Distribution Agreement

In presenting this thesis or dissertation as a partial fulfillment of the requirements for an advanced degree from Emory University, I hereby grant to Emory University and its agents the non-exclusive license to archive, make accessible, and display my thesis or dissertation in whole or in part in all forms of media, now or hereafter known, including display on the world wide web. I understand that I may select some access restrictions as part of the online submission of this thesis or dissertation. I retain all ownership rights to the copyright of the thesis or dissertation. I also retain the right to use in future works (such as articles or books) all or part of this thesis or dissertation.

Signature:

_____ _____

Date

Analyses of Road Traffic Vehicle Crashes, Kingdom of Saudi Arabia, 2007 – 2012

By

Amal Mousa Zaidan
MPH

Global Health

_____ [Chair's signature]
Scott JN McNabb, PhD, MS
Committee Chair

Analyses of Road Traffic Vehicle Crashes, Kingdom of Saudi Arabia, 2007 – 2012

By

Amal Mousa Zaidan

BSc in Biochemistry
King AbdulAziz University
2004

BSc in Nursing
King Saud Bin AbdulAziz University for Health Science
2011

Thesis Committee Chair: Scott JN McNabb, PhD, MS

An abstract of
A thesis submitted to the Faculty of the
Rollins School of Public Health of Emory University
in partial fulfillment of the requirements for the degree of
Master of Public Health
in Global Health
2014

ABSTRACT

OBJECTIVE: The Kingdom of Saudi Arabia (KSA) has a high number of road traffic vehicle crashes (RTVCs), with significant morbidity and mortality. Since the early 1990s, the mortality rates of RTVCs have increased significantly and now account for 4.7% of all mortality in KSA. Because these events are preventable, there is a need to study the epidemiology of RTVCs. Using existing Ministry of Interior (MoI) (i.e., police) data, we studied the trends of RTVCs and the resulting injuries and fatalities from 2007 – 2012.

METHODS: The yearly, aggregated RTVC data for the 13 administrative regions of KSA, collected and recorded by the MoI, were analyzed over time using Microsoft Excel™. Population data were obtained from the Ministry of Economy and Planning, Central Department of Statistics and Information.

RESULTS: There were 2.77 million RTVCs between 2007 and 2012. We observed an upward trend over this time period in the incidence rate (IR) of RTVCs (24.63 to 39.47 per 1000 vehicles) and fatality rates (0.24 to 0.26 per 1000 population) and a downward trend in RTVC-related injuries (1.48 to 1.41 per 1000 population). The IR of RTVCs occurring in the morning increased from 14.2 (per 1,000 vehicles) in 2007 to 25.4 in 2012. At night the IR increased from 10.4 in 2007 to 14.1 in 2012. Saudi citizens had a lower IR (25.5 to 26 per 1,000 population) in comparison to non-Saudis (51.8 to 45.5 per 1000 population). Makkah region had the greatest cumulative number of RTVC-related injuries and fatalities during this time period (71,776 injuries, and 9,939 fatalities). The highest IRs for injuries (9.9) and fatalities (1.6) were observed in the Northern Border region in 2007, while the lowest injury and fatality IRs were observed in Riyadh region.

CONCLUSION: We observed an increasing trend in the IRs for both RTVCs and fatalities from 2007 – 2012. The creation of appropriate policies and regulations to enforce existing traffic regulations, the development of an interagency, standardized RTVC data collection system, and the initiatation of a public health education program, using social networks should be planned and undertaken.

Analyses of Road Traffic Vehicle Crashes, Kingdom of Saudi Arabia, 2007 – 2012

By

Amal Mousa Zaidan

BSc in Biochemistry
King AbdulAziz University
2004

BSc in Nursing
King Saud Bin AbdulAziz University for Health Science
2011

Thesis Committee Chair: Scott JN McNabb, PhD, MS

A thesis submitted to the Faculty of the
Rollins School of Public Health of Emory University
in partial fulfillment of the requirements for the degree of
Master of Public Health
in Global Health
2014

ACKNOWLEDGMENTS

First of all, praise is to Allah, on whom ultimately we depend for sustenance and guidance. I am grateful to my Parent, and family for being there for me; as without their support I would not have come thus far, to my husband Dr Mohammed Ageli for all his support. I must express my gratitude to my supervisor Dr. Scott JN McNabb whose guidance, careful reading, and constructive comments were invaluable. His efficient contribution helped me to develop this research into its final form. I would also like to thank Dean Ahmed Al Amry and the faculty at my alma mater, the College of the Public Health and Health Informatics at King Saud bin Abdulaziz University for Health Sciences, for their support and guidance as I've pursued my higher education. Finally, many thanks to Natalie Schulhofer, and all whose names do not appear here and without whom this study would not have been possible.

ACRONYMS LIST OF

CDSI	Central Department of Statistics and Information
GCC	Gulf Cooperation Council
GDP	Gross domestic product
KSA	Kingdom of Saudi Arabia
MoH	Ministry of Health
MoI	Ministry of Interior
RTVC	Road Traffic Vehicle Crashes
SR	Saudi Riyals
USD	United State Dollar
WHO	World Health Organization

TABLE OF CONTENTS

CHAPTER ONE

INTRODUCTION

CHAPTER TWO

LITERATURE REVIEW

CHAPTER THREE

MANUSCRIPT

CHAPTER FOUR

CONCLUSION

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1

INTRODUCTION

1.1 OVERVIEW

The rise of modern civilization and increases in economic development and the populations of modern cities have been accompanied by widespread use of motor vehicles. This increasing number of motor vehicles has led to a growing number of road traffic vehicle crashes (RTVCs), which incur significant human and economic costs. RTVCs have become a serious public health burden worldwide, but they are preventable. Many studies suggest that RTVCs present the highest risk per unit time of any activity that may lead to accidental (or unintentional) death and injury. The worldwide incidence of RTVCs has increased drastically, estimated to result in 1.24 million deaths, 20 to 50 million non-fatal injuries, and many permanent disabilities [1]. RTVCs also cause serious economic loss due to the high cost of medical and surgical treatment, loss of productivity of the injured patient, and property damage.

By definition, RTVCs occur on roads when there is a collision with another vehicle, human being, animal, or facility. Baguley (2001) defines a RTVC as "a rare, random, multifactor event, which is always preceded by a situation in which one or more road users have failed to cope with their environment" [2]. The causes vary from drivers' behaviour and the weather to the state of the roadways and the conditions of the motor vehicles. Haddon (1972) applied epidemiologic methods to the study of injury, and this method can also be applied to road crashes. He pointed out that crashes are associated with numerous problems that can be grouped by human, vehicle, and environmental factors and analysed as pre, during, and post injury [3]. Hence, RTVCs are predictable and preventable, and with data and results, interventions can be tailored to successfully reduce this huge burden.

For example, in developed countries, RTVC fatalities have decreased since the 1960s because of successful interventions like seat belt utilization and enforcement of speed limits.

1.2 RTVCs in Saudi Arabia

In the Kingdom of Saudi Arabia (KSA), population growth and improved socioeconomic conditions have resulted in an increased number of vehicles on the roads. In 2000, the KSA population was 20.5 million. It increased to 23.3 million in 2005, and reaching 30.4 million in 2013 [4]. This was complemented by economic, technological, and industrial development. People use vehicles more often now as a convenient, effective, and quick method of transportation inside and outside of cities. Moreover, changes in working and living conditions have increased driving duration; people now spend more time driving at night and outside of the cities, in comparison with previous years [4].

In spite of the advantages of using motor vehicles for travel, this trend has generated numerous problems and resulted in the occurrence of many traffic crashes. These have claimed lives, caused injuries, and affected the economy. There were 589,258 traffic crashes in KSA in 2012, resulting in 7,638 deaths. This translates to 1,614 crashes per day or, to break it down further, 67 vehicle crashes per hour [4].

These problems represent a major concern for officials and citizens. The issue of traffic safety has gained more attention through a variety of means and integration of efforts. Numerous organizations have been directed to collaborate with one another in order to monitor factors associated with drivers, vehicles, and the environment to achieve traffic safety. These organizations include the Ministry of the Interior (Department General Directorate of Traffic, and Special Forces for the Security of the Roads), the Ministry of Transport, the Ministry of

Municipal and Rural Affairs, the Ministry of Health, and other entities such as the Ministries of Finance, Trade, Industry, Culture and Information, Education, and finally, the Saudi Red Crescent Society.

