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**Original Research Article**

# Analysis and forecast of road traffic accident in Saudi Arabia from 1990 until 2018

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## ABSTRACT

**Background:** Road traffic accidents (RTAs) are an epidemic problem in Saudi Arabia, resulting in high morbidity and mortality rates. This paper investigates the increasing number of RTAs and their related injuries and mortalities in Saudi Arabia.
**Methods:** This study was performed on the population of Saudi Arabia using secondary data from the general authority for statistics from 1990 to 2018. Correlation among the variables (RTAs, injuries, mortalities, and population) was conducted using statistical package for the social sciences (SPSS), and forecasts of their trends over the next ten years using linear regression was discussed.
**Results:** Eastern, Makkah and Riyadh regions were the top three regions in the number of RTAs accounting for 69% of the total RTAs in Saudi Arabia. All regions have had a pattern of RTA rise from 1990 till 2014 that dropped in the last 4 years. Riyadh had the highest injury rate per 10,000 RTA, although it had the lowest RTA rate per 100,000 population in the period from 2010-2014. Mortality rate in Riyadh doubled between the years 2014 and 2018 while Makkah accounted for the highest RTA-related mortality rates. The correlation between RTAs and mortalities were the highest in the country (r=0.92). In 2030, the average annual increase in the rate of RTAs, related injuries, and related mortalities will be 3%, 2% and 2.1%, respectively.
**Conclusions:** Decision makers in Saudi traffic and transportation department should continue monitoring accidents prevention strategies and their effect. Reasons behind high injury and mortality rates, despite the decrease in the rate of RTAs, should be investigated.

**Keywords:** Road traffic accidents, Road traffic injuries, Road traffic mortalities

## INTRODUCTION

Road traffic accidents (RTAs) are a public health problem. According to the global report on road safety 2018, RTAs cause 20-50 million injuries worldwide, being the 8th major cause of death for all ages.[1] RTAs were categorized as one of the three leading causes of death for the age group 15–44 years and the main cause of death for people aged 15-29 years, globally.[2,3]

One person dies every 24 seconds as a result of RTA.[3] Although having 40% of the world's vehicles, 7% of the deaths in the developed countries are attributed to RTAs as compared to 13% in low income countries.[3]

Rapid expansion of road construction, increase in cities' population, and increase in the number of vehicles might attribute to increasing RTAs in the low-and middle-income nations, by an average rate of 27.5 deaths per 100,000 population.[4]

Saudi Arabia is a large country of 2,149,690 km$^2$ area and a total population of 34 million. A demographic survey of the country in 2016 represented by the general authority for statistics (GSTAT) indicated an annual population growth of 2.54%.[5] Ansari et al reported that a significant percentage of hospital occupants are victims of RTAs, of which 80% of the injured face death.[6] Another study from Saudi Arabia reported that nearly 19 people die daily from RTAs and 4 are injured.[7] In 2018, GSTAT also reported that more than 352 thousand cars were crashed due to RTAs leaving nearly 30,000 injured and 6000 deaths. There has been strong motivation to reduce RTAs and related morbidities and mortalities among different sectors in the country such as the medical and the economic.[5]

Despite physical disability, psychological complications, and the impact of family member loss on the structure of families, RTAs are reaching an alarming level. They also contribute in delaying the economic growth of the country. Annual medical losses and property damages due to RTA related injuries were estimated to cost the country $7 billion.[8]

The negative impact of RTAs has been realized in the fourth strategic goal of the Saudi 2030 vision (reinforcement of traffic safety) reflecting the traffic safety in reducing RTAs mortalities, morbidities, car crashes and the spread of dangerous violation of road regulations.[9] Efforts were implemented throughout the years as the government supports this objective, by enforcing of seat belts, prohibiting the use of mobile phones while driving, introducing camera ticketing systems (Saher) to control speed of vehicles, recording road regulation violations, improving roads and making more stringent traffic violation penalties as documented in the traffic regulation list book (2007).[10]

The aim of this study is investigating the RTAs, RTA related injury and mortality data, to present the correlation among these variables of RTAs, and to forecast the size of these variables in the next 10 years.

