaches will reduce congestions, vehicle delays, and offer customized traffic management avenues. This approach, combined with other elements like GIS, CCTV, and GPS will offer the city a number of benefits. First, it will improve the management of customized congestion. Second, it will maximize the capacity of road networks in an efficient way. Third, it will provide a flexible communication avenue for traffic controllers. Fourth, it will improve traffic management, increase incident detection, and minimize vehicle emissions, and TAs.

The review has also shown that human factors contribute significantly to increased TAs in the country. It has been noted that the drivers' behaviour determines the risk of occurrence of accidents. As indicated in the reviewed studies, some of the risky driving behaviours such as negligence and the lack of respect for other road users can only be addressed by adopting approaches that target behaviour change such as education and the application of strict rules and fines and increased surveillance. However, some of the human-related factors that result in accidents in the UAE are due to errors that could be avoided if the drivers received early warning and were assisted in detecting the risk of crashes and collisions. The errors such as the failure to spot the crossing pedestrian or the failure to spot an oncoming vehicle due to bad weather can be avoided by adopting high-tech solutions. The use of technologies such as WIFI based communication can help the driver to detect the exact position of the pedestrian and to adjust the speed so as to reduce the risk of accidents. Sensors fitted on vehicles can also be used to detect the presence and the position of the pedestrian. The use of VANET-Cloud technology also helps to alert the driver of the oncoming vehicles and therefore assist in early decision making, which is crucial in avoiding crashes. The adoption of high-tech solutions not only warns the drivers of imminent danger but also help in initiating actions that lead to the avoidance of possible crushes and collisions. The high-tech sensor, camera module, and raspberry pi in semi-autonomous vehicles enhance the ability of the drivers to react quickly and appropriately to imminent danger. Such technologies are important, especially in a situation where the ability of the driver to react to possible danger is compromised due to stress, fatigue or illness. Some technologies that help prevent a collision by assisting the driver to adhere to traffic rules include adaptive cruise control technologies. The cooperative adaptive cruise control systems ensure that the accidents caused by factors associated with driving behaviour and errors are eliminated.

Although the adoption of advanced technology is associated with improved road safety and efficiency, little is known about the UAE's effectiveness. Therefore, it is important for further research to determine the importance of the technologies in the UAE’s traffic management.

3 Chapter Three – Methodology

The dissertation critically investigated and evaluated the different causes believed to be behind the growing TAs and congestion in Abu Dhabi Emirate roads. The main dissertation contribution is to create an intelligent system approach in Abu Dhabi to observe and monitor the smooth running of the traffic flow while helping to mitigate congestion and traffic crashes, especially those related to the road environment and road conditions. This chapter describes the descriptive observational methodology that was adopted in this dissertation. First, a general overview of the descriptive observational methods is followed by the detailed methodology used for this research.

3.1 Research Paradigm

The research paradigm refers to the guiding beliefs about how a given research problem should be solved (Tuli, 2010). As indicated by Kuhn (1962), the research paradigm simply describes the approach used by the researchers to understand and address problems. The beliefs regarding how the problems should be solved are informed by the researchers' perception of the world, which informs how they solve research problems (Tuli, 2010). In any given research, it is important for the researcher to determine the research paradigm, which then provides a basis for the development of the various research approaches. The research paradigm is characterized by ontological, epistemological and methodological dispositions (Aliyu et al., 2014).

Ontology is a term that is used to describe the nature of reality (Guarino, 1995). The term also explains how a given phenomenon exists in nature. The reality concerning the existence of a given phenomenon can be dichotomous or be influenced by the context (Mol, 1999; Beech & Cairns, 2001). The dichotomous reality is where regardless of the researchers investigating the phenomenon, each of the investigation arrives at the same conclusion (Beech & Cairns, 2001). However, the reported conclusions vary based on who carried out the researcher, the prevailing conditions during the research period, and other contextual factors for the contextually based reality. Dichotomous nature of reality refers to the positivistic ontology while the contextual based reality refers to the interpret ontology. The epistemology on the hand refers to how the researcher discovers the knowledge or learns about the reality regarding a given research phenomenon (Goldman, 2004). The epistemology is therefore concerned with how the researcher gets to determine the truth regarding the research phenomenon. The epistemological positions emerge from how researchers perceive reality. Therefore, there are to broad types of epistemological positions that a researcher can adopt, with one being the interpretive epistemology while the other is the positivistic epistemology (Stanley, & Wise, 2002).

One of the research paradigms is interpretivism, which is based on the belief that there is no single reality but the reality can adopt multiple forms based on the context and the researcher (Potrac, Jones & Nelson, 2014). Therefore, the interpretive position advocates for multiple and relative realities (Bevir & Rhodes, 2012). According to Lincoln and Guba (1985), the interpretivist position views realities as dependent on the various systems of meaning, resulting in the lack of single fixed meaning. Various characteristics define interpretivist approach, with one being the social construction of meaning rather than objective development of knowledge (Bevir & Rhodes, 2012). The social construction of the meaning places the knowledge and understanding of the research participants at the knowledge development centre (Bevir & Rhodes, 2012; Potrac et al., 2014). The research approaches that are based on the interpretive position consider the researcher as an outside observer and the researchers should not make any attempts to test the validity of the information and knowledge developed from the respondent's views. The interpretive researchers interact with the research participants and through the interaction they let the knowledge to develop gradually. Therefore, the interpretive position allows the use of the human experiences and perceptions in the development of the knowledge (Bevir & Rhodes, 2012; Potrac et al., 2014). The interpretivist position is usually adopted by the qualitative researchers who seek to study a social phenomenon using the experiences and the perceptions of the research participants. The subjective nature of the qualitative studies is associated with the interpretivist position adopted by the researchers (Lincoln & Guba 1985; Bevir & Rhodes, 2012; Potrac et al., 2014).

Although the interpretive position is flexible and allows for the development of knowledge-based on the first hand information, the approach cannot allow the development of generalizable conclusions (Lincoln & Guba 1985). As already noted, the interpretivist position leads to the development of truths that vary across the different context (Bevir & Rhodes, 2012). Therefore, the knowledge and truths developed from an interpretivist-based research are only applicable to the research context and perceptions. The interpretive research also affects the ambiguities inherent in human language (Lincoln & Guba 1985). It should be noted that the interpretive-based research mainly relies on the lived experiences as narrated by the research participants. Such narratives are usually presented using the language of the research participants. The choice of words and the meaning of the words that are used during narratives can result in ambiguities, which affects the quality of the research (Lincoln & Guba 1985). The presence of ambiguities in interpretivist-based research increases the risk of interpretive bias that emerges from the speculation of the meaning of the words and phrases used by the research participants (Bevir & Rhodes, 2012). The interpretive-based research is also limited in providing cause and effect and does not give findings that can predict future trends. It should be noted that interpretive-based research does not make any attempts of quantitative analyse the collected data using approaches such as frequencies or inferential statistics, however, the narratives that are obtained are just presented in detailed description (Potrac et al., 2014). Although the presentation of detailed description allows for identifying the fine details within the data, the findings do not provide statistical evidence of the relationship between the data and statistical projection of the future trends (Lincoln & Guba 1985; Potrac et al., 2014).

The positivist view is different from the interpretive position since it advocates for the presence of single regarding a given phenomenon. Contrary to the interpretive position, the positivist positions argue that reality is not influenced by the context or the research participants (Gollier, 2012). The interpretivist position argues that social science should be carried out using similar approaches and procedures as those used in natural sciences (Carson et al., 2001). According to Hudson and Ozanne (1988), the positivist position allows for the development of universal truth regarding a given research situation or phenomenon regardless of the beliefs held by the researcher. To obtain the single reality that does not change with the change in the context, the positivist position requires the researchers to adopt objective approaches that are based on a rigid and structured design. The positivist-based research first develops appropriate research hypotheses, which then informs the methodological approach. The methodological designs that the positivist researchers adopt allow for the analysis of the data using quantitative statistical approaches that include descriptive and inferential statistics (Hudson & Ozanne, 1988). Using the inferential statistical methods facilitates the researchers to determine cause and effect and make future predictions using the obtained data. The positivist-based research methodologies also incorporate approaches that can be used to test whether the validity and trueness of the obtained data. The statistical significance tests allow the positivist-based research methodologies to produce conclusive findings regarding a given research phenomenon (Hudson & Ozanne, 1988). It should be noted that positivist-based research methodologies advocate for the testing of the suitability of the research instruments used to determine their relevance. The rigorous research approach that is adopted by the positivist-based research methodologies ensures validity (Carson et al., 2001). Unlike for interpretative research, where the development of knowledge occurs as the research interacts with the research participants, the positivist-based researchers are detached from the research participants. The distance that the positivist-based researchers put between themselves and the research participants is important in ensuring that the researchers remain emotionally neutral, which is important in identifying and separating feelings and reason (Carson et al., 2001). The position occupied by positivist-based researchers also allows them to make a sound distinction between science and personal experience and the identification of facts.

It is evident that the use of the positivist-based methodological approaches facilitates the development of time and context-free generalizations. The focus on generalization by the positivist-based researchers is based on the belief that the individual actions, experiences, and perceptions result from the real causes. The positivist-based researchers also believe the research participants are independent entities who do not influence each other (Hudson and Ozanne, 1988). However, it should be noted that the positivist-based researchers are able to identify and present unique findings regarding each of the research participants. By developing generalized facts, the researchers fail to appreciate the fact that the knowledge and the perception regarding a given research phenomenon may vary across the different participants based on the differences in the lived experiences. The positivist position is usually adopted by the quantitative researchers who seek to test a given research hypothesis using objectively obtained and analysed data.

The research paradigm that was adopted in this research was informed by the research objectives, aims and beliefs of the researcher regarding the phenomenon of interest. As already stated, the study's primary objective was to critically investigate and evaluate the different causes believed to be behind the growing TAs and congestion in Abu Dhabi Emirate roads and how AI can be used to address the identified traffic problems. First, the researcher believes that the nature of the problem of TAs and congestion does not vary based on the researchers or contextual variations.

The researcher also believes the causes of TAs are real and can be quantitatively assessed. The language used in structuring the research objective also suggests that the researcher needs to collect and analyse the data using quantitative statistical tools. Based on the nature of the objective and the researcher's beliefs regarding the research phenomenon, it is evident that the most appropriate research paradigm is the positivist's approach. Therefore, the researcher adopted the positivist’s approach, which was characterized by the objective collection and analysis of the data.

3.2 An Overview on Quantitative and Qualitative Research Methods

Two major methods (qualitative and quantitative) can be used for this dissertation. However, the final selection of the method depended on the objectives of the research. It is generally believed that selecting the appropriate method is essential to achieve valid and reliable data (Bryman, 2012). The research was accomplished using predominantly quantitative methodology while the qualitative approach was used in analysis of the data from selected studies. Therefore the study used mixed methods approach. The choice of the mixed methods allowed the research to benefit from the advantageous of using the qualitative and quantitative methods. The use of quantitative research methods over the qualitative approach is associated with the fact the data collected from the qualitative approaches cannot adequately address the aim and the objectives of this research. Contrary to the intended research data (quantitative data), the qualitative approaches focus on the quality of given phenomena (Bernard and Bernard 2012; Creswell & Creswell, 2017). The focus on context dependents views makes the outcome derived from qualitative data subjective and often does not facilitate the development of a conclusive position regarding the research problem (Hussein 2015). The qualitative research methods are also not considered in this study since they are generally based on small sample sizes (Table 3-1), making the study outcome have limited generalizability (Bernard and Bernard 2012; Hussein 2015). Poor generalizability affects the extent to which a given research study, such as this study, can be used to solve practical challenges related to the research phenomenon, it is, therefore, essential to avoid it during the preparation and the execution of the research (Table 3-2). The other reason why the qualitative research approaches are not considered in this research is the poor reliability that is associated with qualitative study outcome (Creswell & Creswell, 2017). The limited reliability that is reported among the qualitative research is associated with the fact that the study outcome varies based on the individual perception and setting (Creswell and Creswell, 2017). The choice of the quantitative approach is informed by the researcher's belief regarding the research phenomenon and how knowledge and reality regarding the phenomenon can be obtained. This study relies on the positivist view, where a single truth regarding a phenomenon exists and that truth can be established using objective approaches. Therefore, the quantitative approach was adopted since the approach is objective in nature and enables the development of conclusive findings regarding the research phenomenon.

The use of the predominantly quantitative approaches in this research was affected by limited challenges that are associated with reliability and generalizability concerns (Table 3-1). The randomly selected and larger sample sizes compared to qualitative studies' sample sizes facilitate the development of research conclusions that can be generalized to the entire population (Bernard and Bernard 2012; Creswell and Creswell, 2017). The quantitative research data that is obtained from the quantitative research approaches can be subjected to statistical analysis, which enhances the reliability of the findings (Hussein 2015). Therefore, the adoption of the quantitative research approaches enhanced the use of the outcome in addressing the research problem since the outcome has high generalizability and reliability. The reliability of the quantitative research studies is also based on the fact, that unlike the qualitative approaches, which are guided by subjectivism, the quantitative studies are guided by objectivism (Table 3-1 and 3-2). The adoption of objectivism facilitates the study to obtain data that can be used to derive truths about a given research phenomenon. Objectivism holds that the findings obtained from a quantitative study represent the general truth about the research question across the population from which the sample was obtained (Bernard and Bernard 2012; Hussein 2015; Creswell and Creswell, 2017).

A quick comparison summary for the objectives and merits of the two approaches is outlined in table (3-1) :

Table 3-1: Comparison of Research Methodologies

Qualitative	Quantitative
Seeks to understand social phenomenon	Seeks to predict
Uses interview in data collection	Mainly use questionnaires
Seeks to discover frameworks	Examine existing frameworks
Data collected is in form of words	Numeric data is collected
Prioritises quality of respondent over sample size	Sample size is vital to the reliability of data
Subjective	Objective
Embedded knowledge	Public
Models of analysis: fidelity to text or words of interviewees	Model of analysis: parametric, non-parametric

Further clarifications about the research techniques of the qualitative and quantitative methods is summarized in table 3-2 below:

Table 3-2: Comparison of Research Methodologies

Qualitative Research Approach	Quantitative Research Approach	Mixed Methodology
Focused on words, such as feeling, emotions, and contents for analysis to understand the phenomenon under question.	It collects data in numerical or statistical form.	Use data collected using both formats, such as numerical or contents/ textual based data.
The data collection techniques include interviews, observations, content analysis, focus groups, action research and others.	The data collection techniques include surveys, hypothesis, ethnography, questionnaire, and others.	Use both tools for qualitative and quantitative approaches for data collection.
Less costly and available a significant amount of content for analysis.	It can help collect a large amount of data with limited effect on validity and reliability.	Using both advantages of qualitative and quantitative for more in-depth analysis.

Source: (Drever, 1995; Corbion and Strauss. 2008, p. 14; Muijs, 2010; Bryman, 2012; Creswell, 2013)

As indicated in Table 3-2, the choice of mixed methods research approaches is also associated with the fact that a large amount of data can be collected from the use of qualitative and quantitative tools (Creswell and Creswell 2017). Some of the quantitative research methods (such as questionnaires surveys) also facilitate collecting numerical data from a large group of respondents within a limited period while the qualitative tools can allow the collection of the textual data (Allwood 2012; Morgan 2013). The limited time associated with the use of quantitative research approaches is facilitated by the fact that, unlike the qualitative approaches, the researchers are not required to immerse themselves in the researched world. Therefore, one can use validated data collection tools that shorten the research duration (Allwood 2012; Morgan 2013; Creswell and Creswell 2017). The bottom line is that the use of the mixed methods approaches allowed for a more in-depth analysis of the research phenomenon.

3.3 The Research Strategy

The researcher was guided by positivist research philosophy in the adoption of the descriptive observational methodology. Positivist research philosophy allows the adoption of an objective approach in the investigation of research phenomenon. The philosophy also facilitates conclusive insights about the research phenomenon that can be generalized. In this study, the researcher is guided by the positivist research philosophy in the adoption of descriptive observational methodology (Hood et al., 1978) as the appropriate strategy for the objective evaluation of the study's research questions regarding the factors responsible for traffic crashes and road congestions. The descriptive nature of this study is informed by the research objectives, which aim to identify the existing status of vehicle accidents in Abu Dhabi and the factors associated with the crashes and the efforts towards the management of TAs (Kothari 2004; Williams 2011). It is evident from the study objectives that the current study does not look to control any variables or to have an intervention but only seeks to describe an existing situation as it is in the actual environment. The description of the study objectives rightly fits the descriptive research approach, which according to Fox and Bayat (2007) is a research that seeks to cast light on current issues by collecting data that comprehensively describe the research phenomenon. The fact that the descriptive research strategies do not require the researcher to introduce any intervention or manipulation makes the strategy closely related to the observational approaches, which does not involve the interference of the phenomenon by the researcher. The use of the descriptive observational strategy in this study enables the study to be conducted within a limited time frame (Fox and Bayat 2007; Williams 2011). The strategy also facilitates the collection of in-depth information that can act as a precursor for the subsequent research studies (Williams 2011). However, the use of descriptive strategy is often subject to the respondent's honesty. To address the issue of honesty, the researcher needs to develop robust data collection tools and base the study on large sample size (Kothari 2004; Fox and Bayat 2007).

The methods of data collection could be cross-sectional or longitudinal. The cross-sectional data collection approach is characterised by the collection of data at a single point in time (Rindfleisch, et al., 2008). The cross-sectional data collection normally involves respondents with varying demographic variables (Pinsonneault and Kraemer 1993). The longitudinal data collection approach, on the other hand, refers to the repeated data collection that is done over the appreciable length of time. The data collection in this study was accomplished using the cross-sectional data collection approach since the researcher intends to only collect the data once at a specific time. The use of the cross-sectional data collection approach is not associated with added costs or prolong period of data collection, which is evident in the longitudinal data collection approach (Rindfleisch, et al., 2008). The use of a cross-sectional data collection approach also allows the researcher to capture data on multiple variables relating to the research topic, which then facilitates the statistical analysis and the development of meaningful conclusions (Rindfleisch, et al., 2008).

In a given research, the timing of data collection is either prospectively, retrospectively or both. The prospective data collection approach is characterised by the following up of the respondents into the future to monitor a given variable. The following up of the respondents can be accomplished through the use of mail questionnaires or periodic interviews. The analysis of in the prospective study is usually based on the established baseline parameters (De Vaus and de Vaus 2013). The prospective data collection approach is associated with the longitudinal studies since the data collection is done at different points in time and the analysis is done once a sufficient number of events have been obtained (Johnson 2001). However, the retrospective data collection approach is based on the collection of data in the past (De Vaus and de Vaus 2013). Using the retrospective data collection approach, the researcher looks backwards in time and asks the respondents to recall some given aspects of the research phenomenon. The use of the retrospective data collection approach in research limits the time needed and the cost of researching since instead of following up with the respondents over time, the retrospective data collection approach enables the research to collect the data once. However, it should be noted that the use of retrospective data collection approach is associated with recall bias, and the researcher needs to ensure that data collection tool is well developed to address the challenge (Tashakkori and Teddlie 2003; De Vaus and de Vaus 2013). In this study, the data were collected retrospectively.

The data could be collected from primary or secondary sources. The main advantage of using the descriptive observational methodology is that the subject under study remains completely unchanged within its environmental context. Therefore, in this regard, there is no influence on the normal occurrence of the phenomena. The other advantage of using descriptive observational research design is that it provided a true snapshot of the phenomenon under observation and analysis. Saunders et al. (2009) argued that descriptive statistics enable the researcher to accurately reflect phenomena or situations. It is also important to note that the descriptive observational methodology agrees with the researchers philosophical standpoint. As already noted, the researcher believes that a single truth exists and that truth can be objectively assessed and the obtained truth can be generalized to the target population. The descriptive observational methodology is based on structured procedures, which ensure that the sample selection and the analysis of the data result in reliable findings that have high generalizability.

Saunders et al. (2009) developed a clear picture of traffic congestion in Abu Dhabi before collecting the information from both secondary and primary sources. This same design enabled the researcher to collect data from broad sources of information, including the literature about traffic congestion in developed countries, optimization of transport networks, and management of traffic systems. The survey method is the appropriate approach of collecting information in a descriptive observational research design (Saunders et al., 2009). The survey approach was mostly used in collecting primary information, solely designed for the sake of the research under consideration. This approach allowed the collection of real-time primary data, which allowed the researcher to collect and analyse data for descriptive and inference purposes.

3.4 Selected Research Methods

This study used quantitative research approaches for collecting both secondary and primary data.

3.4.1 *The baseline data for analysis*

The author used the desk research approach to analyse secondary data, obtained for the TP of Abu Dhabi. The term “Desk Research” is mostly used to describe the collection of secondary data because the process of data acquisition can be carried out without the need to be involved in any fieldwork (Hague et al., 2004). The desk research technique helps to collect information from existing sources such as TP data, company databases and sources, free data on websites, directories, magazines, and other published sources (Yadin, 2002). To undertake this research we obtained our data from the electronic database of Abu Dhabi TP Department. The Traffic Department of Abu Dhabi oversees three traffic regions: Abu Dhabi district, Al Ain District and the Western District (Turaif). Abu Dhabi district, the capital city, constitute the largest traffic district in the emirate of Abu Dhabi followed by Al Ain District and the Western District. The traffic crashes database of Abu Dhabi TP is composed of two datasets, the first included all serious motor vehicle crashes (MVCs) which took place in the Emirate of Abu Dhabi, during the period (2007-2017) and which resulted in injuries or deaths to occupants or other road users (pedestrians, motor cyclists or cyclists). The MVCs dataset included the detailed count of all circumstantial factors leading to the crash, MVC location by district, the driver information, the vehicle conditions, the road environment, the vehicles involved in the crash, the weather and road conditions, the nature of the factors which led to the crash according to Police investigators and the outcomes of the crash. The second database consisted of detailed reports on casualties involved in motor vehicle crashes in Abu Dhabi emirate during the same period. Casualties involved in MVCs were composed of people of all ages, both gender and all nationalities living in Abu Dhabi during the period. The data included detailed count of the sociodemographic characteristics of the casualties involved in MVCs during the period, their seating position before the crash, seatbelt use, the personal characteristics of the casualties, personal factors leading to the crash (alcohol or drug use), and the outcomes of the crash (injury, disability or death). Both datasets were in soft copy and were downloaded with special permission from the Abu Dhabi Police Head Quarters. The soft data was first downloaded from the mainframe computers of the

TP in Microsoft Excel format. The data was originally in Arabic and it was translated into the English language. Then after transferring the file to SPSS program version 25.

Descriptive and analytical methods of epidemiology were used to quantify the risk of injuries and deaths in MVCs in Abu Dhabi emirate and analyse the causes and mechanisms of the problem in Abu Dhabi, UAE. Frequency and relative frequency analysis was used for the descriptive analysis of the data. MVC risk factors was treated as independent risk factors for the model, including drivers' behaviours, socio-demographic characteristics of drivers, the environmental risk factors, the roadway, weather and other traffic conditions, vehicle condition, and a number of personal risk factors included in the database as described by Police, following investigations of the crash. The outcomes of MVCs, mainly injuries (by the severity of injury) and deaths, was treated as the dependent or outcomes for the model.

The complete records in the database consisting of more than 41,000 casualties involved in more than 24,000 crashes during the period 2007 to 2017 were used for the analysis. This database represents the complete census of MVC injuries and fatalities according to Abu Dhabi TP the period 2007 to 2017.

An additional data file to be acquired for the study is the data for non-injury motor vehicle crashes in Abu Dhabi. Non-injury crashes are investigated by a different Police Department in Abu Dhabi which attend to all crashes, reported not involving injuries. Such crashes represent the majority of traffic crashes in the emirate of Abu Dhabi, and usually, they count in hundreds if not thousands each day. These crashes are investigated and reported to determine the liability of the parties involved. The investigation approach is brief and less time to consume to allow for the smooth running of roadway traffic. However, the investigations usually carried out using tablet computers, configured to record GIS coordinates of the crash location, which provide a unique opportunity to identify the geographic locations where crashes tend to cluster in Abu Dhabi roads. As such, the database for non-injury crashes is vital for understanding and identifying the 'black spots' for motor vehicle crashes in Abu Dhabi.

3.4.2 *Collection of Primary Data*

A detailed survey questionnaire was used. The researcher ensured that the developed questionnaires are specific to this study by customising the questions based on the study's research aim and objectives (Farmer et al., 2016). The survey questionnaire assessed the Driver Behaviour. In order to study and evaluate the diverse attitude and their knowledge of the traffic rules in Abu Dhabi, the developed questionnaire used simplified questions, which mainly be made up of closed-ended questions where the participants were provided with varying number of choices for specific questions. The closed-ended questions used are the multiple choice questions, which were included in the 5-level rating scale questions.

The developed questionnaires were distributed to the target individuals (the selected police, drivers, and staff in the relevant department) across the different sectors in Abu Dhabi. A total of 400 questionnaires were printed and distributed, with 60% of the questionnaires being distributed in the Abu Dhabi sector, 25% of 400 questionnaires being distributed in Al Ain sector and the remaining questionnaires (15% of 400) being distributed in the Western sector. The distribution of the questionnaires was done during the low traffic times. Once the questionnaires were issued, the respondents were given a period of one week to fill them after which the researcher collected the questionnaires. The collection of the questionnaires was done by mail, the participants were facilitated to send the completed hard copies by mail. The participants who were unavailable to receive the hard copies of the questionnaires were issued via their e-mail accounts. Such participants were required to fill the soft copy of the questionnaire and send it back using the same e-mail to receive the questionnaires.

The Driver Attitude Questionnaire was first developed by Parker et al. (1996). The questionnaire is made up of 20 items that allow the drivers to fill in their responses regarding a range of prompts on their driving attitudes. In the Driver Attitude Questionnaire, driver attitudes are grouped into four categories: driving when drunk, over speeding, careless overtaking, and driving close to other drivers. The questionnaire items are scored based on a 5-point Likert scale that ranges from 1 referring to strongly disagree to 5, which refers to agree (Davey et al., 2006) strongly. The questionnaire has been widely used for the assessment of the attitude of the driver in different aspects that includes the assessment of the speed awareness training as indicated by Meadows (2002). The Driver Attitude Questionnaire has also been used by Burgess and Webley (2000) in the assessment of the general driver training programs. Anderson and Summala (2004) have also used the Driver Attitude Questionnaire to assess bicycle interventions. The Driver Attitude Questionnaire has also been used by Davey et al. (2006) in the determination of the fleet programs.

Based on the above uses of the Driver Attitude Questionnaire, it is evident that a questionnaire is an effective tool in assessing the driver's attitudes towards the major issues that determine safe driving and limit the occurrence of TAs. As evident from the above studies, the attitudes that can be assessed using Driver Attitude Questionnaire include drunk driving, the tendency of dangerous overtaking, driving beyond the stated speed limit and failure to keep a safe driving distance (Meadows 2002; Davey et al., 2006). High reliability has been observed in the use of the Driver Attitude Questionnaire in the assessment of various traffic rules violation with an alpha value of 0.67. (Davey et al.,2006).

The other questionnaire used in this study is the Driver Behaviour Questionnaire (DBQ), which assesses behaviours such as traffic rule violations slips and lapses that have since been added (Reason et al., 1990; Freeman et al., 2009). The addition has enabled the tool to distinguish between the ordinary violation and the violations that are commitment deliberately (Freeman et al., 2009). The various forms to the DBQ has a total of 30 items that assess the frequency various behaviours. The items are often scored on a 6 point Likert scale that ranges from 0, which refer to "Never" to 5, which refer to Nearly all the times (Harrison 2009).

Various researchers have used the DBQ to assess the nature of risky driving behaviours and likelihood of TAs (Mesken et al., 2002; Rimmo 2002; Lonczak et al., 2007; Stradling 2007). Researchers such as Nabi et al. (2007) and Chliaoutakis et al. (2005) have used Driver Behaviour Questionnaire to assess the association between the psychological attributes of the drivers and their tendency to be involved in traffic offenses. de Craen et al. (2008) have also demonstrated that the questionnaire can be used to determine the trend in the risky behaviour among the novice or the young drivers, while Schwebel et al. (2007) have used the questionnaire among the old drivers. The questionnaire has also been used to assess risky behaviour drivers of among bus and trucks (Sullman et al., 2002), four-wheel drive automobiles (Bener et al., 2008), and motorists (Horswill and Helman 2003). The use of the Driver Behaviour Questionnaire is associated with a high internal consistency of r= 0.65 for the four categories of items that deal with the different behaviour and the high test and re-test reliability of r= 0.75 (Harrison 2009). In this study, only the "Tendency for Violations" aspect of the Driver Behaviour Questionnaire was used. The aspect contains 8 items that assess the driver's behaviours, such as overtaking behaviour, the distance that is kept with the car in front, crossing of junctions, relationship with other drivers, speed limit, and drink driving.

The last questionnaire that was used in this study was the Driving Practice Questionnaire. The questionnaire has been mainly used to assess the association of risky driving and the TAs (Kidd and Huddleston 1994). The Driving Practice Questionnaire has been indicated to have high reliability as indicated by the high test scale coefficient of r= 0.87 and a test-retest correlation of r= 0.94 (Kidd and Huddleston 1994). The "r" refers to the reliability coefficient. The value shows whether the tool used has acceptable reliability. The reliability coefficients can be calculated using correlation statistics, which usually provides internal consistency. Statistical tools such as SPSS provide an automated way of calculating correlational statistics using its wide array of reliability analysis (Leard, 2018). The correlation statistics yield different values of r. An r value above 0.7 is considered acceptable wildax which is below 0.7 is either questionable, poor or unacceptable (Leard, 2018).

The Driving Practices Questionnaire that was used in this study is made of three categories of questions, with the 1st set of questions being made up of prompt on the common causes of road traffic collisions in the UAE. The options range from tiredness, close driving, over speeding, drink driving, violation of the traffic regulations, defective vehicles, inexperience, texting, and poor roads. The second category of item in the Driving Practices Questionnaire was made of 15 items, which were scored based on a 5 point Likert with 0 referring to very important and 4 referring to "Not at all important." The second set of questions also assessed factors such as tiredness, close driving, overspeeding, drink driving, violation of the traffic regulations, defective vehicles, inexperience, texting, and poor roads. The 3rd question prompts the respondents to indicate the importance of wearing a seatbelt in reducing the TAs. The responses to the 3rd set of questions are provided in three different percentages (25 %, 45 %, and 65 %). In addition to the described items, the questionnaire also contained prompts on the socio-demographic characteristics. The details that were sought included gender, educational level, age, and nationality (For more details, see Appendix I).

3.4.2.1 Pilot Survey

A single pilot study is the research study that aimed to conduct before distributing the actual survey among selected participants (Van Teijlingen and Hundley 2001). The aim of the pilot survey that was conducted in this study was to determine if the developed questionnaire works in the real world (Goodman et al., 1998; Van Teijlingen and Hundley 2001). The survey helped the researcher ensure that the participants understand the survey items and ensure that the understanding of the items is similar across all participants (Fottler et al., 2006). The researcher also used the pilot survey to determine whether there are survey items that make the respondents uncomfortable to answer. The discomforting items were removed from the list, or modified to ensure that the response to all items achieved. Through the pilot survey, the researcher was also able to determine the time that took the respondents to complete the questionnaires, which was important in planning the entire research work. A pilot study was not conducted on a large scale as compared to the actual survey but on a smaller scale. Therefore, this research also conducted a pilot study on the survey to identify the variables of interest and remove any issues that might face later in the survey from participants (Van Teijlingen and Hundley 2001).

The pilot survey was conducted immediately after all the items in the data collection tool have been developed. The process of the development of the items was based on the assessment of the relevant studies and the guidelines from the supervisor. The pilot survey was tested on a small fraction (n= 10) of the population that was researched. However, none of the actual research participants was included in the pilot survey. The individuals included in the pilot survey were representative of the actual population in terms of the age, gender, and other demographic variables such as the level of education. The use of a representative sample ensures that the pilot survey mirrors the actual research survey situation, which is key in adequate planning (Van Teijlingen and Hundley 2001; Fottler et al., 2006). The pilot survey sample population was recruited using a convenience sampling approach.

The pilot survey process involved the completion of the survey by the individual respondent by thinking aloud (Fottler et al., 2006). The process of thinking aloud requires the respondent (tester) to answer each item by reading it and telling the researcher what comes to mind upon reading it. The researcher then recorded what was indicated by the respondent. The researcher also observed how the respondents addressed each item. Through observation, the researcher was able to identify areas in which the respondent showed hesitation, which was indicative of a lack of clarity (Van Teijlingen and Hundley 2001). After the pilot survey, the researcher looked for patterns in the obtained feedback. The process involved determining whether there were cases that needed clarification, suggestions for wrong wording, the improper arrangement of the items and lack of meaning. Based on the feedback, the researcher amended the specific sections of the questionnaire to reduce the measurement errors during the actual survey, which enhanced the credibility of the research outcome (Van Teijlingen and Hundley 2001; Fottler et al., 2006).

3.4.2.2 Sample Size and Target Population

The study targeted a population made of the different stakeholders involved in the management of traffic in Abu Dhabi. The study targeted the drivers, the TP officers, and the staff in the traffic department in Abu Dhabi. The study was carried out in different areas of Abu Dhabi, such as the Abu Dhabi sector, Al Ain sector, and the Western sector. The study targeted a total of 400 from the identified population, which included 200 drivers, 100 police officers and 100 staff in the traffic department. The respondents that were included in the research include individuals aged above 18 years. The research included both male and female respondents. The selection was carried out irrespective of the social and economic status of the potential respondents. The sample size was selected based on the recommendations made by Kotrlik and Higgins (2001). The researchers develop a table (Appendix G) used to determine the sample size for the categorical and continuous data given margin of error, p-value and the t-value. In this study the margin of error of 0.05, a p-value of 0.5 and the t-value of 2.58 were considered. Based on the table in Appendix G, the sample size that the study targeted was 250.

The selection of the sample was based on a random sampling approach. The use of a random sampling approach is essential in ensuring that a representative sample is obtained (Seawright and Gerring 2008). Random sampling is also easy to execute and saves time. In this study, the selection of the respondents based on the random sampling approach was accomplished through the use of advertisements. The selection of the sample based on the selection of motorways. These were selected based on the data from different reports from the traffic department in Abu Dhabi. It was also based on different infrastructure units within the city. After selecting the motorways, the researcher distributed the advertisement leaflets to the drivers in the different motorways and the police officer patrolling those motorways. The advertisement leaflets was also distributed among the staff in the traffic department in the target region. The advertisement leaf was prepared and submitted to the ethics board for approval before their use to ensure that they meet the required ethical standards. In this study, the researcher ensured that adverts correctly inform the potential participants about the nature of the study and the role they played as the participants. The purpose of the study was also clearly stated and the criteria used in determining the eligible participants. The benefits of the research were also captured in the advert. The advert was prepared using simple language that was easily understood by the target population. In addition to the description of the study and the detailing of what was expected from the respondents, the advert also featured additional information such as the name of the institution, the name, and contact of the researcher. The advert directed the potential respondents on how and when to communicate their intention to participate. For this study, the respondents were asked to email their response to the researcher's email that was provided in the advert. The provided email also facilitated future correspondence between the researcher and the individual respondents. In case the use of adverts was not able to facilitate the obtaining of the required sample size, the individuals who were willing to participate were asked to invite their colleagues by forwarding the advert to them.

After the issuance of the adverts, the respondents who had communicated their interest in the study were issued with the informed consent letter through their emails. The study provided sufficient time for the respondents to read, understand and sign the consent letter. The researcher avoided any action that was likely to be construed as an act of coercion or influencing the respondent into signing the informed consent. The researcher was available to answer any questions that were asked by the respondents before signing the consent letter.

3.4.3 *Collection of secondary data from the existing studies*

The secondary data was collected from the existing studies that were retrieved from the selected databases. The databases that were searched included Google Scholar, Directory of Open Access Journal, PubMed, Education Resources Information Centre (ERIC), JSTOR, Academic Search Complete and ScienceDirect. The articles were searched using keywords that included the terms such as artificial intelligence, neural network, road crashes or traffic accidents, intelligent transport systems and transport management. The terms were combined in different combinations using the operators such as AND, OR and NOT. The articles were selected based on eligibility criteria that required the selected studies to be English-based, relevant to the research topic, published and based on selected countries that included the US, Lithuania, Saudi Arabia, South Africa, United Kingdom, Kuwait, etc. United Arab Emirates. The studies were selected regardless of the time of publishing. The selection of the retrieved articles was made in stepwise manners, which first sought to eliminate the duplicate articles. De-duplication was done by reading through the reference and the titles to identify the duplicated reference. The abstract of the remaining studies were then read to identify the studies that were relevant to the study. The abstract assessment focused on the objectives of the study and the report summary of the findings. The studies that were selected following the abstract assessment were then subjected to full text analysis where the articles were searched to determine the country of interest and further determine the relevance of the study. The studies that were selected following complete text analysis were then used to extract the data that was used in this study. The extraction of data in this study was carried out by reading through the article while highlighting the texts that answer the question relating to the use and effectiveness of AI in the management of TAs. Textual data that were obtained were then subjected to analysis.

3.5 Data Analysis

For data analysis, the analyses that were carried out included the determination of means and standard deviations for the various demographic variables and quantitative data. Frequency statistics such as percentages were used to describe the causes of TAs and congestion and the traffic challenges facing Abu Dhabi. Chi-square was also carried out to determine whether the factors significantly influenced the frequency of accidents. Trend analysis was undertaken using the data for the period 2007-2017 to analyse the vehicular trends of MVC in Abu Dhabi and determine whether they are increasing or decreasing, and forecast the future trends of MVC. Both SPSS Ver. 25 and Microsoft Excel tools were used in the analysis. The Microsoft Excel tools were used in the development of the graphical representations while SPSS Ver. 25 was used to carry out statistical analysis. The analysis of the data that was obtained from the different studies was carried out using a thematic approach. The approach involved the analysis of the relevant data from the selected studies to identify and group the data with related information into the same categories that were termed themes.

The thematic analysis approach is a qualitative data analysis method that allows the researcher to identify key findings within the collected data relevant to answering the research questions (Gavin, 2008). Unlike the statistical analysis approach, where the findings are summarised using numerical values and the determination of statistical significance, the thematic approach enables the researcher to identify and aggregate the texts that convey a similar message (Clarke et al., 2015). The thematic approach was carried out in five steps (Clarke et al., 2015). The first step of the thematic approach involved the reading and familiarisation with the data. Secondly, the researcher coded the data. The coding process involved the assignment of a specific colour to the text of interest (Clarke et al., 2015). The texts that were deemed to convey similar information were assigned similar colour. The codes were then assessed to aggregate those that were closely related to more significant categories. The developed categories were further assessed with the aim of grouping them into teams that described the same aspects of the research interest.

3.6 Validation of the findings

In this research, the researcher acted as the collector of the data and the analyst, which increased the chances of researcher bias (Miles & Huberman, 1994; Birt et al., 2016). To ensure that the findings presented in this research were reliable and represented the actual situation as reported by the participants, the researcher validated the findings by involving the participants in checking and confirming the findings as suggested by Birt et al. (2016). According to Birt et al. (2016), the validation of the analysed data by sending the participants' findings is termed participant validation or member checking. In this research, the researcher contacted five experts officers in Abu Dhabi who had been interviewed and requested them to give their opinion regarding the outcomes. Using this approach, the researcher sought to enhance the accuracy of the data by allowing the participants to point out extracts that they felt were inaccurate. Once issued with the analysed data, the participants were allowed to delete any information that was deemed extraneous.

The researcher understood that engaging the participants in validating the findings raises ethical questions regarding the protection of participants in research (Birt et al., 2016). However, since the study did not directly quote the participants or present the actual voice of the participants, there was little concern over the possible violation of the confidentiality principle (Birt et al., 2016). The researcher used a five-step process to ensure effective validation of the findings by the selected participants. The first step involved the preparation of a synthesized summary of the findings of the primary data analysis. The researcher then checked the eligibility of the participants to take part in the validation process, which involved the determination of contact details, availability of the participants, and willingness to take part in the validation. The third step involved sending out the findings along with a form detailing what the participants needed to do. The fourth step was gathering the responses, and the final step involved integrating the responses to the findings (Birt et al., 2016).

3.7 Ethical Considerations

This research involved interaction with participants from Abu Dhabi; therefore, an ethical consideration was taken much seriously. According to Corbin and Strauss (2008), ethical consideration is essential for the research, which involved interaction with a human because their information needs to be protected. Therefore, this research obtained a full ethical form before data collection.