In addition to cross-collaboration efforts, many laws and regulations have been issued in KSA to control and decrease this accelerating public health problem. In December 2000, seat belt usage was made compulsory for all drivers and front seat passengers [5]. In April 2010, the Saher System was initiated, "an automated traffic control and management system" found in the largest cities. It consisted of a digital camera network that identified speeding vehicles and their license plate numbers and sends this information to the National Information Centre of Ministry of Interior (MoI) [6]. These drivers are then fined via cell-phone notification.

1.2.1 CAUSES OF RTVCs

Despite the introduction of these rules and regulations, the number of RTVCs is increasing at an alarming rate. Causes can be divided into three main categories: human factors, road and environmental factors, and vehicle condition. These causes are specifically related to RTVCs, but the general causes can be attributed to the increased number of vehicles, expansion of the road network, and multinational drivers of different cultures [7].

1.3 MAGNITUDE OF RTVCs

1.3.1 Health consequences

In KSA, RTVCs are the leading cause of mortality, hospitalization, and chronic disability [11]. Injuries that result from crashes on the roads vary in type and severity. RTVC victims are the most common type of patients in operating rooms and intensive care units. They occupied more than one-fifth of all MOH hospital beds, and most required medical service with long-term

rehabilitation [10]. Furthermore, RTVCs are the main cause of 74% of all cases of partial or total paralysis [10].

Additionally, RTVCs may cause psychological trauma, which is not limited to those directly involved in the accident but extends to all of their companions and families, and even to the observers of the accident. These psychological effects require prolonged treatment over several weeks, months, or years, depending on the circumstances of each individual case.

Many studies performed in other countries have shown the trends of RTVCs in various categories. Developed countries achieved a reduction in the incidence rate (IR). In this study, we aim to improve the understanding of RTVC trends in KSA and discuss the effects of the new regulations on the rate of RTVCs. In doing so, we hope to support policymakers consolidate their efforts to lower the RTVC IR and reduce or eliminate this public health problem.

1.3.2 Economic consequences

RTVCs place a huge financial burden on individuals, communities, and the country due to the cost of medical treatment, damage to vehicles and road infrastructure, cost of administrative follow-up, and the loss of employee productivity [8]. In 2000, the estimated economic cost of RTVCs annually was 21 billion riyals, which suggests that KSA lost between 2.2% and 9% of its national income [7]. Since then, this figure has increased to 26 billion riyals according to the Secretary General of the Shura Council, who said, “The Kingdom is at the forefront of the world in terms of human and physical attrition due to traffic crashes” [9].

Additionally, the injuries caused by RTVCs exact a toll not only on the national economy, but also on the individual financial resources of the affected households, where many families fall into poverty because of the loss of the household income providers and the additional cost of

the medical treatment for accident victims. Moreover, the loss of human energy that results from the high mortality rates, and the increasing number of injuries that lead to many forms of disability and handicap, affect both individuals and communities. Those most prone to crashes are males aged 16-36 years old, who are valuable members of the workforce [10].

1.4 AIMS AND OBJECTIVES

The aim of this research is to analyse the trends related to RTVCs in KSA for the period of 2007 – 2012. In this study we investigated the trend of RTVCs overall, the trends of RTVCs in the morning and night, and the trends of injuries and fatalities throughout KSA and at the regional level.

To fulfill these aims, we have the following objectives:

1. Determine the IRs of RTVCs, including both injuries and fatalities in KSA between 2007 and 2012 and
2. Examine the trends of IRs of injuries and fatalities in KSA regions between 2007 and 2012

1.5 RESEARCH QUESTION

What are the trends of RTVCs in KSA and their consequences?

1.6 SIGNIFICANCE OF THE STUDY

There are a number of reasons why examining RTVC trends in KSA is needed. It is a fact that RTVCs have been increasing substantially over time in KSA, yet there are few studies in the literature analysing this health outcome. By examining recent RTVCs trends, policy makers will be able to ascertain how effective their regulations are and see if new regulations are warranted.

Urgent action is needed in light of the fact that RTVCs are a major component of the percentage of total injuries and fatalities in KSA.

CHAPTER 2

LITERATURE REVIEW

2.1 OVERVIEW

RTVCs are a global problem and a huge burden for the world. The gravity of this problem has drawn much attention and prompted many studies that would aid in the development of a clearer understanding around the drastic worldwide increase of RTVCs. In 2004, the World Health Organization predicted that road crashes deaths would increase by 80% from 2000 to 2020 [8].

There are numerous definitions of RTVC. One comes from the United Nations Economic Commission for Europe (UN/ECE), which calls a RTVC an "accident which occurred or originated on a way or street open to public traffic; which resulted in one or more persons being killed or injured and in which at least one moving vehicle was involved. These crashes therefore include collisions between vehicles, between vehicles and pedestrians, and between vehicles and animals or fixed obstacles. Single vehicle crashes, in which one vehicle alone (and no other road user) was involved, are included" [12].

2.2 The RTVC problem globally

RTVCs present a huge problem worldwide and are considered one of the leading causes of death in both adult and young adolescent groups; it is the second most common cause of death among those ages 5 – 29 and the third most common for those ages 30 – 44 years old [13]. Although RTVCs are decreasing gradually in most industrialized countries, they are increasing in developing countries. In developing countries, RTVCs are estimated to constitute 90% of the disability adjusted, life-years lost and 85% of all deaths [14]. Worldwide, Middle Eastern

countries have the highest rates of RTVC mortality [15]. Many variables related to this need to be addressed. Developed countries have progressed in their success in addressing this trend, but many developing countries have not been as successful.

To forecast RTVCs by geographic region and get a sense of the prevalence in developed and developing countries, the relationship between traffic fatality risk and per-capita income is necessary. Data from 1963 – 1999 for 88 countries were collected, and linear and log linear models used to project traffic fatalities. Researchers concluded that, in general, the death rate would rise in the future. A decline in fatalities would be seen in high-income countries, but China and India would experience fatality rate increases [16].

In 2000, Van Beeck conducted a study to investigate the association between economic development and RTVC mortality in the industrialized world during the period from 1962 – 1990. This study showed that the association between prosperity and RTVC mortality changed from positive linear in the 1960s to concurrent negative in the 1980s. Over the long term, this association shifted: economic development led to an increased number of vehicles, but it also led to improvements in the traffic infrastructure and trauma care system [17].

To investigate the causes of the increase in RTVCs, numerous studies have been conducted in developing countries. In 2012, Augustus found that in Lagos state in Nigeria, there was an increase in RTVCs related to increased road length, population, and the existence of a road safety corps [18]. In some places like Thailand, industrialization was related to the trend of increasing RTVCs. That circumstance was observed in 1986, at the beginning of industrialization and increases in per capita income, the unexpected result of which required the initiation of preventive measures addressing RTVCs [19].

Pratte, *et. al* conducted a study in Nigeria and Kenya and argued that a shortage of data and epidemiologic and anthropological studies were current obstacles against a comprehensive understanding of the problem [20]. In some low- and middle-income countries, like those in the Pacific region, the burden of RTVCs presents a significant problem that has been inadequately addressed in research, despite the increase in road safety awareness [21]. In Cameroon, there are at least four RTVC deaths daily according to the data analysis of accident reports for the period 2007 – 2011; this requires more prevention policies from the government [22]. In Turkey, RTVCs caused a significant incidence rate (IR) of injuries and mortality. A retrospective study shows that in Istanbul, RTVCs caused 43% of the total injuries in all the hospitals [23].

The main risk factors for RTVCs are driver mistakes, vehicle condition, current weather, and road conditions, some of which can be controlled by following protective and self-precautionary measures [26]. Basnet, *et* al., in their study on RTVCs in Kathmandu, discussed the issue of drunk driving. Their findings show that the number of RTVCs in 2012 was 23% less than the number in 2011. Also, they found that the injury-to-fatality ratio decreased by 21% in 2012. These results indicated that the rules and programs addressing driving behaviour should change, as these changes might have a positive impact and decrease the global burden of trauma from RTVCs in lower- and middle-income countries [27]. Some countries, like Cuba, have achieved a reduction in RTVCs in recent years, but RTVCs are still considered costly in terms of economic and public health, representing the fourth highest cause of potential life lost years (DALYs) [28].