This study intends to inform policymakers on setting priorities in building policies and strategies to achieve the 2030 strategic goals for 2030 Saudi vision in relation to road safety.

## METHODS

Descriptive data was extracted from the Saudi GSTAT from 1990 to 2018. Population, RTAs, related injury and mortality data of each region in Saudi Arabia was stratified to 6 groups each representing 5 years. Regions with the highest number of RTAs in the last 5 years (2014-2018) were selected for further analysis. Rates of RTAs were calculated per 100,000 population, injury rates were calculated per 10,000 RTA while mortality rates were calculated per 1000 RTA for each 5 years in the last 30 years, and the trend of these variables were plotted to observe the trend between population congestion and RTAs, injuries due to RTAs, and mortalities due to RTAs.

For each of the selected top three regions, the correlation between population and RTAs, RTAs and their related injuries, and mortalities due to RTAs was calculated to determine the linearity of the relationship. Pearson correlation coefficient was calculated and denoted by the letter "r". The formula for Pearson correlation coefficient r is given by:

$$r = \frac{n(\sum xy) - (\sum x)(\sum y)}{\sqrt{[n\sum x^2 - (\sum x)^2][n\sum y^2 - (\sum y)^2]}}$$

Where, $r$ = Pearson correlation coefficient, $x$ = values in the first set of data, $y$ = values in the second set of data, and $n$ = total number of values.

The result of a correlation is a number between -1 and 1, a value close to either extremes indicates a strong relationship while a value near to 0 means a weak or no relationship. In this study a significant level (p) was 0.01.

Finally, regression was used to predict the RTAs, related injuries and related mortalities in 2030. Yearly population growth in Saudi is 2.4% will aids in the prediction of the population growth. Linear regression was used as there is one variable and it is needed to predict another single variable. In each regression there is: y= dependent variable, X= independent variable, $B_0$= the intersection with the X axis, $B_1$= the slope of the line.

$$Y_n = B_0 + B_1 X_n$$

Analysis of variance (ANOVA) test was used to calculate the significance of the model -if the predictor variable is a good predictor of the outcome variable- and this was determined by $R^2$.

## RESULTS

### *The average number of accidents in Saudi in the last three decades*

Accidents have shown an increase from 1990-2018, within 5-year intervals, from 323,603 to 2,642,874, and only showed a decline in the last 4 years where they dropped to 2,343,277 (Table 1).

Eastern region, Makkah and Riyadh were the top three regions in the number of RTAs.

These three regions accounted for 66.33% of the population, 69% of the total RTAs, 56% of the injuries, and 51.39% of the mortalities due to RTAs in Saudi Arabia.

The rate of RTAs per 100,000 population increased in the period from 2010-2014 in the three regions. Riyadh had the

highest rate of RTAs increase represented by11294 RTA/100,000 population, followed by Makkah, and then Eastern Region which had a rate of 5310 RTA. Generally, as shown in Figure 1, all regions have had a pattern of rise in the number of RTAs from 1990 till 2014 then dropped in the last 4 years.

Although Riyadh region accounted for the highest RTA rate per 100,000 population in the period 2010-2014, it showed the least rate of injuries per 10,000 RTAs compared to Makkah and Eastern Region. However in the period between 2015 and 2018 injuries raised in Riyadh from 157 (2010-2014) to 306 (2015-2018) injuries per 10,000 accident while this slightly changes in the other regions (Figure 2).

On the other hand, mortality rate per 1,000 RTA was the highest in all regions in the period from 1990-1994 then started to decrease in the following years except for the last 4 years where there was a general increase in the mortality rate. Mortality rate in Riyadh doubled in the years after 2014. Yet, Makkah accounted for the highest mortality rate due to RTAs where it had 16 deaths per 1,000 RTA (Figure 3).