This study adhered to confidentiality and ethical privacy guidelines. In this study the privacy requirement is understood as the regulation of the degree, timing and the context of sharing of the participants' details with the public or the third parties (Khanlou and Peter 2005; Giordano et al., 2007). The privacy requirement in this study is also informed by determining the means through which the researcher acquires the information about the participants during the recruitment process (Bulmer 2001; Khanlou and Peter 2005). Confidentiality, on the other hand, is concerned with the protection of the obtained data. Confidentiality mainly relates to the private data that is provided to the researcher by the researcher with the trust that they will not be divulged to third parties (Giordano et al., 2007).

The adherence to the subject's confidentiality and privacy in this study is guided by the two principles that include respect for persons and beneficence. This study understands the principle of respect for persons based on the fact that participants have the autonomy to exercise their freedom of choice to the fullest extent possible, and they hold the right to privacy and the choice to have their private information to remain confidential (Giordano et al., 2007). The principle of beneficence informs the adherence to the confidentiality and privacy requirement by arguing that it is by the adherence to the participants' confidentiality and privacy that one can limit harm to them (Walford 2005). The harm that can befall the participant includes social harms such as job losses due to leaked information or a deep in financial standing resulting from undue disclosure of the private information (Khanlou and Peter 2005). Psychological harm can also occur, which can include distress and embarrassment. The study also understands that the lack of the adherence to the confidentiality and privacy requirement can lead to unwarranted criminal or civil liability to the participants (Giordano et al., 2007).

The adherence to the privacy requirement in this study spanned the entire research protocol starting from the participant’s population, the recruitment approach, and the data collection process. Since the study involved participants from the police and the government employees, the study was keen to conceal their identity. The approach used by the researcher in identifying and contacting the potential participants also adhered to the need for participants' privacy, which was achieved through the use of acceptable methods such as advertisements and sending of introduction letter via colleagues. The study avoided recruitment methods such as the search for eligible individuals through the existing database. The participant's privacy was also considered during the data collection process. By adopting the use of questionnaires, this research addressed the concerns over the need to address whether the participant felt comfortable being interviewed (Bulmer 2001; Khanlou and Peter 2005).

Two-pronged efforts informed the adherence to the confidentiality guidelines in this study. One is through the deliberate efforts towards limiting the collection of data such as names, phone numbers, address, birth dates, race, gender, place of employment and the combination of the listed information, which make can easily be used to identify the participants. The study ensured that the participants were advised to avoid providing identifying details and whenever such information were collected, the researcher removed and destroyed such information as quickly as possible (Giordano et al., 2007). The second approach was to protect and maintain the identifiable data if collected. The study adopted adequate safeguards to ensure the identifiable data were protected. One of the safeguards included the coding of the questionnaire to prevent linking the information to the participant. The other safeguard measure was storing the data in a password-protected laptop that was only accessible to the researcher (Bulmer 2001; Khanlou and Peter 2005). The researcher also limited access to data only to need to know basis. The researcher also ensured that the information obtained from respondents was not shared with other third parties and was only used for the intended purpose. The data was also protected from possible leakage by destroying them once they are no longer needed (Giordano et al., 2007). The extent to which the study adhered to the confidentiality requirement was documented in the informed consent letter.

The other ethical consideration that was adhered to by this study was described in the informed consent (Wiles et al., 2005). Informed consent is essential for a study that involves human participants since it provides a means through which the respondents are informed about the study and what is required from them (Stanley et al., 1998). The informed consent that was used in this research was provided in the form of a letter that documents the study description and subject participation (Wiles et al., 2005). The informed consent letter required the subjects to sign it, upon reading and understanding its content voluntarily. The informed consent letter was detailed in addressing the specifics of the study, such as the potential risks and benefits, if any, and the contribution of the participants to the project goals (Wiles et al., 2005). To enhance the usefulness of the informed consent in educating the subjects about the study, the researcher was available to answer any questions and clarifications that were sought by the subjects. This was made possible by providing contacts of the researcher on the informed consent letter. It is important to note that the research did not take away the subjects' rights to quit the study at any point, even after signing the informed consent letter. The researcher informed the subjects about the data collection process, use, and security through the consent letter. Therefore, in this research, the informed consent letter acted as a tool through which the rights of the participants were protected by spelling out the researcher's expectation and researched and therefore enabling the participants to exercise their freedom.

One of the ethical issues that have been raised concerning informed consent is whether they live up to their promise (Sala et al., 2012). Questions have been raised about whether the consent letters actually disclose all details concerning the research (Wiles et al., 2005). In a bid to limit bias through blinding, some researchers have used deception to conceal the actual objectives of the study from the participants and only reveal them after the completion of the research (Goode 1996). The use of deception is usually prevalent among the researchers who use covert means to obtain the required data (Wiles et al., 2005; Sala et al., 2012). For some research such as qualitative research studies, which are characterized by changes in the research goals as the discovery process continues, full disclosure may not be tenable (Stanley et al., 1998). It is, however, essential to note that while some researchers have argued for the use of deception (Wiles et al., 2005), some regard deception as being not appropriate (Sala et al., 2012). This research study adopted full disclosure and therefore, no deception was incorporated into the informed consent letter.

This study did not comply with the need to observe anonymity. The ethical guidelines regarding anonymity indicate that the researcher should not identify individual subjects' information (Wiles et al., 2008). Anonymity ensures that the researcher cannot be able to trace the responses to a given individual. Although it is advisable to adhere to anonymity requirement, various researchers have shown that the guideline is flexible and can sometimes be sidestepped, especially in research in which the researcher becomes aware of the respondents' contacts and addresses during the recruitment stage (Wiles et al., 2008). Since this study engaged the participants through their email address in addressing issues related to the informed consent letter, the study was anonymous. However, as indicated, the study adhered to the privacy requirement and therefore, the participants' identity remained concealed from third parties (Wiles et al., 2008).

3.8 Chapter summary

The summary of the adopted methodological approach is summarised in Figure 3-1. The figure provides the methodological structure that guided the research.

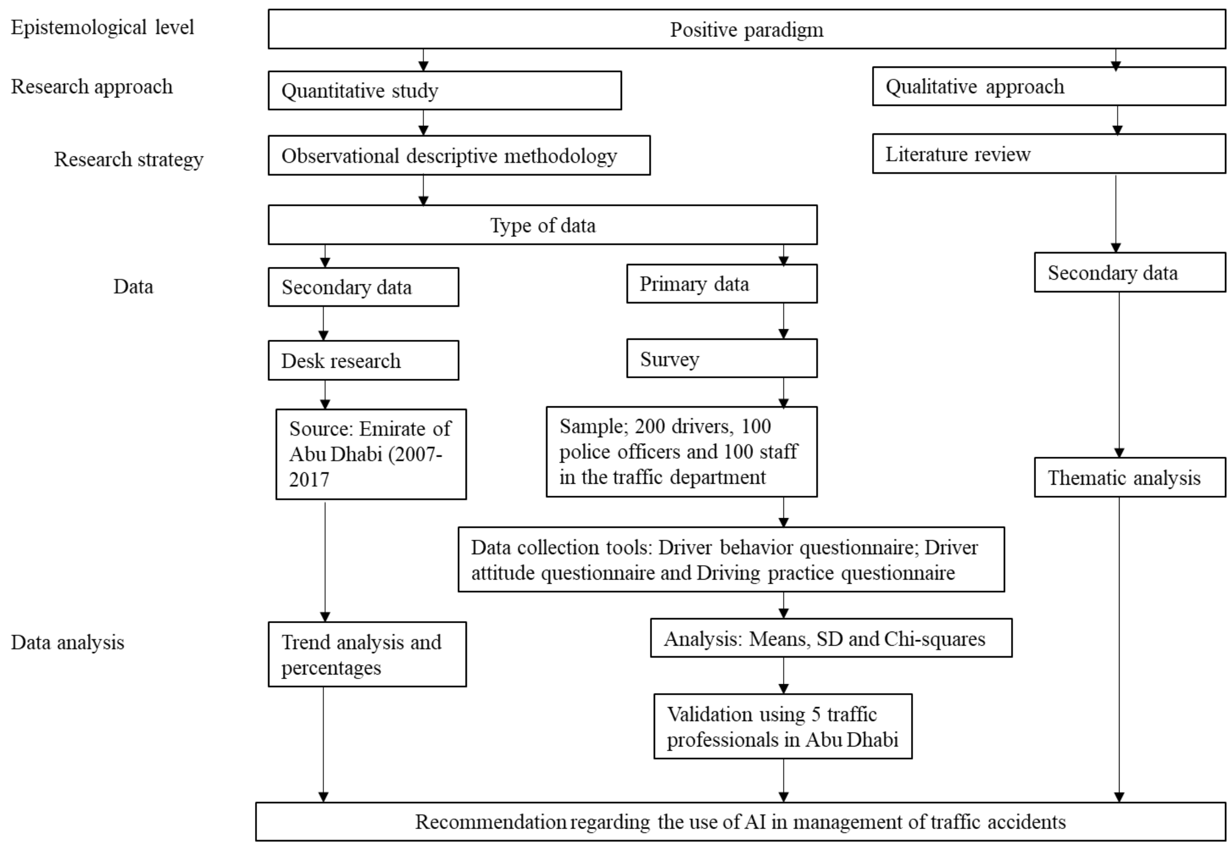


Figure 3-1: Summary of the methodological approach

4 Chapter Four- Results

In this section, the findings obtained from the analysis of the data collected are presented. First, the findings from the baseline analysis (analysis of the secondary data) are presented. The presentation of the baseline analysis findings includes the description of the demographics and accident trends between 2007 and 2017. The description of the projection of the future trends in the frequency of accidents in the three locations is also provided. The second section of the chapter provides the description of the findings of the findings of survey analysis, which include the description of the study demographics and the outcome of the analysis of the traffic problems in the three regions. Thirdly the findings relating to the use of AI in the management of the TAs is provided. The description of the use of AI involves the description of the outcome of the thematic analysis of the secondary data obtained from the selected studies. Finally, a summary of the findings is provided.

4.1Findings of the baseline analysis

4.1.1 *Study demographic*

Participants' age: A total of 25442 accidents were reported between 2007 and 2017, with 65.9 % (n= 16766) being from Abu Dhabi while 22. 9 % (n= 5851) were from Al Ain. The remaining 11.2 (n= 2825) were from the Western region. However, most of the accidents in Abu Dhabi involved individuals aged between 31 and 40 years (Table 4-1). The group age with the second-highest TAs (24. 6 %) in Abu Dhabi was that of 25 to 30 years, while that of 18 to 24 years had the third-highest TAs in Abu Dhabi (20. 6 %). Most of the accidents in Al Ain (29.5 %) were reported among individuals aged 18 and 24 years, while in the Western region, the highest TAs (27.0 %) occurred among individual aged 31 to 40 years (Table 4.1).

Table 4-1: TAs across the different age groups in the three different locations

	Age (years)								
Location	18 to 24	25 to 30	31 to 40	41 to 50	51 to 60	61 to 70	Greater than 70	Less than 18	Unknown
Abu Dhabi (n= 16766)	20.6 %	24.6 %	28.2 %	14.3 %	6.8 %	1.6 %	0.5 %	2.0 %	1.5 %
Al Ain (n= 5851)	29.5 %	21.2 %	23.2 %	12.1 %	6.1 %	1.9 %	1.0 %	3.7 %	1.2 %
Western Region (n= 2825)	18.9 %	21.8 %	27.0 %	15.3 %	8.2 %	1.3 %	1.6 %	4.0 %	2.0 %

Participant's gender: Among the 16766 accidents in Abu Dhabi, 10.8 % involved females while 87.7 % involved male victims. The remaining 1.5 % of the accidents in Abu Dhabi did not indicate their gender. In Al Ain, the female victims were involved in 7.7 % of 5851 accidents from the location, while 91.0 % of the accidents involved male victims. In the Western Region, 2.8 % of the accidents involved female victims, while 95.2 % of them involved male victims (Table 4-2).

Table 4-2: The TAs across the different gender groups

Location	Female	Male	Unknown
Abu Dhabi (n= 16766)	10.8 %	87.7 %	1.5 %
Al Ain (n= 5851)	7.7 %	91.0 %	1.2 %
Western Region (n= 2825)	2.8 %	95.2 %	2.0 %

Nationality of the drivers: Most accidents (41.4 %) in Abu Dhabi were mainly involved individuals of Asia nationality (Table 4-3). In Al Ain most of the accidents (44.1 %) involved individuals of UAE nationality. Most accidents in the Western Region (44.1 %) involved individuals of Asian nationality (Table 4-3).

Table 4-3: The number of accident across the different nationalities in the three different locations

	Unknown	Arab countries	Asian countries	GCC countries	Other countries	UAE
Abu Dhabi (n= 16766)	1.4 %	23.1 %	41.4 %	2.3 %	3.3 %	28.2 %
Al Ain (n= 5851)	1.2 %	17.1 %	31.2 %	4.8 %	1.4 %	44.1 %
Western Region (n= 2825)	1.8 %	18.1 %	44.1 %	6.7 %	1.6 %	27.5 %

Education level of the drivers: It was noted that most of the accidents (55.4 %) in Abu Dhabi involved individuals who were able to read and write with the majority having the highest level of education being secondary level of education (27.4 %). Those with University as the highest education level accounted for 9.7 % of all accidents in Abu Dhabi while the proportion of those with preparatory as the highest education was 2.8 %. Only 0.1 % of the accidents in Abu Dhabi involved individuals who had a master level of education while 0.0 % had PhD level. It was noted that 1.9 % of the accidents in Abu Dhabi involved who did not specify their education level. In Al Ain, it was noted that 40.4 % of the accidents involved individuals who were able to read and write but 1.5 % of the drivers from the location did not specify their education level (Table 4-4). The majority of the Al Ain accidents involved individuals who were noted to have secondary level as their having the highest level of education (38.6 %). Accidents in Al Ain that involved individuals with University as the highest education level accounted for 6.9 % of all the total TAs from the location while the proportion of those with preparatory level as the highest education accounted for 5.0 % of the drivers. Only 0.1 % of the drivers from Al Ain had either master level of education or PhD level of education. Table 4-4 also shows that most of the accidents (62.9%) in the Western Region involved individuals who were able to read and write with the majority having the highest level of education being the secondary level of education (21.2 %). The accident in the Western Region that involved individuals with University level as the highest education level accounted for 5.5 % while the proportion of those with preparatory as the highest education accounted for 3.4 % of all drivers from the location. Only 0.1 % of the accidents in the Western Region involved individuals who had a master level of education while 0.0 % had PhD level (Table 4-4).

Table 4-4: The education level of the drivers from the three different locations

	Unknown	Reads and writes	Master	PhD level	Preparatory	Primary	Secondary	University
Abu Dhabi (n= 16766)	1.9 %	55.4 %	0.1 %	0.0 %	2.8 %	2.8 %	27.4 %	9.7 %
Al Ain (n= 5851)	1.5 %	40.4 %	0.1 %	0.1 %	7.5 %	5.0 %	38.6 %	6.9 %
Western Region (n= 2825)	2.1 %	62.9 %	0.1 %	0.0 %	4.7 %	3.4 %	21.2 %	5.5 %

Marital Status of the drivers: The findings presented in Table 4-5 show that 45.8 % of the accidents in Abu Dhabi involved individuals who were married, and a similar proportion were single, while 6.0 % involved the divorced individuals. Table 4-5 also shows that 0. 3 % of the accidents in Abu Dhabi involved widowers/widows. In Al Ain, 48.0 % of the accidents involved single individuals, while 45.9 % were reported to be married. The divorced individuals accounted for 4.0 % of the accidents in Al Ain. Table 4-5 also shows that 0. 2 % of the accidents in Al Ain were widowers/widows while 1.9 % of the drivers from the location did not specify their marital status. As indicated in Table 4-5, 46.8 % of the accidents in the Western Region involved married individuals while 44.0 % involved single individuals.

Table 4-5: The marital status of the drivers from the three different locations

Location	Unknown	Divorced	Married	Single	Widower/widow
Abu Dhabi (n= 16766)	2.2 %	6.0 %	45.8 %	45.8 %	0.3 %
Al Ain (n= 5851)	1.9 %	4.0 %	45.9 %	48.0 %	0.2 %
Western Region (n= 2825)	2.6	6.3 %	44.0	46.8 %	0.2 %

4.1.2 *Frequency of TAs in the three locations between 2007 and 2017*

The trend of accidents in the three locations in UAE was determined by establishing the frequency of accidents throughout a period of 10 years. The findings presented in Figure 4-1 shows a general reduction in TAs across the three regions during the study period. As shown in

Figure 4-1, TAs in Abu Dhabi reduced from 1883 cases in 2007 to 937 cases in 2017 while in the Western region the accidents reduced from 336 to 145 during the same period. TAs in Al Ain did not change noticeably during the period under study. However, as shown in Figure 4-1, TAs in Abu Dhabi are consistently higher throughout the study period than TAs in the other two locations. The findings presented in Figure 4-1 also show that although there is a general decline in the TAs in the three locations, there are some periods during the study where there is an increase in TAs. The findings from Abu Dhabi show an increase in TAs from 1883 case in the year 2007 to 2165 cases in 2008 and 2207 cases in 2009. An increase in TAs in Abu Dhabi is also evident between the year 2012 (1394 cases) and 2013 (1439 cases). Despite the general lack of noticeable change in TAs in Al Ain, Figure 4-1 also shows increased TAs from 482 cases in 2007 to 675 cases in 2009. Another period of increase in the TAs in Al Ain is shown between the year 2014 (459 cases) and 2016 (645 cases), followed by a period of decline. The same trend was also observed in the Western region, with an increase in TAs being reported between the year 2007 and 2008 and between the year 2014 (174 cases) and 2015 (206 cases).

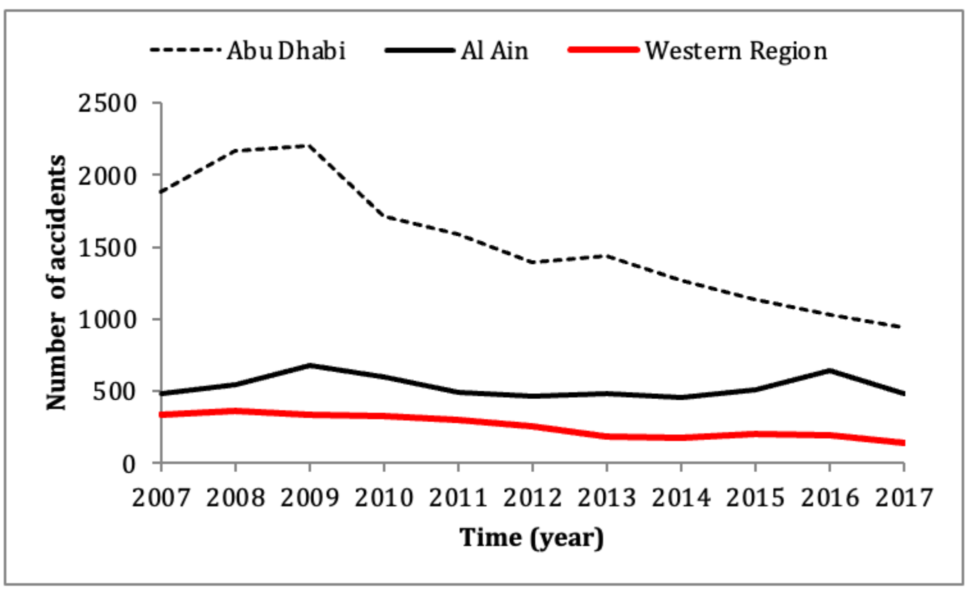


Figure 4-1: TAs in the three locations (Abu Dhabi, Al ain or The Western part) in UAE from 2007 to 2017

The projection of the future trends in the frequency of accidents in the three locations was carried out using Excel's forecast function. The findings presented in Table 4-6 shows a projected decline in TAs in Abu Dhabi between 2017 and 2024. According to the findings, only 49 cases of TAs will be reported in the year 2024, which is a drastic decline from a total of 937 cases reported in 2017. A similar trend in the projected total TAs was reported for the Western Region as for Abu Dhabi. However, for the Western Region, it was projected by the year 2024 there will be only 18 cases of accidents. For the case of Al Ain, the forecast outcome showed minimal change in the total TAs. As shown in Table 4-6, the Al Ain trend shows increased TAs in 2019 (N= 508) from the cases in 2017 (N= 484) followed by a projected minimal decline in 2022 (N= 498) and 2024 (N= 491).

Table 4-6: The frequency of accidents in the three locations between 2007 and 2017

Year	Abu Dhabi	Al Ain	Western Region
2017	937	484	145
2019	664	508	102
2022	295	498	36
2024	49	491	18

4.1.3 *Reasons for accidents*

4.1.3.1 Unlawful overtaking

The factors associated with the reported TAs in the three locations in UAE were determined by establishing the reasons per year per location. One of the reasons for accidents is overtaking in areas where one is not allowed to overtake. The findings presented in Figure 4-2 show changing TAs that are associated with unlawful overtaking across the three locations. During 2007 and 2011, TAs that occurred due to unlawful overtaking were high in Al Ain compared to the other two locations. However, the findings presented in Figure 4-2 shows an increase in TAs caused by unlawful overtaking in Abu Dhabi between 2012 and 2014, which result in the location registering the highest number of unlawful overtaking-related accidents. The findings presented in Figure 4-2 also show that the Western region has the lowest TAs caused by unlawful overtaking. In 2017, Abu Dhabi was noted to be the region with the highest TAs related to unlawful overtaking (Figure 4-2).

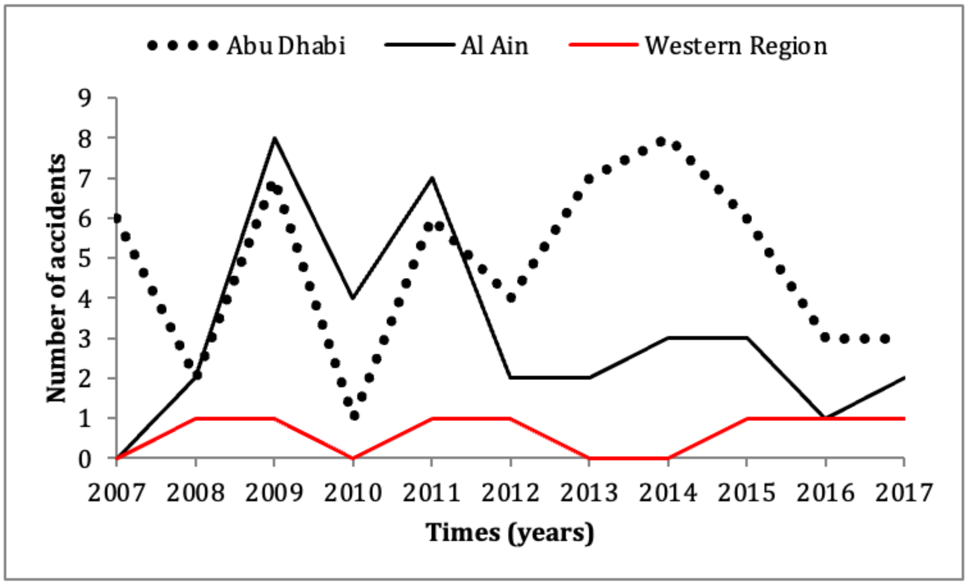


Figure 4-2: TAs caused by overtaking in a road where it is not allowed to overtaking

The projected future trends in TAs caused by overtaking prohibited areas in the three locations was carried out using Excel's forecast function. The findings presented in Table 4-7 show a projected decline in TAs in Al Ain and the Western Region between 2017 and 2024. As shown in Table 4-7, it is projected that only 1 case of TAs will be reported in the year 2024 in Al Ain and the Western Region. For the case of Abu Dhabi, the forecast outcome showed minimal change in TAs caused by overtaking in prohibited areas. As shown in Table 4-7, the Abu Dhabi trend shows a slight decrease in the total TAs in 2019, 2022, and 2024 (N= 5) from cases in 2017 (N= 6).

Table 4-7: TAs caused by overtaking in a road where it is not allowed to overtaking

Year	Abu Dhabi	Al Ain	Western Region
2007	6	0	0
2019	5	2	1
2022	5	2	1
2024	5	1	1

4.1.3.2 Failure to give priority to pedestrian crossing.

The other reason for reported accidents in the three locations is the drivers' failure to prioritise pedestrian crossing. As shown in Figure 4-3, during the year 2007, Abu Dhabi, compared to the other two locations, had the highest TAs caused by the drivers' failure to prioritise pedestrian crossing while Al Ain was the second highest. However, unlike the case in Al Ain where there is an increased TAs due to the drivers' failure to prioritise pedestrian crossing, such TAs reduced in Abu Dhabi from 223 cases in 2007 to just a single case in 2010. However a period of increase in the case in Abu Dhabi followed, with a total of 33 cases being reported in 2013. Al Ain has experienced a steady increase in TAs associated with the drivers' failure to prioritise pedestrian crossing from 25 cases in 2007 to 78 cases in 2012, which was then followed by a period of gradual decline to 60 cases in 2014. The Western region is the region with the least TAs caused by the drivers' failure to prioritise pedestrian crossing. Except for the year 2012 that was observed to have 3 cases, the Western region recorded zero or one TAs related to the drivers' failure to prioritise pedestrian crossing during the entire period. By the end of the study period, Al Ain was the period with the highest TAs associated with the drivers' failure to prioritise pedestrian crossing (Figure 4-3).

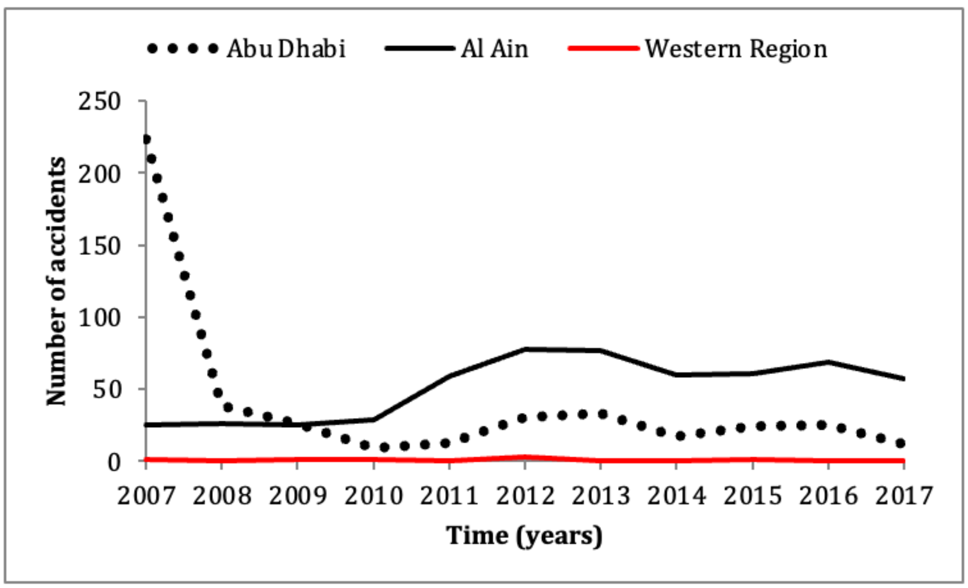


Figure 4-3: TAs caused by failure of the drivers to give priority to pedestrian crossing

The outcome of the projected future trends in TAs caused by the failure of the drivers to give priority to pedestrian crossing showed a decline in Abu Dhabi from 12 cases (2017) to zero cases in 2019 onwards to 2024. For the case of the Western Region, no cases were reported in 2017 and no cases were projected to occur between 2019 and 2024. For the case of Al Ain, the forecast outcome showed an increase in TAs caused by the failure of the drivers to give priority to the pedestrian crossing. The findings in Table 4-8 show that in Al Ain, it is projected that there will be increased TAs from 2019 (N= 85), 2022 (N= 99) and 2024 (N= 108).

Table 4-8: TAs caused by the failure of the drivers to give priority to the pedestrian crossing

Year	Abu Dhabi	Al Ain	Western Region
2017	12	57	0
2019	0	85	0
2022	0	99	0
2024	0	108	0

4.1.3.3 Driving distance

The findings of this study also suggest that the other reason for the reported accidents is the failure to leave enough space. As shown in Figure 4-4, accidents that occur due to the drivers' failure to leave sufficient space with the car in front are high in Abu Dhabi compared to the other two locations throughout the study period. Figure 4-4, indicates that in Abu Dhabi TAs associated with drivers' failure to leave sufficient distance reduces from the year 2008 (230 cases) to the year 2011 (153 cases) after which there a period a small rise to the year 2014 (187 cases), which then is followed a decline to the year 2017 (138 cases). Figure 4-4 also shows that Al Ain has the second-highest accidents caused by drivers' failure to leave sufficient distance. Such TAs in Al Ain is also shown to be characterized by periods of decline and rise with the notable increase being reported from the year 2008 (49 cases) to the year 2009 (71 cases) and from the year 2014 (32 cases) to the year 2016 (71 cases). The Western region has the lowest TAs caused by the drivers' failure to leave sufficient distance, with the highest cases reported in the year 2010 (35 cases) and 2015 (32 cases).

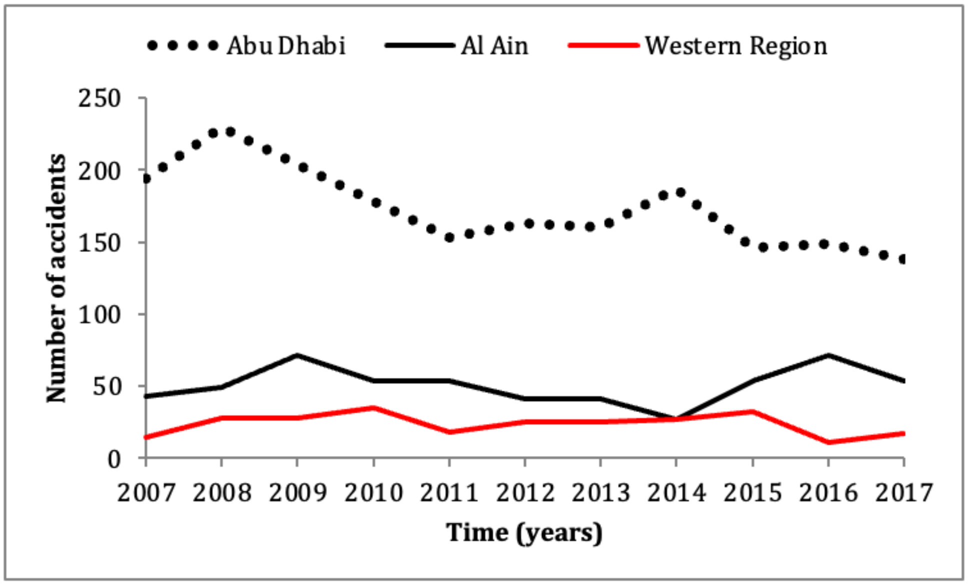


Figure 4-4: TAs caused by the drivers who do not leave enough space

The projection of the future trends in TAs caused by the drivers who do not leave enough space in the three locations was carried out using Excel's forecast function. The findings presented in Table 4-9 shows a projected decline in TAs in Abu Dhabi between 2017 and 2024. According to the findings, only 91 cases of TAs will be reported in 2024, which is fewer than 138 cases reported in 2017. For the case of Al Ain, the forecast outcome showed no change in TAs at the end of the forecast period. As shown in Table 4-9, the Al Ain trend shows a decrease in the total TAs in 2019 (N= 52) from the cases in 2017 (N= 54) followed by a projected minimal increase in accidents in 2022 (N= 53) and 2024 (N= 54). As shown in Table 4-9, the Western region trend shows increased TAs in 2019 (N= 20) from the cases in 2017 (N= 17) followed by a projected minimal decline in 2022 (N= 19) and 2024 (N= 18).

Table 4-9: TAs caused by drivers who do not leave enough space

Year	Abu Dhabi	Al Ain	Western Region
2017	138	54	17
2019	125	52	20
2022	104	53	19
2024	91	54	18

4.1.3.4 Driving in the opposite direction

The other reason for the reported cases in the three locations in UAE is driving in the opposite direction. The findings presented in Figure 4-5 show that the Abu Dhabi region has the highest number of such accidents throughout 2007-2017. Unlike the other two locations, there is a general reduction in TAs caused by driving in the opposite direction in Abu Dhabi. However, the reduction of such as accidents in Abu Dhabi is characterized by periods in increase such as the one experienced between 2007 (12 cases) to 2009 (19 cases), 2010 (11 cases) to 2012 (13 cases), and 2013 (6 cases) and 2014 (9 cases). During the period between 2008 and 2014, the Western region has the lowest TAs caused by driving in the opposite direction, however by the end of the 2017, the region had the second highest number of cases (Figure 4-5). However, the difference in TAs caused by driving in the opposite direction in the three regions differed by not more than 3 cases.

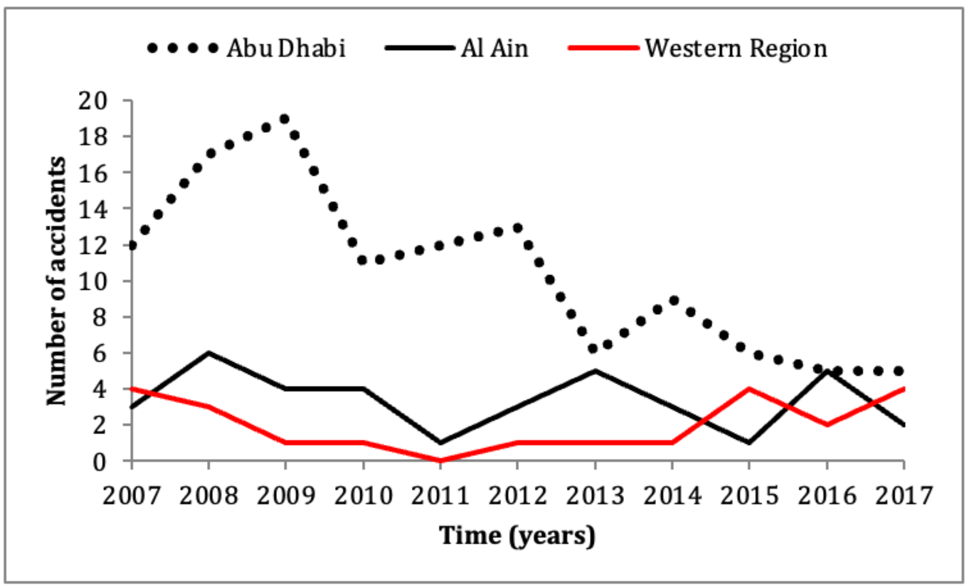


Figure 4-5: TAs caused by driving in the opposite direction

The outcome of the projected future trends in TAs caused by driving in the opposite direction showed a decline in Abu Dhabi from 5 cases (2017) to 2 cases in 2019 followed by zero cases from 2022 to 2024. The Western Region trend shows a decrease in the total TAs in 2019 (N= 2) from the cases in 2017 (N= 4) followed by a projected minimal increase in accidents in 2022 (N=

3) and 2024 (N= 3). Table 4-10 shows no projected change in TAs caused by driving in the opposite direction in Al Ain between 2017 and 2024.

Table 4-10: Projected TAs caused by driving in the opposite direction

Year	Abu Dhabi	Al Ain	Western Region
2017	5	2	4
2019	2	2	2
2022	0	2	3
2024	0	2	3

4.1.3.5 Driving through a red light

The other reason for the reported cases in the three locations in UAE is driving through a red light. The findings presented in Figure 4-6, show that Abu Dhabi region has the highest number of such accidents throughout the study period. However, there is a general reduction in TAs caused by driving through a red light in Abu Dhabi, which is unlike the other two locations. However, Figure 4-6 shows that there are periods in increase such accidents in Abu Dhabi with a notable example being the period between 2011 (208 cases) and 2013 (229 cases). Figure 4-6 also shows that during the period 2007-2017, Al Ain had the second-highest TAs caused by driving through a red light. However, the difference in TAs caused by driving through a red light in Al Ain and the Western region throughout the period 2007-2017.

The projected future trends in TAs caused by driving through a red light showed a projected decline in the cases in Abu Dhabi and Al Ain. As shown in Table 4-11, the Al Ain was projected to have zero accidents from 2022 onwards while Abu Dhabi region was projected to have zero accidents by the year 2024. The Western Region trend shows a decrease in the total TAs in 2019 and 2022 (N= 2) from the cases in 2017 (N= 4) followed by a projected minimal increase in accidents in 2024 (N= 3).

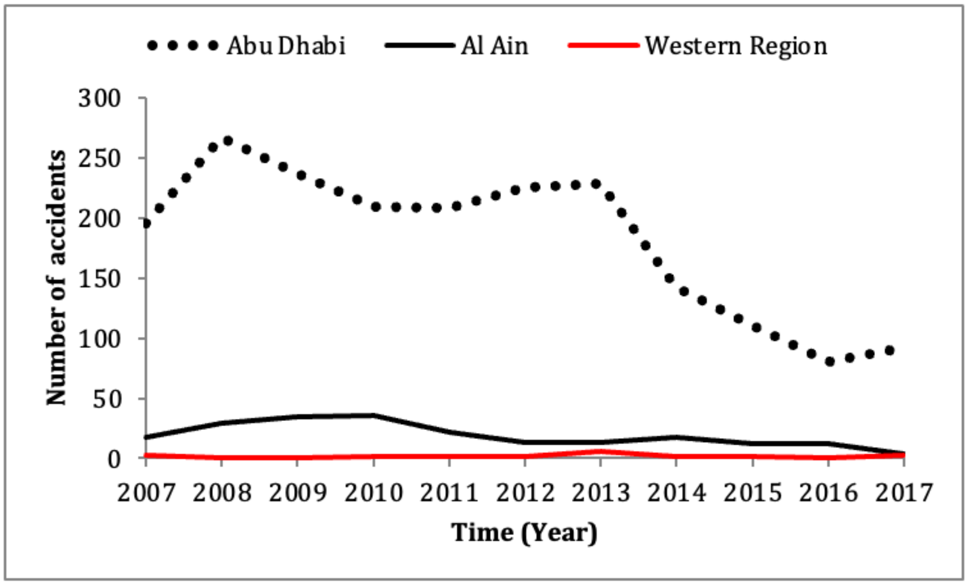


Figure 4-6: TAs caused by driving through a red light

Table 4-11: Projected TAs caused by driving through a red light

Year	Abu Dhabi	Al Ain	Western Region
2017	92	4	3
2019	69	3	2
2022	21	0	2
2024	0	0	3

4.1.3.6 Reckless driving

The other reason for accidents is driving with recklessness. The findings presented in Figure 4-7 show changing TAs associated with driving recklessly across the three locations. During the period 2011- 2013 and 2015-2016, TAs that occurred due to driving recklessness were high in Al Ain compared to the other two locations while Abu Dhabi had the highest numbers between 2013 and 2015 (Figure 4-7). The findings presented in Figure 4-7 also show that during the period 2007-2017, the Western region had the lowest TAs caused by driving with recklessness. In 2017, Al Ain had 3 cases of accidents associated with driving with recklessness, while Western region had 1 case. No cases of accidents due to driving with recklessness were reported in Abu Dhabi in 2017 (Figure 4-7).

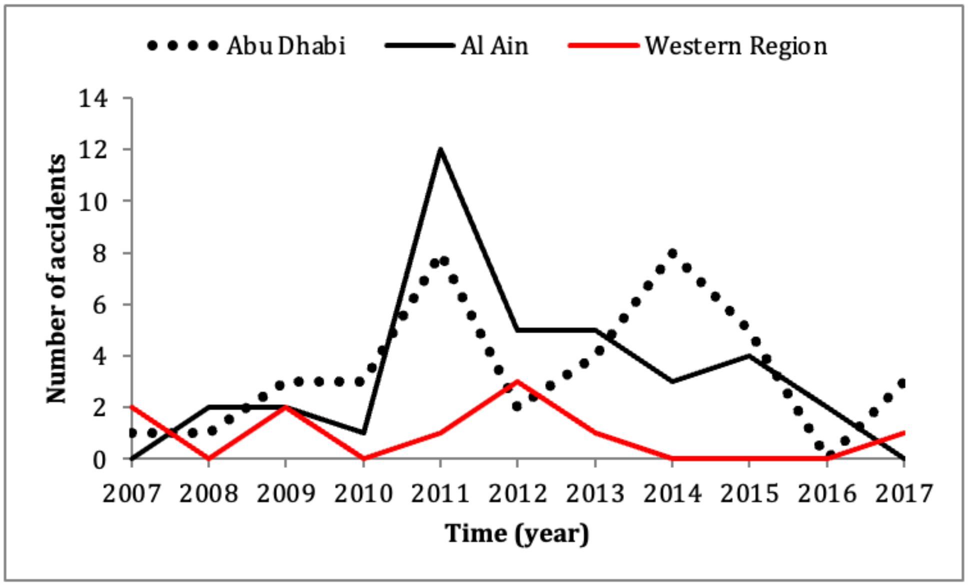


Figure 4-7: TAs caused by driving with recklessness

The findings presented in Table 4-12 shows that based on the obtained data, it is expected that TAs caused by driving with recklessness will increase in Abu Dhabi and Al Ain. By the year 2024, it is expected that TAs caused by driving with recklessness will increase to 5 in Abu Dhabi and 4 in Al Ain. However, the projected trends show that in the Western Region, there will be no cases of accidents caused by driving with recklessness from 2019 to 2024 (Table 4-12).