2.3 The RTVC Problem in the Arabian Gulf Region

In the Gulf Cooperation Council (GCC) countries, discovery of oil led to both development and economic growth, which affects many aspects of life, including transportation habits. More

people are buying and driving vehicles; in consequence, RTVCs have increased over the years, and they are one of the leading causes of death in some GCC countries. This alarming trend has made RTVCs one of the most recognized public health problems in GCC countries, one that needs to be addressed more effectively [29]. In 2000, RTVCs were the third leading cause of death in Qatar, and 71% of these cases were due to careless driving [30].

In the United Arab Emirates (UAE), a study conducted by Bener, *et* al. showed that careless driving was a major factor associated with RTVC, which accounted for over 35% of the incidents, followed by excessive speeding. An exploratory study that discussed the relationship between the growth trends of motorization and the pattern of RTVCs in Oman showed a positive relationship between them from 2000 – 2009, with RTVCs increasing by 26% [31]. Furthermore, 98% of RTVCs occur due to human factors, such as speeding, which is the main cause of RTVCs. Young drivers aged 17-36 are the most affected group [31]. In Kuwait, despite the presence of good transportation and road infrastructures, the problem of RTVCs remains serious, causing 28 fatalities per 100,000 vehicles [15]. In the Kingdom of Bahrain, the average proportion of young males (< 25 years of age) killed by RTVCs from 2003 – 2010 was 82.7%, and they were 3.5 times more likely to die from RTVCs in comparison to the general population [32].

2.4 The RTVC Problem in Saudi Arabia

In KSA, RTVC IRs are accelerating despite the government effort to control this phenomenon. The Secretary General of the Shura Council said, "The Kingdom is at the forefront of the world in terms of human and physical attrition due to traffic crashes" [9]. The RTVC mortality rates have increased significantly since the 1990s, accounting for 4.7% of the total mortality. This figure is alarming when compared to that of other countries. To put it in

perspective, the combined RTVC mortality IR in Australia, England and America is 1.7% of the total mortality [9]. Moreover, RTVCs accounted for 80% -- 85% of the total trauma cases in KSA in 2000 and was projected to cause one death and four injuries hourly in the future [10]. Economically, the annual cost of RTVCs is estimated to range from 2.2% to 9% of the GDP, equal to 21 billion SR (USD $5.6 billion) [10].

Statistics have shown that Riyadh – capital of KSA – has the highest IR of RTVCs in comparison to the rest of the Kingdom. Head, thorax, and spinal injuries were the most serious consequences of RTVCs, while the head, upper and lower extremities accounted for the most common body parts injured [33].

Many causes contribute to the huge IR of RTVCs; two of the main ones are excessive speeding and/or careless driver behaviours, which are responsible for over 65% of the crashes [7]. In 2001, tire failure was the cause of 13% of car crashes, attributed to lack of education about tire selection, usage, and maintenance [34]. Additionally, around 600 collisions annually occur involving camels, and the impact of these crashes is usually severe since they occur on rural highways, where the drivers are moving at high speed most of the time [35].

Lack of a single, standardized source of information is one of the obstacles that is facing KSA; data sources for RTVCs come from either Ministry of Interior (MoI) police reports, which focus on the legal aspect, or from the MoH, which focuses on the health information [9], [7].

CHAPTER THREE

MANUSCRIPT

3.1. INTRODUCTION

The rise of modern civilization, economic development, and the increase in population in modern cities are accompanied by the widespread use of motor vehicles. This increasing number of motor vehicles has led to the growing number of road traffic crashes (RTVCs), which has become a serious public health burden and problem worldwide; its magnitude has had health, economic and social consequences.

The worldwide incidence of RTVCs has increased drastically, estimated to result in 1.24 million deaths, 20 to 50 million non-fatal injuries, and many permanent disabilities [1]. The World Health Organization (WHO) predicted that deaths from road crashes would increase by 80% from 2000 to 2020 [8] and that RTVCs would cause 1.2 million deaths annually [36]. RTVCs are considered the second most common cause of death among those aged 5 to 29 and the third most common cause of death among those aged 30 to 44 years old [13].

In the developing countries, road traffic injuries are estimated to constitute 90% of the disability adjusted life years lost and 85% of all deaths [14]. Worldwide, Middle Eastern countries have the highest rates of RTVC mortality [15]. The Kingdom of Saudi Arabia (KSA) is a Middle Eastern country with a high incidence of RTVC-associated mortality and morbidity. RTVCs represent the leading cause of mortality, hospitalization, and chronic disability [11]. Since the 1990s, the RTVC mortality rate has increased significantly; it accounts for 4.7% of the total mortality. The size of this figure is alarming in comparison to 1.7% mortality rate in Australia, England and America combined [9]. Moreover, RTVCs accounted for 80% to 85% of

the total trauma cases in KSA and are projected to cause one death and four injuries hourly in the future [10]. Victims of RTVCs occupied more than a fifth of all Ministry of Health (MoH) hospital beds, and most of them required medical service with long-term rehabilitation [10]. Furthermore, RTVCs are the main cause of 74% of all cases of paralysis, such as hemiplegia and paraplegia [10]. Those rates are an accelerating problem despite the government effort to control this phenomenon. Statistics have shown that Riyadh, the capital of KSA, has the highest rate of crashes in comparison to the rest of KSA. Head, thorax, and spinal injuries were the most serious consequences of RTVCs, while the head, upper and lower extremities accounted for the most common body parts injured in RTVCs [33].

Economically, the annual cost of RTVCs is estimated to be 2.2% to 9% of the GDP, equal to 21 billion Saudi Riyals (USD $5.6 billion) [10]. This figure has increased to 26 billion riyals according to the Secretary General of the Shura Council, who said, “The Kingdom is at the forefront of the world in terms of human and physical attrition due to traffic crashes” [9]. Many causes have led to this huge IR of RTVCs; excessive speeding and/or careless drivers behaviours caused over 65% of the crashes, and the increased number of vehicles, expansion of the road network, and multinational drivers of different cultures have also increased the incidence of RTVCs [7]. In 2001, tire failure was the cause of 13% of car crashes, and the main reasons were lack of education about tire selection, usage, and maintenance [34]. Additionally, around 600 collisions occur annually involving camels, and the impact of these crashes is usually severe since they occur on rural highways, where the drivers are moving at high speed most of the time [35].

In KSA, the lack of a single, standardized source of information is an obstacle; data sources for RTVCs come from either the Ministry of Interior (MoI) police reports, which focus

on the legal aspect, or from the Ministry of Health, which focuses on the health information [9] [7]. Many studies of other countries have described the trends of RTVCs in various categories. Some countries, mostly developed, have achieved a reduction in the IR. In this study, we aim to improve the understanding of RTVC trends in KSA and discuss the effect of the new regulations on the rate of RTVCs. We hope to urge policymakers to consolidate their efforts to overcome and control the RTVC rate and the percentage of total injuries and total fatalities in KSA, and to reduce and eventually eliminate this public health problem.

3.2. METHODS

3.2.1. Study Population and Data Sources

This descriptive, retrospective analysis was conducted in KSA. The source of RTVC data for the study years 2007 – 2012 was the MoI, General Directorate of Traffic, which captures all RTVCs occurring within KSA. This included yearly RTVCs, time of day when RTVC occurred (morning or night), number of vehicles involved, nationality of the drivers, number of injuries, and number of fatalities; we drew statistical information from this data, and they comprised this study's variables. Injuries were counted when their extent was anywhere from mild to severe and they required medical attention, while the fatalities were counted when there were deaths [37].

The population data was the yearly aggregate data for the total population, which is divided by nationality (Saudis vs. non-Saudis), and for the 13 administrative regions: Riyadh, Makkah, Madinah, Qasim, Eastern, Asir, Tabouk, Northern Border, Jizan, Najran, Hail, Al Baha, and Al Jawf. This data was recorded in the register of the KSA Ministry of Economy and Planning, Central Department of Statistics and Information, for the period 2007 – 2012 [4].

3.2.2. Statistical Analyses

Total RTVC IRs and RTVC morning and night IRs were calculated per 1000 vehicles. Total injury and fatality IRs were calculated per 1000 population. The drivers involved in the crash were divided by nationality and calculated per 1000 population according to their nationality (Saudis and non-Saudis). Trends were classified as increasing, decreasing, or stable, and compared using 95% confidence intervals (CIs). IR was calculated on a yearly basis. Further proportional analysis by region was performed for comparison. Statistical analyses, graphs, and tables were generated using Microsoft Excel™.