Overall, injury rate per 10,000 RTA was the highest in the period 2010-2018. Surprisingly, this rate was the lowest in Riyadh since1990, until 2018. In the period 2010-2018, Riyadh had small drop in mortalities accounting for 1 death per 1,000 of RTA. The opposite was found in Makkah which had the most increase in mortality rate (3 deaths per 1,000 RTA). Generally, mortalities in Makkah represented the highest rate of accident related injuries since1990 (Figure 4).

***Correlation between the variables***

Correlation analysis was performed on the data from 1990 to 2018. Considering the whole country, there is a positive strong correlation between population size and the number of RTAs, r=0.84. This correlation is positive for all three regions as well. Thus, representing a linear relationship between these two variables.

There is sufficient evidence to conclude that there is a significant linear relationship between the RTAs and injuries in the country (r=0.81), Eastern region (r=0.59) and Makkah (r=0.62), except in Riyadh, where the relationship was a weak positive, insignificant relationship (r=0.02).

The pattern of correlation between RTAs and mortalities were the highest in the country compared to the correlation between population and RTAs and RTAs and related injuries (r=0.92). The correlation between RTAs and mortalities in Makkah, Eastern Region and Riyadh was 0.73, 0.69 and 0.26, respectively.

***Regression and forecasts***

The regression between the population (independent variable) and the RTAs (dependent variable) was performed and the adjusted $R^2$ was found to be 0.874.

$$R^2 \times 100 = 87.4\%$$

This means that 87.4% of variance observed in the RTAs is explained by changes in the population. RTAs, injuries and mortalities were predicted from 2020 (Table 2).

In 2030, injuries due to RTAs will reach an average of 806 injured cases annually, while mortality will reach an average of 156 deaths. Figures 5a-c show a linear regression between the variables.

The average annual increase in the rate of RTAs will be 3%. Mortality due to RTAs will reach 8415 cases by the end of 2030 that is explained by the average annual increase in mortality rate of 2.1%. The average annual increase rate of injuries due to RTAs will reach 2%.

**Table 1: Number of RTAs in Saudi Arabia in the last three decades and the rate of RTA in Riyadh, Makkah and Eastern Region from year 1990-2018.**

| Year | Total number of RTAs | Number of RTAs Riyadh | Number of RTAs Makkah | Number of RTAs eastern region |
|---|---|---|---|---|
| **1990-1994** | 323603 | 697 | 1706 | 1004 |
| **1995-1999** | 843221 | 2452 | 3967 | 2062 |
| **2000-2004** | 1339510 | 2861 | 4196 | 1835 |
| **2005-2009** | 1794139 | 4964 | 5128 | 2466 |
| **2010-2014** | 2642874 | 11294 | 6868 | 5310 |
| **2015-2018** | 2343277 | 8500 | 6498 | 3135 |

**Table 2: Predicted population, RTAs, RTA related injuries and mortalities for the years 2025 and 2030.**

| Year | Population | RTAs | Injuries | Mortalities |
|---|---|---|---|---|
| **2025** | 38526233 | 645676 | 43709 | 7591 |
| **2030** | 43376682 | 752386 | 47978 | 8415 |