Table 4-12: Projected TAs caused by driving with recklessness

Year	Abu Dhabi	Al Ain	Western Region
2017	3	0	1
2019	5	3	0
2022	5	4	0
2024	5	4	0

4.1.3.7 Driving without a license

The other cause of accidents in the UAE is driving without a license. As shown in Figure 4-8, TAs committed by drivers who do not have driving license increased. Figure 4-8 shows that between the year 2007 and 2012, there were no cases of accidents caused by drivers without a license in all three locations. However, the findings show a steady increase in the cases from 2013 to 2017. Abu Dhabi is shown to have high cases of accidents between 2013 to 2015 while between 2015 and 2017, Al Ain is shown to have the highest TAs caused by drivers without a license. In 2017 TAs caused by drivers without a license was 19 in Al Ain, 18 in Abu Dhabi and 2 in the Western Region (Figure 4-8).

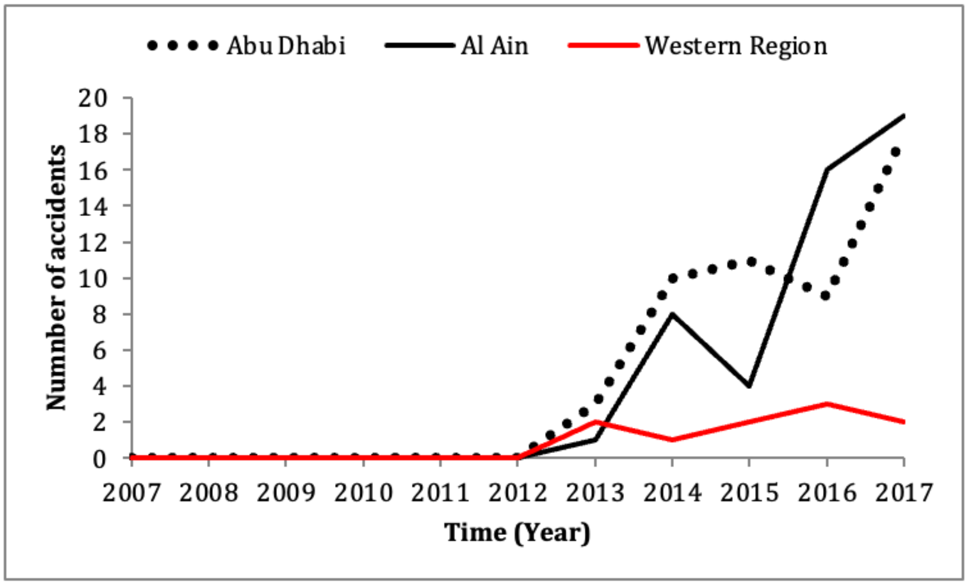


Figure 4-8: TAs caused by driving without a license

The findings presented in Table 4-13 shows that based on the obtained data, it is expected that TAs caused by driving without a license will increase in the three regions. In Abu Dhabi, Table 4-13 shows a projected increase in TAs caused by driving without a license to 24 cases by the year 2024 compared to 18 cases in 2017. In Al Ain, TAs caused by driving without a license are projected to increase to 25 cases by 2024, which is higher than 19 cases in 2017. The Western region trend shows an increase to 4 cases by the year 2024, which is higher than 2 cases in 2017 (Table 4-13).

Table 4-13: TAs caused by driving without a license

Year	Abu Dhabi	Al Ain	Western Region
2017	18	19	2
2019	16	16	3
2022	21	21	4
2024	24	25	4

4.1.3.8 Unsafe entrance to a main road

The other reason for the reported cases in the three locations in UAE is unsafe entrance to the main road. The findings presented in Figure 9, show that through out the period 2007-2017, Abu Dhabi region has the highest TAs caused by unsafe entrance to the main road. Unlike the other two locations, there is a general reduction in TAs caused by a unsafe entrance to the main road in Abu Dhabi. The reduction in such accidents in Abu Dhabi is characterized by periods of increase such as the one experienced between 2011 (30 cases) to 2013 (47 cases). During the period between 2007 and 2017, the Western region has the lowest TAs caused by driving in the opposite direction (Figure 9). By 2017 TAs caused by the unsafe entrance to the main road was 23 in Al Ain, 27 in Abu Dhabi and 12 in the Western Region (Figure 9).

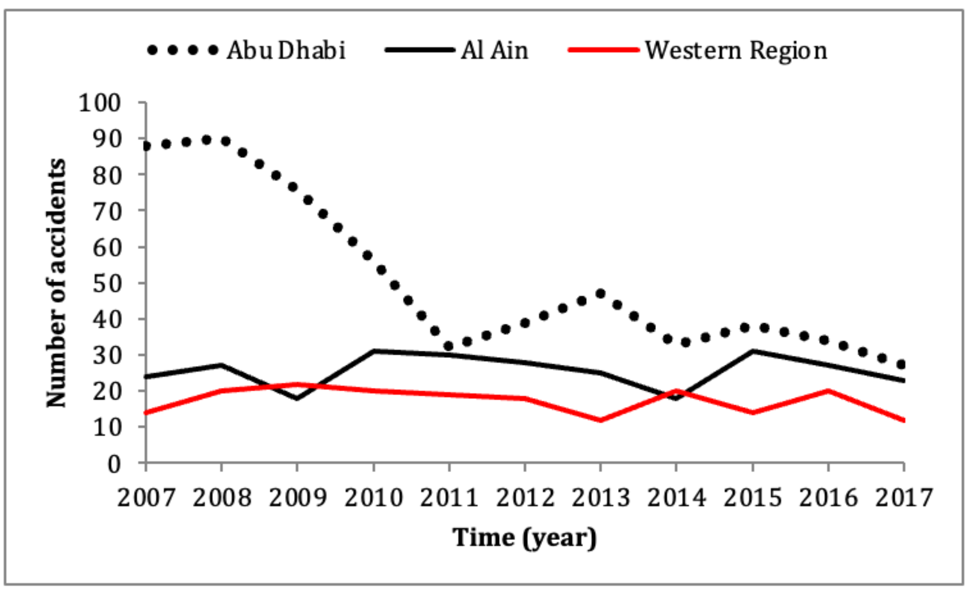


Figure 4-9: TAs caused by unsafe entrance to the main road

The outcome of the projected future trends in TAs caused by a driver entering the main road without making sure it is free showed a decline in Abu Dhabi from 27 cases (2017) to 8 cases in 2019 followed by zero cases from 2022 to 2024. In Al Ain, the TAs caused by a driver entering the main road without making sure it is free are projected to increase to 26 cases by 2024, which is higher than 23 cases in 2017. As shown in Table 4-14, the Western region trend shows increased TAs in 2019 (N= 15) from the cases in 2017 (N= 12) followed by a projected minimal decline in 2022 (N= 14) and 2024 (N= 13).

Table 4-14: projected TAs caused by unsafe entrance to the main road

Year	Abu Dhabi	Al Ain	Western Region
2017	27	23	12
2019	8	26	15
2022	0	26	14
2024	0	26	13

4.1.3.9 Entry into a forbidden place

The other reason for accidents is entry into a forbidden place. The findings presented in Figure 4-10 show changing TAs that are associated with the entry into a forbidden place. During 2007-2009 and 2010-2011, TAs that occurred due to the entry into a forbidden place were high in Al Ain compared to the other two locations, while Abu Dhabi had the highest numbers between 2012 and 2013 (Figure 4-10). The findings presented in Figure 10 also show that during the period 2011-2014, the Western region had no cases of accidents caused by driving with recklessness. However, In 2017 Abu Dhabi and the Western region each had 2 cases of accidents that occurred due to the entry into a forbidden place. No cases of accidents due to the entry into a forbidden place were reported in Al Ain in 2017 (Figure 4-10).

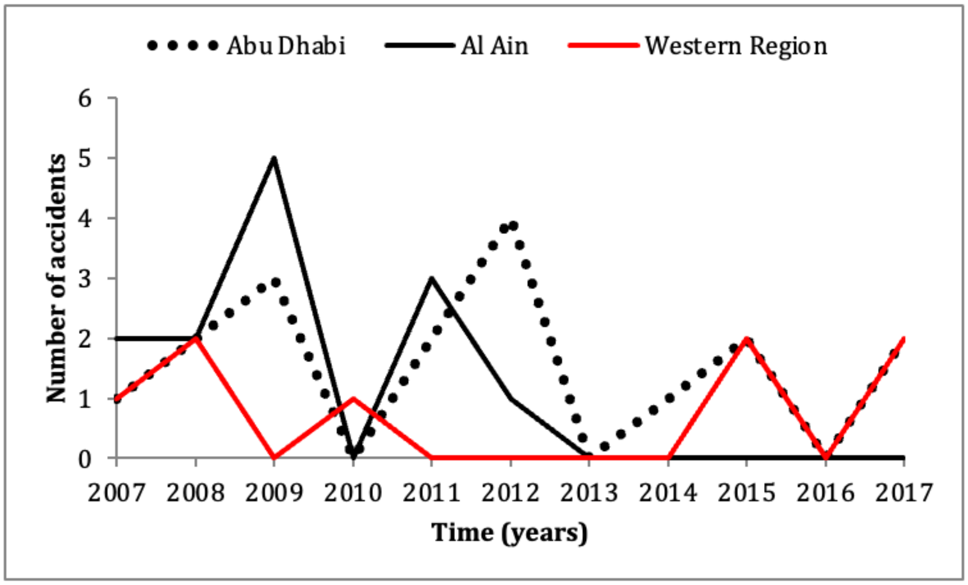


Figure 4-10: TAs due to entry into a forbidden place

The findings presented in Table 4-15 shows that based on the obtained data, it is expected that the TAs due to entry into a forbidden place will decrease in Abu Dhabi Western region to only case each by the year 2024. No accidents due to entry into a forbidden place are expected in Al Ain by the year 2024 (Table 4-15).

Table 4-15: Projected TAs due to entry into a forbidden place

Year	Abu Dhabi	Al Ain	Western Region
2017	2	0	2
2019	1	0	1
2022	1	0	1
2024	1	0	1

4.1.3.10 Over speeding

The other reason for the reported accidents in the three locations in UAE is overspeeding. The findings presented in Figure 4-11 show that the Abu Dhabi region has the highest TAs caused by overspeeding throughout the study period. However, unlike in Al Ain and the Western region, there is a general reduction in TAs caused by overspeeding in Abu Dhabi. However, Figure 4-11, shows that there are periods in increase accidents due to over speeding in Abu Dhabi such as the period between 2010 (27 cases) and 2012 (44 cases). Al-Ain and Western region are observed to have same TAs due over speeding except for the period 2009-2012 where Al Ain is shown to have the second-highest TAs caused over speeding. Figure 4-11 shows that in 2017 TAs caused by overspeeding was 2 in Al Ain, 4 in Abu Dhabi and 1 in the Western Region.

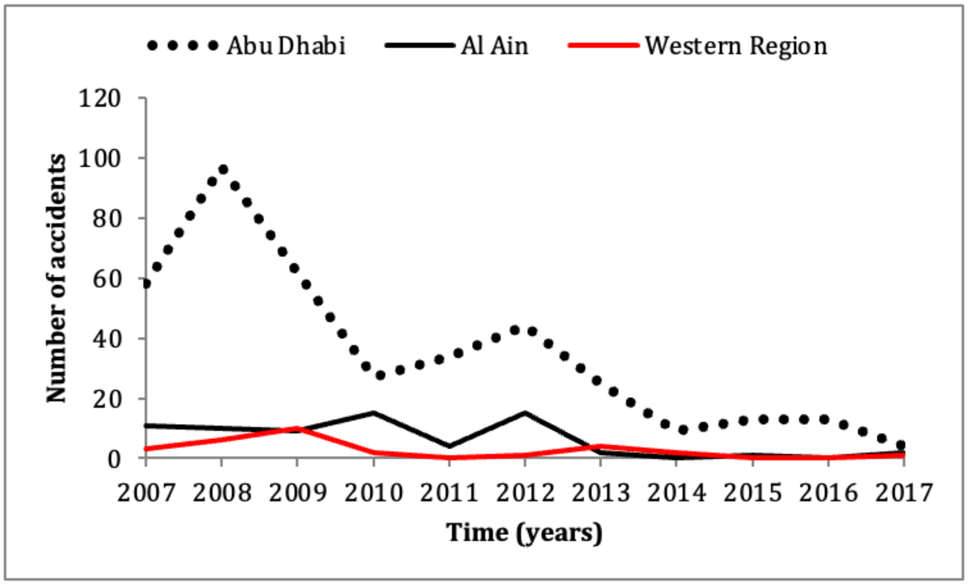


Figure 4-11: TAs due to over speeding

The projection of the future trends in TAs due to over speeding in the three locations was carried out using Excel's forecast function. The outcome shows that no accidents due to over speeding are expected in any of the three regions by the year 2024 (Table 4-16).

Table 4-16: Projected TAs due to over speeding

Year	Abu Dhabi	Al Ain	Western Region
2017	4	2	1
2019	0	0	0
2022	0	0	0
2024	0	0	0

4.1.3.11 Fatigue and sleepiness

The other reason for the reported accidents is fatigue and sleepiness. The findings presented in Figure 4-12 show changing TAs that are associated with fatigue and sleepiness. During 2007 and 2011, TAs that occurred due to fatigue and sleepiness were high in Western region compared to the other two locations while Abu Dhabi had the highest numbers between 2012 and 2014 (Figure 12). Al Ain is also shown to have had the highest TAs that occurred due to fatigue and sleepiness between 2014 and 2015. The findings presented in Figure 4-12 also show that in 2014, the Western region and Abu Dhabi had the same number of cases of accidents caused by fatigue and sleepiness. However, in 2017, the Western region had the highest cases (7 cases) while Al Ain had 4 accidents due to fatigue and sleepiness. Only 2 cases of accidents due to fatigue and sleepiness were reported in Abu Dhabi in 2017 (Figure 4-12).

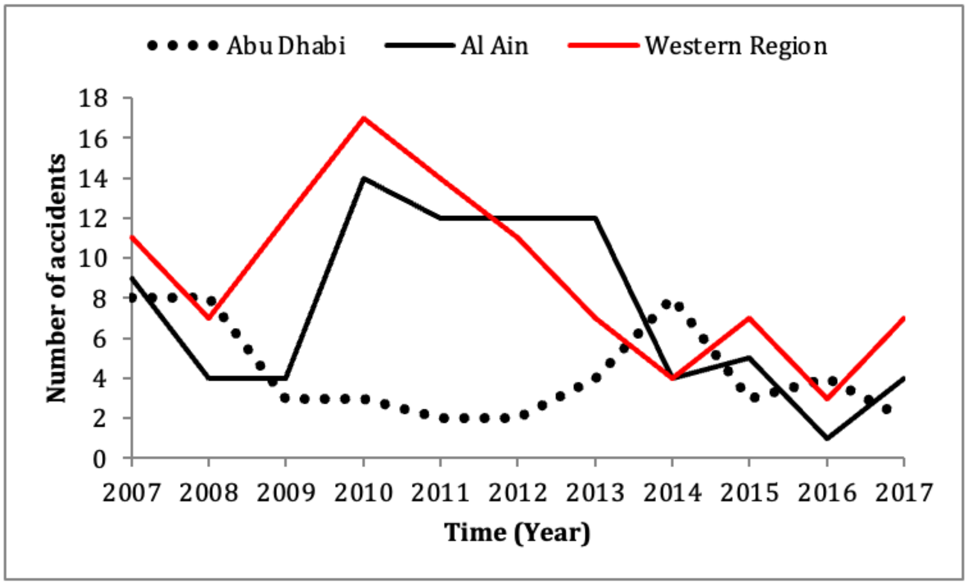


Figure 4-12: TAs due to fatigue and sleepiness

The findings presented in Table 4-17 shows that based on the obtained data, it is expected that the TAs due to fatigue and sleepiness will decrease in Abu Dhabi to only one case by 2024, which is lower than the cases reported in 2017 (2 cases). Cases in Al Ain are also expected to drop to only one case and a drop to zero cases in the Western region by 2024 (Table 4-17).

Table 4-17: Projected TAs due to fatigue and sleepiness

Year	Abu Dhabi	Al Ain	Western Region
2017	2	4	7
2019	2	4	4
2022	1	2	1
2024	1	1	0

4.1.3.12 Unsafe reversing

The other reason for the reported accidents in the three locations in UAE is unsafe reversing. The findings presented in Figure 4-13 show that the Abu Dhabi region had the highest TAs caused by unsafe reversing throughout the study period. Figure 4-13 also shows a general reduction in TAs caused by drivers unsafe reversing in Abu Dhabi. Figure 13 also shows that there are periods of increase in accidents in Abu Dhabi, such as the period between 2012 (7 cases) and 2014 (17 cases). Al Ain and Western region are observed to have relatively unchanged trends in TAs due to drivers unsafe reversing except for 2012 in Al Ain no accidents associated with drivers unsafe reversing were reported. Figure 4-13 shows that in 2017 TAs caused by unsafe reversing was 3 in Al Ain, 7 in Abu Dhabi and 1 in the Western Region.

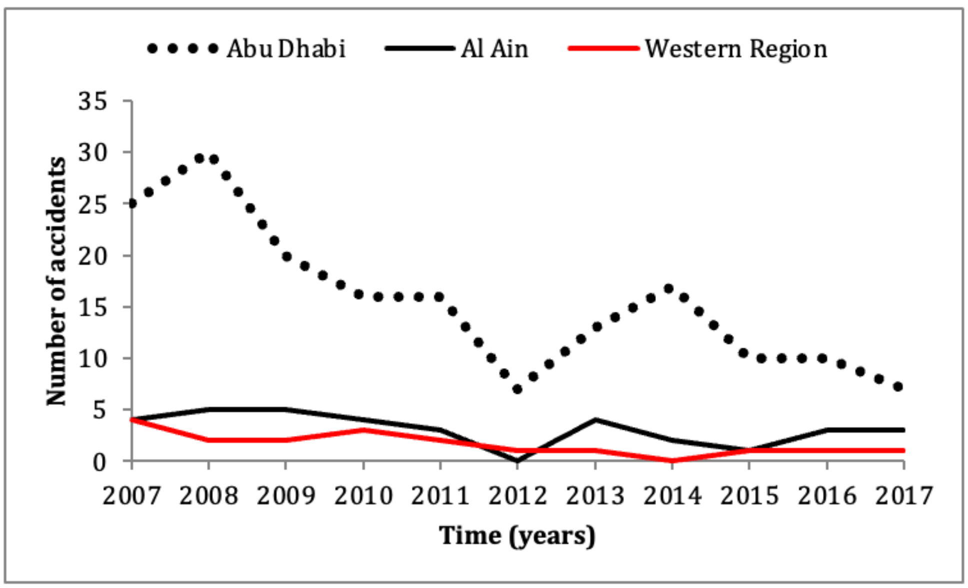


Figure 4-13: TAs caused by unsafe reversing

The findings presented in Table 4-18 shows that based on the obtained data, it is expected that the TAs caused by unsafe reversing will decrease in Abu Dhabi to zero from 2022. In Al Ain, it is expected that the cases will drop to zero by 2024. In the Western region, it is expected that the cases will drop to zero from 2019 (Table 4-18).

Table 4-18: Projected TAs caused by unsafe reversing

Year	Abu Dhabi	Al Ain	Western Region
2017	7	3	1
2019	3	1	0
2022	0	1	0
2024	0	0	0

4.1.3.13 Poor vision

The findings presented in Figure 4-14 also show that poor vision is one reason for accidents in UAE. As shown in Figure 4-14, there are periods where no accidents due to poor vision are recorded. In Abu Dhabi, no accidents were reported in 2009, 2011, 2012, 2014 and 2016. In the Western region, no accidents were reported from 2011 to 2014. In Al Ain no accidents were reported from 2010 to 2013. However, a drastic increase in TAs due to poor vision was reported in Al Ain between 2015 (1 case) and 2016 (77 cases) (Figure 4-14).

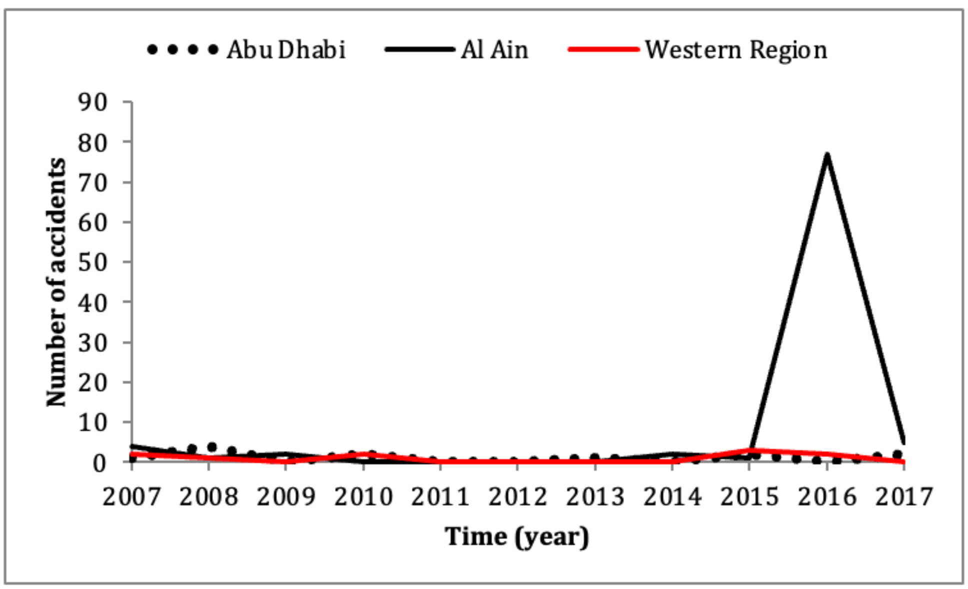


Figure 4-14: TAs caused by poor vision

The findings presented in Table 4-19 shows that based on the obtained data, it is expected that TAs caused by poor vision will decrease in Abu Dhabi to zero from 2022. However, in Al Ain, TAs are projected to increase to 42 cases by 2024, which is higher than 5 cases in 2017. In the Western region, TAs is projected to increase to 1 by 2024 (Table 4-19)

Table 4-19: Projected TAs caused by poor vision

Year	Abu Dhabi	Al Ain	Western Region
2017	2	5	0
2019	1	28	1
2022	0	37	1
2024	0	42	1

4.1.3.14 Lack of driving knowledge

The other reason for the reported accidents is the lack of driving knowledge. The findings presented in Figures 4-15 show changing TAs associated with the lack of driving knowledge. During 2007 and 2009, TAs that occurred due to the lack of driving knowledge were high in Abu Dhabi compared to the other two locations, while Al Ain had the highest numbers between 2009 and 2017 (Figure 4-15). Compared to the trend in the other two locations, there seems to be no drastic change in TAs that are associated with the lack of driving knowledge in Al Ain between in 2007 (32 cases) and 2017 (30 cases). In Al Ain, there are periods during the study period where there is high fluctuation in TAs, such as the period between 2008 (17 cases) and 2012 (33 cases). However, in Abu Dhabi the TAs reduced from 27 cases in 2007 to 6 cases in 2017 while in the Western region the TAs reduced from 11 cases in 2007 to 1 case in 2017 (Figure 4-15).

The findings presented in Table 4-20 shows that based on the obtained data, it is expected that the TAs caused by the lack of driving knowledge will decrease in Abu Dhabi and the Western region to zero from 2019. In Al Ain, it is expected that the cases will drop to 19 by 2024.

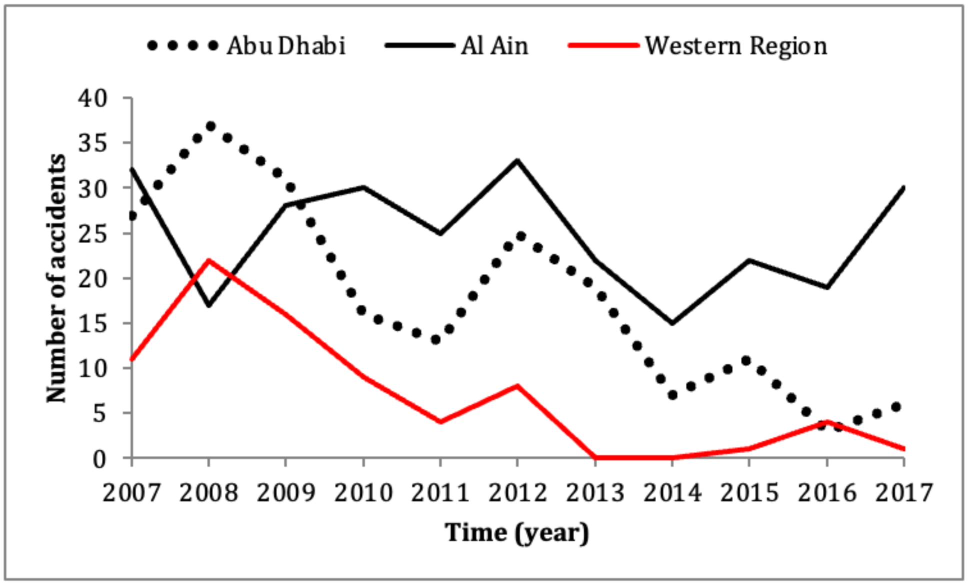


Figure 4-15: TAs caused by the lack of driving knowledge

Table 4-20: Projected TAs caused by the lack of driving knowledge

Year	Abu Dhabi	Al Ain	Western Region
2017	6	30	1
2019	0	21	0
2022	0	20	0
2024	0	19	0

4.1.3.15 Lack of attention

The other reason for the reported accidents in the three locations in UAE is the lack of attention. The findings presented in Figure 4-16, show that between 2007 and 2012 Abu Dhabi has the highest TAs caused by the lack of attention, and the highest cases were reported in 2009 (398 cases). The Al Ain has the second-highest cases of accidents between 2008 and 2010 while Western region has the second-highest TAs due to lack of attention between 2011 and 2014. Figure 4-16 shows that Abu Dhabi has registered a drastic decline in accidents due to lack of attention between 2007 and 2017 compared to the other two regions.

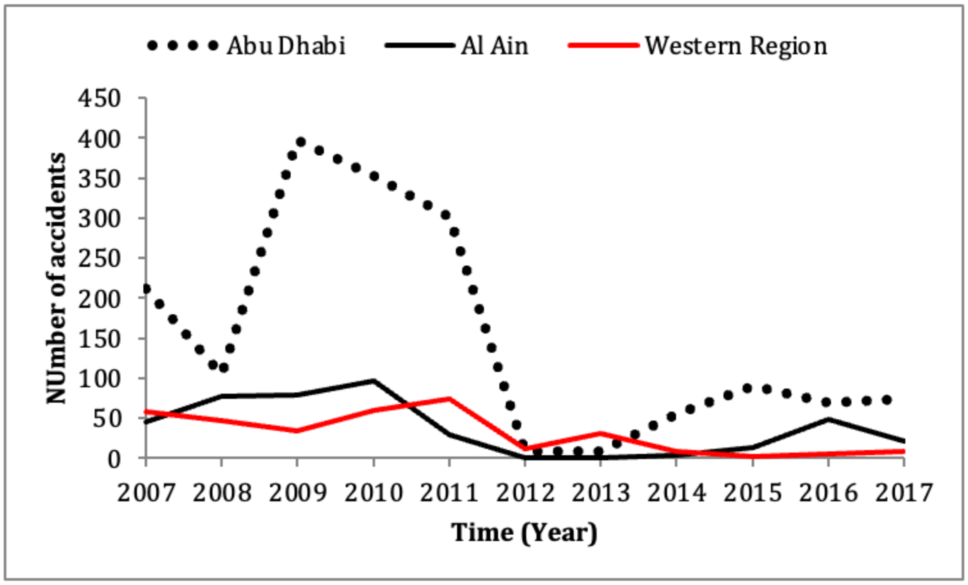


Figure 4-16: TAs caused by lack of attention

The projection of the future trends in TAs caused by a lack of attention in the three locations was carried out using Excel's forecast function. The outcome shows that no cases of accidents caused by lack of attention are expected in any of the three regions from the year 2019 (Table 4-21).

Table 4-21: Projected TAs caused by lack of attention

Year	Abu Dhabi	Al Ain	Western Region
2017	74	21	9
2019	0	0	0
2022	0	0	0
2024	0	0	0

4.1.3.16 Non-compliance with a stop sign

The other reason for the reported cases in the three locations in UAE is the non-compliance with a stop sign. The findings presented in Figure 4-17, show that throughout the period 2007-2017, Abu Dhabi region had the highest TAs caused by the non-compliance with a stop sign. As is the case with Al Ain, there is a general increase in TAs caused by the non-compliance with a stop sign in Abu Dhabi. The increase in such accidents in Abu Dhabi is characterized by periods of a sharp increase in the TAs such as the one experienced between 2009 (23 cases) to 2010 (42 cases), 2011 (15 cases) to 2013 (25 cases), and 2014 (18 cases) to 2015 (27 cases). During the period between 2007 and 2017, the Western region was noted to have the lowest cases of accidents caused by non-compliance with a stop sign (Figure 4-17). In Al Ain, the cases of accidents caused by non-compliance with a stop sign were observed to increase from 2011 to 2017. By 2017 TAs caused by the non-compliance with a stop sign was 7 in Al Ain, 18 in Abu Dhabi and zero in the Western Region (Figure 4-17).

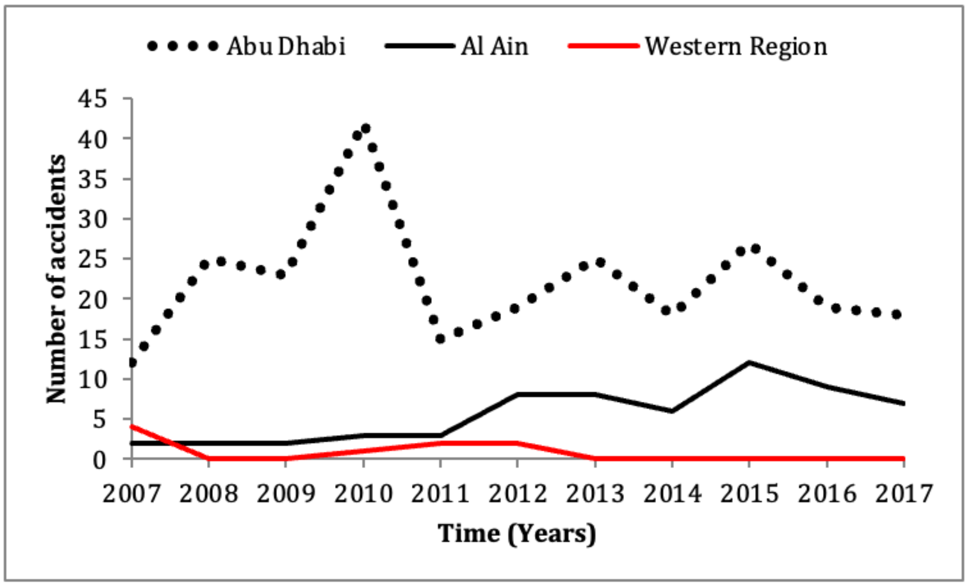


Figure 4-17: TAs caused by non-compliance with a stop sign

The outcome of the projected future trends in TAs caused by non-compliance with a stop sign showed an increase in Al Ain to 16 cases by 2024, which is higher than 7 cases in 2017. The cases in Abu Dhabi are also projected to increase to 20 cases by the year 2024, which is higher compared to 18 cases in 2017. As shown in Table 4-22, no TAs caused by non-compliance with a stop sign are expected in the Western region trend from 2019 onwards.

Table 4-22: Projected TAs caused by non-compliance with a stop sign

Year	Abu Dhabi	Al Ain	Western Region
2017	18	7	0
2019	21	12	0
2022	20	14	0
2024	20	16	0

4.1.3.17 Non-compliance with other traffic signal

Figure 4-18 shows that the non-compliance with other traffic signal is the other reason for the TAs in UAE. Accidents due to non-compliance with other traffic signal were observed to increase in the Western region between 2007 to 2010 after which the cases declined to zero in 2016. The TAs due to non-compliance with another traffic signal in Abu Dhabi is characterized by alternating periods of increase and reduction, while in Al Ain the accidents are shown to reduce to zero in 2009 to 2016 (Figure 4-18).

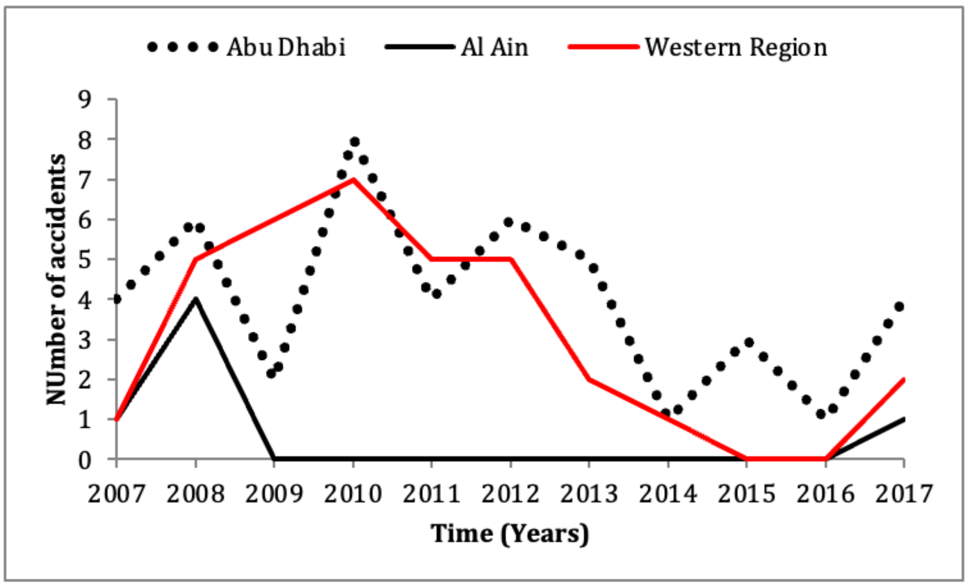


Figure 4-18: TAs caused by non-compliance with other traffic signals

The findings presented in Table 4-23 shows that based on the obtained data, it is expected that the TAs caused by non-compliance with other traffic signals will decrease to zero cases by 2019 in Al Ain and the Western region. In Abu Dhabi, the cases are expected to decline to just one by 2022 (Table 4-23).

Table 4-23: Projected TAs caused by non-compliance with other traffic signals

Year	Abu Dhabi	Al Ain	Western Region
2017	4	1	2
2019	2	0	0
2022	1	0	0
2024	1	0	0

4.1.3.18 Lack of road awareness

The lack of road awareness is also one reason for the reported cases of accidents in UAE. Al Ain is shown to have high TAs associated with the lack of road awareness between 2009 to 2017. The TAs associated with the lack of road awareness is also noted to increase in the region (Al Ain) during the study period. Despite the sharp increase in accidents in 2013, Abu Dhabi is observed to experience fairly unchanged trends between 2007 and 2017 (Figure 4-19).

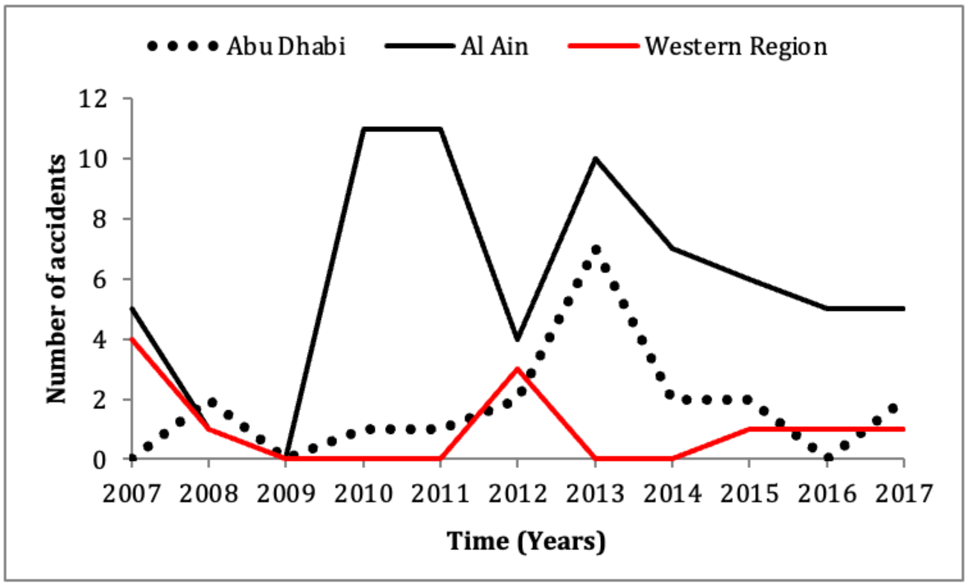


Figure 4-19: TAs caused by the lack of road awareness

In Abu Dhabi, Table 4-24 shows a projected increase in TAs caused by the lack of road awareness to 3 cases by 2024, which is higher than 2 cases in 2017. In Al Ain, TAs caused by the lack of road awareness are projected to increase to 9 cases by 2024. However, in the Western region, the TAs caused by the lack of road awareness are expected to decrease to zero cases by 2019 (Table 4-24).

Table 4-24: Projected TAs caused by the lack of road awareness

Year	Abu Dhabi	Al Ain	Western Region
2017	2	5	1
2019	3	8	0
2022	3	8	0
2024	3	9	0

4.1.3.19 Poor estimation of user's road

The other reason for the reported cases of accidents in the three locations in UAE is the poor estimation of user's road. The findings presented in Figure 4-20, show that throughout the period 2007-2017, Abu Dhabi region had the highest TAs caused by the poor estimation of user's road. Unlike in the other two regions, there is a general decline in TAs caused by the poor estimation of user's road in Abu Dhabi. The decline in such accidents in Abu Dhabi is characterized by a period of a sharp increase in the TAs, such as the one experienced between 2007 (113 cases) to 2008 (476 cases). During the period between 2007 and 2011, Al Ain was noted to have the lowest cases of accidents caused by the poor estimation of user's road (Figure 20). In Al Ain, the cases of accidents caused by poor estimation of user's road were observed to second highest from 2011 to 2013. By 2017 TAs caused by the non-compliance with a stop sign was 18 in Al Ain, 164 in Abu Dhabi and 13 in the Western Region (Figure 4-20).

In Abu Dhabi, Table 4-25 shows a projected decline in TAs caused by poor estimation of user's road to 88 cases by the year 2024. In Al Ain, TAs caused by poor estimation of user's road are projected to decrease to zero by 2022. However, in the Western region, the accidents caused by poor estimation of user's road are expected to increase to 21 cases by 2024 (Table 4-25).

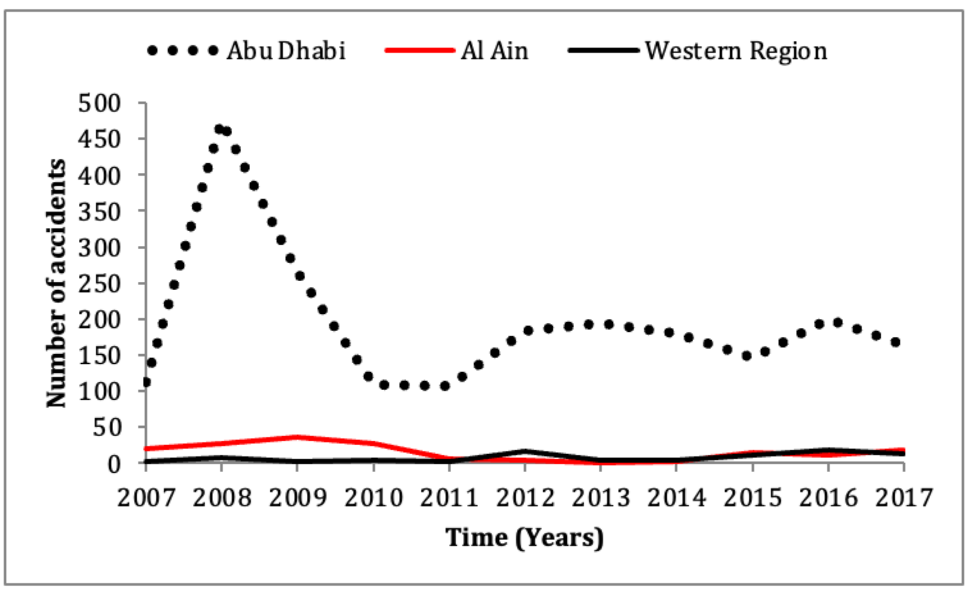


Figure 4-20: TAs caused by poor estimation of user's road

Table 4-25: Projected TAs caused by poor estimation of user's road

Year	Abu Dhabi	Al Ain	Western Region
2017	164	18	13
2019	133	3	16
2022	106	0	19
2024	88	0	21

4.1.3.20 Not giving way

The other reason for the reported cases of accidents in the three locations in UAE is not giving way. During 2007-2013, the Abu Dhabi region had the highest TAs caused by not giving way (Figure 4-21). Abu Dhabi and Western region reduced the accidents caused by not giving way while Al Ain seem to have a fairly unchanged trend. In 2014, Al Ain reported a spike in TAs caused by not giving way (22 cases).