3.2.3. Ethics

All of the data analysed was secondary, completely de-identified, and without personal identifiers. The Institutional Review Board (IRB) at Emory University exempted this study from human subject review in January 2014.

3.3. RESULTS

The increasing number of registered vehicles in KSA is linked to an increasing number of RTVCs, which numbered 2.8 million over the period from 2007 – 2012. At the beginning of the study period (2007) the IR of RTVCs was 24.6 per 1000 vehicles. This rate increased significantly until 2009, when it reached 38 per 1000 vehicles. In 2011, the rate dropped to 35.2 per 1000 vehicles, and in 2012, it increased again to 39.5 per 1000 vehicles (Table 1).

Table 1. Number of road traffic vehicle crashes and incidence rates, by year, Kingdom of Saudi Arabia, 2007 – 2012

Year	# RTVCs (IR °)	95% CI *
2007	283,648 (24.6)	24.5 - 24.7
2008	435,264 (35.9)	35.8 - 36
2009	485,931 (38)	37.9 - 38.1
2010	484,805 (36.1)	35.9 - 36.2
2011	498,203 (35.2)	35.1 - 35.3
2012	589,258 (39.5)	39.4 - 39.6
Total	2,777,109	

RTVCs = road traffic vehicle crashes
°IR = incidence rate per 1,000 vehicles
*CI = confidence interval

The injury IR was 5.5 times higher than the fatality IR over the 6-year study period (Table 2). The number of traffic-related injuries increased steadily from 35,884 to 41,086, but the incidence rate per 1000 population decreased slightly from 1.44 to 1.41. The number of fatalities also increased gradually; by 2012, the fatalities IR had reached 0.26 per 1000 population.

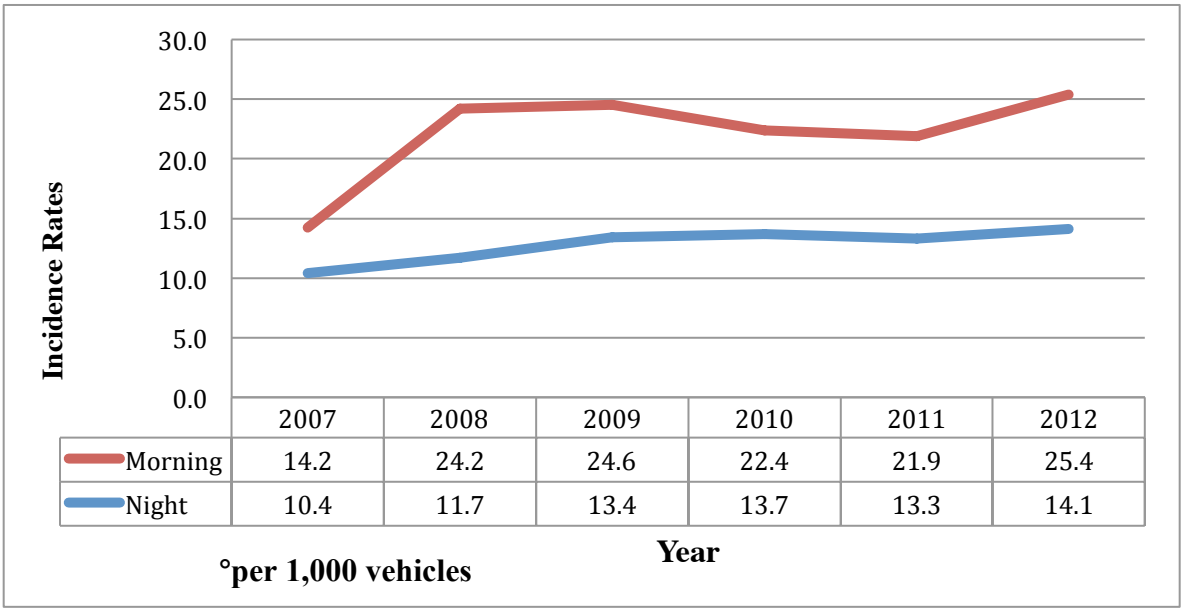
Table 2. Number of injuries and fatalities and incidence rates due to road traffic vehicle crashes, by year, Kingdom of Saudi Arabia, 2007 – 2012

	Injuries		Fatalities	
Year	# (IR°)	95% CI*	# (IR°)	95% CI*
2007	35,884 (1.4)	1.4 - 1.5	5,883 (0.2)	0.2 - 0.2
2008	36,025 (1.4)	1.4 - 1.4	6,358 (0.3)	0.2 - 0.3
2009	36,489 (1.4)	1.4 - 1.4	6,458 (0.2)	0.2 - 0.3
2010	34,605 (1.3)	1.2 - 1.3	6,142 (0.2)	0.2 - 0.2
2011	38,595 (1.4)	1.4 - 1.4	6,596 (0.2)	0.2 - 0.2
2012	41,086 (1.4)	1.4 - 1.4	7,638 (0.3)	0.3 - 0.3
Total	222,684		39,075	

°IR = incidence rate per 1,000 population
*CI = confidence interval

The number of RTVCs by time of day showed higher crash rates in the morning than at night (Fig 1). The morning RTVC IR trend from 2007 – 2012 fluctuated, but in general, the rate increased from 14.2 in 2007 to 25.4 per 1000 vehicles in 2012. The nighttime RTVC IR reflected a steady upward trend from 2007 to 2012 (10.4 to 14.1 per 1000 vehicles).

Figure 1. Incidence Rates° of Road Traffic Vehicle Crashes Occurring in the Morning or at Night, Kingdom of Saudi Arabia, 2007— 2012



We conducted further analysis to examine drivers involved in RTVCs by nationality (Table 3). We found that non-Saudi drivers had a higher RTVC IR than Saudi drivers. The number of Saudi drivers involved in RTVCs increased from 450,846 to 516,742 over the study period, but the IR of RTVCs per 1000 Saudi population fluctuated during that time; overall, it increased significantly (25.48 to 26.05 per 1000 Saudi people), though it was highest toward the beginning of the study period, in 2008 (27.24 per 1000 Saudi people). The number of non-Saudi drivers increased from 375,752 to 426,045 over the study period, but the IR of RTVCs involving non-Saudi drivers decreased significantly (51.83 to 45.53 per 1000 non-Saudi people).

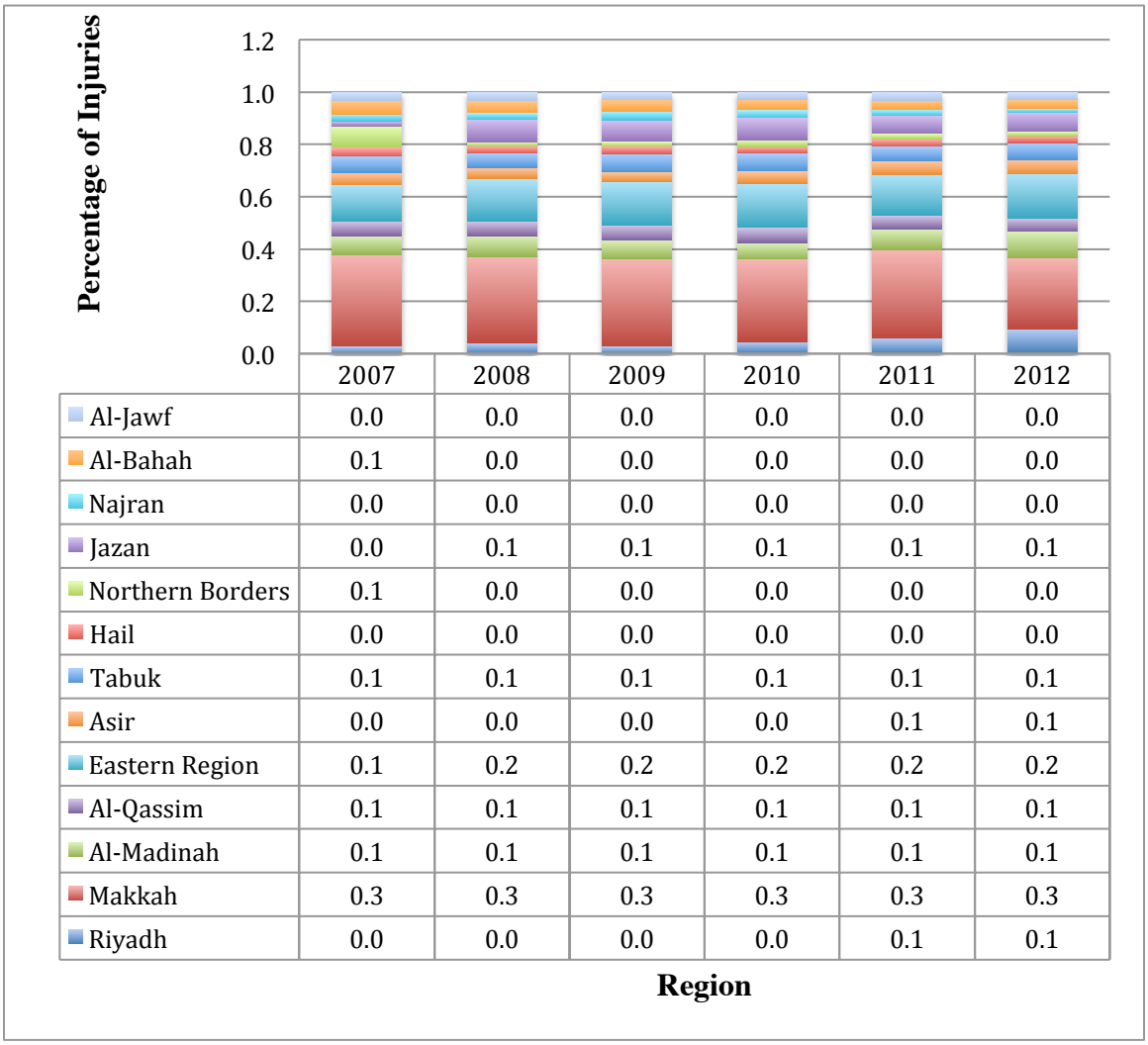
Table 3. Number of road traffic vehicle crashes drivers and incidence rates, by nationality, Kingdom of Saudi Arabia, 2007 – 2012

	Saudi		Non-Saudi	
Year	# (IR°)	95% CI*	# (IR°)	95% CI*
2007	450,846 (25.5)	25.4 - 25.6	375,752 (51.8)	51.7 – 52
2008	493,447 (27.2)	27.2 - 27.3	408,789 (53.3)	53.1 - 53.5
2009	484,676 (26.1)	26.2 - 26.2	399,116 (49.2)	49.0 - 49.3
2010	497,437 (26.2)	26.2 - 26.3	415,523 (48.4)	48.2 - 48.5
2011	506,078 (26.1)	26.0 - 26.2	417,510 (46.5)	46.4 - 46.7
2012	516,742 (26.1)	26 - 26.1	426,045 (45.5)	45.4 - 45.7
Total	2,949,226		2,442,735	

°IR = incidence rate per 1,000 population
*CI = confidence interval

By region, from 2007 – 2012, Makkah showed the highest proportion of injuries, followed by the Eastern Region; the lowest percentage of injuries occurred in Jazan and Al Jawf. There was an upward trend in injuries in Riyadh (from 2.8% in 2007 to 9.5% in 2012) and Eastern Region (from 13.9 in 2007 to 16.8 in 2012) and a downward trend in Makkah (from 34.9% in 2007 to 27.17% in 2012) (Fig. 2). Fatality proportions were highest in Makkah, Eastern Region, Assir, than Jazan.

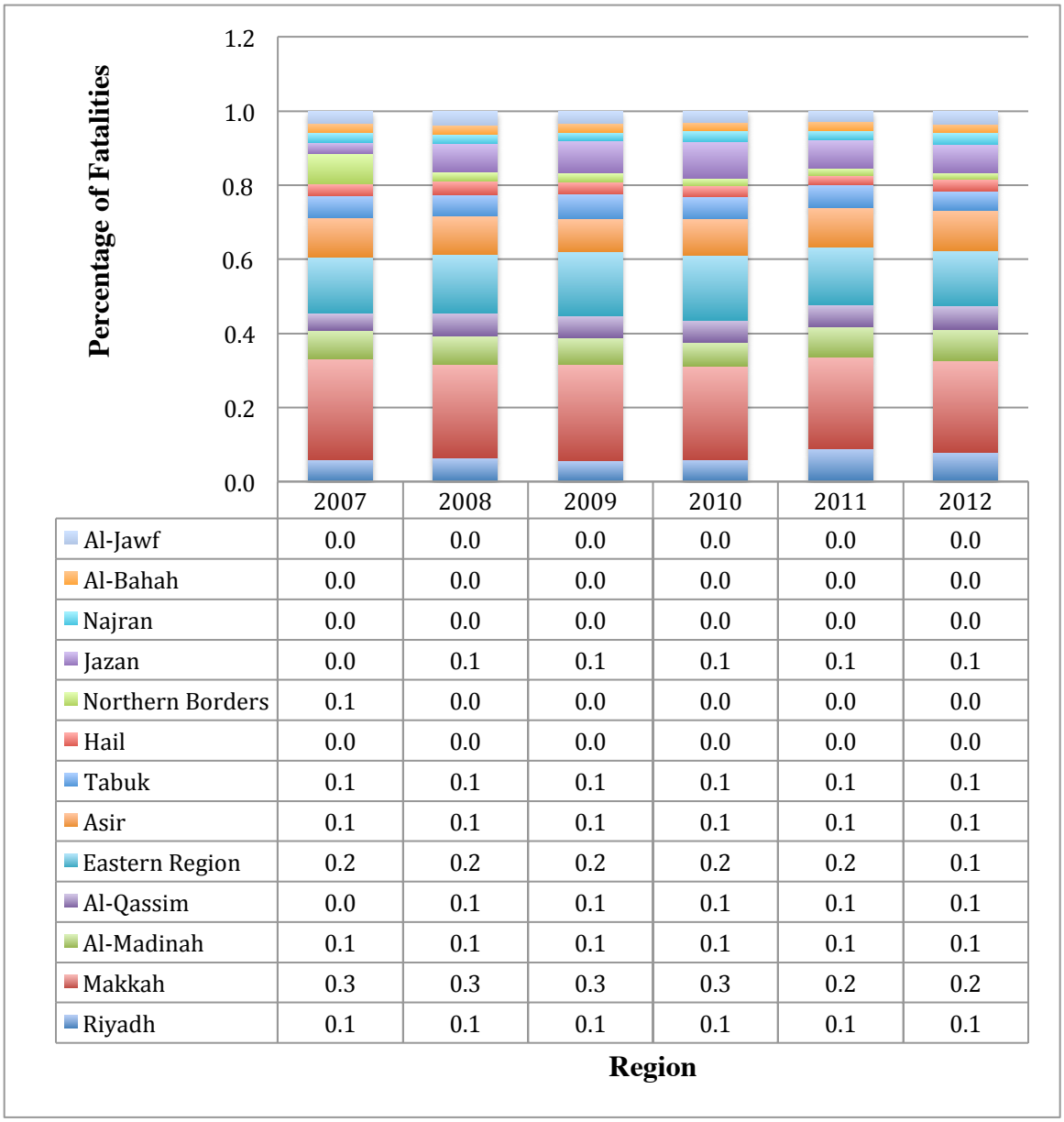
Figure 2. Proportion of Injuries Due to Road Traffic Vehicle Crashes, by Year and Region, Kingdom of Saudi Arabia, 2007 — 2012



	2007	2008	2009	2010	2011	2012
Al-Jawf	0.0	0.0	0.0	0.0	0.0	0.0
Al-Bahah	0.1	0.0	0.0	0.0	0.0	0.0
Najran	0.0	0.0	0.0	0.0	0.0	0.0
Jazan	0.0	0.1	0.1	0.1	0.1	0.1
Northern Borders	0.1	0.0	0.0	0.0	0.0	0.0
Hail	0.0	0.0	0.0	0.0	0.0	0.0
Tabuk	0.1	0.1	0.1	0.1	0.1	0.1
Asir	0.0	0.0	0.0	0.0	0.1	0.1
Eastern Region	0.1	0.2	0.2	0.2	0.2	0.2
Al-Qassim	0.1	0.1	0.1	0.1	0.1	0.1
Al-Madinah	0.1	0.1	0.1	0.1	0.1	0.1
Makkah	0.3	0.3	0.3	0.3	0.3	0.3
Riyadh	0.0	0.0	0.0	0.0	0.1	0.1