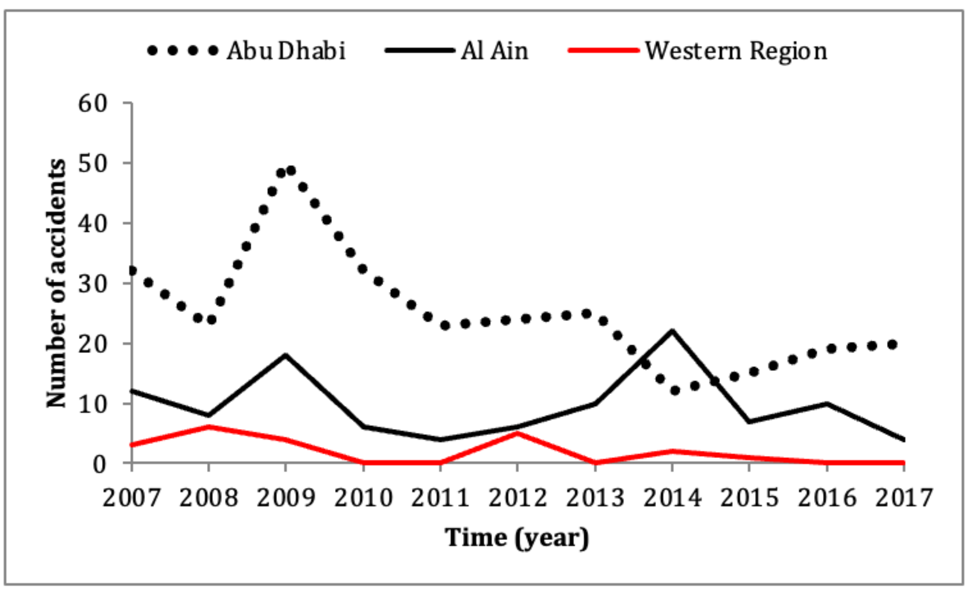


Figure 4-21: TAs caused by not giving way

Table 4-26 shows a projected decline in TAs caused by not giving way to one case by the year 2024 in Abu Dhabi. In the Western region, no cases of accidents caused by not giving way are expected from 2019 onwards. However, in Al Ain, the accidents caused by not giving way are expected to increase to 7 cases by 2024 (Table 4-26).

Table 4-26: Projected TAs caused by not giving way

Year	Abu Dhabi	Al Ain	Western Region
2017	20	4	0
2019	11	8	0
2022	5	7	0
2024	1	7	0

4.1.3.21 Road defects

Road defects are also noted to contribute to the occurrence of accidents in the UAE. The findings presented in Figure 4-22 show changing TAs that are associated with road defects. During 2010 and 2013, TAs that occurred due to road defects were high in Western region compared to the other two locations, while Abu Dhabi had the highest numbers between 2013 and 2017 (Figure 4-22). Al Ain is also shown to have had the highest TAs that occurred due to f road defects between 2007 and 2008. The findings presented in Figure 22 also show that in 2014, the Western Region and Al Ain registered a slight reduction in the number of cases of accidents caused by road defects. However, a slight increase in TAs was reported in Abu Dhabi (Figure 4-22).

Table 4-27 shows a projected decline in TAs due to road defects to three cases by the year 2019 in Abu Dhabi. In Al Ain, no cases of accidents due to road defects are expected from 2019 onwards. In the Western region, the accidents due to road defects are expected to decline to zero by 2022 (Table 4-27).

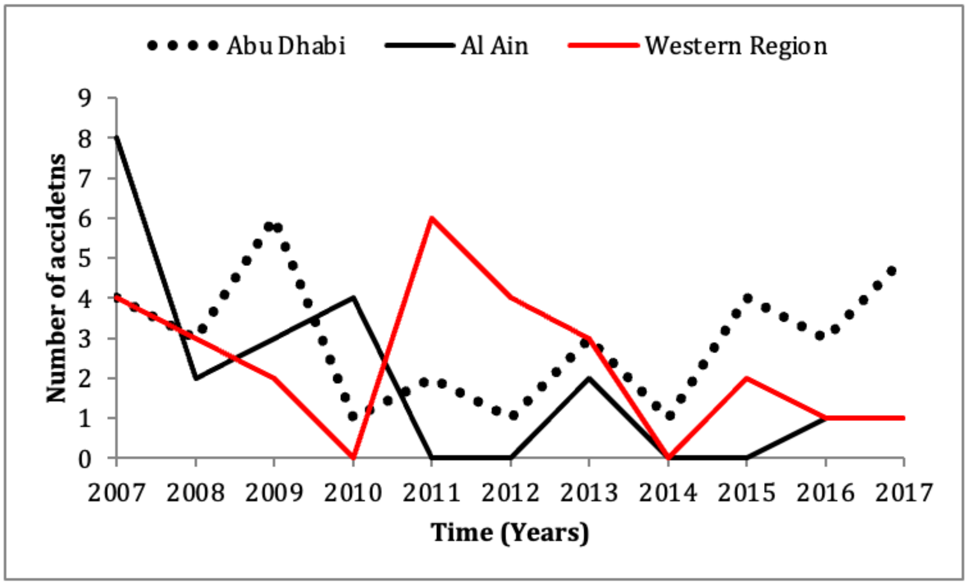


Figure 4-22: TAs due to road defects

Table 4-27: Projected TAs due to road defects

Year	Abu Dhabi	Al Ain	Western Region
2017	5	1	1
2019	3	0	1
2022	3	0	0
2024	3	0	0

4.1.3.22 Speeding without taking into account road conditions

Speeding without taking into account road conditions is also shown to contribute to the reported TAs in UAE. As shown in Figure 4-23, accidents due to speeding without considering road conditions, increased in Abu Dhabi from 2007 to 2011, after which it reduced to 2017 while in Al Ain an increase was observed between 2008 to 2013. TAs due to speeding without taking into account road conditions was observed to remain reasonably low in the Western region during the 2007-2017 period (Figure 4-23).

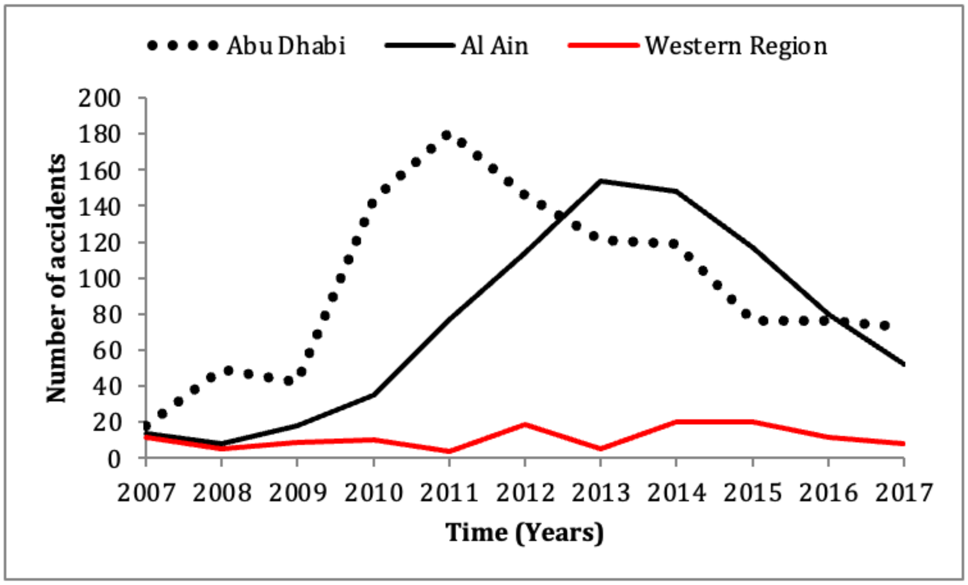


Figure 4-23: TAs due to speeding without taking into account road conditions

Table 4-28 shows a projected increase in TAs due to speeding without considering road conditions to 136 cases by the year 2024 in Abu Dhabi. In Al Ain, TAs due to speeding without taking into account road conditions are projected to increase to 192 cases by the year 2024. In the Western region, the accidents due to speeding without considering road conditions are expected to increase to 18 cases by 2024 (Table 4-28).

Table 4-28: Projected TAs due to speeding without taking into account road conditions

Year	Abu Dhabi	Al Ain	Western Region
2017	73	52	8
2019	119	143	15
2022	129	172	17
2024	136	192	18

4.1.3.23 Sudden stopping

Sudden stopping was also observed to be one of the reasons for accidents in the UAE. In Al Ain such accidents were observed to reduce from 4 cases in 2007 to zero in 2011, while Abu Dhabi showed an alternating period of fluctuation in TAs. The Western region was observed to have the lowest TAs due to sudden stopping during the period 2007-2017 (Figure 4-24).

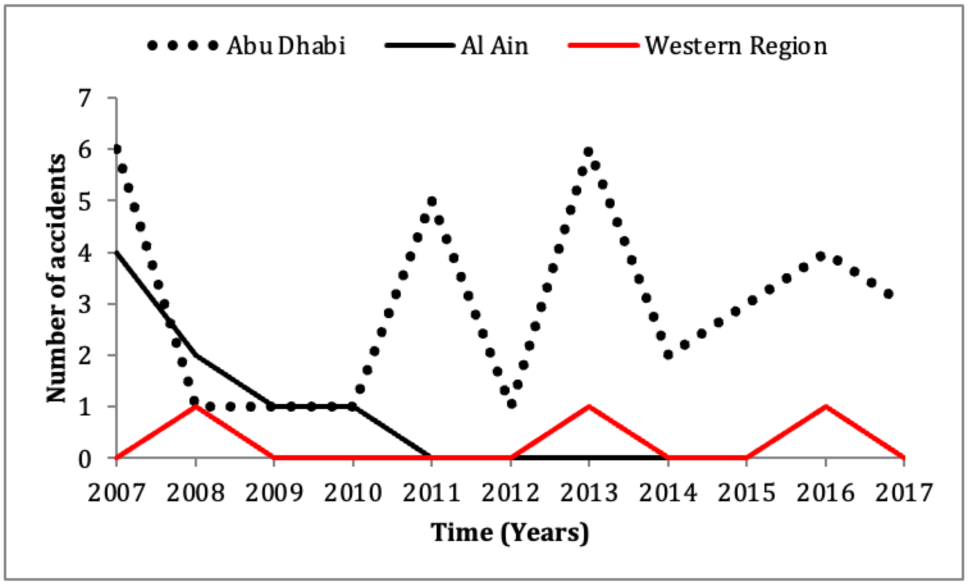


Figure 4-24: TAs due to sudden stopping

4.1.3.24 Sudden turn

The other reason for the reported cases of accidents in the three locations in UAE is sudden turn. The findings presented in Figure 4-25, show that throughout the period 2007-2017, Abu Dhabi region had the highest TAs caused by sudden turn. Unlike in the other two regions, there is a general decline in TAs caused by the sudden turn of user's road in Abu Dhabi. However, there are periods of increase in the accidents associated with sudden turn in Abu Dhabi, with notable examples being the period between 2008 (393 cases) and 2009 (473 cases). During the period between 2008 (165 cases) and 2010 (84 cases) and after 2014, Al Ain was noted to have the second-highest TAs caused by sudden turn (Figure 22). In the Western region, the cases of accidents caused by sudden turn were observed to second highest from 2010 (99 cases) to 2014 (5 cases). By 2017 TAs caused by the sudden turn was 83 in Al Ain, 135 in Abu Dhabi and 3 in the Western Region (Figure 4-25).

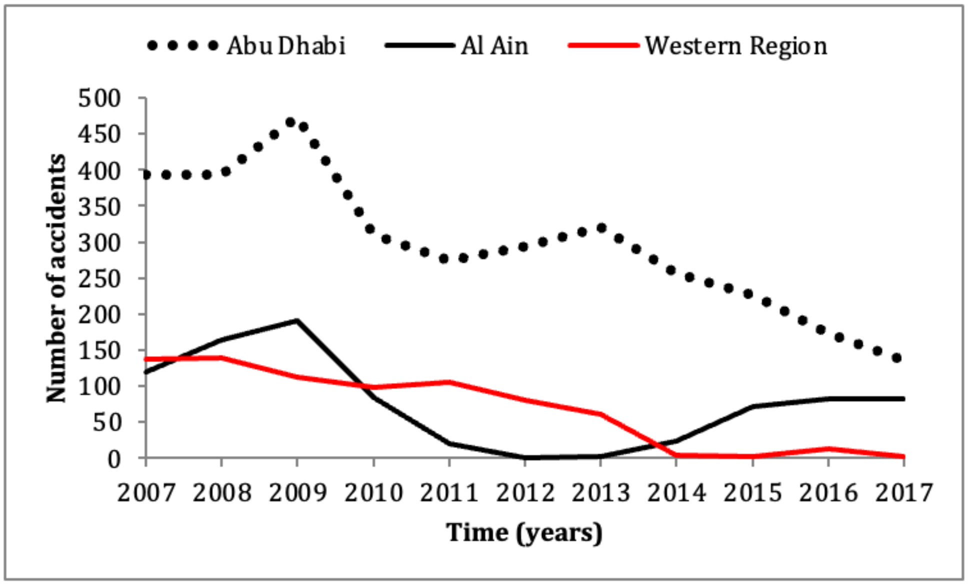


Figure 4-25: TAs due to suddenly turn

Table 4-29 shows a projected decrease in TAs due to a sudden turn to zero cases by the year 2024 in Abu Dhabi. In Al Ain, TAs due to sudden turn is projected to decrease to zero cases by the year 2022. In the Western region, the accidents due to sudden turn are expected to decrease to zero cases by 2019 (Table 4-29).

Table 4-29: Projected TAs due to suddenly turn

Year	Abu Dhabi	Al Ain	Western Region
2017	135	83	3
2019	106	12	0
2022	25	0	0
2024	0	0	0

4.1.3.25 Tyre explosion

The other reason for the reported cases of accidents in the three locations in UAE is the tyre explosion. The findings presented in Figure 4-26 show that the period 2007 to 2015, Abu Dhabi region had the highest TAs caused by tyre explosion. Just as the case with the other two regions, a general decline in TAs caused by tyre explosion, was noted in Abu Dhabi. The decline in the TAs in Abu Dhabi was characterized by periods of increase in the accidents, such as the period between 2010 (29 cases) to 2011 (47 cases). During the period between 2007 to 2016 (after 2014, Al Ain was noted to have the least TAs caused by tyre explosion (Figure 4-26). By 2017 TAs caused by tyre explosion was noted to be similar in Abu Dhabi and the Western region (4 cases), while Al Ain had 9 cases of accidents caused by tyre explosions (Figure 4-26).

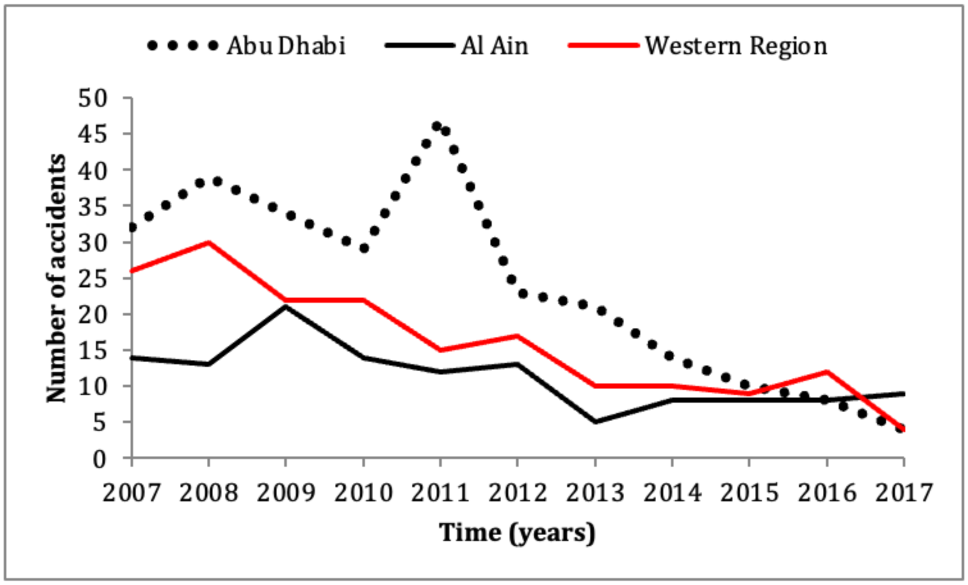


Figure 4-26: TAs due to tyre explosion

Table 4-30 shows a projected decrease in TAs due to the tyre explosion to zero cases by 2019 in Abu Dhabi and Western. In Al Ain, TAs due to the tyre explosion are projected to decrease to zero cases by 2024.

Table 4-30: Projected TAs due to tyre explosion

Year	Abu Dhabi	Al Ain	Western Region
2017	4	9	4
2019	0	5	0
2022	0	2	0
2024	0	0	0

4.1.3.26 Failure to obey the traffic road line

Failure to obey the traffic road line was also noted to be one of the reasons for the reported accidents in UAE. The TAs due to failure to obey the traffic road line is observed to increase in Al Ain and Western region from 2007 to 2017. However, Abu Dhabi is observed to have the highest cases of accidents related to failure to obey the traffic road line between 2007 and 2009 (Figure 4-27).

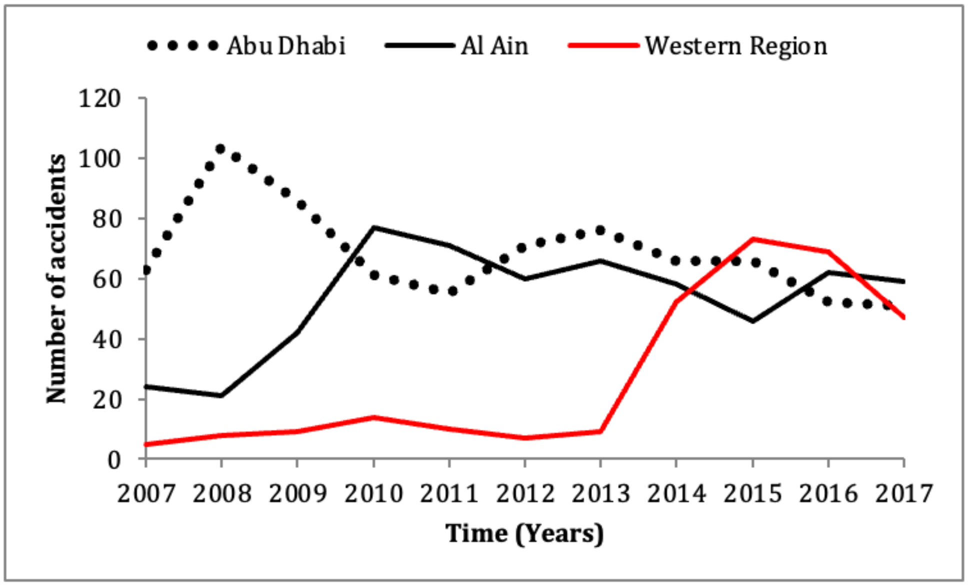


Figure 4-27: TAs due to failure to obey the traffic road line

Table 4-31 shows a projected decrease in TAs due to failure to obey the traffic road line to 36 cases by the year 2024 in Abu Dhabi. However, in Al Ain, TAs due to failure to obey the traffic road line are projected to increase to 87 cases by 2024. In the Western region, the accidents due to failure to obey the traffic road line are also expected to increase to 106 cases by 2024 (Table 4-31).

Table 4-29: Projected TAs due to failure to obey the traffic road line

Year	Abu Dhabi	Al Ain	Western Region
2017	51	59	47
2019	49	73	73
2022	41	81	93
2024	36	87	106

4.1.3.27 Alcohol intoxication

The other reason for the reported cases of accidents in the three locations in the UAE is alcohol intoxication. The findings presented in Figure 4-28, show that throughout the period 2007-2017, Abu Dhabi region had the highest TAs caused by alcohol intoxication. Figure 4-28 shows that

TAs due to alcohol intoxication remained unchanged during 2007-2017 period in Abu Dhabi while the cases increased in Al Ain. However, it should be noted that despite TAs being the same in 2007 and 2017 (52 cases), Abu Dhabi experienced periods of fluctuation, such as the period between 2009 (67 cases), 2012 (40 cases) and 2014 (68 cases). Figure 4-28 also shows that during the period between 2008 (6 cases) and 2012 (22 cases) Al Ain experienced an increase in TAs caused by alcohol intoxication (Figure 4-28). The Western Region is shown to have had the least cases of accidents caused by alcohol intoxication during the period 2007-2017 (Figure 4-28).

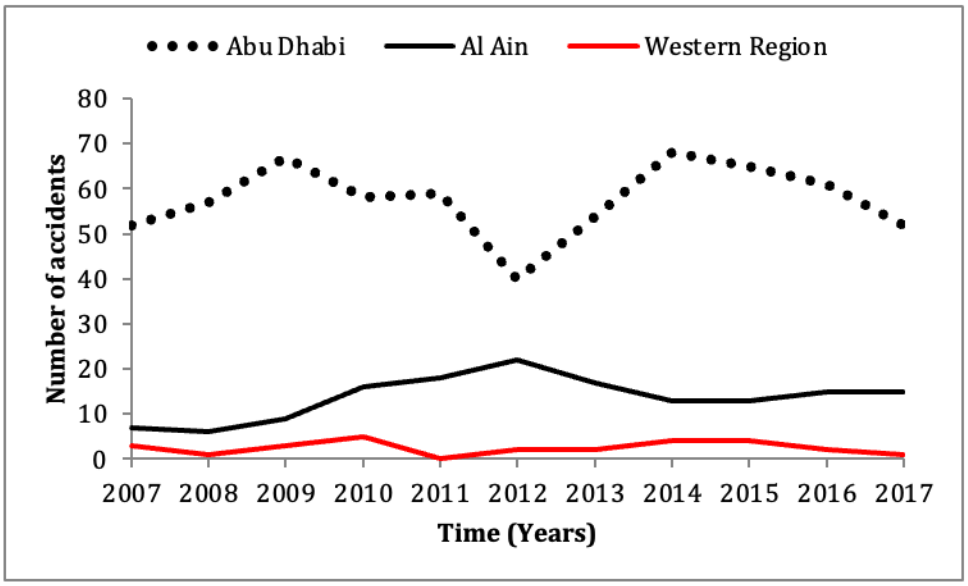


Figure 4-28: TAs due to alcohol intoxication

Table 4-32 shows a projected increase in TAs due to alcohol intoxication to 60 cases by the year 2022 in Abu Dhabi. In Al Ain, TAs due to alcohol intoxication is also projected to increase to 23 cases by the year 2024. However, in the Western region, the accidents due to alcohol intoxication are expected to decrease to 2 cases by 2024 (Table 4-32).

Table 4-30: Projected TAs due to alcohol intoxication

Year	Abu Dhabi	Al Ain	Western Region
2017	52	15	1
2019	59	19	2
2022	60	21	2
2024	60	23	2

4.1.3.28 Mobile phone use/texting

Texting is also shown to contribute to the observed accidents in UAE (Figure 4-29). The Western region is observed to have the highest cases of accident associated with mobile phone use/texting between 2009 and 2016. However, from 2016 to 2017, the findings show a drastic increase in the accident caused by the mobile phone use/texting in Abu Dhabi (Figure 4-29).

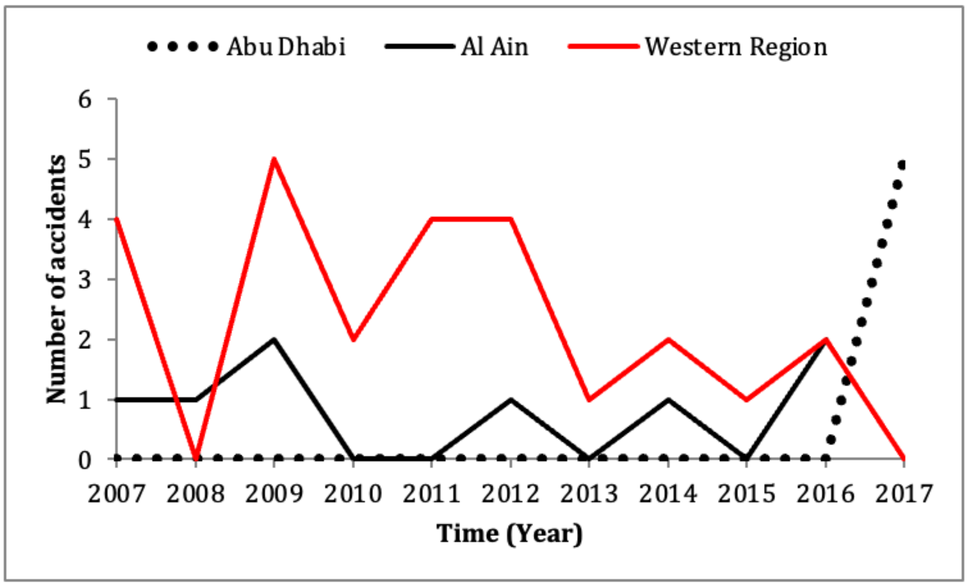


Figure 4-29: TAs due to using mobile phone while driving

Table 4-33 shows a projected decrease in TAs due to using a mobile phone while driving to three cases by the year 2022 in Abu Dhabi. In Al Ain and the Western region, TAs using a mobile phone while driving are projected to decline to zero cases from 2022 (Table 4-33).

Table 4-31: Projected TAs due to using a mobile phone while driving

Year	Abu Dhabi	Al Ain	Western Region
2017	5	0	0
2019	2	0	1
2022	3	0	0
2024	3	0	0

4.1.3.29 Vehicle defects

The other reason for the reported cases of accidents in the three locations in UAE is vehicle defects. As evident in Figure 4-30, the Abu Dhabi region had the highest TAs caused by vehicle defects throughout 2007-2017. Figure 4-30 also shows that TAs due to vehicle defects remained unchanged during 2007-2017 period in Abu Dhabi while the cases decreased in Western region. However, Abu Dhabi experienced periods of increase in accidents related to vehicle defects, such as the period between 2007 (482 cases), 2009 (675 cases) and 2014 (549 cases) to 2016 (645 cases). Figure 4-30 also shows that during the 2007 to 2017 Western region, the second highest cases of accidents were caused by vehicle defects while Al Ain had the least number of cases. In 2017 TAs caused by vehicle defects were 484 in Abu Dhabi, and 145 in Western region, while Al Ain had only 1 TAs caused by vehicle defects (Figure 4-30).

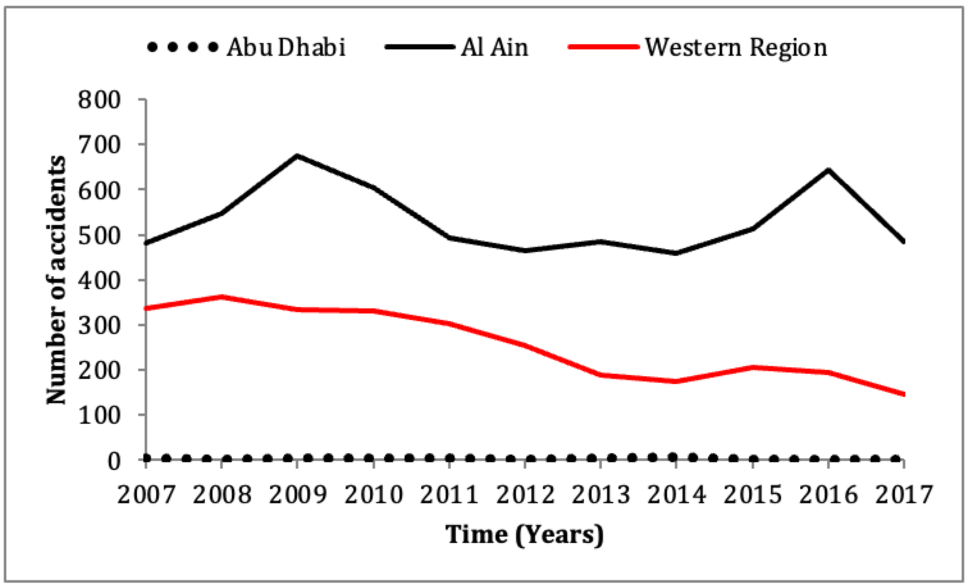


Figure 4-30: TAs due to Vehicle defects

Table 4-34 shows a projected decrease in TAs due to vehicle defects to 491 cases by the year 2024 in Al Ain. In the Western region, the accidents due to vehicle defects are also expected to decrease to zero cases by 2024 (Table 4-34). However, in Abu Dhabi, there is no projected change in the TAs due to vehicle defects, with the projected number of cases in 2024 (n= 1) being similar to the number of cases in 2017.

Table 4-32: Projected TAs due to vehicle defects

Year	Abu Dhabi	Al Ain	Western Region
2017	1	484	145
2019	2	508	102
2022	2	498	36
2024	1	491	0

4.1.4 *Summary of the reasons for accidents per city*

The summary of the accidents for each of the three cities was based on calculating the percentage of the accidents associated with each of the highlighted reasons per year between 2007 and 2017. Since several reasons were given for the different accidents, this section only reports the main reasons for accidents, which in this case are those responsible for more 1 % of all accidents in the city per year. As shown in Table 4-35, the sudden turn by the drivers is responsible for the highest number of accidents in Abu Dhabi each year from 2007 to 2015. However, for 2016 and 2017, the poor estimation of user's road is reported to be responsible for the highest cases of accidents. Other major causes of accidents in Abu Dhabi during the year 2007 and 2017 include the drivers who do not leave enough space with the car in front, driving through a red light, neglect and lack of attention and driving under the influence of alcohol.

Table 4-35 Summary of the reasons for accidents in Abu Dhabi

		Percentage (%) of accidents associated with the different causes												
Year	TAs	FGPP	NLES	DRL	EMRNF	SP	LDK	NLA	NCSS	PEUR	NGW	ST	TE	DIA
2007	1883	11.8	10.3	10.4	4.7	3.1	1.4	11.2	0.6	6.0	1.7	20.9	1.7	2.8
2008	2165	1.8	10.6	12.3	4.2	4.5	1.7	4.8	1.2	22.0	1.1	18.2	1.8	2.6
2009	2207	1.2	9.2	10.7	3.4	2.8	1.4	18.0	1.0	12.1	2.3	21.4	1.5	3.0
2010	1715	0.5	10.4	12.2	3.3	1.6	0.9	20.5	2.4	6.4	1.9	18.1	1.7	3.4
2011	1588	0.8	9.6	13.1	2.0	2.1	0.8	19.0	0.9	6.8	1.4	17.3	3.0	3.7
2012	1394	2.2	11.7	16.1	2.8	3.2	1.8	0.6	1.4	13.2	1.7	21.1	1.6	2.9
2013	1439	2.3	11.1	15.9	3.3	1.7	1.3	0.6	1.7	13.6	1.7	22.2	1.5	3.8
2014	1272	1.3	14.7	11.2	2.6	0.7	0.6	4.3	1.4	14.2	0.9	20.1	1.1	5.3
2015	1137	2.1	12.8	9.7	3.3	1.1	1.0	8.0	2.4	12.9	1.3	19.9	0.9	5.7
2016	1029	2.4	14.5	7.8	3.3	1.3	0.3	6.8	1.8	19.4	1.8	16.8	0.8	5.9
2017	937	1.3	14.7	9.8	2.9	0.4	0.6	7.9	1.9	17.5	2.1	14.4	0.4	5.5

In Table 4-35 above FGPP refers to failure of the drivers to give priority to pedestrian crossing; NLES refers to the drivers who do not leave enough space; DRL refers to driving through a red light; EMRNF refers to driver enter a main road without making sure it is free; SP refers to accidents due to over speeding; LDK refers to lack of driving knowledge; NLA refers to Neglect and lack of attention; NCSS refers to non-compliance with a stop sign; PEUR refers to poor estimation of user's road; NGW refers to not giving way; RD refers to Road defects ; ST refers to suddenly turn; TE refers to tyre explosion; DIA refers to driving under the influence of alcohol.

Table 4-36 shows that the sudden turn by the drivers was responsible for the highest number of accidents in In Al Ain in 2007, 2008, and 2009. In 2010, the drivers' neglect and lack of attention resulted in the highest cases of accidents. However, for the subsequent four years (2011 to 2014) the failure of the drivers to give priority to the pedestrian crossing was responsible for the highest percentage of accidents per year. For each of the last three years (2015 to 2017) the sudden turn by the drivers was responsible for the highest number of traffic accidents. Other significant causes of accidents in Al Ain during 2007 and 2017 include the drivers who do not leave enough space with the vehicle ahead and the driver's entrance to the main road without making sure it is free.

Table 4-33: Summary of the reasons for accidents in Al Ain

Year	TAs	Percentage (%) of accidents associated with the different causes												
		FGPP	NLES	DRL	EMRNF	SP	LDK	NLA	NCSS	PEUR	NGW	ST	TE	DIA
2007	482	5.2	8.9	3.7	5.0	2.3	6.6	9.3	0.4	4.1	2.5	24.9	2.9	1.5
2008	546	4.8	9.0	5.3	4.9	1.8	3.1	14.3	0.4	5.1	1.5	30.2	2.4	1.1
2009	675	3.7	10.5	5.2	2.7	1.3	4.1	11.7	0.3	5.5	2.7	28.3	3.1	1.3
2010	603	4.8	9.0	6.0	5.1	2.5	5.0	15.9	0.5	4.5	1.0	13.9	2.3	2.7
2011	492	12.0	11.0	4.5	6.1	0.8	5.1	6.1	0.6	1.2	0.8	4.3	2.4	3.7
2012	466	16.7	8.8	2.8	6.0	3.2	7.1	0.0	1.7	0.9	1.3	0.0	2.8	4.7
2013	485	15.9	8.5	2.7	5.2	0.4	4.5	0.0	1.6	0.0	2.1	0.6	1.0	3.5
2014	459	13.1	5.9	3.9	3.9	0.0	3.3	0.9	1.3	0.7	4.8	5.2	1.7	2.8
2015	514	11.9	10.5	2.3	6.0	0.2	4.3	2.7	2.3	2.9	1.4	13.8	1.6	2.5
2016	645	10.7	11.0	1.9	4.2	0.0	2.9	7.6	1.4	1.9	1.6	12.9	1.2	2.3
2017	484	11.8	11.2	0.8	4.8	0.4	6.2	4.3	1.4	3.7	0.8	17.1	1.9	3.1

In Table 4-36 above FGPP refers to failure of the drivers to give priority to the pedestrian crossing; NLES refers to the drivers who do not leave enough space; DRL refers to driving through a red light; EMRNF refers to driver enter a main road without making sure it is free; SP refers to accidents due to over speeding; LDK refers to lack of driving knowledge; NLA refers to Neglect and lack of attention; NCSS refers to non-compliance with a stop sign; PEUR refers to poor estimation of user's road; NGW refers to not giving way; RD refers to Road defects ; ST refers to suddenly turn; TE refers to tyre explosion; DIA refers to driving under the influence of alcohol.

Table 4-37 shows the findings of the summary of reasons for the TAs in the Western region each year between 2007 and 2017. The sudden turn by the drivers is responsible for the highest number of accidents in the Western region each year from 2007 to 2013. But for the subsequent two years (2014 to 2015) the failure of the drivers to t leave enough space with the vehicle ahead was responsible for the highest number of accidents. In 2016, the entrance of the driver to the main road without making sure it is free caused the highest number of accidents, while in 2017 the highest number of accidents was due to the failure of the drivers to t leave enough space with the vehicle ahead. The other major reasons for accidents in the Western region include neglect, lack of attention, and the tyre explosion.

Table 4-34: Summary of the reasons for accidents in the Western region

Year	TAs	Percentage (%) of accidents associated with the different causes												
		FGPP	NLES	DRL	EMRNF	SP	LDK	NLA	NCSS	PEUR	NGW	ST	TE	DIA
2007	336	0.3	4.5	0.9	4.2	0.9	3.3	17.3	1.2	0.9	0.9	40.8	7.7	0.9
2008	361	0.0	7.8	0.0	5.5	1.7	6.1	13.0	0.0	1.9	1.7	38.5	8.3	0.3
2009	333	0.3	8.4	0.0	6.6	3.0	4.8	10.5	0.0	0.6	1.2	33.6	6.6	0.9
2010	330	0.3	10.6	0.6	6.1	0.6	2.7	18.2	0.3	1.2	0.0	30.0	6.7	1.5
2011	302	0.0	6.0	0.3	6.3	0.0	1.3	24.8	0.7	1.0	0.0	35.1	5.0	0.0
2012	255	1.2	9.8	0.4	7.1	0.4	3.1	4.7	0.8	6.7	2.0	31.8	6.7	0.8
2013	189	0.0	13.2	3.2	6.3	2.1	0.0	16.4	0.0	2.1	0.0	32.8	5.3	1.1
2014	174	0.0	15.5	1.1	11.5	1.1	0.0	4.6	0.0	2.3	1.1	2.9	5.7	2.3
2015	206	0.5	15.5	0.5	6.8	0.0	0.5	1.0	0.0	5.3	0.5	1.0	4.4	1.9
2016	194	0.0	5.7	0.0	10.3	0.0	2.1	3.1	0.0	9.3	0.0	6.7	6.2	1.0
2017	145	0.0	11.7	2.1	8.3	0.7	0.7	6.2	0.0	9.0	0.0	2.1	2.8	0.7

In Table 4-37 above FGPP refers to failure of the drivers to give priority to pedestrian crossing; NLES refers to the drivers who do not leave enough space; DRL refers to driving through a red light; EMRNF refers to driver enter a main road without making sure it is free; SP refers to accidents due to over speeding; LDK refers to lack of driving knowledge; NLA refers to Neglect and lack of attention; NCSS refers to non-compliance with a stop sign; PEUR refers to poor estimation of user's road; NGW refers to not giving way; RD refers to Road defects ; ST refers to suddenly turn; TE refers to tyre explosion; DIA refers to driving under the influence of alcohol.

4.2 Findings of the survey analysis

4.2.1 *Study demographics*

From the 400 questionnaires that were issued, only 75 % of them were completed and returned. Among the 300 questionnaires that were completed, 160 were from respondents from Abu Dhabi sector, while 80 and 60 of the completed questionnaires were from the Al Ain and the Western sector, respectively (Table 4-38). Most of the respondents were males (71 %). However, the gender varied across the different sectors, with the 66.9 % of the Abu Dhabi sector being male while 73.7 % of the respondents from Al Ain sector were observed to be males. A total of 78.3 % of the respondents from the Western sector were found to be males.

As shown in Table 4-38, the age of the respondents also varied across the different sectors. In the Abu Dhabi sector, those aged between 18-25 years made up the highest proportion of 46.2 %, while the respondents aged between 26-35 made up 26.9 % of all the total number of respondents from the sector. The respondents aged between 36-45 and those aged above 45 years made up 17.5 % and 9.4 % of the total population. In the Al Ain sector, those aged between 18-25 years made up the highest proportion of 38.7 % while the respondents aged between 26-35 made up 31.3 % of all the total number of respondents from the sector. The respondents aged between 36-45 and those aged above 45 years made up 22.5 % and 7.5 % of the total population. In the Western sector, those aged between 18-25 years made up 35.0 %, while the respondents aged between 26-35 made up 25.0 % of all the total number of respondents from the sector. The respondents aged between 36-45 and those aged above 45 years made up 26.7 % and 13.3 % of the total population. For this study, the highest number of respondents were aged between 18 to 25 years while the age bracket with the least number of respondents was noted to be the age bracket above 45 years. The respondents aged between 26 and 35 years and those aged between 36 and 45 years made up 27.7 % and 20.7 % of the total number of respondents (n= 300), respectively.