The fatality proportions from 2007 – 2012 decreased in some regions such as Makkah (27.2% to 24.5%) and Northern Borders (8.1% to 1.7 %), and increased in Riyadh (5.8% to 7.9%) (Fig. 3)

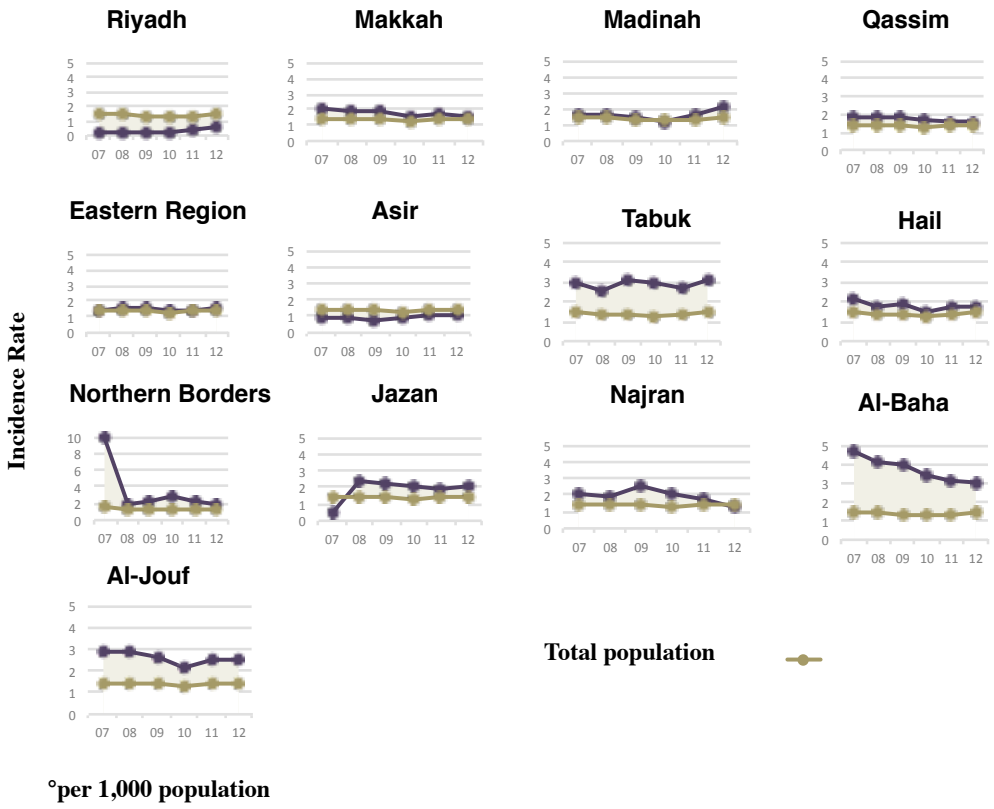
Figure 3. Proportion of Fatalities Due to Road Traffic Vehicle Crashes, by Year and Region, Kingdom of Saudi Arabia, 2007— 2012



	2007	2008	2009	2010	2011	2012
Al-Jawf	0.0	0.0	0.0	0.0	0.0	0.0
Al-Bahah	0.0	0.0	0.0	0.0	0.0	0.0
Najran	0.0	0.0	0.0	0.0	0.0	0.0
Jazan	0.0	0.1	0.1	0.1	0.1	0.1
Northern Borders	0.1	0.0	0.0	0.0	0.0	0.0
Hail	0.0	0.0	0.0	0.0	0.0	0.0
Tabuk	0.1	0.1	0.1	0.1	0.1	0.1
Asir	0.1	0.1	0.1	0.1	0.1	0.1
Eastern Region	0.2	0.2	0.2	0.2	0.2	0.1
Al-Qassim	0.0	0.1	0.1	0.1	0.1	0.1
Al-Madinah	0.1	0.1	0.1	0.1	0.1	0.1
Makkah	0.3	0.3	0.3	0.3	0.2	0.2
Riyadh	0.1	0.1	0.1	0.1	0.1	0.1

During this same period, the injury IR per 1000 population was high in Al Jawf, Al Baha, and Tabouk, and it was low in Riyadh. The IR had an upward trend in Riyadh (from 0.17 to 0.53 per 1000 population) and a downward trend in Makkah (from 2 to 1.5 per 1000 population) and Northern Borders (from 9.9 to 2 per 1000 population) (Fig. 4).

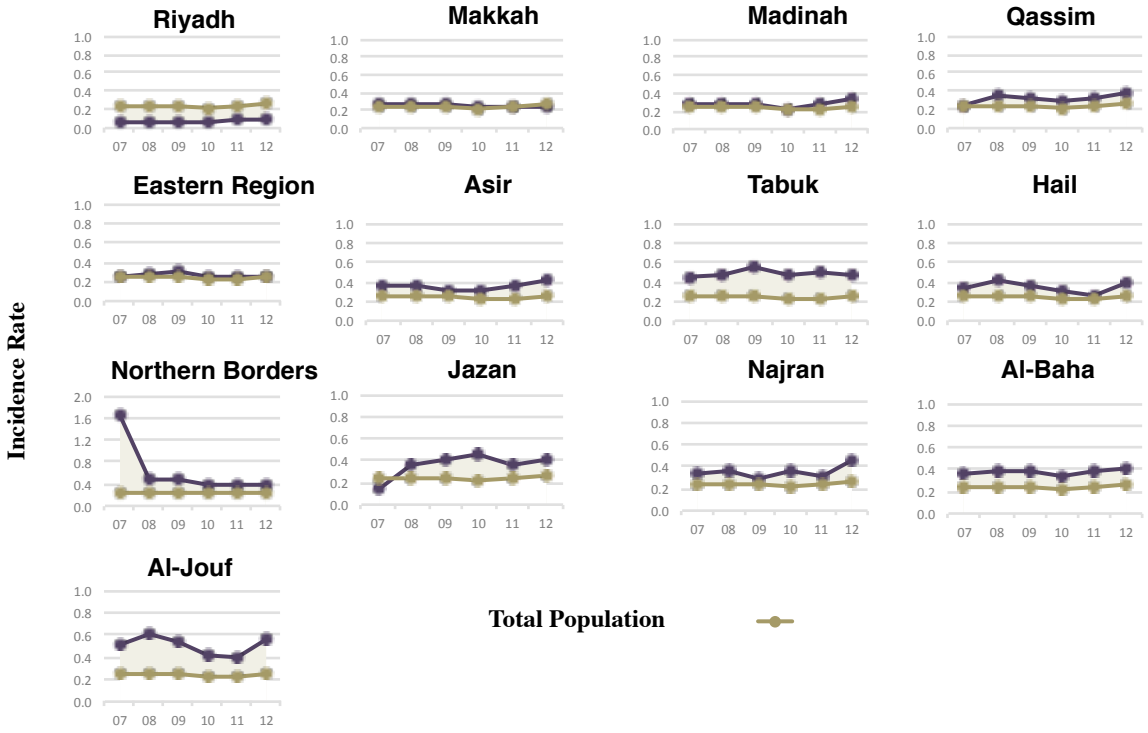
Figure 4. Incidence Rates° of Injuries Due to Road Traffic Vehicle Crashes, by Year and Region, Kingdom of Saudi Arabia, 2007 – 2012



°per 1,000 population

The fatality IR per 1000 population increased in regions such as Riyadh (0.05 to 0.08) and decreased only in Makkah (0.3 to 0.2), and Northern Borders (9.9 to 3.8). In 2007, the highest IRs was observed in Northern Boarder, IR for injuries 9.9 and 1.6 fatalities per 1000 population (Fig. 5).