Table 4-38 also indicates that most of the respondents (45 %) had “other” educational level while 39 % and 16 % had University undergraduate and University postgraduate educational levels, respectively. However, it should be noted that the educational level of the respondents from the different sect differed. In the Abu Dhabi sector, the respondents with the University undergraduate educational level made up 42.5 % of the total while the respondents with

University postgraduate educational level made up 17.5 % of all the respondents from the region. The education level of the remaining 40 % of the respondents was categorised as other. In the Al Ain sector, 47.5 % of the respondents had the educational level that was categorised as other. The respondents with the University undergraduate educational level made up 37.5 % of the total while the respondents with University postgraduate educational level made up 17.5 % of all the respondents from the region. In the Western sector, the respondents with the University undergraduate educational level made up 31.7 % of the total, while the respondents with University postgraduate educational level made up 10.0 % of all the respondents from the region. The education level of the remaining 58.3 % of the respondents was categorised as other.

It is also evident from Table 4-38 that most (52.3 %) of the respondents were Emirati nationals, while 22.3 %, 16.7 %, 6.3 %, 1.7%, and 0.7 % of the respondents were of Asian nationals, Expatriates of Arab origin, Africans, Europeans, and others respectively. However, the nationality of the respondents varied across the different locations. For the Abu Dhabi sector respondents, the UAE nationals made up 45.0 % of all the respondents. The expatriates of Arab origin made up 16. 9 % of the 160 respondents from the sector while the respondents of the Asian and European descent made up 26.9 % and 1.9 % of the total respondents from the sector. The respondents from the African nationality made up 8.1 % while the remaining 1.2 % of the respondents were categorised as being from the other nationality. For the respondents from Al Ain sector, most of the respondents (58.7 %) were the UAE nationals, while the second largest group were respondents of the Asian descent (21.3 %). The respondents from the European nationality made up 1.3 % while those from the African nationality constituted 3.7 % of the respondents from the sector. For the respondents from the Western sector, the UAE nationals made up 63.3 % of the respondents. The expatriates of Arab origin made up 18.3 % of the 160 respondents from the sector, while the Asian and European descent respondents made up 11.7 % and 1.7 % of the total respondents from the sector. The respondents from the African nationality made up 5.0 % (Table 4-38).

Table 4-35: The demographic description of the study respondents (n= 300)

		Frequency (%)			
		Abu Dhabi (n =160)	Al Ain (n= 80)	Western (n= 60)	Overall (n= 300)
Gender	Male	66.9 %	73.7 %	78.3 %	71.0 %
	Female	33.1 %	26.3 %	21.7 %	29.0 %
Educational level	University undergraduate	42.5 %	37.5 %	31.7 %	39.0 %
	University postgraduate	17.5 %	17.5 %	10.0 %	16.0 %
	Other	40.0 %	47.5 %	58.3 %	45.7 %
Age (yrs)	18-25	46.2 %	38.7 %	35.0 %	42.0 %
	26-35	26.9 %	31.3 %	25.0 %	27.7 %
	36-45	17.5 %	22.5 %	26.7 %	20.7 %
	Above 45	9.4 %	7.5 %	13.3 %	9.7 %
Nationality	UAE	45.0 %	58.7 %	63.3 %	52.3 %
	Expatriate of Arab origin	16.9 %	15.0 %	18.3 %	16.7 %
	Asian	26.9 %	21.3 %	11.7 %	22.3 %
	European	1.9 %	1.3 %	1.7 %	1.7 %
	African	8.1 %	3.7 %	5.0 %	6.3 %
	Other	1.2 %	0.0 %	0.0 %	0.7 %

4.2.2 *The traffic problems on Abu Dhabi's roads*

The traffic problems that were noted to be prevalent on the Abu Dhabi roads were categorised into three main groups: driver-related factors, vehicular factors, and road condition-related factors. As shown in Table 4-39, among the driver-related factors, the highly prevalent traffic problem is the use of hand-held mobile phones, which was reported by 87.3 % of the respondents (n= 300). The findings presented in Table 4-39 show that the respondents who reported using hand-held mobile phones while driving vary across the three sectors in Abu Dhabi. The Abu Dhabi sector (n= 160) had the highest reports (90.6 %) of the use of hand-held mobile phones by drivers, while the problem was reported by 86.3 % and 80.0 % of the respondents from Al Ain sector (n= 80) and the Western sector respectively. The second most prevalent driver-related the traffic problem in the Abu Dhabi is unsafe overtaking, which was reported by the 74.0 % of study respondent (n= 300). However, the frequency of unsafe overtaking varied across the three sectors in Abu Dhabi. In the Abu Dhabi sector (n= 160) 76.3 % of the respondents reported unsafe overtaking as a major traffic problem. A total of 75.0 % and 66.7 % of the respondents from the Al Ain sector (n= 80) and the Western sector (n= 60) respectively, reported unsafe overtaking as a major traffic problem (Table 4-39). The other observed driver-related the traffic problems included driver tiredness, alcohol intoxication, and speeding, which were reported by 63.3 %, 59.7 % and 53 % of the study respondents, respectively. According to this study, the least prevalent driver-related traffic problem on the Abu Dhabi roads is reckless driving/riding, which was reported by 44 % of the respondents.

The vehicular factors that are associated with traffic problems on Abu Dhabi's roads include illegal, defective or underinflated tyres, which were reported by 52.7 % of the respondents. The findings presented in Table 4-39 show that the prevalence of defective or underinflated tyres varies across the three sectors that were considered in this research. As shown in Table 4-39, the defective or underinflated tyres were reported by 59 % and 57.5 % of the respondents from the Abu Dhabi sector (n= 160) and Al Ain (n= 80) respectively. However, only 35.0 % of the respondents from the Western sector (n= 60) reported the problem. The other vehicular factor is driving a defective vehicle, which was reported by 61.7 % of the respondents (Table 4-39). The prevalence of the reports regarding the use of defective vehicles on the Abu Dhabi roads varied across the different sectors. As shown in Table 4-2, 71.9 % and 61.7 % of the respondents from the Abu Dhabi sector (n= 160) and the Western sector (n= 60) reported the use of defective vehicles on the roads. However, only 41.3 % of the respondents from the Al Ain sector (n= 80) reported the problem.

This study noted that the road condition-related factors that are associated with traffic problems on Abu Dhabi's roads include slippery road surface, poorly maintained roads, and poor visibility, which was reported by 17.3 %, 20 %, and 43.3 % of the respondents respectively (Table 4-39). The study noted that a high percentage (30 %) of the respondent from Al Ain roads reported that poorly maintained roads constitute the common traffic problems while only 18.8 % and 16.9 % of the respondents from Abu Dhabi sector and the Western sector highlighted the poorly maintained roads as one of the traffic problems. The percentage of the respondents who mentioned poor visibility as a common traffic problem was the same (17.5 %) in Abu Dhabi sector (n= 160) and the Al Ain sector (n= 80). Only 16.7 % of the respondents from Western sector (n= 60) mentioned poor visibility as a problem (Table 4-39).

Table 4-39: Common traffic problems on Abu Dhabi's roads

Traffic problems		Abu Dhabi sector (n= 160)	Al Ain Sector (n= 80)	Western Sector (n= 60)	Overall (n= 300)
Driver related factors	Reckless driving/ riding	45.0 %	42.5 %	43.3 %	44.0 %
	Drivers/riders under the influence of alcohol	61.9 %	58.8 %	55.0 %	59.7 %
	Drivers/riders distracted by hand-held mobile phones.	90.6 %	86.3 %	80.0 %	87.3 %
	Speeding	55.0 %	52.5 %	48.3 %	53.0 %
	Unsafe overtaking	76.3 %	75.0 %	66.7 %	74.0 %
	Tiredness	65.6 %	62.5 %	58.3 %	63.3 %
Vehicular factors	Illegal, defective or underinflated tyres.	56.9 %	57.5 %	35.0 %	52.7 %
	Driving a defective vehicle.	71.9 %	41.3 %	61.7 %	61.7 %
Road related factors	Slippery road surface.	17.5 %	17.5 %	16.7 %	17.3 %
	poorly maintained roads	16.9 %	30.0 %	18.8 %	20.0 %
	Poor visibility	45.0 %	42.5 %	40.0 %	43.3 %
Pure chance		20.6 %	20.0 %	25.0 %	21.3 %

4.2.3 *Violations leading to traffic problems on Abu Dhabi's roads*

Based on the analysis of the traffic violations observed to be frequently reported, it was noted that the problems associated with TAs in Abu Dhabi roads are also related to the direct violation of the traffic rules. The major violations that lead to traffic problems on Abu Dhabi's roads are reported below

4.2.3.1 Overtaking on the inside/ risky overtaking

One of the traffic violations that the study assessed focused on the violation that is committed during overtaking. As shown in Table 4-40, 30.3 % of the drivers on the Abu Dhabi roads occasionally engage in risky overtaking by overtaking on the inside, while 11.7 % indicated that they quite often do so. The findings in Table 4-38 also indicate that 8.7 % of the drivers frequently engage in risky overtaking by overtaking on the inside. Although the percentage of the drivers who overtake on the inside lane nearly all the times on the Abu Dhabi roads were noted to be 10.0 %, the proportion was higher (16.7 %) for the drivers who were sampled from the Western Sector roads (n= 60).

Table 4-36: The tendency of a driver on Abu Dhabi roads to overtake using the inside lane

Options	Percentage (%) response			
	Abu Dhabi sector (n= 160)	Al Ain Sector (n= 80)	Western Sector (n= 60)	Overall (n= 300)
Never	26.3 %	23.8 %	21.7 %	24.7 %
Hardly ever	16.3 %	12.5 %	13.3 %	14.7 %
Occasionally	30.6 %	31.3 %	28.33 %	30.3 %
Quite Often	11.9 %	12.5 %	10.0 %	11.7 %
Frequently	8.1 %	8.8 %	10.0 %	8.7 %
Nearly all the times	6.9 %	11.3 %	16.7 %	10.0 %

The assessment of whether the drivers' frequency engages in risky overtaking by overtaking on the inside differs significantly was determined using the Chi-square test (Table 4-41). The outcome of the study was statistically significant: $\chi2(5) = 69.880$, $p < 0.000$. The study findings indicate that the difference between the responses on the frequency with which the drivers engage in risky overtaking by overtaking on the inside is statistically significant with hardly never (n= 44), quite often (n= 35), frequently (n= 26), nearly all the times (n= 30) responses being less compared to the occasionally (n= 91) and never (n= 74) responses (Table 4-41).

Table 4-37: The Chi-Square test for the response regarding the tendency of a driver on Abu Dhabi roads to overtake using the inside lane

	Observed N	Expected N	Residual	Chi-Square	df	Asymp. Sig.
Never	74	50.0	24.0	69.880a	5	0.000
Hardly never	44	50.0	-6.0			
Occasionally	91	50.0	41.0			
Quite often	35	50.0	-15.0			
Frequently	26	50.0	-24.0			
nearly all the times	30	50.0	-20.0			
Total	300					

a. 0 cells (0.0%) have expected frequencies less than 5. The minimum expected cell frequency is 50.0.

The other overtaking related violation that was observed was the tendency of the drivers to overtake someone that is taking a right turn. As shown in Table 4-42, 31.0% of the drivers on the Abu Dhabi roads often overtake someone taking a right turn while 25.3 % do so frequently. The findings also indicated that 21.7 % of the drivers who took part in the study nearly always overtake someone taking a right turn (Table 4-42).

Table 4-38: The tendency of a driver on Abu Dhabi roads to overtake someone that is taking a right turn

Options	Percentage (%) response			
	Abu Dhabi sector (n= 160)	Al Ain Sector (n= 80)	Western Sector (n= 60)	Overall (n= 300)
Never	10.6 %	11.3 %	11.7 %	11.0 %
Hardly ever	5.6 %	6.3 %	8.3 %	6.3 %
Occasionally	4.4 %	5.0 %	5.0 %	4.7 %
Quite Often	31.9 %	31.3 %	28.3 %	31.0 %
Frequently	26.3 %	25.0 %	23.3 %	25.3 %
Nearly all the times	21.3 %	21.3 %	23.3 %	21.7 %

The analysis of whether the frequency with which the drivers often overtake someone that is taking a right turn differs was determined using the Chi-square test (Table 4-43). The outcome of the study was statistically significant: $\chi2(5) = 105.920$, $p < 0.000$. The study findings indicate that the difference between the responses on the frequency with which the drivers often overtake someone that is taking a right turn is statistically significant with never (n= 33), hardly never (n= 19), and occasionally (n= 14) responses being less compared to the quite often (n= 93), frequently (n= 76), and nearly all the times (n= 65) responses (Table 4-43).

Table 4-39: The Chi-Square test for the response regarding the tendency of a driver on Abu Dhabi roads to overtake someone that is taking a right turn

	Observed N	Expected N	Residual	Chi-Square	df	Asymp. Sig.
Never	33	50.0	-17.0	105.920a	5	0.000
Hardly never	19	50.0	-31.0			
Occasionally	14	50.0	-36.0			
Quite often	93	50.0	43.0			
Frequently	76	50.0	26.0			
nearly all the times	65	50.0	15.0			
Total	300					

a. 0 cells (0.0%) have expected frequencies less than 5. The minimum expected cell frequency is 50.0.

4.2.3.2 Driving close to the car in front

The other traffic violation observed among the drivers who took part in the study is related to the driving distance maintained by the car in front. It was noted that 16.3 % of the drivers in Abu Dhabi occasionally violate the need to keep a safe distance with the car in front by driving close to it while 24.7 % of the drivers commit the offence frequently (Table 4-44). The findings also indicated that 38.7 % of the drivers who took part in the study nearly always violate the need to keep a safe distance with the car in front by driving close to it (Table 4-44).

Table 4-40: The tendency of a driver on Abu Dhabi roads to violate the rules relating to a distance between two vehicles

Options	Percentage (%) response			
	Abu Dhabi sector (n= 160)	Al Ain Sector (n= 80)	Western Sector (n= 60)	Overall (n= 300)
Never	4.4 %	6.3 %	6.7 %	5.3 %
Hardly ever	5.0 %	8.8 %	10.0 %	7.0 %
Occasionally	8.1 %	8.8 %	6.7 %	8.0 %
Quite Often	16.3 %	13.8 %	20.0 %	16.3 %
Frequently	25.6 %	23.8 %	23.3 %	24.7 %
Nearly all the times	40.6 %	38.8 %	33.3 %	38.7 %

The analysis of whether the drivers' frequency violates the need to keep a safe distance with the car in front by driving close to it differs was determined using Chi-square test (Table 4-45). The outcome of the study was statistically significant: $\chi 2(5) = 152.120$, $p < 0.000$. Therefore the difference between the responses on the frequency with which the drivers violate the need to keep a safe distance with the car in front by driving close to it is statistically significant with never (n= 16), hardly never (n= 21), occasionally (n= 24), and quite often (n= 49) responses being less compared to the frequently (n= 74), and nearly all the times (n= 116) responses (Table 4-45).

Table 4-41: The Chi-Square test for the response regarding the tendency of a driver on Abu Dhabi roads to violate the rules relating distance between two vehicles

	Observed N	Expected N	Residual	Chi-Square	df	Asymp. Sig.
Never	16	50.0	-34.0	152.120a	5	0.000
Hardly never	21	50.0	-29.0			
Occasionally	24	50.0	-26.0			
Quite often	49	50.0	-1.0			
Frequently	74	50.0	24.0			
nearly all the times	116	50.0	66.0			
Total	300					

a. 0 cells (0.0%) have expected frequencies less than 5. The minimum expected cell frequency is 50.0.

4.2.3.3 Violation of the traffic lights

The other traffic violation that the study assessed focused on the violation relating to intentional failure to observe the traffic lights. As shown in Table 4-46, 9.0 % of the drivers on the Abu Dhabi roads occasionally violate the traffic lights commands while crossing the junctions, while 1.3 % indicated that they quite often do so. Table 4-46 also indicates that 1.0 % of the drivers frequently violate the traffic lights commands while crossing the junctions.

Table 4-42: The tendency of a driver on Abu Dhabi roads to violate the traffic lights

Options	Percentage (%) response			
	Abu Dhabi sector (n= 160)	Al Ain Sector (n= 80)	Western Sector (n= 60)	Overall (n= 300)
Never	80.0 %	77.5 %	70.0 %	77.3 %
Hardly ever	11.3 %	12.5 %	10.0 %	11.3 %
Occasionally	8.8 %	10.0 %	8.3 %	9.0 %
Quite Often	0.0 %	0.0 %	6.7 %	1.3 %
Frequently	0.0 %	0.0 %	5.0 %	1.0 %
Nearly all the times	0.0 %	0.0 %	0.0 %	0.0 %

The assessment of whether the drivers' frequency violates the traffic lights commands while crossing the junctions varies significantly was determined using Chi-square test (Table 4-47). The outcome of the study was statistically significant: $\chi2(5) = 628.900$, $p < 0.000$. The outcome shows that there is a statistically significant difference in the response on the frequency with which the drivers violate the traffic lights commands while crossing the junctions with hardly never (n= 34), occasionally (n= 27), quite often (n= 4), and frequently (n= 3) responses being less compared to the never (n= 232) response (Table 4-47).

Table 4-43: The Chi-Square test for the response regarding the tendency of a driver on Abu Dhabi roads to violate the traffic lights

	Observed N	Expected N	Residual	Chi-Square	df	Asymp. Sig.
Never	232	60.0	172.0	628.900 a	5	0.000
Hardly never	34	60.0	-26.0			
Occasionally	27	60.0	-33.0			
Quite often	4	60.0	-56.0			
Frequently	3	60.0	-57.0			
Total	300					

a. 0 cells (0.0%) have expected frequencies less than 5. The minimum expected cell frequency is 60.0.

4.2.3.4 Disregard of speed limits

The other traffic violation that the study assessed focused on the intended failure to observe the speed limits. As shown in Table 4-48, 17.0 % of the drivers on the Abu Dhabi roads occasionally violate the regulation on speed limits during the early hours of the day and the night, while 26.3 % indicated that they quite often do so. The findings in Table 4-48 also indicate that 17.3 % of the drivers frequently violate the regulation on speed limits during the early hours of the day and during the night. Although the percentage of the drivers who disregard the speed limits in Abu Dhabi roads were noted to be 23.7 %, the proportion was higher (24.4 %) for the drivers who were sampled from the Abu Dhabi sector (n= 160).

Table 4-44: The tendency of a driver on Abu Dhabi roads to violate the speed limits

Options	Percentage (%) response			
	Abu Dhabi sector (n= 160)	Al Ain Sector (n= 80)	Western Sector (n= 60)	Overall (n= 300)
Never	5.6 %	5.0 %	10.0 %	6.3 %
Hardly ever	8.1 %	8.8 %	13.3 %	9.3 %
Occasionally	16.9 %	17.5 %	16.7 %	17.0 %
Quite Often	27.5 %	26.3 %	23.3 %	26.3 %
Frequently	17.5 %	18.8 %	15.0 %	17.3 %
Nearly all the times	24.4 %	23.8 %	21.7 %	23.7 %

The assessment of whether the drivers' frequency disregarded the speed limits late at night or early in the morning differed was determined using Chi-square test (Table 4-49). The outcome of the study was statistically significant: $\chi2(5) = 54.640$, $p < 0.000$. These findings show that the difference in the frequency with which the drivers violate the regulation on speed limits during the early hours of the day and during the night is statistically significant with never (n= 28), and hardly never (n= 21) responses being less compared to the occasionally (n= 51), quite often (n= 79) frequently (n= 52), and nearly all the times (n= 71) responses (Table 4-49).

Table 4-45: The Chi-Square test for the response regarding the tendency of a driver on Abu Dhabi roads to violate the speed limits

	Observed N	Expected N	Residual	Chi-Square	df	Asymp. Sig.
Never	19	50.0	-31.0	54.640 a	5	0.000
Hardly never	28	50.0	-22.0			
Occasionally	51	50.0	1.0			
Quite often	79	50.0	29.0			
Frequently	52	50.0	2.0			
nearly all the times	71	50.0	21.0			
Total	300					

a. 0 cells (0.0%) have expected frequencies less than 5. The minimum expected cell frequency is 50.0.

4.2.3.5 Drunk driving

Drunk driving was also noted to be one of the other traffic violations reported among the drivers who took part in the study. As shown by the findings presented in Table 4-50, 1.3 % of the drivers in Abu Dhabi occasionally drive while intoxicated with alcohol above the permitted consumption level. The findings also indicated that 0.7 % of the drivers who took part in the study often drive while intoxicated with alcohol above the permitted consumption level (Table 4-50).

Table 4-46: The tendency of a driver on Abu Dhabi roads to violate rules relating to drunk driving

Options	Percentage (%) response			
	Abu Dhabi sector (n= 160)	Al Ain Sector (n= 80)	Western Sector (n= 60)	Overall (n= 300)
Never	90.0 %	87.5 %	80.0 %	87.3 %
Hardly ever	10.0 %	12.5 %	10.0 %	10.7 %
Occasionally	0.0 %	0.0 %	6.7 %	1.3 %
Quite Often	0.0 %	0.0 %	3.3 %	0.7 %
Frequently	0.0 %	0.0 %	0.0 %	0.0 %
Nearly all the times	0.0 %	0.0 %	0.0 %	0.0 %

The analysis of whether the frequency with which the drivers drive while they are intoxicated with alcohol above the permitted consumption level differ significantly was determined using Chi-square test (Table 4-51). The outcome of the study was statistically significant: $\chi2(5) = 629.173$, $p < 0.000$. Based on the observed outcome, there is a statistically significant difference in the frequency with which the drivers drive while they are intoxicated with alcohol above the permitted consumption level with hardly never (n= 32), occasionally (n= 4), and quite often (n= 2) responses being less compared to the never (n= 262) response (Table 4-51).

Table 4-51: The Chi-Square test for the response regarding the tendency of a driver on Abu Dhabi roads to violate rules relating to drunk driving

	Observed N	Expected N	Residual	Chi-Square	df	Asymp. Sig.
Never	262	75.0	187.0	629.173 a	5	0.000
Hardly never	32	75.0	-43.0			
Occasionally	4	75.0	-71.0			
Quite often	2	75.0	-73.0			
Total	300					

a. 0 cells (0.0%) have expected frequencies less than 5. The minimum expected cell frequency is 75.0.

4.2.3.6 Getting involved in unofficial 'races'

The study's findings also noted that there are cases of drivers who engage other drivers in unpermitted races. As shown in Table 4-52, 12.0 % of the respondents who took part in this study reported occasionally engaging other drivers in unpermitted races. The findings also indicated that 1.7 % of the drivers in Abu Dhabi quite often engage other drivers in unpermitted races while only 0.7 % of the respondents agreed to frequently engage other drivers in unpermitted races (Table 4-52).

Table 4-47: The tendency of a driver on Abu Dhabi roads to get involved in unofficial races on the highway

Options	Percentage (%) response			
	Abu Dhabi sector (n= 160)	Al Ain Sector (n= 80)	Western Sector (n= 60)	Overall (n= 300)
Never	80.0 %	76.3 %	70.0 %	77.0 %
Hardly ever	8.8 %	8.8 %	8.3 %	8.7 %
Occasionally	11.3 %	15.0 %	10.0 %	12.0 %
Quite Often	0.0 %	0.0 %	8.3 %	1.7 %
Frequently	0.0 %	0.0 %	3.3 %	0.7 %
Nearly all the times	0.0 %	0.0 %	0.0 %	0.0 %

The analysis of whether the drivers' frequency engaged other drivers in unpermitted races varies significantly was determined using the Chi-square test (Table 4-53). The outcome of the study was statistically significant: $\chi2(5) = 622.700$, $p < 0.000$. There is. Therefore, a statically significant difference in the frequency with which the drivers engaged other drivers in unpermitted races with hardly never (n= 26), occasionally (n= 36), quite often (n= 5), and frequently (2) responses being less compared to the never (n= 231) response (Table 4-53).

Table 4-48: The Chi-Square test for the response regarding the tendency of a driver on Abu Dhabi roads to get involved in unofficial races on the highway

	Observed N	Expected N	Residual	Chi-Square	df	Asymp. Sig.
Never	231	60.0	171.0	622.700 [a]	5	0.000
Hardly never	26	60.0	-34.0			
Occasionally	36	60.0	-24.0			
Quite often	5	60.0	-55.0			
Frequently	2	60.0	-58.0			
Total	300					

a. 0 cells (0.0%) have expected frequencies less than 5. The minimum expected cell frequency is 60.0.

4.3 Best approaches to be used in Abu Dhabi to reduce car accidents

The determination of the best approaches that can be used in Abu Dhabi to reduce car accidents was carried out based on the respondents' feedback regarding the questionnaire item on the enforcement of some of the considered traffic regulations. The best approaches were also determined based on the feedback regarding the driver attitudes. The outcome regarding the various best approaches that can be used to address the issue of car accidents is presented below.

4.3.1 *Enforcement of the regulation on close driving*

The study's findings noted that most (54.3 %) of the drivers strongly disagree with the fact that it is not a serious offence to violate the regulation regarding driving close to the car in front, while 22.3 % of them also disagree (Table 4-54). It is only 16.0 % and 6.6 % of the drivers who agree and strongly agree with the fact that it is not a serious offence to violate the regulation regarding driving close to the car in front, respectively (Table 4-54).

Table 4-49: Summary of the responses to the fact that close following isn't really a serious problem

Options	Percentage (%) response			
	Abu Dhabi sector (n= 160)	Al Ain Sector (n= 80)	Western Sector (n= 60)	Overall (n= 300)
Strongly disagree	58.1 %	50.0 %	50.0 %	54.3 %
Disagree	23.8 %	21.3 %	20.0 %	22.3 %
Nether agree or disagree	0.0 %	1.3 %	1.7 %	0.7 %
Agree	13.8 %	18.8 %	18.3 %	16.0 %
Strongly agree	4.4 %	8.8 %	10.0 %	6.6%

The assessment of whether the frequency of the driver's feedback regarding the fact that it is not a serious offence to violate the regulation regarding driving close to the car in front differs was determined using Chi-square test (Table 4-55). The outcome of the study was statistically significant: $\chi2(4) = 262.767$, $p < 0.000$. The results indicate that there is a statistically significant difference in the frequency of the driver's responses regarding the fact that it is not a serious offence to violate the regulation regarding driving close to the car in front with strongly agree (n= 20), agree (n= 48), and neither agree or disagree (n= 2) responses being less compared to the disagree (n= 67) and strongly disagree (n= 163) response (Table 4-55).

Table 4-50: The Chi-Square test for the response regarding the fact that close following isn't really a serious problem

	Observed N	Expected N	Residual	Chi-Square	df	Asymp. Sig.
Strongly Disagree	163	60.0	103.0	262.767 [a]	4	0.000
Disagree	67	60.0	7.0			
Neither agree or disagree	2	60.0	-58.0			
Agree	48	60.0	-12.0			
Strongly agree	20	60.0	-40.0			
Total	300					

a. 0 cells (0.0%) have expected frequencies less than 5. The minimum expected cell frequency is 60.0.

The findings presented in Table 4-56, which shows that most drivers regard close driving as a problem in Abu Dhabi, reflect their thoughts on the enforcement of the regulation regarding the close following to reduce car accidents in the region. As shown in Table 4-54, 46.3 % of the drivers agree that there is a need to enforce the close-following regulation and that they would be happy to see the regulation being applied. The findings also show that 39.7 % of the drivers who took part in the study strongly agree with the enforcement of the regulation on the close following. Only 0.3 % and 7.7 % of the respondents strongly disagree or disagree with the enforcement of the regulation on the close following (Table 4-56).

Table 4-51: The views on the enforcement of the close-following regulations

Options	Percentage (%) Response			
	Abu Dhabi sector (n= 160)	Al Ain Sector (n= 80)	Western Sector (n= 60)	Overall (n= 300)
Strongly disagree	0.0 %	0.0 %	1.7 %	0.3 %
Disagree	3.8 %	11.2 %	13.3 %	7.7 %
Nether agree or disagree	5.6 %	7.5 %	5.0 %	6.0 %
Agree	48.1 %	43.8 %	45.0 %	46.3 %
Strongly agree	42.5 %	37.5 %	35.0 %	39.7 %

The analysis of whether the frequency of the driver's feedback regarding the enforcement of the regulation regarding the close following to reduce car accidents in the region varies significantly was determined using Chi-square test (Table 4-57). The outcome of the study was statistically significant: $\chi 2(4) = 272.267$, $p < 0.000$. Based on the observed outcome, there is a statistically significant difference in the frequency of the driver's responses regarding the enforcement of the regulation regarding close following as a means of reducing car accidents in the region with disagreeing (n= 23), strongly disagree (n= 1), and neither agree or disagree (n= 18) responses being less compared to the agree (n= 139), and strongly agree (n= 119) responses (Table 4-57).

Table 4-52: The Chi-Square test for the response regarding the views on the enforcement of the close-following regulations

	Observed N	Expected N	Residual	Chi-Square	df	Asymp. Sig.
Strongly Disagree	1	60.0	-59.0	272.267 [a]	4	0.000
Disagree	23	60.0	-37.0			
Neither agree or disagree	18	60.0	-42.0			
Agree	139	60.0	79.0			
Strongly agree	119	60.0	59.0			
Total	300					

a. 0 cells (0.0%) have expected frequencies less than 5. The minimum expected cell frequency is 60.0.

4.3.2 *Enforcement of the regulation on speed*

The study also observed that the enforcement of the regulation on speed limit is one of the approaches that can help to address car accidents in Abu Dhabi. First, it was noted that most of the drivers disagree with the perception that the violation of speed limits is not a serious problem if the driver is careful. As shown in Table 4-58, 27.0 % of the drivers who took part in the study strongly disagreed with the perception that the violation of speed limits is not a serious problem if the driver is careful, while 35.0 % of them disagreed. Only 19.7 % and 16.3 % of the respondents agreed and strongly agreed with the perception that the violation of speed limits is not a serious problem if the driver is careful, respectively (Table 4-58).

Table 4-53: Summary of the responses regarding whether the violation of speed limits is not a serious problem if the driver is careful

	Percentage (%) response			
	Abu Dhabi sector (n= 160)	Al Ain Sector (n= 80)	Western Sector (n= 60)	Overall (n= 300)
Strongly disagree	28.1 %	26.3 %	25.0 %	27.0 %
Disagree	36.3 %	35.0 %	31.7 %	35.0 %
Nether agree or disagree	1.9 %	2.5 %	1.7 %	2.0 %
Agree	20.0 %	20.0 %	18.3 %	19.7 %
Strongly agree	13.8 %	16.3 %	23.3 %	16.3 %

The analysis of whether the frequency of the driver's feedback on whether the violation of speed limits is not a serious problem if the driver is careful differs was determined using Chi-square test (Table 4-59). The outcome of the study was statistically significant: $\chi 2(4) = 91.733$, $p < 0.000$. Therefore, there is a statistically significant difference in the frequency of the driver's responses on whether the violation of speed limits is not a serious problem if the driver is careful with the neither agree or disagree (n= 6) agree (n= 59), and strongly agree (n= 59) responses being less compared to the disagree (n= 105), strongly disagree (n= 81), responses (Table 4-59).

Table 4-59: The Chi-Square test for the response on whether the violation of speed limits is not a serious problem if the driver is careful

	Observed N	Expected N	Residual	Chi-Square	Df	Asymp. Sig.
Strongly Disagree	81	60.0	21.0	91.733 [a]	4	0.000
Disagree	105	60.0	45.0			
Neither agree or disagree	6	60.0	-54.0			
Agree	59	60.0	-1.0			
Strongly agree	49	60.0	-11.0			
Total	300					

a. 0 cells (0.0%) have expected frequencies less than 5. The minimum expected cell frequency is 60.0.

The findings presented in Table 4-60 show that most of the study respondents did not agree with driving faster, informs the opinion regarding the need to enforce strict regulations on speed limits. The outcome presented in Table 4-58 shows that 46.3 % of the drivers who took part in the study agree that reduced cases of accidents can be achieved by strictly enforcing the adherence to 80 Km/Hr speed in the designated roads. It is also evident that 39.6 % of the drivers strongly agree on the effectiveness of the strict enforcement of the stricter enforcement of 80 Km/Hr speed limits in the designated roads as a means of managing traffic crashes. Only 0.3 % and 7.7 % of the respondents strongly disagreed and disagreed with the effectiveness of the stricter enforcement of 80 Km/Hr speed limits in the designated roads as a means of managing traffic crashes, respectively (Table 4-60).

Table 4-60: Summary of the responses on the importance of the enforcement of strict speed limits on 80 KM in the reduction of TAs

	Percentage (%) response			
	Abu Dhabi sector (n= 160)	Al Ain Sector (n= 80)	Western Sector (n= 60)	Overall (n= 300)
Strongly disagree	1.8 %	3.8 %	5.0 %	0.3 %
Disagree	2.5 %	5.0 %	6.7 %	7.7 %
Nether agree or disagree	0.0	0.0 %	3.3 %	6.0 %
Agree	30.0 %	60.0 %	26.7 %	46.3 %
Strongly agree	65.6 %	31.3 %	58.3 %	39.6 %

The analysis of whether the frequency of the driver's feedback regarding the importance of the enforcement of strict speed limits on 80 KM in the reduction of TAs varies was determined using Chi-square test (Table 4-61). The outcome of the study was statistically significant: $\chi2(4) = 366.633$, $p < 0.000$. The findings, therefore, suggest that the difference in the frequency of the driver's responses regarding the importance of the enforcement of strict speed limits on 80 KM in the reduction of TAs is statistically significant with the disagree (n= 12), strongly disagree (n= 9), and neither agree or disagree (n= 2) responses being less compared to the agree (n= 112), and strongly agree (n= 165) responses (Table 4-61).

Table 4-54: The Chi-Square test for the response regarding the importance of the enforcement of strict speed limits on 80 KM in the reduction of TAs

	Observed N	Expected N	Residual	Chi-Square	Df	Asymp. Sig.
Strongly Disagree	9	60.0	-51.0	366.633[a]	4	0.000
Disagree	12	60.0	-48.0			
Neither agree or disagree	2	60.0	-58.0			
Agree	112	60.0	52.0			
Strongly agree	165	60.0	105.0			
Total	300					

a. 0 cells (0.0%) have expected frequencies less than 5. The minimum expected cell frequency is 60.0.

Further, the study noted that most drives backed the strict enforcement of speed limits. As shown in Table 4-62, 48.0 % of the drivers who took part in the study indicated that they strongly supported the strict enforcement of the speed limits. The outcome of the study also showed that 25.7 % of the respondents were in support of the strict enforcement of the speed limits. Only 10.3 % and 13.0 % of the respondents strongly disagreed and disagree with the strict enforcement of the speed limits respectively (Table 4-62).

Table 4-55: The summary of the support for the strict enforcement of the speed limits

	Percentage (%) response			
	Abu Dhabi sector (n= 160)	Al Ain Sector (n= 80)	Western Sector (n= 60)	Overall (n= 300)
Strongly disagree	8.1 %	10.0 %	16.7 %	10.3 %
Disagree	11.9 %	12.5 %	16.7 %	13.0 %
Nether agree or disagree	0.6 %	1.3 %	1.7 %	1.0 %
Agree	51.9 %	41.3 %	46.7 %	48.0 %
Strongly agree	23.8 %	35.0 %	18.3 %	25.7 %

The assessment of whether the frequency of the driver's feedback on whether they support the strict enforcement of the general regulations on speed limits varies significantly was determined using the Chi-square test (Table 4-63). The outcome of the study was statistically significant: $\chi2(4) = 201.850$, $p < 0.000$. Based on the observed outcome, the difference in the frequency of the driver's responses on whether they support the strict enforcement of the general regulations on speed limits is statistically significant with the disagree (n= 39), strongly disagree (n= 31), and neither agree or disagree (n= 3) responses being less compared to the agree (n= 144), and strongly agree (n= 77) responses (Table 4-63).

Table 4-56: The Chi-Square test for the response regarding the support for the strict enforcement of the speed limits

	Observed N	Expected N	Residual	Chi-Square	Df	Asymp. Sig.
Strongly Disagree	31	58.8	-27.8	201.850[a]	4	0.00
Disagree	39	58.8	-19.8			
Neither agree or disagree	3	58.8	-55.8			
Agree	144	58.8	85.2			
Strongly agree	77	58.8	18.2			
Total	294					

a. 0 cells (0.0%) have expected frequencies less than 5. The minimum expected cell frequency is 58.8.

4.3.3 *Monitoring of drunk driving*

The other approach to reducing the TAs in Abu Dhabi, as shown by the response from the drivers who took part in the study, is the monitoring of drunk driving. As shown in Table 4-64, 28.0 % of the drivers agreed that there is a need to monitor drunk driving by randomly testing of breath. The findings of the study also indicate that 41.3 % of the drivers strongly agree that there is a need to monitor drunk driving by random testing of breath. Only 1.7 % and 12.0 % of the study respondents strongly disagreed and disagreed with the need to introduce random breath testing of drivers, respectively (Table 4-64).

Table 4-57: Response regarding the need to introduce random breath testing of drivers

	Percentage (%) response			
	Abu Dhabi sector (n= 160)	Al Ain Sector (n= 80)	Western Sector (n= 60)	Overall (n= 300)
Strongly disagree	0.0 %	0.0 %	8.3 %	1.7 %
Disagree	8.1 %	18.8 %	13.3 %	12.0 %
Nether agree or disagree	18.1 %	15.0 %	16.7 %	17.0 %
Agree	30.0 %	26.3 %	25.0 %	28.0 %
Strongly agree	43.8 %	40.0 %	36.7 %	41.3 %

The analysis of whether the frequency of the driver's feedback on whether there is a need to monitor drunk driving by random testing of breath differs was determined using the Chi-square test (Table 4-65). The outcome of the study was statistically significant: $\chi 2(4) = 139.233$, $p < 0.000$. Based on the observed outcome, the difference in the frequency of the driver's responses on whether there is a need to monitor drunk driving by random testing of breath is statistically significant with the disagree (n= 36), strongly disagree (n= 5), and neither agree or disagree (n= 51) responses being less compared to the agree (n= 84), and strongly agree (n= 124) responses (Table 4-65).

Table 4-58: The Chi-Square test for the response on whether there is a need to monitor drunk driving by random testing of breath

	Observed N	Expected N	Residual	Chi-Square	Df	Asymp. Sig.
Strongly Disagree	5	60.0	-55.0	139.233[a]	4	0.00
Disagree	36	60.0	-24.0			
Neither agree or disagree	51	60.0	-9.0			
Agree	84	60.0	24.0			
Strongly agree	124	60.0	64.0			
Total	300					

a. 0 cells (0.0%) have expected frequencies less than 5. The minimum expected cell frequency is 60.

4.3.4 *Addressing the driver behaviour*

The analysis of the responses obtained from drivers who took part in the study revealed some of the driver's behaviours that need to be addressed to reduce problems associated with the high risk of TAs. One of the behaviours is overtaking behaviour. Based on the findings presented in Table 4-66, it is evident that although a majority, 72.0 % of the drivers who took part in the study, strongly disagree with the perception that taking of some risks during overtaking is fine, some of them agree (9.0 %) and strongly agree (1.3 %).

Table 4-59: Response on whether taking of some risks during overtaking is ok

	Percentage (%) response			
	Abu Dhabi sector (n= 160)	Al Ain Sector (n= 80)	Western Sector (n= 60)	Overall (n= 300)
Strongly disagree	75.6 %	68.8 %	66.7 %	72.0 %
Disagree	18.1 %	13.8 %	15.0 %	16.3 %
Nether agree or disagree	0.0 %	2.5 %	3.3 %	1.3 %
Agree	6.2 %	11.3 %	13.3 %	9.0 %
Strongly agree	0.0 %	3.8 %	1.7 %	1.3 %

The assessment of whether the frequency of the driver's feedback on whether taking some risks during overtaking is ok differs significantly was determined using the Chi-square test (Table 4-67). The outcome of the study was statistically significant: $\chi2(4) = 530.300$, $p < 0.000$. Based on the observed outcome, the difference in the frequency of the driver's responses on whether taking of some risks during overtaking is ok is statistically significant with the neither agree or disagree (n= 4), agree (n= 27), strongly agree (n= 4), and disagree (n=49) responses being less compared to the strongly disagree (n= 216) response (Table 4-67).

Table 4-60: The Chi-Square test for the response on whether taking of some risks during overtaking is ok

	Observed N	Expected N	Residual	Chi-Square	Df	Asymp. Sig.
Strongly Disagree	216	60.0	156.0	530.300[a]	4	0.00
Disagree	49	60.0	-11.0			
Neither agree or disagree	4	60.0	-56.0			
Agree	27	60.0	-33.0			
Strongly agree	4	60.0	-56.0			
Total	300					

a. 0 cells (0.0%) have expected frequencies less than 5. The minimum expected cell frequency is 60.0.

The findings of the study also noted that some of the drivers think that risky overtaking is okay for those who are in control of their driving (Table 4-68). The study's outcome showed that although half of the respondents (50.7 %) strongly disagree with the perception that risky overtaking is okay for those who are in control of their driving, 12.3% of them agreed and 1.0 % strongly agreed (Table 4-68).

Table 4-61: Response on whether risky overtaking is okay for those who are in control of their driving

	Percentage (%) response			
	Abu Dhabi sector (n= 160)	Al Ain Sector (n= 80)	Western Sector (n= 60)	Overall (n= 300)
Strongly disagree	53.1 %	50.0 %	45.0 %	50.7 %
Disagree	33.1 %	30.0 %	26.7 %	31.0 %
Nether agree or disagree	4.4 %	3.8 %	8.3 %	5.0 %
Agree	9.4 %	16.3 %	15.0 %	12.3 %
Strongly agree	0.0 %	0.0 %	5.0 %	1.0 %

The analysis of whether the frequency of the driver's feedback on whether risky overtaking is okay for those who are in control of their driving varies significantly was determined using the Chi-square test (Table 4-69). The outcome of the study was statistically significant: $\chi2(4) = 255.933$, $p < 0.000$. Therefore the difference in the frequency of the driver's responses on whether risky overtaking is okay for those who are in control of their driving is statistically significant with the neither agree or disagree (n= 15), agree (n= 37), and strongly agree (n= 3) responses being less compared to the strongly disagree (n= 152) and disagree (n=93) responses (Table 4-69).

Table 4-69: The Chi-Square test for the response on whether risky overtaking is okay for those who are in control of their driving

	Observed N	Expected N	Residual	Chi-Square	Df	Asymp. Sig.
Strongly Disagree	152	60.0	92.0	255.933[a]	4	0.00
Disagree	93	60.0	33.0			
Neither agree or disagree	15	60.0	-45.0			
Agree	37	60.0	-23.0			
Strongly agree	3	60.0	-57.0			
Total	300					

a. 0 cells (0.0%) have expected frequencies less than 5. The minimum expected cell frequency is 60.0.

The observed presence of drivers who think it is okay to overtake in dangerous circumstances (Table 4-69) and those who think that acceptable to take a slight risk when overtaking (Table 4-67) could be linked to the fact that some of them do not know precisely the risks that can be taken when overtaking. As shown in Table 4-70, some of the drivers (15.3 %) who took part in the study disagreed with the fact that they know precisely the risks that can be taken when overtaking, while 1.7 % strongly disagreed.

Table 4-62: Assessment of whether drivers know exactly the risks that can be taken when overtaking

	Percentage (%) response			
	Abu Dhabi sector (n= 160)	Al Ain Sector (n= 80)	Western Sector (n= 60)	Overall (n= 300)
Strongly disagree	0.0 %	0.0 %	8.3 %	1.7 %
Disagree	13.8 %	16.3 %	18.3 %	15.3 %
Nether agree or disagree	0.0 %	1.3 %	1.7 %	0.7 %
Agree	20.0 %	21.3 %	16.7 %	19.7 %
Strongly agree	66.3 %	61.3 %	55.0 %	62.7 %

The assessment of whether the frequency of the driver's feedback on whether drivers know exactly the risks that can be taken when overtaking differs was determined using the Chi-square test (Table 4-71). The outcome of the study was statistically significant: $\chi 2(4) = 382.833$, $p < 0.000$. The findings show that the difference in that the frequency of the driver's responses on whether they know exactly the risks that can be taken when overtaking is statistically significant with the neither agree or disagree (n= 2) disagree (n= 46), strongly disagree (n=5) and agree (n= 59) responses being less compared to the strongly agree (n= 188) response (Table 4-71).

Table 4-63: The Chi-Square Test for the response on whether drivers know precisely the risks that can be taken when I overtaking

	Observed N	Expected N	Residual	Chi-Square	Df	Asymp. Sig.
Strongly Disagree	5	60.0	-55.0	382.833[a]	4	0.00
Disagree	46	60.0	-14.0			
Neither agree or disagree	2	60.0	-58.0			
Agree	59	60.0	-1.0			
Strongly agree	188	60.0	128.0			
Total	300					

a. 0 cells (0.0%) have expected frequencies less than 5. The minimum expected cell frequency is 60.0.

The other driving behaviour that was noted is close to driving. The findings presented in Table 4-72 show that 8.7 % of the drivers who took part in the study agreed with the perception that it is quite acceptable to violate the regulations on the recommended safe distance while driving while 3.7 % of them strongly agreed.

Table 4-64: Perception of the drivers on whether it is acceptable to violate the regulations on the recommended safe distance while driving

	Percentage (%) response			
	Abu Dhabi sector (n= 160)	Al Ain Sector (n= 80)	Western Sector (n= 60)	Overall (n= 300)
Strongly disagree	43.8 %	41.3 %	35.0 %	41.3 %
Disagree	45.0 %	42.5 %	38.3 %	43.0 %
Nether agree or disagree	2.5 %	2.5 %	5.0 %	3.0 %
Agree	5.0 %	7.5 %	20.0 %	8.7 %
Strongly agree	3.1 %	6.3 %	1.7 %	3.7 %

The assessment of whether the frequency of the driver's feedback on whether it is acceptable to violate the regulations on the recommended safe distance while driving varies significantly was determined using the Chi-square test (Table 4-73). The outcome of the study was statistically significant: $\chi 2(4) = 251.084$, $p < 0.000$. Based on the observed outcome, the difference in the frequency of the driver's responses on whether it is acceptable to violate the regulations on the recommended safe distance while driving is statistically significant with the neither agree or disagree (n= 9), agree (n= 26), and strongly agree (n=11) responses being less compared to the strongly disagree (n= 124) and disagree (n= 129) responses (Table 4-73).

Table 4-65: The Chi-Square Test for the response on whether it is acceptable to violate the regulations on the recommended safe distance while driving

	Observed N	Expected N	Residual	Chi-Square	Df	Asymp. Sig.
Strongly Disagree	124	59.8	64.2	251.084[a]	4	0.00
Disagree	129	59.8	69.2			
Neither agree or disagree	9	59.8	-50.8			
Agree	26	59.8	-33.8			
Strongly agree	11	59.8	-48.8			
Total	299					

a. 0 cells (0.0%) have expected frequencies less than 5. The minimum expected cell frequency is 59.8.

The analysis of the responses obtained from drivers who took part in the study revealed the other driver's behaviour that needs to be addressed to reduce problems associated with a high risk of TAs is the perception regarding the driving speed. Based on the findings presented in Table 4-74, it is evident that although a majority 35.0 % of the drivers who took part in the study, disagree with the perception that taking of some risks during overtaking is ok some of them agree (19.7 %) and strongly agree (16.3 %).

Table 4-66: Perception of the drivers on whether its OK to drive faster than the speed limit as long as you drive carefully

	Percentage (%) response			
	Abu Dhabi sector (n= 160)	Al Ain Sector (n= 80)	Western Sector (n= 60)	Overall (n= 300)
Strongly disagree	28.1 %	26.3 %	25.0 %	27.0 %
Disagree	36.3 %	35.0 %	31.7 %	35.0 %
Nether agree or disagree	1.9 %	2.5 %	1.7 %	2.0 %
Agree	20.0 %	20.0 %	18.3 %	19.7 %
Strongly agree	13.8 %	16.3 %	23.3 %	16.3 %

The analysis of whether the frequency of the driver's feedback on the perception of the drivers on whether its OK to drive faster than the speed limit as long as you drive carefully differs was determined using Chi-square test (Table 4-75). The outcome of the study was statistically significant: $\chi 2(4) = 91.733$, $p < 0.000$. Based on the observed outcome, the difference in the frequency of the driver's responses on the perception of the drivers on whether its OK to drive faster than the speed limit as long as you drive carefully is statistically significant with the neither agree or disagree (n= 6), agree (n= 59), and strongly agree (n=49) responses being less compared to the strongly disagree (n= 81) and disagree (n= 105) responses (Table 4-75).

4.4 Findings of thematic analysis

In this section, a description of the findings relating the use of AI in the transport sector is provided. First the studies from which the data were obtained are described. The obtained themes relating to the use of AI are then described. The description of the use of AI will first focus on the selected countries across the world first, after which the situation in Abu Dhabi is described. The selected countries were those that had a record of traffic accidents that were comparable to that of the UAE.

Table 4-67: The Chi-Square test for the response on the perception of the drivers on whether its OK to drive faster than the speed limit as long as you drive carefully

	Observed N	Expected N	Residual	Chi-Square	Df	Asymp. Sig.
Strongly Disagree	81	60.0	21.0	91.733[a]	4	0.00
Disagree	105	60.0	45.0			
Neither agree or disagree	6	60.0	-54.0			
Agree	59	60.0	-1.0			
Strongly agree	49	60.0	-11.0			
Total	300					

a. 0 cells (0.0%) have expected frequencies less than 5. The minimum expected cell frequency is 60.0.

The assessment of the effectiveness of IA in the management of TAs was based on the thematic analysis of the findings obtained from 18 selected studies. As shown in Table 4-76, most (n= 8) of the studies described the different aspects of AI of the transport sector in the US. The findings presented in Table 4-76 also show that the study retrieved and obtained data relating to AI in transport sector in the countries such as, Lithuania, Saudi Arabia and the United Kingdom from 2 studies each while only one of the retrieved studies described the adoption of AI in the South African roads. Most of the retrieved studies (n= 8) were based on a descriptive analysis approach while studies were based on an experimental approach. Table 4-76 also shows that two (2) of the retrieved studies were based on the case study approach while the remaining studies were based on literature review, independent review, or mixed methods research approaches.

Table 4-68: The summary of the selected articles

Author (Year)	Country	Research approach	Area of focus
Smith (2013)	United States of America	Descriptive analysis	Assessment of the use of automated vehicles
Johnson and Trivedi (2011)		Case study	Assessment of the use of AI in the management of the driving behaviour
Zhao et al. (2013)		Experimental approach	Use of AI in the management of the driving behaviour
Bergasa et al. (2014)		Descriptive analysis	AI techniques used to improve driver attentiveness
Bagdadi (2013)		Experimental approach	Use of AI in assessment of high risk drivers
Meiring and Myburgh (2015)		Literature review	Assessment of the use of AI systems and related algorithms
Dai et al. (2010)		Descriptive analysis	Use of AI in detection of drunk driving
Gifford (2010)		Descriptive analysis	Government policies towards use of AI in transport and the associated effectiveness
Hall and Pesenti (2017)	United Kingdom	Independent review	Assessment of the growth and application of AI in UK
Gilmore (1993)	United Kingdom	Descriptive analysis	Use of AI in the management of traffic systems
Čižiūnienė and Matijošius (2015)	Lithuania	Mixed methods research	Management of the factors that predetermine the accident rates
Jarasuniene (2007)	Lithuania	Experimental approach	Implementation of AI in the management of traffic systems
Alyahya et al. (2017)	Saudi Arabia	Descriptive analysis	Use of AI in detection of offenders (number plate recognition)
Andersen and Summala, (2004)	South Africa	Descriptive analysis	Use of AI in the assessment of the driving behaviour

Ali, Al-Harthei & Garib (2013)	Abu Dhabi	Descriptive analysis	Use of AI in the control traffic challenges associated with bad weather
Al Junaibi, (2016)	Abu Dhabi	Case study	Effective deployment of AI in Abu Dhabi roads

4.4.1 *Adoption of AI in the management of TAs in selected countries across the world*

The description of the findings relating to the adoption of AI in the management of TAs in selected countries across the world is presented in Table 4-77. One of the AI applications in road safety management in the US is through the adoption of self-driving vehicles (Smith, 2013). However, it should be noted that not all States in the US have adopted the concept of unmanned vehicles. The states that have enacted the laws that guide the adoption of the unmanned vehicles include Nevada, Florida and California (Smith, 2013). The other states that have enacted laws that guide the use of the automated vehicles include District of Columbia and the State of Michigan (Smith, 2013).

The other problems associated with TAs in the US are related to driver's behaviour. One of the major behaviour that is associated with high cases of accidents in the risky or aggressive driving style (Johnson & Trivedi, 2011; Zhao et al., 2013). It is estimated that about 56 % of the deadly crashes that occurred in the US between 2003 and 2007 were due to driver behaviour related accidents (Johnson & Trivedi, 2011; Zhao et al., 2013). Evidence also shows that the inattentive driving style also contributes to a high percentage of US accidents (Bagdadi, 2013). According to Bergasa et al. (2014), about 3092 people were killed due to accidents caused by the inattention of the drivers. Fatigue among the drivers and distraction has also been indicated to result in fatal accidents. The driver's behaviours that have been associated with high cases of accidents in the US include drunk driving (Meiring & Myburgh, 2015). It is estimated that 32 % of the fatal accidents that occurred in the US between 2007 and 2008 were caused by errors committed by drunk drivers (Dai et al., 2010). To address the driver's behaviour problem in the US, there are various AI strategies that have been adopted. Some of the strategies include the DAS and the advanced DAS, which enhance positive behaviour by alerting the driver of the risks (Meiring & Myburgh, 2015). Other approaches such as drowsiness detection using image processing systems are also important in accident prevention. Driver distraction detection systems such as the early warning applications are also vital in preventing accidents (Meiring & Myburgh, 2015).

The US also has the IntelliDriveSM program, which consists of computer technologies that allow the vehicle to vehicle communication and communicate the vehicles with the infrastructure (Gifford, 2010). IntelliDriveSM program aims at preventing collisions by enabling initiate evasive action when it senses the risk of collision. The vehicles to infrastructure communication component of the IntelliDriveSM program allows the drivers to receive information regarding the condition of the road and therefore adopt driving behavior that enhances the safety under given condition. Therefore, the vehicles to infrastructure communication component are important in the prevention of the crashes caused by bad weather and poor road conditions (Gifford, 2010).

The other artificial intelligent-based application used in the US is the active traffic management system, which combines multiple technologies (Gifford, 2010). The technologies included in the active traffic management system are the overhead gantries (provide real-time traffic information), speed limit control systems, junction control systems, and the travel time signs for the provision of information regarding the different traffic conditions (Gifford, 2010). The US also has automated traffic enforcement systems, which are important in tracking traffic offenders such as those that run red lights or exceed speed limits.

The use of AI in the management of the problems associated with the TAs in the UK is mainly evident through the use of safe autonomous systems (Hall & Pesenti, 2017). As shown in Table 2-24, safe autonomous systems help address the problems such as traffic rule violations and the management of the driver's behaviour that is likely to result in TAs. As indicated by Hall and Pesenti, (2017), the safe autonomous systems that have been adopted in the UK include the FiveAi and Oxford's Oxbotica. The other system used in the UK is the selenium system, which uses lasers and cameras to ensure enhanced safety by managing the driver's driving style and behaviour. Gilmore J.F. (1993) also indicates the UK has in place the SCOOT system capable of collecting information about traffic flow and advising on management options.

Various AI based approaches have been used to address the traffic problems in Lithuania, which mainly includes overspeeding, and bad weather conditions (Čižiūnienė and Matijošius 2015). One of the approaches is used in the management of traffic problems is the automatic traffic data collection and dissemination systems. The other AI based approach is the use of variable message signs, which are LED that are displayed on the roadside and there are important in the management of the traffic. The variable message signs can convey the information regarding bad weather and advise the motorists on the speeds (Jarasuniene 2007).

The SA traffic authorities also use AI to manage the driving behaviours among road users. One of the approaches that are used is the Saudi license plate recognition system, which uses the artificial neural network (Alyahya et al., 2017). The other AI-based approach used to improve road safety in SA is the SmartMobility Road Suite, which is used to manage interurban expressway traffic. The SmartMobility Road Suite provides the users with real-time information on traffic conditions. The application also provides real-time solutions to predicted and existing traffic problems. SmartMobility Road also helps in the prevention of TAs by providing the safest travel routes.

There is limited research evidence regarding the use of AI approaches in the management of traffic in Kuwait. The available information suggests that adopting the AI approaches in the country is at the initial stages, with the police being the only ones that have been indicated to use the technology largely. The Kuwait national police use what they term as smart patrols to monitor, track down and apprehend traffic law violators. The patrols are equipped with equipment that collect different types of data. The patrols have radars that are capable of monitoring the speed of the passing vehicles and alert the officer in charge of the speed status of the vehicle. The patrols are also fitted with sensors and cameras that are able to automatically detect the number plates of the vehicles and scan the record of the vehicles and the driver.

There is limited research evidence regarding the AI application in the management of traffic problems in South Africa. Andersen (2004) only published an article that was noted to report the use of the application of AI in the South African transport sector. The researcher highlighted several AI-based approaches that include Ben Schoeman ITS pilot project, which uses the Variable Message Signs, CCTV camera system and traffic detectors to manage the congestion and TAs. The other approach is the emergency management systems, which has been deployed in the Huguenot tunnel in the Western Cape. The driver information and warning sign system has also been piloted. The system alerts the drivers of the accidents ahead and provides instruction regarding the speed lead across the different sections of the highway. The driver information and warning sign system also provide information about the road condition and warn the drivers of the traffic problems to enhance attentiveness and safe driving. South Africa has also piloted with the incident detection equipment, which help in the collection of data and alerting of the road users of the condition of the road.

Table 4-69: Summary of the AI approaches that are used in the management of road safety in the various part of the world

Traffic problems	Solution using AI
Use of AI to reduce the TAs in the US	
Vehicle to vehicle distance, lane departure and violation	Automated vehicles
Human errors; Risky driving; aggressive driving style	Driver behaviour modelling systems
Bad weather and poor visibility	IntelliDrive^{SM} program Active traffic management system, Automated traffic enforcement systems
Use of AI to reduce the TAs in the UK	
Vehicle to vehicle distance, lane departure and violation	Safe autonomous systems (FiveAi and Oxford's Oxbotica)
Human errors; Risky driving; aggressive driving style	Cars fitted with lasers and cameras management of traffic flow using SCOOT system
Bad weather	
Use of AI to reduce the TAs in the Lithuania	
Overspeeding; violation of traffic rules	Use of automatic traffic data collection and dissemination system;
Traffic congestion in the large cities	The use of Variable Message Signs
Bad weather	
Use of AI to reduce the TAs in SA	
Vehicle to vehicle distance, lane departure and violation	License plate recognition system based on artificial neural

Human errors; Risky driving; aggressive driving style	network. SmartMobility Road Suite
Use of AI to reduce the TAs in Kuwait	
Over-speeding	Smart patrols
Human errors; Risky driving; aggressive driving style	
Bad weather and poor visibility	
Use of AI to reduce the TAs in South Africa	
Vehicle to vehicle distance, lane departure and violation	Ben Schoeman ITS pilot project (Variable Message Signs, CCTV camera system and traffic detectors). Emergency management systems Driver information and warning sign system Incident detection equipment
Human errors; Risky driving; aggressive driving style	
Bad weather	

4.4.2 *Adoption of AI in the management of TAs in Abu Dhabi*

Poor visibility due to the presence of fog is one of the challenges that lead to accidents in Abu Dhabi (Elsheshtawy, 2008). The massive accidents that happened in March 2008 and April 2011 that involved 200 and 130 vehicles, respectively were attributed to poor visibility caused by foggy conditions (Ali, Al-Harthei & Garib, 2013). The provision of early warning regarding the sections of the road that have to fog is key in reducing collisions. Ali et al. (2013) proposed an early real-time warning technology that can be used to detect fog and subsequent warning of the drivers of the danger ahead. The technology proposed by Ali et al. (2013) also instructs the drivers on the level of speed during foggy conditions and the possible alternative routes. The proposed technology involves the installation of sensors in light poles and other positions and structures in the highways. The role of the sensors is to send the data on the formation of fog from the sensors to the data collection point where the data is analysed. The technology also integrates the traffic movement detection devices that are installed in the vehicles. The devices detect the build-up of traffic and slow traffic movement and send the data to the data collection and analysis centre. The technology also integrates the signals from the police cars, which indicate the zone covered by fog. The data collection and analysis centre then perform the appropriate analysis and use the geographic information system of Abu Dhabi to determine the geographical areas that are covered by fog. The accuracy of the information produced by the technology is based on the quality and the accuracy of the data that is received at the collection and analysis centre. The information regarding the areas covered by fog and the recommended speed is then relayed to the drivers through the Changeable Message Signs (CMS) that are found on the highways.

The CMS-based technology proposed for adoption in Abu Dhabi has been successfully implemented in other cities across the world. Georgia is one of the cities that have implemented the CMS based fog detection and warning technology, which help to alert the drivers and the authorities about the fog formation and automatically turn on the streetlights (Ali et al., 2013). The CMS-based fog detection system is also used in Tennessee to reduce collisions. The data received from the fog and speed detectors are analysed and the obtained information is relayed to the drivers through Highway Advisory Radio Messages and CMS platforms. The use of CMS-based fog detection system has resulted in the complete prevention of fog-related accidents in

Tennessee (Ali et al., 2013).

Few studies have examined the impact of the use of technologies on the factors associated with the high incidences of TAs in the UAE. The study carried out by Al Junaibi, (2016) provides important insights into the effectiveness of ITS technologies in addressing the problem. The researchers noted that the adoption of the technologies such as speed monitoring technologies is associated with significant deterrence of risky behaviours among UAE drivers. Al Junaibi (2016) also noted that UAE motorists regard the adoption of advanced technologies as important in reducing accidents associated with bad weather. The researcher also noted that the use of speed detection cameras is effective in deterring the drivers from over speeding. However, Al Junaibi (2016) noted that the use of warning messages such as the CMS or the variable message signs is less effective than the use of speed limit detectors. Based on the analysis of the expert opinion regarding the importance of technology in addressing TAs in the Abu Dhabi, Al Junaibi, (2016) observed that most of the experts were satisfied with the effectiveness of the technologies. The researcher noted that 75 % of the experts agreed that speed detection technologies lead to enhanced adherence to the speed regulations. Al Junaibi, (2016) also noted that the use of technologies is important in enhancing driver education, which is key in minimising the errors committed by the drivers and leads to enhanced adherence to the traffic rules. However, Al Junaibi, (2016) argued that the technologies should not be depended upon as the only platform for carrying out driver education. Al Junaibi, (2016) also observed that the use of technologies enhances response time during emergencies.

4.5 Summary of the findings

In this section, findings to the research relating to the traffic problems in the Abu Dhabi roads, the violations that lead to the observed problem and the best approaches that can be used in Abu Dhabi to reduce car accidents. The study findings show that the common traffic problems on Abu Dhabi's roads include the driver-related factors, vehicular factors, and road condition related factors. Hand-held mobile phones are the most frequently reported (87.3 % of the respondents) driver-related factors. Driving a defective vehicle was noted to be the highest reported vehicular factor (52.7 % of the respondents) while poor visibility was the commonest (43.3 % of the respondents) road condition-related factors.

The findings also show that there are various violations that are associated with the traffic problems on Abu Dhabi's roads. Risky overtaking such as the overtaking on the inside lane was noted to be one the violations, with the number of the those who reported to commit the offense occasionally (n=91) being significantly higher ($\chi2(5) = 69.880$, $p < 0.000$) than the expected (50) but those who committed the frequently and nearly all the times was noted to be significantly less. Overtaking when is taking a right turn was also observed to be the other violation with those who commit the violation quite often (n= 93), frequently (n= 76), and nearly all the times (n= 65) being significantly higher ($\chi2(5) = 105.920$, $p < 0.000$) than the expected (50). The tendency to violate the need to keep a safe distance from the car in front by driving close to it is the other violation. The findings indicate that the number of those who commit the violation frequently (n= 74), and nearly all the times (n= 116) is significantly higher ($\chi2(5) = 152.120$, $p < 0.000$) than the expected (50). The number of those who violate the speed limits quite often (n= 79) frequently (n= 52), and nearly all the times (n= 71) was observed to significantly higher ($\chi2(5) = 54.640$, $p < 0.000$) than the expected (50).

Some of the examine violations were noted to be less common. The findings show that the number of those who violate the traffic lights at the junction quite often (n= 4), and frequently (n= 3) is significantly lower ($\chi2(5) = 628.900$, $p < 0.000$) than the expected value. The number of those who violate rules relating to drunk driving occasionally (n= 4), and quite often (n= 2) was also noted to significantly lower ($\chi2(5) = 629.173$, $p < 0.000$) than the expected (75). Similar findings was observed for the number of those who get involved in unofficial races on the highway, with those the number of those who quite often (n= 5), and frequently (2) commits the offence being significantly lower ($\chi2(5) = 622.700$, $p < 0.000$) than the expected (60). The findings on the best approaches that can be used in Abu Dhabi to reduce car accidents showed that there are various approaches that lead to a significant reduction in the TAs. The number of those who agreed (n= 139), and strongly agreed (n= 119) with the enforcement regulation regarding close following as a means of reducing car accidents was significantly higher ($\chi2(4) = 272.267$, $p < 0.000$) than the expected (60). The findings also indicate that the number of those who agreed (n= 112), and strongly agreed (n= 165) with the enforcement of strict speed limits on 80 KM in the reduction of TAs was significantly higher ($\chi2(4) = 366.633$, $p < 0.000$) than the expected (60). A significantly higher number of the respondents compared to the expected (60) also agreed (n= 84), and strongly agreed (n= 124) with the need to introduce random breath testing of drivers, $\chi2(4) = 139.233$, $p < 0.000$. The findings also show that certain driver behaviour should be addressed to reduce the number of TAs. The behaviours include risky overtaking, driving close to the car in the front and driving beyond the recommended limit.

The obtained findings also show the importance of AI in the management of TAs. The outcome of the thematic analysis of the data from 18 studies from five different countries showed that AI has the potential to address the challenges associated with TAs in Abu Dhabi. The obtained findings showed that AI solutions such as automated driving systems, driver behaviour modelling systems, safe autonomous systems and automatic traffic data collection and dissemination system are essential in addressing the various causes of accidents such as cause associated with human errors, bad weather, road and vehicle defects.

4.6 Validation of the findings

Validation of the findings was necessary for this study because the researcher acted as the collector of the data and the analyst, which increased the chances of researcher bias (Miles & Huberman, 1994; Birt et al., 2016). The validation of the findings of the primary data analysis was carried out based on Birt et al. (2016) 's and it involved sending the findings to the participants for them to check and give their opinion regarding the relevance and generalisability. It should, however, be noted that the approach that was taken in this study was slightly different from what Birt et al. (2016) proposed since this study validated the findings that were collected from existing studies and not directly from the participants. The researcher also used validation of the findings to obtain the participants' reflection on their experiences and allow them to add to the data. The researcher took the validation of the findings are a means to determine the relevance of the findings and was ready to undertake further analyses if the responses from the validation process suggested the need for further assessment.

The first step in the validation of the findings was to prepare a summary of the findings that emerged from the questionnaires. The summary included a brief description of how the findings were obtained. The summary of the findings was presented in non-scientific wording in order to ensure that the participants fully understood and engaged with the findings. For ease of engaging with the participants, the researcher highlighted the main themes, and immediately after each theme, open questions were posed, and spaces are left for the participants to give feedback (see Table 4-78). The researcher ensured that the recruited participants were accessible, willing, and had the capacity to understand and respond to the findings. Since the findings that were obtained from existing studies focused on the causes of traffic accidents and approaches used in the prevention of traffic accidents, the researcher viewed that traffic management experts in Abu Dhabi were best suited to validate the findings. The research also shows the traffic control officers since yet the contact details collected from those who had participated in the interviews. Therefore, the researcher identified five experts traffic officers in Abu Dhabi and requested them to give their opinion regarding the outcomes. The summarised findings were then sent to the five participants and given a week to respond. The participants were informed that they were free to give their opinion regarding any of the findings based on their own understanding. The responses that were data from the participants were integrated into the findings.

Table 4-70: Summary of the synthesized findings that were submitted to the validators for the validation of the findings

Parameter	**Description**
Finding 1	**Summary of finding**: The common traffic problems on Abu Dhabi's roads include the driver related factors, vehicular factors, and the road condition related factors. **Question:** Do you agree that agree that the various traffic problems in Dhabi fall in the stated three groups? **Response:**
Finding 2	**Summary of finding**: Risky overtaking, Over speeding, and violation of the need to keep a safe distance are the major violations that are associated with the traffic problems on Abu Dhabi's roads **Question:** Is it correct to state the three stated causes of accidents are the major in Abu Dhabi? **Response:**
Finding 3	**Summary of finding**: The best approaches that can be used in Abu Dhabi to reduce car accidents include the enforcement regulation regarding close following, enforcement of strict speed limits on 80 KM roads, random breath testing of drivers, and addressing driver behaviour including risky overtaking, driving close to the car in the front and driving beyond the recommended limit **Question:** Do you agree that the four stated approaches represent the best strategies to address car accidents in Abu Dhabi? **Response:**

Table 4-79 summarizes the feedback obtained from findings validation. The responses that were obtained from the participants confirmed that that the common traffic problems on Abu Dhabi's roads include driver-related factors, vehicular factors, and road condition-related factors. However, it was noted that clarification on the causes associated with bad weather was needed to be made under road conditions. The feedback also confirmed that risky overtaking, over-speeding, and violation of the need to keep a safe distance are the major violations associated with the traffic problems on Abu Dhabi’s roads. Finally, the identified four stated approaches were noted to represent the best strategies to address car accidents in Abu Dhabi. Additionally, the need to consider technology-based “real-time, adaptive and proactive strategies” as a possible approach for addressing car accidents in Abu Dhabi was highlighted.

Table 4-71: Summary of the responses obtained from validators

Findings	Summary of the response	Steps taken
Finding 1.	Three respondents agreed that the common traffic problems on Abu Dhabi's roads include the driver related factors, vehicular factors, and the road condition related factors. Two noted that there is a need to clarify cause associated with weather conditions. One noted that vehicular factors are not common (negligible).	Although no alteration was introduction, the researcher ensured that the clarification of causes associated with bad weather was made under road conditions.
Finding 2.	All the five participants agreed the stated three causes of accidents are the major in Abu Dhabi.	No alterations was made.
Finding 3	Two participants agreed that the four stated approaches represented the best strategies to address car accidents in Abu Dhabi. Three of them indicated that the only realistic solution should target the driver behaviour or adoption on real-time, adaptive and proactive strategies based on emerging technologies	No alterations was made however, since the primary findings did not provide insights on the technology-based “real-time, adaptive and proactive strategies” secondary analysis was carried out to identify the approaches.

The outcome of validation process affirms the findings of the primary data analysis regarding the causes of traffic accidents. Therefore based on the outcome the causes of accidents include the driver related factors, vehicular factors, and the road condition related factors.

5 Chapter - Five Discussion

This study focused on investigating and evaluating the different causes that are believed to be behind the growing TAs and congestion in Abu Dhabi Emirate roads. The study analysed the data that was obtained from three locations in the UAE, which included three locations. Prior to analysing the primary data obtained from the stated three locations, the researcher carried out baseline data for analysis, which involved analysis of the 2007 to 2017 MVC injuries and fatalities data. In this chapter, the findings described in the results chapter are discussed with focus on how AI can help solve the problem. First, the chapter summarises the findings, after which the observed trends are discussed based on the evidence from the existing studies. The implications of the findings are then discussed, after which the limitations associated with the study are presented.

5.1 Summary of the findings

The findings regarding the frequency of accidents in the three regions within a period of 10 years (2007 to 2017) revealed a general reduction in TAs however, the reduction in Al Ain was minimal. The study's outcome also showed the trend in the occurrence of accidents in the three regions is characterised periods of increase in the frequency of accidents with Al Ain registering the most recent increase in the frequency of accidents. The findings also show that compared to the other two regions TAs in Abu Dhabi is shown to be consistently higher.

The study identified various reasons for accidents across the three regions. One of the identified reasons is unlawful overtaking. According to this study, Abu Dhabi has the highest number of unlawful overtaking-related accidents, and it is attributed to the increase in such accidents between 2012 and 2014. The study noted that the Western region has the lowest TAs caused by unlawful overtaking. The study also noted that the drivers' failure to prioritise pedestrian crossing is the other cause of accidents in the three regions. However, the study showed that TAs caused by the failure of the drivers to give priority to pedestrian crossing increased in Al Ain while there was a decline in Abu Dhabi. The Western region registered the lowest TAs due to the drivers' failure to prioritise pedestrian crossing during the 10-year period.

The study also noted that the failure to leave enough space is one of the reasons for the reported accidents in the three regions. Although the study showed a decline in TAs caused by the failure to leave enough space in Abu Dhabi, the region is shown to have high cases through the 10-year period. The accidents caused by the failure to leave enough space in Al Ain is shown to be characterized periods of decline and rise while the Western region is shown to have the lowest number of such accidents but there is an increase between 2016 and 2017. The findings of the study also indicate that accidents in the three regions occur due to driving in the opposite direction. Although TAs due to driving in the opposite direction are consistently high in Abu Dhabi, the region has a steady decline in such accidents during the 10-year period. For Al Ain, there are periods of decline and rise, while in the Western, a period of decrease between 2007 and 2012 is followed by an increase.

The findings of the study also noted that the other cause of accidents in the three regions is by driving through a red light. However, the frequency of accidents caused by driving in the opposite direction is shown to decline in the three regions with Western and Al Ain having the least number of such accidents by 2017.

The other reason for accidents reported in the study is driving recklessness, which is more prevalent in Al Ain and Abu Dhabi alternating periods during the 10-year study period. By 2017, accidents caused by driving with recklessness are the highest in Abu Dhabi and lowest in Al Ain. The study also reported that driving without a license is associated with the accidents that occur in UAE. According to the study, the three regions in UAE experienced an increase in the frequency of accidents caused by driving without a license with Al Ain having the highest number of such accidents by 2017 while the Western had the lowest frequency. The study also noted that the accidents that occur in the three locations in UAE are associated with the driver entering the main road without making sure it is free. According to the obtained findings, the three regions registered a gradual decline in the accidents caused by driver entering the main road without making sure it is free with Abu Dhabi having the highest frequency and Western region the lowest in 2017. The study also reported that the other reason for accidents is entry into a forbidden place. According to the study's findings, the accidents caused by the entry into a forbidden place fluctuated throughout the 10 years with no cases of such accidents being reported in Al Ain from 2013 while at the end of 2017 Abu Dhabi and the Western region had 2 cases of such accidents. Over speeding was also noted to be one of the reasons for reported accidents in the three locations in the UAE. However, the study's outcome showed a gradual decline in the frequency of accidents due to speeding across the three locations in UAE.

The study also noted that fatigue and sleeplessness is the other reason for the reported accidents in the three locations in UAE. According to the study's findings, there is a decline in TAs caused by fatigue and sleeplessness across the three locations in UAE. However, the Western region is noted to have higher cases of accidents caused by fatigue and sleeplessness during most periods in the 10-year period and at the end of the study period (2017). According to this study, unsafe reversing is the other reason for accidents in the three locations in UAE. The findings showed a reduction in the accidents caused by going back without making sure the road. However, by the end of the 10 year study period Abu Dhabi was shown to have more such cases while Western region was observed to have the least number. The study also noted that poor vision is the other reason for the reported accidents in the three locations in UAE. However, unlike in Western region and Abu Dhabi where the accidents caused by poor vision were observed to remain low and sometimes zero during the 10-year period, Al Ain registered a surge in such accidents in 2016 followed by a sharp decline.

The study's findings also indicate that the lack of driving knowledge is the other cause of reported accidents in Al Ain, Abu Dhabi and the Western region. However, cases of such accidents were noted to increase from 2014 to 2017 in Al Ain while the other two regions registered a decline. The study’s outcome also indicated that the lack of attention among the drivers is the other cause of accidents in the three locations in UAE. According to the outcome of the study, the frequency of accidents caused by the lack of attention in Al Ain and the Western region are low throughout the 10-year period. However, the frequency of such accidents in Abu Dhabi is shown to decline prior to 2012 followed by an increase between 2012 and 2017. The study also noted that non-compliance with a stop sign is the other reason for the reported cases in the three locations in UAE. According to the study's outcome, Abu Dhabi has high frequency of accidents due to non-compliance with a stop sign while the frequency of such accidents is on the rise in Al Ain. The findings of the study also reported a general decline in cases of accidents due to the non-compliance with other traffic signals in Abu Dhabi and Western region while Al Ain registered zero cases from 2009 to 2016 with an increase in the cases being reported in 2017. The outcome of the study also indicated that the lack of awareness is the other cause of accidents in the three locations in UAE. According to the study, Al Ain have high cases of the accidents associated with the lack of road awareness. The findings of the study suggest that the accidents due to the poor estimation of user's road are on the decline in the three regions. However, Abu Dhabi is reported to have a high frequency of accidents such accidents than the Western region and Al Ain.

The study outcome also indicates that the other reason for the reported cases of accidents in the three locations in UAE is not giving way, but the evidence shows a decline in such cases across the three locations during the 10 years. The study also suggests that accidents in UAE are associated road defects with an increase in such cases being reported in Abu Dhabi from 2014 to 2017. The study also suggests that speeding without considering road conditions contributes to the reported TAs in UAE. According to the findings of the study, Al Ain and Abu Dhabi have high cases of accidents due to speeding without taking into account road conditions, while the Western region is also shown to register an increase in the cases of such accidents. The study outcome also indicates that the other reason for the reported cases of accidents in the three locations in UAE is sudden stopping, however, such accidents are more concentrated in Abu Dhabi where they are shown to fluctuate. The study also indicates that the other cause of accidents in UAE is sudden turn. The accidents caused by sudden turn are shown to be on the decline except for Al Ain where an increase was reported from 2013.

The findings of the study also indicate that tyre explosion accounts for a TAs that occur across the three locations in UAE. However, the cases of accidents caused by tyre explosion are on the decline. The study shows that the accidents due to the failure to obey the traffic road line are on the increase in the Western region and Al Ain while there is a slight decline in Abu Dhabi. According to the findings of the study, alcohol intoxication is the other reason for accidents in the three locations in UAE. Abu Dhabi is shown to have high cases of accidents that are related to alcohol intoxication, while the other regions have a lower number of cases but they are on the rise. The outcome of the study also shows that mobile phone use/texting is associated with accidents in UAE with the Western region being observed to have a higher number of cases except for 2017 where no cases were registered. Finally, the study showed that vehicles defects also account for the accidents in UAE, with high cases of such accidents being reported in Al Ain while Abu Dhabi experience the least number of such accidents.

The obtained findings regarding the future trends in the frequency of accidents showed a projected decline in the frequency of accidents in Abu Dhabi and the Western Region by 2024. The frequency of accidents in Al Ain is, however projected to slightly increase. Regarding the projected major causes of accidents, the findings of the study show projected decline in TAs in the three regions between 2017 and 2024. Regarding the accidents caused by the drivers' failure to prioritise pedestrian crossing, the study projected a decline to zero in Abu Dhabi and slightly increased in the Western region, while the findings suggest that Al Ain will experience a gradual increase. The study’s projection of the future trends in TAs caused by the drivers who do not leave enough space shows a decline in Abu Dhabi and the Western region while no change is observed in Al Ain. The study also projects that TAs caused by driving in the opposite direction is set to decline in Abu Dhabi while the frequency of accidents will fluctuate in the Western region and there will be no change in the frequency of such accidents in Al Ain. The projected future trends in TAs caused by driving through a red light show a projected decline in Abu Dhabi and Al Ain cases, while the Western Region is projected to have a minimal increase of such accidents in 2024. Concerning the accidents caused by driving recklessly, the study projected that there will be an increase in Abu Dhabi and Al Ain while no cases of accidents caused by driving recklessly will be reported in the Western region. Concerning the accidents caused by driving without a license, the outcome of the study projects an increase in the frequency between 2019 and 2024 across the three regions. The study’s outcome of the projected future trends in TAs caused by a driver entering the main road without making sure it is free shows a projected decline in Abu Dhabi while it is expected that there will be an increase in the accidents in Western region and Al Ain. The projection regarding the accidents due to the entry into a forbidden place showed that no cases of such accidents are expected in Al Ain while both the Western region and Abu Dhabi are expected to register a decline with only one case being registered by 2024. According to this study, the accidents caused by overspeeding are expected to decline zero in the three locations in UAE by 2019 onwards. The projection regarding the accidents due to fatigue and sleepiness show a projected decline in such TAs between 2017 and 2024. The Western region is projected to have zero cases of such accidents by 2024 while Abu Dhabi and Al Ain are expected to have only one case each. The study also projected a decline in TAs caused by going back without making sure the road with the Western region, Abu Dhabi and Al Ain, predicted to have zero cases of such accidents by 2024. According to the projections made in this study, the accidents caused by poor vision are expected to reduce to zero in Abu Dhabi by 2022 while no change is expected in Western region with one case being expected by 2024. However, the cases of accidents caused by poor vision are expected to increase steady in Al Ain between 2017 and 2024. The study also projects that the accidents caused by the lack of driving knowledge are expected to decline between 2017 and 2024 The Western region and Abu Dhabi are expected to register zero cases by 2024 while 19 cases are expected in Al Ain. Based on the study's outcome, the accidents caused by the lack of attention are expected to reduce to zero by 2024 in Al Ain, Abu Dhabi and the Western region. The study's projection regarding TAs associated with non-compliance with a stop sign show expected to increase in Al Ain and Abu Dhabi while the Western region is expected to register no accidents. The study's projection regarding TAs associated with non-compliance with other traffic signals show expected to decrease in Abu Dhabi to only a single case while the Western region and Al Ain are expected to register no accidents by 2024. The study's outcome projects an increase in TAs caused by the lack of road awareness in Al Ain and Abu Dhabi while the Western region is expected to register no such accidents from 2019. The findings regarding the expected accidents caused by poor estimation of user's road indicates expected increase in the Western region and a reduction in Abu Dhabi and Al Ain with the latter being expected to register zero cases by 2024.