Figure 5. Incidence Rates° of Fatalities Due to Road Traffic Vehicle Crashes, by Year and Region, Kingdom of Saudi Arabia, 2007 – 2012

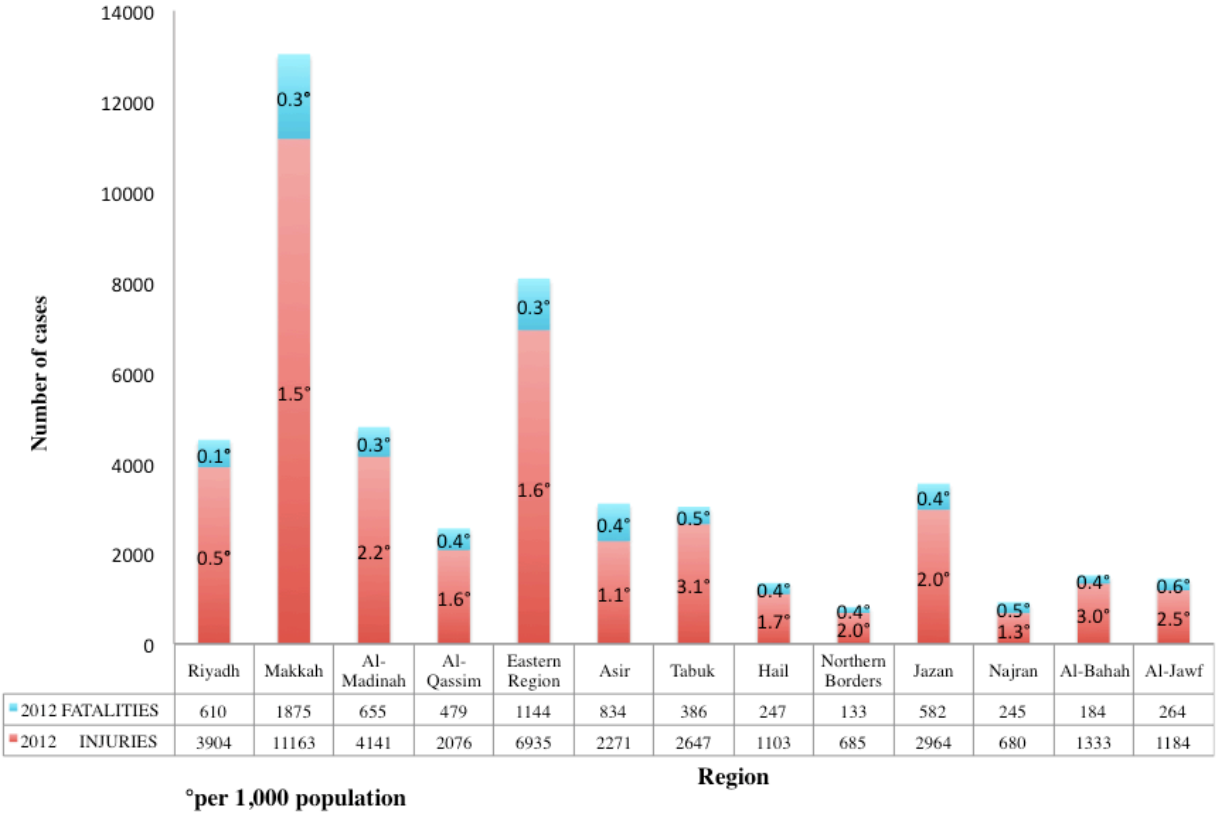


°per 1,000 population

Makkah Region, which has the highest population, showed the highest number of injuries (27.2%) and fatalities (24.5%) out of the total RTVC injuries and fatalities in KSA in 2012. That same year, the Eastern Region's RTVC-related injuries represented 16.8% of the country's total RTVC-related injuries and 14.9% of the total RTVC-related fatalities, the second highest proportion in KSA. Madinah region was third with 10.1% of the RTVC injuries and 8.6% of the RTVC fatalities, followed by Riyadh with 9.5% of the injuries and 8% of the fatalities. At the other end, Najran had the lowest percentage of RTVC injuries in KSA (1.6%), and Northern Borders the lowest proportion of total fatalities (1.7%). The injury IR was high in Tabouk and Al Baha, with 3 per 1000 population, and low in Riyadh, with 0.5 per 1000 population. The fatality

IR was high in Al Jawf (0.6) and Najran (0.4) and low in Riyadh (0.1), Makkah (0.2), and Eastern Region (0.3) (Fig. 6).

Figure 6. Incidence Rates° and Number of Cases of Injuries and Fatalities Due to Road Traffic Vehicle Crashes, by Year and Region, Kingdom of Saudi Arabia, 2012



	Riyadh	Makkah	Al-Madinah	Al-Qassim	Eastern Region	Asir	Tabuk	Hail	Northern Borders	Jazan	Najran	Al-Bahah	Al-Jawf
2012 FATALITIES	610	1875	655	479	1144	834	386	247	133	582	245	184	264
2012 INJURIES	3904	11163	4141	2076	6935	2271	2647	1103	685	2964	680	1333	1184

3.4. DISCUSSION

This study shows the trends of RTVCs per 1000 vehicles and the injuries and fatalities due to RTVCs per 1000 population for the period 2007 – 2012. Further analysis was done to examine data on the nationality of the drivers (Saudi vs. non-Saudi per 1000 population). We observed an upward trend over time in the IR of total RTVCs (from 24.6 to 39.5 per 1000 vehicles) and fatalities (from 0.2 to 0.3 per 1000 population). The injury IR showed a downward trend (from

1.5 to 1.4 per 1000 population) over the same period. In general, the morning IR trend shifted up from 14.2 in 2007 to 25.4 in 2012 per 1000 vehicles. The nighttime RTVC IR increased from 10.4 in 2007 to 14.1 in 2012 per 1000 vehicles.

The RTVC IR for drivers who are Saudi is lower in comparison to that of non-Saudis, but the RTVC IR for Saudi drivers did increase significantly from 2007 – 2012 (25.5 to 26.1 per 1000 Saudi people), while RTVC IR for non-Saudi drivers decreased significantly (51.8 to 45.5 per 1000 non-Saudi people).

Makkah region had the highest number of injuries and fatalities, followed by the Eastern Region. The highest injury IR was observed in Al Baha, while the highest fatality IR was observed in Northern Border. Riyadh had both the lowest injury and fatality IRs.

Some limitations of the study were the limited amount of data available and the absence of a centralized data source. The data had to be collected from two different entities: the Ministry of Interior and the Ministry of Economy and Planning, Central Department of Statistics and Information.

We recommend the adoption of more policies and regulations to strengthen the existing rules, violation fines, secret traffic policemen, and Saher System, and to effect change in driver behaviour. We recommend the development of a standardized data collection system for all the regions in KSA to facilitate RTVC studies on an ongoing basis to overcome this problem. More collaboration and scientific studies in the fields of health, engineering, and education have to be conducted to reduce the rate of traffic vehicle crashes. The design and construction of roads should be improved to reduce the potential for crashes. The possibility of manufacturer's defects and vehicle usage duration in certain vehicles should also be investigated.

Public health education has to be established, especially for the young, to increase their knowledge and awareness of the dangers of risky behaviour and consequently change their habits on the roads. Government and community groups should continue to raise awareness around traffic safety protocols and promote the use of safety equipment throughout the year via the media and within the school curriculum, focusing on the consequences of health and economic losses from RTVCs.

Further investigation must be undertaken to examine the many hypotheses that originate from this study. We observed the highest rate of injuries and fatalities in Makkah region; is this high rate due to road engineering, people's behaviours, or to the presence of a high number of foreigners visiting for the Hajj and Omrah seasons? We also found an upward trend in the fatality and injury rates in Riyadh, despite the strict implementation of traffic safety policies and regulations. Finally, Makkah Region had a 3-fold higher injury and fatality rate than the Riyadh region, and both are the most populated cities in KSA.

CHAPTER 4

CONCLUSION

4.1 INTRODUCTION

This study provides the trends of RTVCs per 1000 vehicles, and injuries and fatalities per 1000 population for the period 2007 – 2012. We observed an upward trend over time in the incidence rate of total RTVCs (24.6 to 39.5 per 1000 vehicles), with a slight downturn in 2010 and 2011, which might have been the result of stricter traffic regulations and violation fees, the initiation of secret traffic policemen, and the introduction of the Saher System. This decrease in the RTVC IR didn't last; by 2012, it had increased again.

The RTVC IR trend wasn't congruent with the trend for injuries: the injuries IR showed a downward trend (from 1.5 to 1.4). In comparison, the fatalities IR showed an upward trend (from 0.2 to 0.3) over the study years, despite all of the laws and regulations implemented to control this phenomenon.

By time of day, the traffic pattern in KSA mirrors that of the rest of the world: the highest number of vehicles is on the road during the morning rush hour due to work, school, and government administration schedules. This is reflected in the difference between daytime and night time total RTVC numbers and in the IR, which was higher in the morning. Between Saudi and non-Saudi drivers, the non-Saudis had a higher RTVC IR, which can be attributed to their small total number in comparison to the total Saudi population.