According to this study, it is expected that TAs caused by not giving way will increase in Al Ain between 2017 and 2024 while Abu Dhabi will experience a decline. No cases of accidents caused by not giving way are expected in the Western region. The study projects that TAs due to road defects will decline between 2017 and 2024 across the three location in UAE with no cases being expected in Al Ain and the Western region from 2022. The study projects that TAs due to speeding without considering road conditions will increase between 2017 and 2024 across the three locations in UAE. The study projects that TAs due to sudden turn, and tyre explosion will decline between 2017 and 2024 in Al Ain, Abu Dhabi and the Western region with no cases being expected across the three location in UAE by 2024. Concerning the accidents caused by the failure to obey the traffic road line, the study's outcome suggests that an increase in such accidents is expected in Al Ain and the Western region, while Abu Dhabi is expected to register a reduction in such accidents. The study projects that TAs due to alcohol intoxication will increase between 2017 and 2024 in Al Ain, Abu Dhabi and the Western region. The study also predicts that the accidents associated with mobile phone use/texting will reduce to zero by 2022 in Al Ain and Western region while Abu Dhabi is also expected to register a decline in cases. According to this study, TAs that occur due to vehicle defects are expected to increase in Al Ain while a decline in cases are expected in Abu Dhabi and the Western region.

5.2 Discussion of the findings

It is evident from the outcome of this study's baseline analysis that the frequency of accidents in Al Ain indicates the most recent increase in motor crashes. The observed increase in the motor crashes in Al Ain could be associated with the reported increase in accidents associated with the drivers' failure to prioritise pedestrian crossing. It should also be noted that the observed increase in the TAs associated with the failure of the drivers to give priority to pedestrian crossing is expected to continue to 2024, which calls for a need to address the issue. Evidence presented in this study also point to the accidents caused by the poor vision for the increase in the cases of motor vehicle crashes in Al Ain. Without adopting the appropriate measures to address the problem, the study suggests that there will be increased cases of accidents caused by poor vision in the region. The accidents caused by the lack of driving knowledge and those caused by sudden turn are also posed major road safety concerns in Al Ain given the reported increase between 2014 and 2017. Future trends also suggest that the Al Ain is likely to experience increased TAs caused by not giving way and those that are associated with vehicle defects. There are accidents in Al Ain, which based on the baseline analysis show fluctuation in frequency. Some of such accidents are caused by drivers who do not leave enough space and drive in the opposite direction, which according to this study are not expected to change (reduce) in the future. Although the previous trends (2007-2017) accidents caused by driving through a red light also show fluctuation in frequency in Al Ain, the study projects such accidents to decline.

As shown by the outcome of the study, frequency of accidents in the Western region has been on a decline since 2007 and it is expected that the frequency will keep reducing in the future. Despite the region having the least TAs the study indicates that accidents caused by the failure to leave enough space increased towards the end of the 10-year study period and are expected to increase. Although the study's outcome shows a decline in TAs caused by fatigue and sleeplessness and mobile phone use/texting in the three locations in the UAE, the presented evidence raises concern over the high number of such accidents in the Western region. There is also concern over the accidents caused by the driving in the opposite direction in the Western region since evidence show an increase in such accidents from 2013 to 2017 Future trends also suggest that the Western region is likely to experience increased TAs caused by the drivers who drive through the red lights and the poor estimation of user's road.

Although the study's findings show that the frequency of accidents in Abu Dhabi is higher than Al Ain and the Western region, the 2007 to 20017 trends show a decline in accidents in the region and the decline is expected to continue to continue 2024. The observed decline could be attributed to the reduction in the TAs caused by the drivers to prioritise pedestrian crossing. However, the accidents caused by the lack of attention among the drivers are a major concern in Abu Dhabi given the reported increase between 2012 and 2017. The accidents caused by road defects are also major concern to road safety in Abu Dhabi given the observed increase in such cases between 2014 and 2017. Although the previous trends (2007-2017) accidents caused by driving through a red light also show fluctuation in frequency in Abu Dhabi, the study projects such accidents to decline.

Although the accidents caused by lack of road awareness are high in Al Ain compared to Abu Dhabi, the study predicts an increase in such accidents in the two locations unless effective mechanisms are put in place to address the issue. According to this study, accidents caused by driving recklessness are also major concerns in Al Ain and Abu Dhabi. The evidence shows high cases of such accidents during 2007 and 2017, and they are projected to increase in the future. This study also suggests that accidents caused by non-compliance with a stop sign pose an increasing threat to road safety in Al Ain, given the observed increase in their frequency towards the end of the 10 years period of study. The findings regarding the future trends in accidents also suggest Abu Dhabi also faces increased road safety threat posed by accidents caused by the non-compliance with a stop sign.

According to this study there is a need to pay attention to the accidents caused by a driver entering the main road without making sure in the Western region and Al Ain since such accidents are expected to increase in the future. As evident from the outcome of the study, Western region and Al Ain also face road safety threat from accidents caused by the failure to obey the traffic road line and such accidents are expected to increase in Al Ain if appropriate measures are not taken to address the issue.

The outcome of this study also suggests that the accidents caused by the unlicensed drivers, alcohol intoxication, and speeding without considering road conditions are on the rise in the UAE with all the three regions experience increasing cases of such accidents towards the UAE end of the 10 year period. Without appropriate control measures, the study project will increase TAs caused by the unlicensed drivers and those who drive while drunk.

It is also evident from the study's outcome that most of the offenders in Abu Dhabi are males. The high number of male offenders in the region could be associated with the fact that, unlike their male counterparts, social and legal constraints limit the females from driving (Al-Madani & Al-Janahi, 2002; Hamad, 2016). According to the survey outcome of the study, it is evident that most of the drivers in Abu Dhabi are aged between 18 and 25 years. The age of the drivers is important in determining the risk of accidents. According to the study that was carried out by Hamad (2016), most of the accidents that occurred in the UAE between 2001 and 2014 involved the individuals aged between 18 to 30 years while only limited cases of accidents involved individuals aged above 45 years. Hammoudi, et al. (2014) also noted that most of the accidents in the UAE involve the individuals who are aged 20 to 25 years. Hammoudi, et al. (2014) based their study on the findings obtained from the analysis of the data obtained from a questionnaire-based survey that involved 291 participants from Abu Dhabi. The study carried out by Alkheder (2017) also noted that the frequency of accidents vary across the different age groups. According to Alkheder (2017), increased rate of TAs is reported among the drivers who are aged between 18 to 30 years old. Although the conclusions made by Alkheder (2017) support the findings of the current study, it should be noted that the researchers only based their findings on the people from Abu Dhabi’s local community. Alkheder (2017) targeted the local individuals who had previously been involved in accidents either as a passenger or a driver. As expected, the study noted that most of the accidents involved the Emiratis. However, evidence presented in the current study also shows that expatriates of Arab origin are also involved in most cases of accidents. The study carried out by Hazarmerdi et al. (2016) focused on the students aged not less than 18 years, which are according to the current study constitute the highest percentage of the individuals involved in TAs. The researchers based their study on the data that was collected from one of the universities in the UAE. The findings obtained by Hazarmerdi et al. (2016), explains why most accidents involve young people. According to Hazarmerdi et al. (2016), most of the drivers aged below 30 years have poor knowledge regarding the road safety practices. Additionally, the findings obtained by Hazarmerdi et al. (2016) reported that the young people are likely to engage themselves in unsafe driving practices. However, it should be noted that the current study did not examine why the individuals aged between 18 to 24 years old. Therefore it is important for the future researcher to further examine this area.

The study supports the study's findings regarding the nationality of driver responsible for accident carried out by Hamad (2016), which also showed that most of the accidents involve Emirati drivers and the drivers from the GCC and other Arab nations. It should be noted that the projection of the accident occurrence in Abu Dhabi provide a different picture from the projections that were made prior to 2007. As noted from the current study's findings, the projection of the TAs shows a decline between 2017 and 2024. However, the projections that was made by Ibrahim (2014) shows that the prior to 2007, (1977 to 2007), TAs were expected to increase. According to the predictions made in this study regarding the future trends in the frequency of TAs, it is evident that the cases of the TAs will rise across the three sectors in the Abu Dhabi. The findings of this study corroborate the findings obtained by Khalil (2017), where they concluded that although there is evidence of a sustained and continued yearly decline in the frequency of TAs, the TAs still remain serious problem in the Emirate of Abu Dhabi.

Across all the three regions in Abu Dhabi roads, the study's findings showed general decline in the number of road related accidents. The observed general decline in TAs in the Abu Dhabi roads support the findings of the previous researchers who have assessed TA trends in UAE. One such researcher is Mohammed (2015), whose findings indicate that TAs in the country are on the decline. The observed findings also reflect the trends reported by the WHO (2013). According to WHO (2013), the road fatalities have been on the decline in about 88 countries from year 2007 to 2010. The comparison of the UAE TAs report of 2009 (WHO 2009) to that of 2013 (WHO 2013) shows a major reduction in the rate of accidents, which agrees with the findings of the current study. The findings obtained in this study regarding the trend in the cases of TAs in Abu Dhabi also agree with the findings obtained by Hassana et al. (2012). Based on the assessment of the UAE TA and violation records recorded between 2004 and 2009, Hassana et al. (2012) reported an initial decrease in TAs to 2006, followed by 2009. Although the research reports a general decline in TAs in the Abu Dhabi roads, the study did not carry out a cause and effect analysis, therefore it does not provide in-depth explanation for the observed general reduction in TAs. According to the WHO (2013), the observed reduction in TAs in Abu Dhabi could be due to the development and commitment towards road safety by the relevant stakeholders in the country. The observed general reduction in TAs in the Abu Dhabi roads has also been reported in other countries such as the US (NHTSA, 2016).

Although the study reported a general decline in TAs in Abu Dhabi roads, it should be noted that the outcome of this study’s baseline analysis suggests that the frequency of accidents in Al Ain shows most recent increase in motor crashes. The reported increase in the number TAs corroborates the findings by previous researchers such as Osman et al. (2015) who, despite focusing on the accidents caused by drunk driving, noted reported an increase in TAs in Al Ain. The findings obtained by Mohammed (2015) from the analysis of the data that was obtained in the month of 2014 also support the findings of the current study regarding the role played by driving while under the influence of alcohol in the accidents that occur in UAE. The observed increase in TAs in Al Ain is also not unique to the region since evidence has also shown that other countries such as the US have experienced an increase in TAs between 2011 and 2015 (NHTSA, 2016). As indicated by the findings of the study, there is a need to adopt the approaches that focus on addressing the failure of the drivers to give priority to pedestrian crossing since the study noted that the accidents caused by the problem are on the increase and are expected to increase in the future.

The adoption of the strategies that aids in the management of the accidents caused by poor vision is important in reducing the observed recent increase in the TAs in Al Ain. It is important to focus on the problem of poor vision since, without the adoption of the appropriate measures to address the problem, the study suggests that there will be increased cases of accidents caused by poor vision in the region. The findings of the study regarding the link between poor vision and cases of accidents in Abu Dhabi support the findings obtained by the previous researchers (Elsheshtawy, 2008). Ali et al. (2013) also reported massive accidents that happened in 2008 and 2011 due to poor visibility caused by foggy conditions. It is therefore essential to adopt effective approaches towards addressing poor visibility in Abu Dhabi roads. As argued by Ali et al. (2013), the accidents caused by poor visibility can be limited by providing early warning regarding the sections of the road with poor visibility. According to Ali there is a need to adopt technologies that can detect poor visibility and provide subsequent warning to the drivers of the danger ahead. To this end, Ali et al. (2013) proposed an AI-based technology that involved sensors that detect poor visibility and traffic situation in the affected area. The data is then sent for analysis and the feedback is subsequently relayed to the drivers in the form of changeable message signs. The use of the changeable message signs in the management of road safety in areas with poor visibility has been successfully implemented in various parts of the world, such as the Netherlands (Ali et al., 2013), Australia (Ali et al., 2013), England (Hodgson, 1986), Finland (MacHutchon & Ryan, 1999; Gimmestad et al., 2004) and Germany (Berman, Liu &

Justison, 2009; Werkmeister et al., 2013). It is therefore expected that the adoption of the CMS based technology in Abu Dhabi will also result in sustained prevention of the accidents caused by poor visibility. The road safety concern that is associated with poor visibility, as reported in the current study, can also be linked with the dust storms that are frequent in the UAE (Basha et al., 2019). According to Basha et al. (2019), UAE is regarded as one of the major areas that experience dust storms in the globe. The variation in the weather conditions in the UAE results in dust storms that negatively affect visibility in Abu Dhabi roads (Basha et al., 2019).

AI can also address the safety concerns associated with unfavourable road conditions such poor vision caused by poor weather conditions. The artificial intelligent systems such as the traveller information systems and the Advanced Traveler Information Systems can collect information and warn the drivers of the bad weather and advise them on the required speed (Lendel & Štencl, 2010). The accidents that occur due to poor vision that is caused by bad weather can also be addressed using artificial intelligence techniques such as SmartMobility Road Suite, which is a technique that has been widely adopted in SA (Alyahya et al., 2017). The adoption of smart mobility Road Suite in Abu Dhabi will provide the users with the real-time information on traffic conditions. The application also provides real-time solutions to the predicted and existing traffic problems. SmartMobility Road also helps in the prevention of TAs by providing the safest travel routes.

The other problem that needs to be addressed in order to reduce the accidents in Al Ain is the lack of driving knowledge and sudden turn. As evident from the study outcome, accidents caused by the lack of driving knowledge and those caused by sudden turn are set to increase if effective approaches are not undertaken to address the problems. The research supports the study's findings regarding the role of the lack of driving knowledge in the occurrence of TAs carried out by Hammoudi et al. (2014). The researchers reported that RTAs in Abu Dhabi is associated with lack of road safety information, especially among the new drivers. The study that was carried out by Mohammed (2015) also corroborates the finding of this study regarding the increased rate of TAs caused by the sudden change in lanes in the UAE. According to Mohammed's study (2015), the sudden change of lanes is responsible for the highest TAs that occur in UAE. However, Mohammed (2015) based their findings on the analysis of the data obtained on the first eight months of 2014.

The violation of the traffic rules such as the failure of the drivers to leave enough space and to drive in the right direction also emerged as the major problems that need to be addressed by the relevant authorities in the UAE so as to ensure improved road safety in the UAE. As indicated by the study's outcome, the drivers in Al Ain are reported to drive in the opposite direction and failure to obey the red light with most them driving through a red light. The findings obtained by Mohammed (2015) from the analysis of the data that was obtained on the month of 2014 also support the findings of the current study regarding the role played by the running red lights caused in the accidents that occur in UAE. The study carried out by Sahnoon et al. (2016) also noted that the failure of the drivers to stop at the red light also results in high cases of accidents in Abu Dhabi roads. According to the findings obtained by Sahnoon et al. (2016), the accidents that occur due to the failure stop at the red light is even frequent in signalized intersections. The study carried out by Sahnoon et al. (2016) noted that the drivers' tendency to drive through the red light can be minimized if technologies that facilitate real-time monitoring of the offenders can be adopted. According to Sahnoon et al. (2016), the automated camera systems at the signalized intersections that enable the at-fault drivers to be identified reduce the number of drivers who drive through the red light by half. Sahnoon et al. (2016) based their study on the data collected from 150 intersections on the Abu Dhabi roads with 108 automated red-light cameras. The findings obtained by Hammoudi et al. (2014) also agree with the obtained findings regarding the role played by traffic violation in increasing the increased rate of TAs reported in the UAE. Even in the Western region, which was reported to have the lowest TAs among the three regions in Abu Dhabi, the accidents caused by the violation of the required distance between vehicles was shown to be high. The observation made in this study is supported by the work conducted by Mohammed (2015) where he reported that the misjudgements of the road users and the failure to keep safe driving distance account in the UAE. The findings obtained by Mohammed (2015) from the analysis of the data that was obtained on the month of 2014 also support the findings of the current study regarding the role played by the misjudgements of road users in the accidents that occur in UAE. The findings obtained by Hammoudi, et al. (2014) also support the reported findings that associate driving too closely behind with accidents. As is the case with the current study, Hammoudi et al. (2014) based their findings on the analysis of the data obtained from a questionnaire-based survey that involved 291 participants from Abu Dhabi. The study that was carried out by Shawky et al. (2017) also highlights the role played by the human-related factors in determining the occurrence of the TAs in Abu Dhabi. The conclusions made by Shawky et al. (2017) support the current study's findings regarding how the at-fault drivers contribute to the high cases of TAs in Abu Dhabi. As is reported in this study, Shawky et al. (2017) also noted that most of the accidents occur due to the violation of traffic rules by the drivers. Shawky et al. (2017) went a step further and demonstrated that there is a strong association between the occurrence of accidents and the violation of the traffic rules by the drivers. Shawky et al. (2017) therefore support the findings of this study, which suggest the need to curb traffic rule violation as a means of reducing the future risk of accidents. As is the current study, Shawky et al. (2017) also based their study on the data that was collected from dataset systems in Abu Dhabi TP. Without an adequate mechanism to enhance the adherence to the traffic rules, it is expected that the accidents caused by the lack of the road users to adhere to traffic rules such as keeping safe driving distance will increase in the future. The findings obtained by Mohammed (2015) from the analysis of the data that was obtained on the month of 2014 also support the findings of the current study regarding the role played by the failure of road users to leave a sufficient amount of distance between vehicles in the accidents that occur in UAE.

As noted from the outcome of the study, the three regions in Abu Dhabi, Al Alain, the Western region reported a decline in TAs caused by fatigue and sleeplessness and mobile phone use/texting. It should be noted that the obtained findings constitute the initial evidence regarding fatigue and sleeplessness and the use of mobile phone in the three regions. However, for Al Ain there is existing evidence that shows that the texting while driving is associated with increased rate of TAs that is reported in the area (Eid & Abu-Zidan, 2017). In a prospective study carried out by Eid and Abu-Zidan (2017) and involved 444 drivers, the researchers reported that 40 % of the accidents that occurred due to the distraction of the driver were associated with the use of the mobile phone while driving. According to National Safety Council (2015), a distraction can be caused by drivers' diversions of attention from driving and focus on their activities. The findings obtained by Mohammed (2015) from the analysis of the data that was obtained in the month of 2014 also support the findings of the current study regarding the role played by the negligence and lack of attention in the accidents that occur in UAE. The findings obtained by Hammoudi et al. (2014) also support the reported findings that associate driving recklessly with accidents. Various researchers have also reported that texting while driving is one of the road safety risk that is becoming common among road users (Lee, Champagne & Francescutti, 2013). Some researchers have indicated that driving while using the mobile phone increases the risk of TAs fourfold (Redelmeier & Tibshirani, 1997). As noted in this study, accidents that occur due to the use of phones while driving are not confined to a single place, but it is a widespread problem. Eid and Abu-Zidan (2017) also concluded that using the mobile phone while driving is a common behaviour among most of the road users in the UAE. In UAE, accidents that occur due to the distractions caused by using the mobile phone while driving continue to be reported despite the fact that the country has enacted laws that prohibit such practices (Eid & Abu-Zidan, 2017).

The current study suggests that there are a number of problems associated with TAs in The three locations that are on a decline. One of such problems is the failure of the drivers to give priority to pedestrian crossing. The accidents that occur due to failure of the drivers to prioritise pedestrian crossing suggest that the current measures that are meant to protect pedestrians in the Abu Dhabi roads, such as pedestrian crossing, need to be improved. The findings obtained by Mohammed (2015) from the analysis of the data obtained on the month of 2014 also support the findings of the current study regarding the role played by the failure to prioritise crossing pedestrians in the accidents that occur in UAE. However, it should be noted that the previous research studies on TAs in UAE show that accidents that involve pedestrians are on the rise (Hammoudi, Karani & Littlewood, 2013). The observation made by the previous researchers is mainly based on the assessment of the accidents that occur at the various places on the road and not particularly on the locations designated for pedestrian crossing. Unlike the current, the study, the study that was carried out by Hammoudi et al. (2013) reported that the violations committed by the pedestrians are associated most the accidents that involve pedestrians. However, according to Hammoudi et al. (2014), the accidents involving pedestrians are mainly associated with the failure of the drivers to pay attention, especially at the location designated for pedestrian crossing.

Apart from the behaviour of the drivers, the study also noted that the accidents that occur in Abu Dhabi roads are associated with poor road conditions. It is evident from this study that road defects are associated with high cases of accidents in Abu Dhabi, and there is a need to adopt appropriate approaches that ensure the limited occurrence of such accidents. The findings obtained from this study corroborate the findings reported by WHO (2013), which indicated that high number of fatalities and injuries due to RTAs is associated with poor infrastructure and lack of road facilities and the legislation that is not strong enough to prevent people from making inappropriate driving's. Wang et al. (2013) argued that there is a need for proper planning to ensure that the quality of the roads is maintained. However, it should be noted that the problem of road defects is unique to Abu Dhabi since evidence has shown that country such as those in Africa and in the West also register accidents attributed to poor road conditions (WHO, 2013).

The study also highlighting overspeeding as one of the major problems associated with the increased rate of TAs in the Abu Dhabi. Previous researchers support the findings of this study regarding the danger posed by over speeding. According to Ayuso et al. (2010) speeding is the major causative factor for accident injuries, deaths, and damage to properties. The findings of the study also agree with the outcome obtained by Mohammed, (2015) and Bener, Özkan & Lajunen (2008), which highlighted that most accidents are caused by the human-related errors such as violation of traffic rules such as over speeding. Mohammed (2015) also noted that the lack of adherence to speed limits results in high cases of TAs in the UAE. The findings obtained by Mohammed (2015) from the analysis of the data that was obtained on the month of 2014 support the findings of the current study regarding the role played by speeding in the accidents that occur in UAE. The findings that were obtained by Alkheder (2017) through the assessment of the data from Abu Dhabi also highlighted overspeeding as the major cause of accidents in the region. According to Alkheder (2017), exceeding the speed limit is the dominant cause of accidents in Abu Dhabi.

The other challenge that needs to be addressed is the problem of the unlicensed drivers. It is evident from the study, some of the accidents that are reported Al Ain, Abu Dhabi and the Western region occur due to errors committed by unlicensed drivers. The outcome of the study regarding the problem posed by the unlicensed drivers in Abu Dhabi is supported by the findings obtained by El Bcheraoui et al. (2015). According to El Bcheraoui et al. (2015), the accidents caused by the unlicensed drivers have mainly associated the high likelihood of such drivers to take risks while driving. Unlicensed drivers are also likely to have limited experience, which according to Hammoudi et al. (2014) is one of the major reasons associated with the increased rate of TAs.

As noted from the evidence obtained from this study, most of the accidents are caused by errors that can be associated with human intervention. Therefore, one way of limiting such accidents in Abu Dhabi roads is by reducing human intervention. The assessment of the existing literature in this research reveals that the adoption of the AI techniques such as the use of unmanned vehicles eliminates human error in driving, which leads to increased highway safety (Tullio et al., 2017). Evidence from various countries has demonstrated that the use of the safe autonomous systems

The use of computer-controlled vehicles leads to the reduction in the errors that result in accidents by enabling the adoption of a driving pattern is easily predictable and controlled (Tullio et al., 2017). The unmanned vehicle's safety integration system also enables the collection and processing of data used to make enhanced safety decisions. Therefore the use of unmanned vehicles in the Abu Dhabi roads can help to limit the accidents associated with human intervention, such as the accidents that occur as a result of the violation of the driving distance, profiles of acceleration and deceleration, and the lane positioning (Tullio et al., 2017). It is important to note that the AI techniques found in unmanned vehicles can enable cars to make computerised real-time decisions, which is critical in preventing the occurrence of accidents (Tullio et al., 2017). The deployment of unmanned vehicles in Abu Dhabi roads can be based on the approaches used by the countries that have already adopted the technologies. According to Hall and Pesenti (2017), the use of safe autonomous systems in the UK has helped in addressing the problems such as traffic rule violations and the management of the driver's behaviour that is likely to result in TAs.

As shown in this study, the behaviour of the drivers is major determinant of the risk of accidents in Abu Dhabi roads. The study that was carried out by Khalil (2017) also placed the human factors to be the most cause of accidents in Abu Dhabi. According to Khalil (2017), about 80 % of accidents can be controlled by managing human-related factors. The accidents that occur due to the failure to keep adequate distance, maintain the recommended speeds and reckless driving can be addressed by encouraging the drivers to adopt the driving behaviours that promote road safety. The AI techniques have been suggested to be effective in modelling the driver behaviour to ensure the optimization of the roles of the driver, which includes supervision, control, actuation, and detection of danger (Lin et al., 2005). The AI features that have been used in the modelling of driver behaviour include sophisticated artificial neural network architectures (Lin et al., 2005). There are various AI strategies that can be adopted to address the driver's behaviour problem in the Abu Dhabi roads. Some of the strategies include the DAS and the advanced DAS, which enhance positive behaviour by alerting the driver of the risks (Meiring & Myburgh, 2015). Image processing systems can also be used in drowsiness detection while the driver distraction detection systems such as the early warning applications are also key in the prevention of accidents (Meiring & Myburgh, 2015).

The management of the drivers' behaviour can also be achieved by adopting AI techniques that help identify and track the violators of traffic rules. The authorities in the Abu Dhabi roads can adopt the plate recognition system that has been successfully used by SAn traffic authorities to manage driving behaviours among the road users (Alyahya et al., 2017). The plate recognition system uses the artificial neural network and enables the authorities to quickly identify the traffic rule violators. As noted from this study, the other most common violation of the traffic rules includes the non-compliance with a stop sign, which is highly reported in Al Ain and is expected to increase in Abu Dhabi. The drivers in the Western region and Al Ain are also reported to lack caution when entering the main road. The findings obtained by Mohammed (2015) from the analysis of the data that was obtained on the month of 2014 also support the findings of the current study regarding the role played by entering a road before making sure it is clear in the accidents that occur in UAE. The findings that were obtained by Hammoudi, et al. (2014) also support the reported findings that associate entering the road without checking whether there are other vehicles with the occurrence of accidents. The challenge posed by the violation of the traffic rules in the three regions is serious is likely to increase if no adequate steps are taken to address the issue.

The accidents caused by the failure to keep safe driving distance can be addressed using the AI techniques that enable automatic breaking or the initiation of other evasive actions that help avoid collisions. As indicated by Gifford (2010), the IntelliDriveSM program that has been adopted in the US roads can be used in the Abu Dhabi roads to manage the vehicle collisions caused by the failure to keep safe driving distance. IntelliDriveSM program aims at preventing collisions by enabling initiate evasive action when it senses the risk of collision (Gifford, 2010).

The study supports the proposed adoption of the artificial intelligent approaches in addressing the various challenges associated with the TAs in the Abu Dhabi roads carried out by Al Junaibi, (2016). According to the researcher, ITS technologies effectively address factors associated with the high incidences of TAs in the UAE. Additionally, Al Junaibi, (2016) also noted that the introduction of ITS technologies in the management of the road safety in UAE is likely to be well received by UAE motorists. However, the researcher highlighted the need for research to determine the type of ITS technologies that is most effective in solving the specific problems associated with the TAs in the Abu Dhabi roads. The importance of the highlighted use of artificial intelligent tools in the management of road safety in Abu Dhabi is supported by a study that was carried out by Georgakis et al. (2017), the researchers based their study on the questionnaire-based survey that involved 100 traffic safety experts in Abu Dhabi Emirate. Based on their findings, Georgakis et al. (2017) concluded that the adoption of the artificial intelligent safety technologies has a positive impact on the traffic safety. Georgakis et al. (2017) noted the deployment of the artificial intelligent approaches enhances the road safety by increasing the adherence to the enforcement practices.

The chart shown in Figure 5-1 describes the intelligent system approach that can be used to address the various causes of the TAs in Abu Dhabi. In this study, the identification of AI approaches appropriate for addressing traffic accidents in Abu Dhabi was based on the outcome of the analysis of secondary data retrieved from existing studies and relating the outcome with the primary data collected from research participants from Abu Dhabi. First, the researcher identified the candidate AI approaches established to effectively address specific causes of traffic accidents in other countries. This was necessary because the researcher noted that there was no sufficient evidence from Abu Dhabi regarding applying AI techniques for the prevention of traffic accidents. Therefore, the customisation approach involved the identification of causes of accidents in Abu Dhabi and linking them with the identified effective AI approaches that emerged from the analysis of secondary data. As shown in Figure 5-1, the researcher was only able to identify AI solutions to a specific number of causes of accidents. This was the case because the analysis of secondary data only provided a limited number of AI approaches that were relevant to the identified causes of traffic accidents in Abu Dhabi.

As identified from the outcome of this study, there are three major causes of TAs in Abu Dhabi that include driver, vehicle and road-related causes of road accidents. However, the approaches that were identified from the findings of this study did not provide appropriate AI solutions to the traffic accidents associated with vehicle-related causes. Therefore, the AI solutions provided in Figure 5-1 only refer to specified driver-related causes of traffic accidents and causes associated with Abu Dhabi's conditions. As shown in Figure 5-1, the driver-related traffic accidents in Abu Dhabi caused by driver's drowsiness could be addressed using advanced driver assistance systems, which act as the driver alert system. The failure of drivers to keep a safe driving distance can be addressed by using cooperative adaptive cruise control systems and plate the recognition system. Risky entry at junctions and overspeeding can also be addressed using the plate recognition system which helps to track down traffic offenders. The active traffic management system is also used in managing overspeeding. The TAs that occur as a result of poor visibility can be addressed using Advanced Traveller Information Systems that collect information and warn the drivers of the bad weather. The Changeable Message Signs can also be used to manage the TAs that are associated with poor visibility. To address the accidents that occur as a result of the factors associated with vehicle defects, it is recommended that intelligent approaches such as fast vehicle inspection should be implemented before a journey. Although the study findings focused on Abu Dhabi, the contribution of this research is also projected to all countries since the AI techniques were collected from different countries, which can be implemented in other countries.

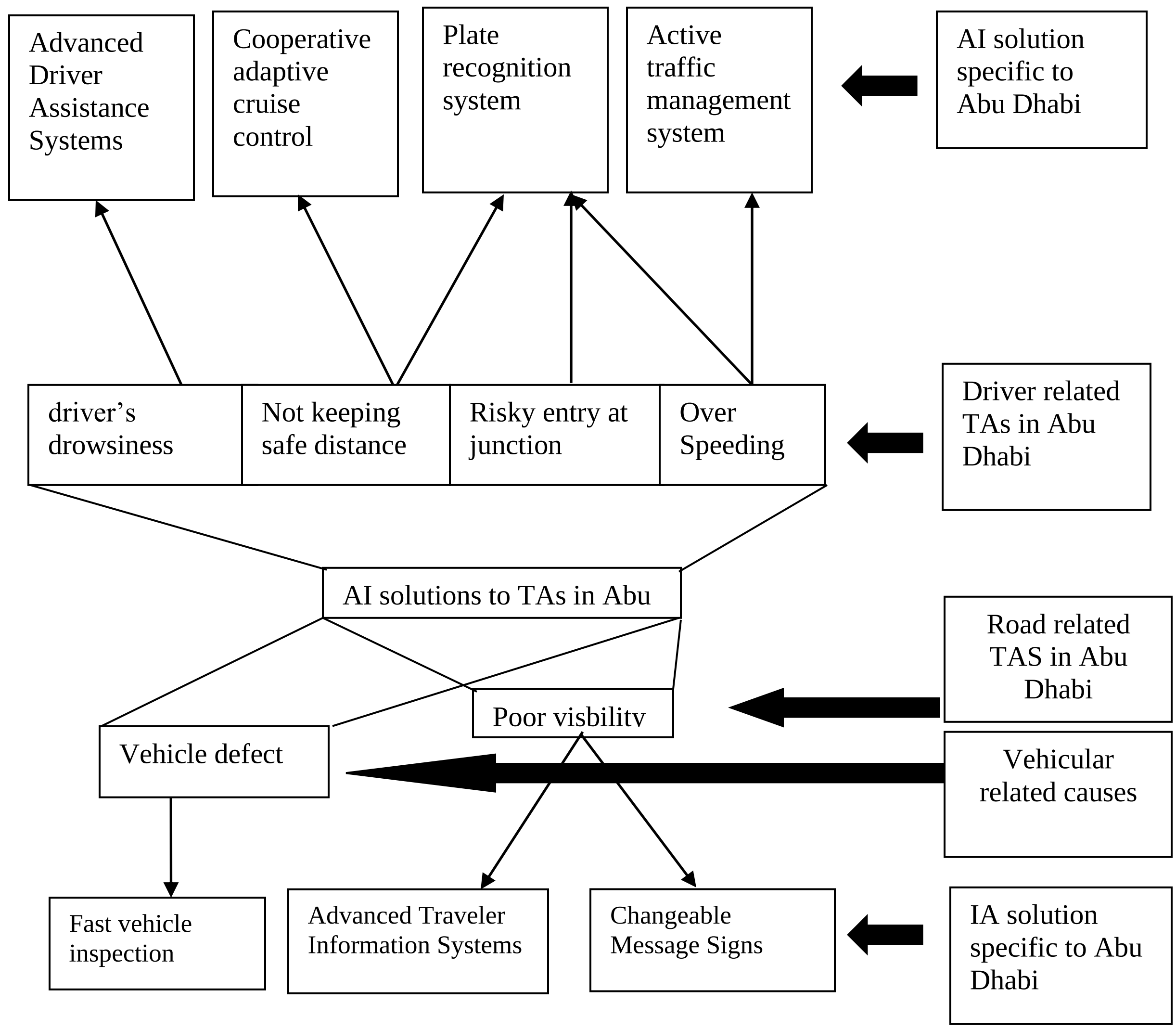


Figure 5-1: Description of the intelligent system approach-based solutions to the various causes of TAs

6 Chapter - Six Conclusion and Recommendation

The study's overarching aim was to conduct a critical analysis of traffic solutions, identifying case-based evidence of control deficiencies and monitoring limitations in Abu Dhabi to propose interventions and solutions for mitigating TAs and maximizing the efficiency of traffic flow patterns. The above aim was assessed based on four main research objectives: to establish the causes of TAs and congestion in Abu Dhabi. Secondly, the challenges facing Abu Dhabi in relation to traffic, summarizing key technological, operational, systemic limitations, and drivers' education were identified. The third objective was the determination of how AI systems can be used to solve traffic problems. The fourth objective was to recommend an intelligent system approach for UAE. This chapter is concluded by explaining how the research has addressed the identified aim and gaps related to each objective that need to be addressed by future researchers. The reflection on the study approach, areas that have been identified as areas for future improvement and recommendations that emerged from the obtained findings is also provided.

6.1 Synthesis of the objectives

6.1.1 *Objective one*

The first objective was to establish the causes of TAs and congestion in Abu Dhabi. This was accomplished through the analysis of the obtained questionnaire data on TA and causes. The categories of causes of TA (driver-related factors, vehicular factors, and road condition-related factors) emerged from the analysis. It emerged that use of hand-held mobile phones while driving is the leading cause of TA while others include unsafe overtaking, driver tiredness, alcohol intoxication and speeding. It also emerged from this study that unlawful overtaking, reckless driving, non-compliance with a stop sign, and the lack of road awareness need to be addressed to avoid the projected future increase in TA due to the factors. This study also highlights driving in the opposite direction and speeding as important causes of TA, especially in the Western region. Failure of drivers to prioritise a pedestrian crossing, a driver entering the main road without making sure it is free, and poor estimation of user's road also emerged an important cause of the TAs in the Western, which if not controlled, could lead to future increase in TAs.

6.1.2 *Objective two*

The second objective was to identify the challenges facing Abu Dhabi in relation to traffic solutions, summarizing key technological, operational, systemic limitations and education of the drivers. Insights into the challenges facing Abu Dhabi relation to traffic solutions were obtained through the analysis of questionnaire data on TA and causes. In Al Ain, this study draws attention to the need to address the failure of the drivers to give priority to pedestrian, driving in the opposite direction, reckless driving, poor vision, non-compliance with a stop sign, and poor road awareness among the road users.

Therefore, it is evident from the obtained outcome that there is a need to focus on the driver-related factors to limit TAs in Abu Dhabi. However, desk research noted that the conventional approach that depends little on technology and more on the physical presence of police officers is associated with limited positive impact. It should, however, be noted that the study reported that the road users are receptive to the introduction of effective strategies that can enhance road safety in the region.

6.1.3 *Objective three*

The third objective was the determination of how AI systems can be used to solve traffic problems. This objective was achieved by using quantitative surveys involving police, drivers and staff in the department that compile statistics. Desk research was also carried out to determine AI systems that can be used in Abu Dhabi. It emerged from the quantitative surveys that there is a need to adapt interventions to limit the occurrence of accidents and enhance road safety. The desk research outcome revealed that artificial intelligent approaches offer effective strategies towards solving the traffic problems experienced in Abu Dhabi. The accidents that are caused due to human errors can be addressed through the use of unmanned or autonomous vehicles.

It is concluded that artificial intelligent approaches, when implemented effectively, are likely to address the reported road safety challenges in Abu Dhabi. This study noted from the outcome of desk research that AI approaches such as those used in semi-autonomous vehicles are capable of limiting drivers' mistakes in responding to the feedback from the vehicle to vehicle and the vehicle to passage communication and enable the driver to react quickly to imminent danger. It also emerged from the desk research that human behaviours associated with increased TAs could be addressed by adopting the AI techniques that help identify and track the violators of traffic rules. The study also concludes that real-time offender identification systems such as plate recognition systems effectively control traffic rules violations such as driving through the red light. Some of the key AI systems that were highlighted as having the potential to address major causes of TAs in Abu Dhabi include the AI-based approaches such as Advanced Traveler Information Systems, SmartMobility Road Suite.

6.1.4 *Objective four*

The fourth objective was to recommend an intelligent system approach for UAE. This objective was achieved through the analysis of the study findings along with the existing literature. The artificial intelligent based approaches provide effective strategies for addressing the traffic safety problems experienced in Abu Dhabi roads. The outcome of secondary analysis of existing data provided various approaches that could be applied in Abu Dhabi to address various causes of traffic accidents. Advanced driver assistance systems are one of the appropriate AI approaches in addressing driver-related traffic accidents in Abu Dhabi and, in particular, accidents caused by driver drowsiness or fatigue. This study noted that TAs caused by the failure of drivers to keep a safe driving distance familiar in Abu Dhabi. These accidents could be addressed by using a late recognition system, which helps to track down drivers who violate safe driving distance traffic rules. The other AI approach identified from the analysis of secondary data is cooperative adaptive cruise control system that was shown to be effective in addressing traffic accidents caused by the failure of drivers to keep a safe distance. This study also noted that the risky entry at the junction and overspeeding, which are also common causes of accidents in Abu Dhabi could be addressed through the use of a plate recognition system. Another AI approach that was noted to Practical approach to the management of Accidents caused by overspeeding is an active traffic management system. The relevant authorities in Abu Dhabi need to adopt artificial intelligent approaches to address the accidents caused by poor vision, while unmanned vehicles can help solve risky driver behaviour problems. Relevant authorities in Abu Dhabi should consider adopting the AI-based approaches used in modelling driver behaviour to address problems such as reckless driving and overspeeding.

The recommended use of AI in the management of TAs in the UAE is based on the intelligent system approach that was developed in this study based on the literature review findings and the outcome of primary data analysis (Figure 5-1). As observed from the intelligent system approach, various AI approaches can be used in Abu Dhabi to address the various causes of TAs.

6.2 Limitations and strengths

The current study has various strengths and limitations that should be considered when interpreting the obtained findings. One of the study's limitations is the use of secondary data in the assessment of the aspects relating to the use of AI in addressing the transport challenges. Although the study provides various artificial intelligence-based solutions for addressing the TAs in Abu Dhabi, it should be noted that the discussion of the artificial intelligence-based approaches is not based on the primary data that were collected from the current study. The study based the discussion of the artificial intelligent approaches on the data collected from the existing studies. The dependence of study on the data derived from the works of others subjects they study to possible limitations and biases inherent in those studies. It should also be noted that the studies that were used in this study were also conducted in different countries across the world, which makes it challenging to directly indicate that the solutions that work for such countries also work for the UAE.

The other limitation of the study relates to the scope of the research. Although the current study provides the trends in the frequency TAs in Abu Dhabi, the study does not provide an in-depth description of the reasons for the observed trends. Therefore, the researcher is not in a position to comment on the changes in the number of recorded cases of TAs to particular causes. However, it should be noted that the research provides some of the causes of TAs in Abu Dhabi during 2018.

One of the study's strengths is the fact that the researcher examined both the previous data and the current data. Both sets of data enabled the study to describe the previous trends, which provides historical perspective of the research problem. The trends developed from the archived data collected between 2007 and 2017 enabled the researcher to provide a deeper insight into the research problem. The 2007 to 2017 data also enable the researcher to predict the future trends regarding the TAs. The use of the current data alongside the archived data enabled the researcher to provide updated findings. The data that was collected by the researcher using the surveys provided in-depth descriptive findings regarding the current situation of accidents in Abu Dhabi.

Further, another strength of the study is with regard to the study population that was considered. The study focused on various stakeholders who are involved in the management of TAs in Abu Dhabi. The study included the participants such as the drivers, the selected police, drivers, and staff in the relevant department across the different sectors in Abu Dhabi. The participants, who were included in the study, therefore increased the chance that the study was able to obtain in-depth findings. The selection of the study participants from the different stakeholders also increased the chance that the findings of the study were more relevant and readily accepted by the different stakeholders since their views were taken into consideration.

The study also has high generalizability. The generalizability of the study findings determines how well the findings and conclusions of the study can be extended from the study to the population at large. The current study met the generalizability requirements since its sample that was made up 300 participants, was large enough to facilitate generalizability. The fact that the study included participants from the different set individuals who involved in the management of TAs in Abu Dhabi also increases the generalizability of the study to UAE. The generalizability of the study findings is also enhanced by the participant's selection approach that was adopted. The use of the random sampling approach in the current study ensured that a representative sample was obtained. The use of the representative sample in the current study enhanced the study's ability to collect views and data that were representative of the study population.

The reliability of the primary data collection instrument further offers strength to the study. The study used the Driver Attitude Questionnaire, which has been shown to be an effective tool in the assessment of the driver's attitudes (Davey et al., 2006). The Driver Attitude Questionnaire has also been shown to have high reliability (Davey et al., 2006). The other tool that was used is the Driver Behaviour Questionnaire, which has also been shown to have high reliability and internal consistency (Harrison, 2009). The attributes of the two tools enabled that research to obtain results with high reliability that has high acceptability. However, it should be noted that the use of the Driver Attitude Questionnaire and Driver Attitude Questionnaire in the current study brought up the issues related to inflexibility and depth. Given the fact the study used the pre-developed tools that had a specified number of questions. After the piloting stage, it is hard to change the questions in the questionnaire despite the possible presence of confusion regarding some items, therefore, making the study inflexible. The use of the questionnaires also makes the study lack depth, especially where the researcher is restricted to a set of questions, limiting the researcher's ability to obtain comprehensive findings.

6.3 Contribution to theory and practice

The direct research contributions are evident in the opportunities created by the research outcomes to address the problems associated with TAs that led to conducting this study. Firstly, the study has shown that TAs present a major challenge in the UAE and different countries. Further to this, tha most of accidents in Abu Dhabi is associated with driver behaviour. It should also be noted that Abu Dhabi records the highest TAs in the UAE region compared to other places like Al Ain. This is because the region has a relatively larger number of motor vehicles and highest population density compared to other regions in UAE.

As a result of conducting this study, an intelligent system approach was created to address the challenge faced by Abu Dhabi. Although the study findings focused on Abu Dhabi the contribution of this research is also projected to all countries since the TAs are similar which depend upon the three factors (dreiver, road and vehicle). Further, countries who deploy AI can benefit from this research, as the AI techniques were collected from different countries that can be implemented in different countries worldwide by using the best practices.

6.3.1 *Addressing road accidents in UAE*

The study can help to fill the gap regarding the use of the AI in the management of the TAs in Abu Dhabi. Existing literature lack information on how AI can be applied in address the challenge faced by Abu Dhabi in addressing TAs. This study addressed this gap by identifying the specific causes of TAs and the AI approaches that can be used to address the cause.

The study also adds to the existing literature regarding the causes of the accidents in Abu Dhabi. This study explicitly categorises the accidents based on the causes into three categories: accidents that cause driver behaviour, accidents associated with road-related causes, and accidents associated with vehicle defects. This categorization is expected to guide the development of further prevention strategies. The study also adds to the knowledge regarding accidents by creating an intelligent system approach, which is expected to guide the decision on areas to target.

6.3.2 *Contribution to the research methodology*

This study was carried out based on a descriptive observational methodology (Hood et al., 1978) where questionnaires were used to collect the data. This study has shown that the use of descriptive observational methodology by its use of qualitative data from the literature review and quantitative data from questionnaires provides an effective way of obtaining in-depth insights into the issue of road accidents. Therefore, this study supports the call for adoption of mixed methods when studying causes of road accidents and future trends in road accident cases. However, for academic research, assessing the importance of AI approaches in addressing traffic-accident requires enormous financial resources and advanced technic technical know-how, which is sometimes inaccessible to students. Therefore given the highlighted challenge, desk research based on analysis of secondary data could be more feasible.

6.3.3 *Contribution to the existing literature*

The outcome of this study provided up to date knowledge regarding the Tas in Abu Dhabi and management approaches. Prior to this study, little information was available on causes and trends in TA in Abu Dhabi. The findings presented in this study identified the specific causes of TAs in Abu Dhabi and particularly highlighted the driver behaviour related causes. The study also identified AI approaches that are likely to discourage the risky behaviours and address other identified causes of TA. The findings presented provides a foundation upon which future researchers can further assess the topic.

The outcome of this study adds to the growing literature on the use of AI in the management of Tas. Although previous researchers had documented how AI could be used to address various causes of TAs, there was a lack of information regarding AI's receptiveness by the traffic management authorities in Abu Dhabi and the specific AI approaches that could be used to address the challenge associated TAs in the area. The summary of the contribution of the study to the literature is provided in the diagram below. Information presented in Figure 6-1 is specific for Abu Dhabi. The information can be generalized to different countries worldwide because of the similar factors in the causes of traffic accidents in different areas and the level of adoption of AI approaches. as shown in Figure 6-1, the current state's literature regarding the use of AI in Abu Dhabi is characterized by limited research on the use of AI in addressing traffic accidents. However, with the study's contribution, the new states of literature are characterized by information on AI approaches that could potentially be adopted in Abu Dhabi to address traffic accidents. Confirming literature on the causes of traffic accidents in Abu Dhabi, the current state of literature is characterized by findings that indicate human-related errors as the only causes of accidents. The new state of literature concerning causes of accidents recognizes road-related and vehicle-related aspects as the other causes of traffic accidents in Abu Dhabi.

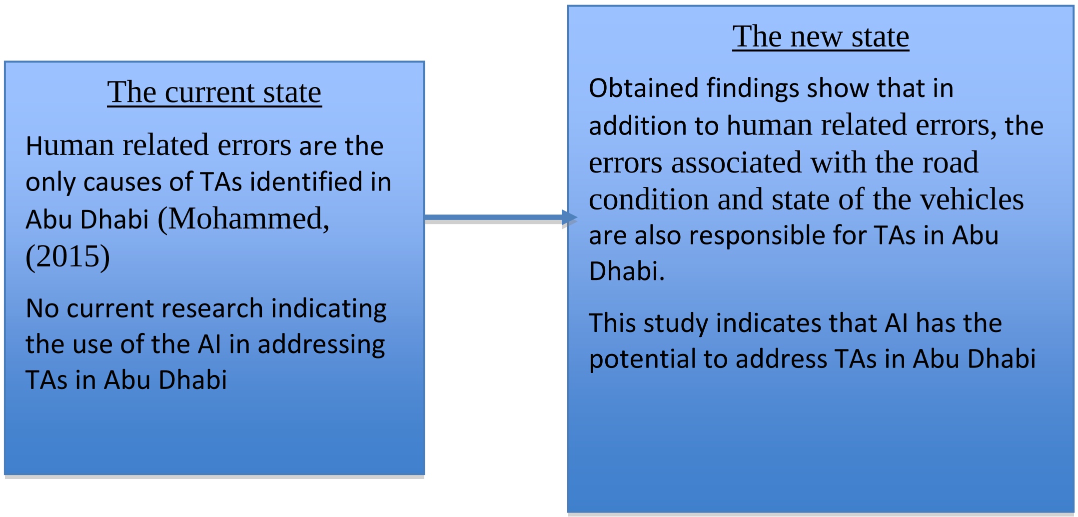


Figure 6-1: Summary of the contribution of the study to literature

6.4 Recommendation

The recommendations include those that focus on the strategies that need to be adopted in Abu Dhabi and other parts of the world to limit the occurrence of TAs. The other recommendations provide the areas that future researchers should focus on so as to enhance the understanding of the researched topic. The various recommendations are provided below:

I. Road safety authorities and other relevant stakeholders should focus on the control of the risky driver behaviour in the management of road safety. This recommendation is based on the fact that most of accidents in Abu Dhabi is associated with driver behaviour. Risky driver behaviour targeted by the road safety authorities in Abu Dhabi and other relevant stakeholders includes the failure to keep adequate distance, maintain the recommended speeds, and reckless driving. Driving while under the influence of alcohol, failure to keep proper lane, driving through the red light, and using mobile phones while driving are other risky driver behaviours that need to be addressed. The highlighted risky behaviours are associated with an increased rate of TAs in the three sectors in Abu Dhabi. High TAs can be prevented if the effective strategies that discourage risky driving behaviours among drivers are adopted.

II. Road safety authorities should focus more its resources and attention towards Al Ain in the management of future cases of TAs. This recommendation is based on the fact that the frequency of accidents in Al Ain to be on the increase. Al Ain is expected to experience a continued increase in the frequency of accidents if appropriate measures are not taken. The key areas that the road safety authorities in Al Ain should focus on include the management of the accidents caused by the failure of the drivers to give priority to the pedestrian crossing, poor vision, the lack of driving knowledge, sudden turn, drivers who do not leave enough space and driving in the opposite direction.

III. Road safety authorities should adopt artificial intelligent approaches in the management of road safety. This recommendation is based on the fact that artificial intelligence-based approaches provide effective road safety management strategies. The road safety authorities should adopt artificial intelligent-based approaches such as Advanced Traveler Information Systems, SmartMobility Road Suite, to manage accidents caused by poor visibility and over speeding. Real-time offender identification systems such as the plate recognition system should be used in monitoring traffic rules violators while unmanned or autonomous vehicles provide means of reducing human related errors that increase the risk of accidents. To ensure effective implementation of the artificial intelligent approaches, there is a need for the relevant authorities to ensure the development of skilled personnel and training of the existing workforce on how to implement the approaches. The road users should also be educated on the importance and the use of the approaches.

IV. More data should be collected on the implementation and effectiveness of artificial intelligence based approaches. This recommendation is based on the fact that although the study highlighted the importance of AI in road safety management, the research depended on secondary data. Recent primary data from Abu Dhabi could provide more precise and specific insights into the importance of artificial intelligence-based approaches in the management of road safety problems.

6.5 Recommendation for further research

Based on the outcome of this study, it is evident that there is a need for further studies in some areas. Although the study's findings indicate that most of the accidents involve the individuals aged between 18 and 24 years old, there is an explanation for the reported results. It should be noted that it is important to identify the precise reasons why the younger drivers tend to be involved in accidents so as to develop strategies that are more effective at solving the problem. Given the inability of the current study to address this issue, it is important for future researcher to further examine this area. Future researchers need to determine whether there are factors that are unique to the drivers within the ages of 18 and 24 years, making them more at the risk of being involved in accidents than drivers of other age groups.

It is also evident that although the research reported a general decline in TAs in the Abu Dhabi roads, the study did not describe the reasons for the observed decline. Understanding the specific interventions that led to the decline in TAs in Abu Dhabi during the 10-year period is important in developing effective intervention to reduce the accidents further to ensure improved road safety. Therefore, future researchers should aim to carry out in-depth studies to identify the cause of the reduction in TAs in the region.

The study’s description of the artificial intelligence based solution to the road safety issues in Abu Dhabi is the other area that needs to be further examined. Although the study provided various artificial intelligence based solutions for addressing the TAs in Abu Dhabi, it should be noted that the discussion of the artificial intelligent based approaches is not based on the primary data that were collected from the current study. Future researchers need to focus on the use of artificial intelligent approaches based on the Abu Dhabi context since the current study mainly depended on the studies that were completed in other countries.

In conclusion, this study showed that the most common traffic problems on Abu Dhabi's roads include driver-related factors, vehicular factors, and road condition-related factors. Most of the accidents in Abu Dhabi are associated with driver behaviour. The study’s findings relating to the forecasting of the accident trends in Abu Dhabi showed that accidents would continue to be reported in the region, but the trends will vary across the three different sectors. Road safety authorities in Abu Dhabi and other relevant stakeholders should focus on controlling the risky driver behaviours in the management of road safety. The study also notes that road safety authorities in Abu Dhabi should adopt artificial intelligent approaches in the management of road safety.

7 References

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APPENDIX A: CAUSES OF THE TAS

The Impact Alcohol of Driving

Alcohol forms another significant cause of motor vehicle accident in these regions. Traffic fatalities due to alcohol increased by a less than the percentage from 2012 to 2013. In 2013, there were 10,076 people died in TAs resulting from alcohol impairment. Males cause about 80 % of these accidents. This occurs despite the laws, which prohibit alcohol intoxication. Excessive speeding entailed 29 percent of the total TAs in 2013 and killed about 9,613 people. This factor is directly related to alcohol involvement because driving under influence of alcohol leads to over speeding and thus causing accidents (NHTSA, 2015).

The Effect of Human Behaviour and Attitude

Beyond the scope of systems analysis and predictive traffic patterns, academic and empirical studies are focusing on driver-oriented services and interventions (Xu et al., 2012; Borhade et al., 2012; Sivaraman and Trivedi, 2013). Systems such as the 'automatic pedestrian detection' module described by Borhade et al. (2012) seek to reduce the vulnerability of drivers to road distractions by creating on-board attention-focusing solutions:

- ✓ Extending such pattern improvement systems to the broader.
- ✓ Macro-level road domain Milanes et al. (2012).
- ✓ Describe intelligent traffic flow management that is built upon a 'cooperative vehicle infrastructure system' that enables accident aversion and threat mitigation through road mapping.
- ✓ Auto-to-auto communications.
- ✓ Infrastr

ucture design.

The foundations for these support-based considerations are based upon a field of behavioural and psychological study in which Stanton and Salmon (2009), Staubach (2009), and Otte et al. (2012) seek to address human error taxonomies, the precursors to TAs, and the vulnerability of drivers to attention deficits, performance errors, and aggressive behavior in complex traffic scenarios. Through practical analysis of accident patterns, Staubach (2009), for example, has identified the causal links between human activities, anticipation, and on-road behaviours in order to develop practical solutions that can be applied to future assistance systems and network support resources.

Distracted Driving

Another cause of accidents in the US is distracted driving. Epidemiological surveys show that texting while driving increases the risk of crashing by fourfold. In this case, both free and handheld phones contribute to motor vehicle accidents in the same magnitude. The National Safety Council showed that the use of text messaging and use of cell phones contributes to approximately 26 percent of total traffic crashes. Use of phones contributes to approximately 21 percent, while sending text messages makes the remaining 5 percent of accidents. As a result, various states in the US have established a law, which bans the use of handheld and free phones while driving (National Safety Council, 2015).

Distraction during driving occurs when drivers divert their attention from the task of driving and focus on other activities. Such distraction occurs from activities like using electronic devices like cell phone or navigation gadgets and more conventional types of eating and interaction with passengers. Distraction affects drivers in three ways. First, visual distractions make the drivers shift their look from the road to obtain visual information from other places. Second, manual distraction makes the driver take their hands off the steering and manipulate other secondary devices. Third, the cognitive distraction that entails mental workloads and makes drivers shift their thinking away from the driving tasks. Engaging in distracting activities for a long period of time while driving increases the frequency of motor vehicle crash (Thomas, 2015).

Speeding

Speeding is argued to be the major causative factor for accident injuries, deaths, and damage to properties. Excessive speed limits the driver's time to react to the various dangerous situation on the roads. It increases the distance for vehicle stopping and lowers the ability of the safety structures on the road like crash cushions, impact attenuators, concrete barriers, guardrails, and median dividers. Therefore, states in the USA have passed the maximum speed limits for various types of vehicles to prevent crashes resulting from over speeding. In the UK, there is the average traffic speed on roads with free flow. Such road rules enable drivers to avoid an accident and decreases both numbers and severity of accidents and casualties during the accident. Moreover, both engineering and technological improvement of highways and vehicles in these countries have significantly contributed to the declining motor crashes.

APPENDIX B: POSSIBLE SOLUTIONS FOR TAS

Ban on Use of Handheld Devices during Driving

According to the National Safety Council Injury facts, no state has established a total ban on the texting while driving. However, the District of Columbia and the other 14 states have a ban on the use of handheld devices while driving.

Driving Under Influence of Alcohol

On alcohol, about 26 states have the mandatory breath alcohol ignition device, which determines the alcohol level of drivers. The survey of the National Highway Traffic Safety Administration showed that approximately 10,076 individuals were killed in 2013 due to alcohol-impaired accidents. These crashes comprise at least one motorcycle operator and driver who has a Blood Alcohol Concentration of either 0.08 grams per decilitre (g/dL) or more. As a result, the most states in the US have passed the minimum alcohol level at 0.08g/dL for drivers. Accordingly, all states imposed 21 years to be the minimum age for legal drinking.

Use of Safety Belt

There has been a significant increase in the use of the safety belt due to the mandatory law on safety belt use. In turn, it has led to the decline in unrestrained accident fatalities largely. In addition, many personal vehicles installed the child restraint for kids with less than 8 years. Booster seats or safety seats are also used for this category of children to reduce deaths during accidents. When utilized properly, safety belts lower fatal injury to car occupants by 45 percent.

A study carried out in Abu Dhabi showed that half of road fatalities and injuries can be lowered with safety belts. However, the UAE law on safety belt requires front passengers to put on the protection belts and not those in the back seat. In the UAE, the statics does not include alcohol drinking as a cause of TA. The law of driving while drunk is strict in UAE and entails a fine of USD 1860, less than two years imprisonment, and cancellation of the driving license (Hammoudi, Karani, & Littlewood, 2014, p. 10).

Airbags and Helmets

Combining shoulder or lap belts with air bags provides the best protection mechanism for vehicle occupants during the accident. This combination reduces the fatality of an accident by about 11 percent. Air bags only act as the supplement for protection and are utilized during severe frontal crashes. Fir motorcycle, the law requires them to have a helmet for both operators and the passenger. Helmet use is estimated to save fatal injuries by 37 percent to operators and 41 percent of the passengers.

Control Speeding

Abdelfatah et al (2015, p. 226) proposed three ways of controlling speed and they include narrowing, horizontal speed control, and vertical speed control. Vertical controlling the speed of motor vehicles include the placing of humps across the highways or other roadways. The horizontal approach forces the driver to shift direction to pass the hump. Lastly, the narrowing approach entails the use of curb extension with the aim of reducing the space where a car is supposed to pass. Accordingly, designing the traffic flow in a homogeneous way may help reduce traffic congestion and related accidents (Scellato, Fortuna, Frasca, G´omez-Gardenes, & Latora, 2010).

Control Measures in Abu Dhabi

Currently, the UAE government has placed a number of measures to ensure road safety across the regions. First, there are strict legal provisions, which include obtaining of legal driving license, observance of traffic rules, signals, and regulations. The TP and transport authorities are equipped with smart technology equipment to minimize violation of traffic rules. Second, traffic laws and fines that prohibit\its driving under influence of alcohol, using cell phones while driving, and observing the mandatory speed limits on highways, internal streets, and main roads. Third, road safety initiatives like Abu Dhabi Strategic Traffic Safety Plan based on four elements of education, engineering, enforcement, and emergency medical services. It also includes road safety audit, road safety awareness, Central Traffic Control System 'SCOOT', strategies for managing speed, Roads and Transport Authority (RTA) strategic plan, and traffic safety strategy. The SCOOT acts as the central system for controlling traffic and it is designed with sensors, which count the volume of motor vehicles with an aim of improving the flow of traffic at main junctions (Government. ae, 2017).

Manage Traffic Network

According to Davara and Pandya (2016), road intersections forms the most critical attributes in determining the performance of road networks in cities. This makes traffic signals act as critical devices for controlling traffic in such intersections. There are two main approaches that can be utilized to manage traffic congestion on highways and major roads in cities like Abu Dhabi. First, developing more bypasses, expressways, flyovers, and wider roads. However, such approaches require significant space and resources in the form of finance. The second approach is managing the current traffics with existing infrastructure capacity through utilization of technology and involving commuters. The second approach is based on the utilization of Intelligent Transportation Systems (ITS) based on Information Communication Technology to eliminate traffic congestion on the roads. In this case, both car drivers and commuters can utilize the information to schedule their transportation plans through choosing the less congested road or adjusting the time of travel to evade traffic during peak hours (Davara & Pandya, 2016).

Countries like Sydney utilizes the adaptive traffic systems know as SCATS (Sydney Coordinated Adaptive System) to manage and control traffic flows. The system is based on innovative and computerised intelligent transportation to minimize light traffics or stop, travel time, and heavy traffic or delays. The SCAT system collects real-time information on traffic flows. The data is channeled to the central computer through traffic controller. The computer develops incremental adjustments of the timing of traffic signals according to time by time changes in the flow of traffic at each intersection. The working of SCAT is based on real-time improvement of traffic flow (Studer, Ketabdari, & Marchionni, 2015). SCOOT system is also an alternative to the SCAT in optimizing road capacity through the management of network congestion. SCOOT offers a number of benefits like customised systems for congestion management; maximization of the network efficiency; offers a flexible architecture of communication; enhances traffic management; and offers comprehensive information about traffic (Studer, Ketabdari, & Marchionni, 2015).

In Abu Dhabi, SCAT can be deployed to control a large number of traffic and signals through an adaptive approach. In this case, traffic controllers will be able to pre-calcualte the relationship between time and signals. SCAT will enhance traffic control through the integration of signal intersections. The will offer the city with significant reduction of Delay, Fuel Consumption, Stoppage Time, and Travel Time. Currently, the city utilises the SCOOT (Split Cycle Offset

Optimization) approach in controlling the traffic. The approach collects information and data recorded by vehicle detectors and processes this data in order to optimize traffic signals and lower delays and stops (Studer, Ketabdari, & Marchionni , 2015).

Another example of a traffic management flow approach that can be used in Abu Dhabi is the Traffic Signal Design and Coordination between Two Intersections (Davara & Pandya, 2016). This approach is beneficial in two ways. First, it creates an effective way of optimizing the intersection of signal timing through minimizing total delay for both pedestrians and vehicles. Second, it designs the guidance, which helps pedestrians crossing the road. This approach gives traffic technicians short introductions on traffic signals and practical guidelines on obtaining safe and good results (Chaudhary, 2014).

Optimization of Traffic Patterns

The spectrum of research in this field is diversified by the core objectives relating to effective traffic control and management solutions. Flow management and control intervention research conducted by Hernandez et al. (2002) and Hegyi et al. (2009) focuses on the optimisation of traffic patterns through monitoring, network architecture, and control systems (e.g. lights, routes, access). Once systems are active and operational, researchers including Hernandez et al. (2002), Levinson, and Chen (2006) focus on real time data analysis and pattern monitoring in order to develop solutions that can improve efficiency and reduce risks and vulnerabilities to accidents. Ultimately, such interventions are based upon objectives, best practices, and technological capabilities which Stevanovic (2010) has modelled through a comparative study of distributed ATMS systems across the international community.

In addition to traffic pattern analysis, more advanced network solutions such as:

- Self-organising traffic lights (Cools et al., 2012).
- Short-term forecasting and route improvement (Vlahogianni et al., 2014).
- Advan

ced sensing networks (Hancke et al., 2013) create a mesh of autonomous.

- Appropriating technologies that offer practical solutions to congestion and accident mitigation problems.

Optimization of Road Networks

According to Scellato et al (2010) road optimization entails the efficient use of available road infrastructure in order to accommodate the increasing demand of road use. This requires the design of effective approaches to deal with the complex congestion networks in cities like Abi Dhabi. Some of the approaches like the Congestion-Aware Routing has significantly improved navigability and routing in big cities. In this approach, the routers or transport nodes redirect the information across the road lane with fewer congestions leading to increased capacity network. There are various key characteristics of transport networks that facilitates optimization. First, transport networks contain the roads or links which accommodate the flow of motor vehicles. Therefore, quality of motor vehicle movement across the road determines the overall working of the entire transport system. Second, congestion of vehicles is geographically distributed across various networks in this optimization approach.

Scellato et al (2010) designed an optimization model which can be adopted in Abu Dhabi to curb the increasing demand for road capacity. The model entails three elements which include vehicular dynamics, substrate graphs, and routings entailed in street crossing. Urban graphs capture the dynamics of the automobile and it is made of edges and nodes. The edge represents the street used by the vehicle during movement while nodes represent the intersections occurring between these streets. For simple cases, the model assumes that every edge facilitates movement of the vehicles in each direction. The vehicular dynamic element shows how the vehicle approaches the street nodes. In this model, one vehicle is only allowed for a given period of time to facilitate competition for the nodes by vehicles approaching from adjacent streets. This enables slow down of the vehicle as they approach the intersection. Since only one vehicle is allowed at a time, the traffic congestion is controlled. Lastly, the routing strategy of the model uses the Congestion-Aware Routing. This approach is the minimization in nature because it considers the traffic on the specific route and the length of the selected path (Scellato, Fortuna, Frasca, G´omez-Gardenes, & Latora, 2010, p. 304).

In Abu Dhabi, this model can be used to control traffic congestion through the use of the communication networks. Achieving the required level of optimization will require the integration of three main ingredients that determine the flow of vehicles across the city. They include the graph structure of Abu Dhabi city patterns; the cellular of automat of vehicle dynamics, including the street links; and the Congestion-Aware Routing approach which utilizes the Internet for provision of traffic congestion information. In this approach, the traffic authorities can utilize the local knowledge on traffic flow to improve the optimal performance of the road networks in Abu Dhabi.

APPENDIX C: CONSTRUCTION OF ROAD NETWORKS

First study Contribution

According to (Joshua et al 2011) there has been a constant rise in the number of vehicles per country. This can be attributed to the growth of different economies. On the other hand, the construction of road networks in these countries has not responded positively to the growing demands of people. This has been attributed to inadequate funding of public works especially in third world countries. Consequently, this has led traffic congestions, which can be defined. Different scholars attribute the causes of most TAs to congestion (Zhu and Roy 2003) asserts that when vehicles are congested, any disturbance could potentially lead to accidents. In addition, once there is congestion, crashes at the rear end may occur at the end of the queue due to the large difference in the speeds of the cars. Moreover, different road users could look for alternative means to reach their destination, which are perceived as faster routes. However, if the routes are in poor condition, the risks of accidents are higher (Xia 2009).

Second study Contribution

On the other hand, some scholars claim that congestions possibly reduce TAs. This is because the vehicles operate at a slower speed, which decreases the chances of accidents. Even though the latter seems logical, looking at the current traffic conditions, it becomes less obvious (Bando et al 1995) claim that as the flow of traffic increases, the density on the other hand approaches the critical value making the traffic flow unstable. When the traffic becomes congested, the average speed of the number of the different vehicles interactions increases and the flow conditions become unstable. Even though as hypothesized, there will be fewer crashes; however, the unstable flow conditions will result into higher frequency of crashes in the rear ends. In addition, side effects crashes and run off roads increase. Therefore, the changes in the flow conditions influence directly the type, frequency and the severity of crash (Bando et al 1995).

Third study Contribution

In another study conducted by (Deakin and Frick 2009) the authors found out that the severity of rear end crashes depends on several factors such as traffic approaches. As drivers approach a certain queue, they are more likely to get shocked thus getting into more severe crashes than those occurring within the queue (Salmon and Stanton 2009) suggest that there are two types of congestions including structural and incidental. While structural congestions occur when the capacity is lower than the demand, incidental occurs due to factors such as bad weather among others. These scholars suggest that the types of accidents occurring at structural congestions are less frequent and less severe compared to those that occur at incidental congestions. This is because structural congestions can be anticipated at certain locations during specific times. Moreover, incidental congestion leads to shock, which may change the behaviour of drivers. Casas and Codina 2005 claim that the extent to which the drivers get shocked depends on other factors such as the visibility of the queue and the use of modern technology to warn drivers of impeding congestions. Velaga 2009 claims that the extent to which modern technology assist drivers is not only limited to notifying the drivers of potential congestion, but also providing them with alternative routes, which are much safer to avoid congestion. Consequently, the choosing of different alternative routes also increases the mobility of the roads.

APPENDIX D: ITS

Many countries struggle to reduce traffic congestion in attempts to solve most traffic related issues through the construction of roads. However, in most of countries, public funding on roads, especially in developed countries is often limited. Current research bases in the application of ITS as a way of solving current issues in the transport sector. ITS include real time signal control, which entail controlling traffic signals in real time and operating them automatically. This depends in the demand in traffic. Another application of ITS can be applied in traffic load predictions and computation. Different researchers are focusing on different ways of improving the traffic by forecasting and load prediction. These scholars claim that reliable monitoring and short term forecasting models of traffic flow are important for the success of any traffic management system. (Hall 2006) described a computer application of vision techniques that can be used for surveillance.

Geographical information system

Different scholars to explore the fields on intelligent transport management have used different approaches. Some of these approaches include the Geographical information system. This forms a very important aspect in the road systems. (Svitekin 2006) their research proposed that a number of applications such as ArcInfo and ArcView in this area, which are used in the automation process of building the traffic topology network. Other researchers stressed that GIS can be used to solve many traffic solutions (Akomolafe et al 2001) claim that GIS systems are capable of analyzing different crashes on different lanes using a lane-by-lane basis on roads characterized by different lanes. In their research, the authors used the ArcGIS to combine road data, crash data and traffic characteristics as a dot matrix plot for GIS on an aerial photo. The ArcGIS is also made up of features that display the crash trends basing on characteristics on of individual crashes. In another research conducted by (Helfert, et al 2016) these authors indicated the use of Geospatial technology for the capture, storage, retrieval and analysis of data that related to positions in the earth, which helped in ensuring easy location of accidents on roads.

AI

Another approach is the use of AI. AI is currently being used in various fields including the management of traffic. In one research (Roozemond, 2001) developed a traffic system, which can respond to the demands and optimize different online timing plans and implement a real time control over them. This indicates that these systems are very adaptive according to the demands of the traffic and can help solve foreseeable issues. (Williams 2008) in another research, a complex adaptive system was suggested in which different agents' adept to a certain behavior in order to collaborate with other agents and thus achieve the intended goals. This system can therefore be used to communicate to different road users about the current condition of the roads to avoid causing traffic jams. In another research, a tool was developed for estimating the travel time in signalized urban networks that based on probe data. This tool is a self-learning that can be applied to the description of basing network instead of using a detailed modelling network structure. Therefore, the researchers used a Bayesian network for predicting the travel time on a particular route.

Real time systems

Another approach is using real time systems. These systems as aforementioned collect data in the real time and analyse it using different types of approaches to monitor and control traffic (Cobo, et al 2014). Several researchers have developed different vision based sensors that detect presence or absence of vehicles basing on captured images automatically in the real time (Woo, Yu and Lee 2016). Another approach is using real time systems. These systems as aforementioned collect data in the real time and analyse it using different types of approaches to monitor and control traffic. Several researchers have developed different vision based sensors that detect presence or absence of vehicles basing on captured images automatically in the real time (Dangi, et al 2010).

Wireless sensor networks

Some of the technologies used in ITS include technologies such as GPS, wireless sensor networks, CCTV and others. These technologies provided information that can be processed by different data analytic methods to provide solutions to the current traffic issues. Wireless sensor networks according to (Tay and Huang 2013) control the flow of traffic using wireless sensors. Wireless sensor networks instruments are used to control the traffic signals. On the other hand, intelligent transport controller was developed to control the operations of the traffic infrastructure that is supported by the wireless sensor networks. These systems have their own algorithms for the controller. Traffic lights can be used in the real time traffic control. Wireless sensors, which can detect the numbers of vehicles, their speeds are deployed and communicate to the nearest stations for any information

CCTV

Another application can be seen in CCTV; different scholars argue that CCTVs have the potential to reduce traffic related issues (Queen and Albers 2008). These can be installed at different hotspots in cities that are prone to traffic congestion. CCTV can be used in collecting information by capturing images. These images can then be analysed by using image-processing systems. In addition, CCTVs can also be used to predict the traffic speed at different areas (Wen 2008).

In summary, the inadequate development in the transport sector in most cities in the world, results to traffic congestion. In addition, as noted, traffic congestion potentially results into TAs depending on different circumstances. ITS as noted can greatly contribute to the reduction of traffic related issues by providing information, which can be processed to give insights as to what can be done at a particular time. Specifically, the use of CCTV in reducing traffic related issues could provide images, which can offer road users insightful information such as which route to avoid.

APPENDIX E: Training & Development activity undertaken since January 2017

Date	Title of training course/module/conference	Key learning point
Wednesdays sessions/February 2017	MSc Transport Students.	Collect research material.
Wednesdays sessions/March 2017	MSc Transport Students.	Collect research material.
26/4/2017	Referencing, citation and plagiarism.	Research writing.
19/7/2017	Referencing your work APA (Harvard) style.	Research writing.
21/7/2017	Get ready for the Viva Workshop.	Develop confidence with a practice opportunity.
26/7/2017	Get Ahead with Computing, Library & Study Essentials.	Research writing.
2/10/2017	Introduction to critical and analytical skills.	Looking at how to be a critical student.

APPENDIX F: Questions for Research Questionnaire

QUESTIONNAIRE

This is research survey is made by Ibrahim Alshamsi in view of completing PhD in reducing vehicle accidents to improve road safety in Abu Dhabi. I am therefore requesting for your voluntary participation in filling this questionnaire. All information provided by you will be held in confidence and will be used for the sole purpose of this research without reference to your name or person.

Abu Dhabi TP Directorate

Abu Dhabi Emirate

Drivers Attitudes and Behavior towards Driving in the UAE

Part 1: Sociodemographic Characteristics

Serial No.: ---

1. Gender:

Male	☐	1
Female	☐	2

2. Educational level:

University undergraduate	☐	1
University postgraduate	☐	2
Other: Specify ________________________________	☐	3

3. Age: …………

4. Nationality

1. UAE
2. Expatriate of Arab origin
3. Asian
4. European
5. African
6. Other nationality

Part 2. The Driver Attitudes Questionnaire (DAQ)

1. To what extent do you agree with EACH of the following statements?

		I strongly disagree	**I Disagree**	**I nether agree or disagree**	**I agree**	**I strongly agree**
1.	Some people can drive perfectly safe without wearing the safety seatbelt	1	2	3	4	5
2.	People stopped by the police for close-following are unlucky because lots of people do it	1	2	3	4	5
3.	Speed limits are often set too low, with the result that many drivers ignore them	1	2	3	4	5
4.	It is quite acceptable to take a slight risk when overtaking	1	2	3	4	5
5.	Close following isn't really a serious problem at the moment	1	2	3	4	5
6.	I know exactly how fast I can drive and still drive safely	1	2	3	4	5
7.	Some drivers can be perfectly safe overtaking in situations which would be risky for others	1	2	3	4	5
8.	Even driving slightly faster than the speed limit makes you less safe as a driver	1	2	3	4	5
9.	I would be happier if close-following regulations were more strictly applied	1	2	3	4	5
10.	Stricter enforcement of speed limits on 80 KM roads would be effective in reducing the occurrence of TAs	1	2	3	4	5
11.	I think it is okay to overtake in risky circumstances as long as you drive within your own capabilities	1	2	3	4	5
12.	I would be happier if the speed limits were more strictly enforced	1	2	3	4	5

13.	People stopped by the police for risky overtaking are unlucky because lots of people do it	1	2	3	4	5
14.	It's OK to drive faster than the speed limit as long as you drive carefully	1	2	3	4	5
15.	I know exactly what risks I can take when I overtake	1	2	3	4	5
16.	Random breath testing of drivers should be introduced	1	2	3	4	5
17.	Speeding is one of the main causes of TAs	1	2	3	4	5
18.	It is quite acceptable to drive closer to the car in front than is recommended	1	2	3	4	5
19.	Sometimes you have to drive in excess of the speed limit in order to keep up with the flow of traffic	1	2	3	4	5
20.	Risky overtaking isn't really a serious problem as the moment	1	2	3	4	5

Part 2: The Driver Behavior Questionnaire (DBQ) – Tendency for Violations

For each driving behavior described in the table below, please indicate how often you have done this whilst travelling on your way home in the last [3] months. Please indicate this by circling a number in each line.

		Never	Hardly ever	Occasionally	Quite Often	Frequently	Nearly all the times
1.	You become impatient with a slow driver in the outer lane and overtake on the inside	0	1	2	3	4	5
2.	Drive especially close to the car in front as a signal to the driver to go faster or get out of the way	0	1	2	3	4	5
3.	Attempt to overtake someone that you hadn't noticed to be taking a right turn	0	1	2	3	4	5

4.	Cross a junction knowing that the traffic lights have already turned against you	0	1	2	3	4	5
5.	Angered by another driver's behavior, you chase him/her up with the intention of giving him/her a piece of your mind	0	1	2	3	4	5
6.	Disregard the speed limits late at night or early in the morning	0	1	2	3	4	5
7	Drive even though you realize you might be over the legal blood alcohol level	0	1	2	3	4	5
8	Get involved in unofficial 'races' with other drivers	0	1	2	3	4	5

Part 3: Driver Practice Questionnaire (DPQ)

1. **Which of the following do you think are the three most common causes of road traffic collisions in the UAE (UAE)? (Please tick three only)**

- ❑ Driving when tired
- ❑ Following the vehicle in front too closely
- ❑ Drivers exceeding the speed limit
- ❑ Alcohol intoxication
- ❑ Drivers not paying enough attention to the road
- ❑ Driving a defective vehicle e.g. worn tyres
- ❑ Pure chance
- ❑ Drivers lacking in experience
- ❑ Using a mobile phone while driving
- ❑ Poorly maintained roads

2. **How important do you think the following factors are in causing road traffic collisions?** *(Please tick the appropriate column).*

	Very important	Important	Neutral	Not Important	Not at all important
Illegal, defective or underinflated tyres.					
Driving a defective vehicle.					
Drivers/riders vision affected by stationary or parked vehicles.					

Drivers/riders being reckless or in a hurry.					
Drivers/riders not signalling.					
Drivers/riders under the influence of alcohol.					
Drivers/riders not looking properly.					
Driving/riding too close.					
Slippery road surface.					
Drivers/riders distracted by hand-held mobile phones.					
Driving/riding when tired.					
Drivers/riders travelling too fast for conditions.					
Drivers/riders overtaking when it is unsafe to do so.					
Drivers/riders taking risks.					
Pure chance.					

3. Wearing a seat belt can reduce your risk of death by how much?

- ❑ 25%
- ❑ 45%
- ❑ 65%

Appendix G: Minimum sample size table

Population size	Sample size					
	Continuous data (margin of error=0.03)			Categorical data (margin of error=0.05)		
	alpha=0.10 t=1.65	alpha=0.05 t=1.96	alpha=0.01 t=2.58	p=.050 t=1.65	p=0.50 t=1.96	p=0.50 t=2.58
100	46	55	68	74	80	87
200	59	75	102	116	132	154
300	65	85	123	143	169	207
400	69	92	137	162	196	250
500	72	96	147	176	218	286
600	73	100	155	187	235	316
700	75	102	161	196	249	341
800	76	104	166	203	260	363
900	76	105	170	209	270	382
1,000	77	106	173	213	278	399
1,500	79	110	183	230	306	461
2,000	83	112	189	239	323	499
4,000	83	119	198	254	351	570

6,000	83	119	209	259	362	598
8,000	83	119	209	262	367	613
10,000	83	119	209	264	370	623