At the regional level, Makkah region had the highest number of injuries and fatalities, followed by the Eastern Region; the highest injuries and fatalities IR was observed in Northern Boarders, while the lowest IRs in both categories was observed in Riyadh.

4.2 RECOMMENDATIONS

We recommend the adoption of more policies and regulations in addition to the existing rules, violation fines, secret traffic policemen, and Saher System to aid in changing driver behaviours. We recommend the development of a standardized data collection system for all the regions in KSA to facilitate RTVCs studies on an ongoing basis to overcome this problem. More collaboration and scientific studies in a various in the fields of health, engineering, and education have to be conducted to reduce the rate of traffic crashes. The design and construction of some roads should be improved to reduce the potential and risks for crashes. The possibility of manufacture's defects, and the vehicles usage duration in certain vehicles should also be investigated.

Public health education has to be established, especially for young people, to increase their knowledge and awareness of the dangers of risky behaviour and, consequently, to change their habits on the roads. Government and community groups should continue to raise awareness around traffic safety protocols and promote the use of safety equipment throughout the year via the media and within the schools curriculum, focusing on consequences of health and economic losses from RTVCs.

Further investigation must be undertaken to examine the many hypotheses that originate from this study. We observed the highest rate of injuries and fatalities in Makkah region; is this high rate due to road engineering, people's behaviours, or to the presence of high number of

foreigners visiting for the Hajj and Omrah seasons? We also found an upward trend in the fatality and injury rates in Riyadh, despite the strict implementation of traffic safety policies and regulations. Finally, Makkah Region had a 3-fold higher injury and fatality rate than the Riyadh Region, and both are the most populated cities in KSA.

REFERENCES

1. Global status report on road safety 2013. 2013 [cited 2014 01/02]; Available from: http://www.who.int/violence_injury_prevention/road_safety_status/2013/en/.

2. Baguley, C., The importance of a road accident data system and its utilisation, in International Symposium on Traffic Safety Strengthening and Accident Prevention. 2001: Nanjing, China.

3. T, C. and G. S, Injury Prevention and Public Health: Practical Knowledge, Skills, and Strategies. Second Edition ed. 2006: Jones & Bartlett Learning, 2006.

4. Annual Statistics Book. [cited 2013 11/03]; Available from: http://www.cdsi.gov.sa/english/.

5. Bendak, S., Seat belt utilization in Saudi Arabia and its impact on road accident injuries. Accid Anal Prev, 2005. 37(2): p. 367-71.

6. Saher. 2010 [cited 2013 02/29]; Available from: http://www.saher.gov.sa/e_Default.aspx.

7. Ansari, S., et al., Causes and effects of road traffic accidents in Saudi Arabia. Public Health, 2000. 114(1): p. 37-9.

8. E, K. and C.M. G., Traffi c fatalities and economic growth. . 2003.

9. Barrimah, I., F. Midhet, and F. Sharaf, Epidemiology of road traffic injuries in qassim region, saudi arabia: consistency of police and health data. Int J Health Sci (Qassim), 2012. 6(1): p. 31-41.

10. MY, A.-N., A. MA, and A.-I. FS., Trauma care systems in Saudi Arabia: an agenda for action. Ann Saudi Med, 2010. 30(1).

11. MS., A.-J., A retrospective study on traumatic spinal cord injury in an inpatient

rehabilitation unit in central Saudi Arabia. . Saudi Med J. , 2013. 34(2): p. 161-165.

12. OECD Health Data 2013, Definitions, Sources and Methods. Injuries in road traffic accidents 2013.

13. T., A., et al., ROAD TRAFFIC ACCIDENT: A LEADING CAUSE OF THE GLOBALBURDEN OF PUBLIC HEALTH INJURIES AND FATALITIES, in International Conference on Mechanical Engineering. 2007: Dhaka, Bangladesh.

14. Nantulya, V.M. and M.R. Reich, The neglected epidemic: road traffic injuries in developing countries. BMJ, 2002. 324(7346): p. 1139-41.

15. M., H., Traffic Accidents in Kuwait: A Decision Making Analysis. INTERNATIONAL JOURNAL OF APPLIED MATHEMATICS AND INFORMATICS, 2012. 6(2).

16. Kopits, E. and M. Cropper, Traffic fatalities and economic growth. Accid Anal Prev, 2005. 37(1): p. 169-78.

17. Van Beeck EF, Borsboom GJ, and M. JP:, Economic development and traffic accident mortality in the industrialized world,1962–1990.
. Int J Epidemiol (29:503-9.).

18. Augustus, A., A Monthly Analysis of Road Traffic Accident in Selected Local Government Areas of Lagos State, Nigeria. Mediterranean Journal of Social Sciences. Vol. 3 (11).

19. Sintuvanich, A., The impact of industrialization on road traffic accidents in Thailand. J Med Assoc Thai, 1997. 80(10): p. 631-5.

20. Pratte, D., Road to Ruin: Road Traffic Accidents in The Developing World. NEXUS, 1998. 13: p. 46-62

21. Herman, J., S. Ameratunga, and R. Jackson, Burden of road traffic injuries and related

risk factors in low and middle-income Pacific Island countries and territories: a systematic review of the scientific literature (TRIP 5). BMC Public Health, 2012. 12: p. 479.

22. Sobngwi, J., P. Taniform, and E. Lagarde, TRENDS OF ROAD TRAFFIC ACCIDENTS IN CAMEROON

BETWEEN 2007 AND 2011. Inj Prev 2012. 18: A241.

23. Karamehmetoglu, S.S., et al., Traumatic spinal cord injuries in Istanbul, Turkey. An epidemiological study. Paraplegia, 1995. 33(8): p. 469-71.

24. Crawford, T. and D. McGrowder, Road Traffic Injury Epidemic in Jamaica: Implications for Governance and Public Policy. Asian Social Science, 2008. 4(10).

25. Sulehri, M.A. and A.P. Qasim, ROAD TRAFFIC ACCIDENTS; FATALITIES IN FAISALABAD. Professional Medical Journal, 2012. 19(2): p. 180.

26. Jabbar, M., et al., Risk Factors of Road Traffic Accidents (RTA) in context of Bangladesh. Journal of Dhaka Medical College, 2009. 18(2).

27. Basnet, B., et al., Road traffic accidents in Kathmandu--an hour of education yields a glimmer of hope. Scand J Trauma Resusc Emerg Med, 2013. 21: p. 19.

28. Garcell, H.G. and C.M. Quesada, Epidemiology and Prevention of Traffic Accidents in Cuba. Health Management - Different Approaches and Solutions, Dr. Krzysztof Smigorski (Ed.),. InTech. 498.

29. A., B. and C. D., Road traffic accidents in the United Arab Emirates compared to Western countries. . Adv. Transportation Stud. , 2005. 6: p. 5–12.

30. Bener, A., The neglected epidemic: road traffic accidents in a developing country, State of Qatar. Int J Inj Contr Saf Promot, 2005. 12(1): p. 45-7.

31. Islam, M.M. and A.Y.S.A. Hadhrami, Increased Motorization and Road Traffic

Accidents in Oman. Journal of Emerging Trends in Economics and Management Sciences (JETEMS) 2012. 3(6): p. 907-914.

32. Hamadeh, R.R. and N.M. Ali, Fatalities from road traffic accidents among the young in Bahrain. East Mediterr Health J, 2013. 19(10): p. 854-60.

33. Al-Shammari, N., S. Bendak, and S. Al-Gadhi, In-depth analysis of pedestrian crashes in Riyadh. Traffic Inj Prev, 2009. 10(6): p. 552-9.

34. Ratrout, N.T., Tire condition and drivers' practice in maintaining tires in Saudi Arabia. Accid Anal Prev, 2005. 37(1): p. 201-6.

35. Al-Ghamdi, A.S. and S.A. AlGadhi, Warning signs as countermeasures to camel-vehicle collisions in Saudi Arabia. Accid Anal Prev, 2004. 36(5): p. 749-60.

36. Organization, W.H. and D.o.V.I.P.D. (VIP), GLOBAL STATUS REPORT ON ROAD SAFETY. 2009, World Health Organization: Geneva.

37. TRAFFIC, G.D.O., Accidents Statistics Report. 2010, Ministry of Interior: Saudi Arabia.