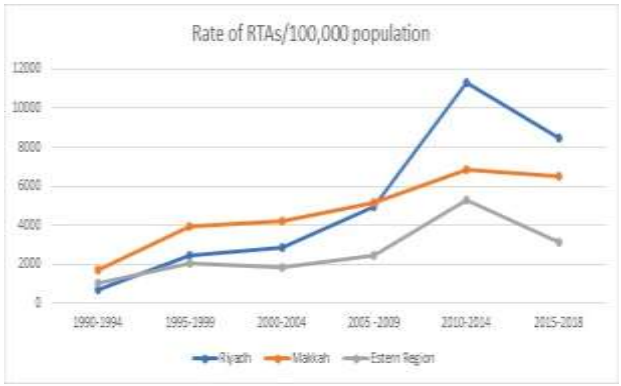


**Figure 1: Trend of change in the rate of RTAs in the top regions in number of accidents.**

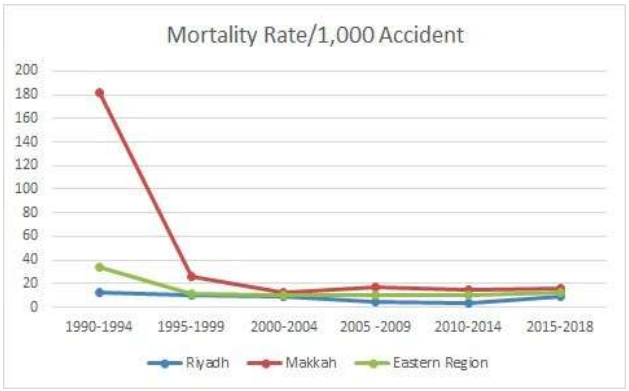


**Figure 3: Trend of change in the rate of mortality due to RTAs in the top regions in terms of number of accidents.**

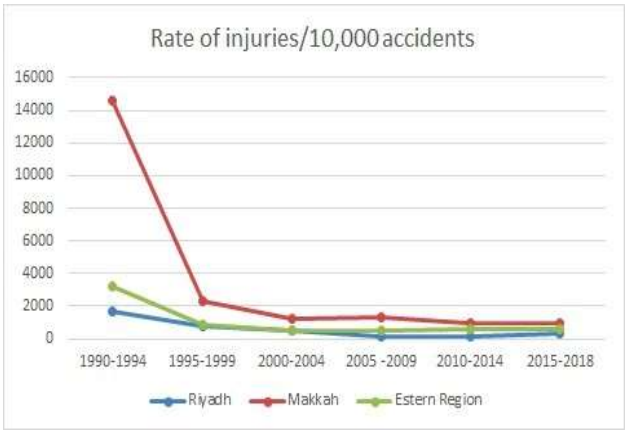


**Figure 2: Trend of change in the rate of RTA-related injuries in the top regions in number of accidents.**

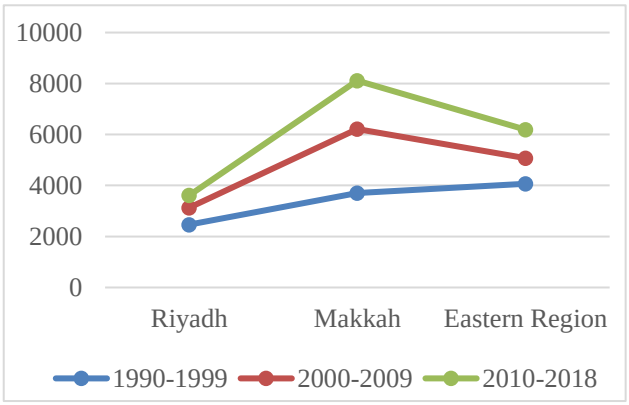


**Figure 4: Injury rate per 10,000 RTA showing the trend in 10 years interval**


**Figure 5: (a) the regression between RTAs and population, (b) the regression between RTAs and injuries, and (c) the regression between RTAs and mortalities.**

## DISCUSSION

This paper showed that Eastern, Makkah and Riyadh regions were the top three regions in the number of RTAs. It also detected a stronger correlation between RTAs and mortalities compared to injuries due to RTA. Furthermore, it showed that RTAs and its related injuries and mortalities will keep increasing in the next 10 years.

Comparing the three regions during the last 10 years, the Eastern region showed the highest rate of RTAs reduction, while minimal RTAs reduction was reported in Makkah. Since 2014, the decline of RTAs in all mentioned regions was expected due to the improvement in the accident recording policy during these years, implementation of more traffic regulations, Saher application and violation ticketing payments. However, high death rates per 100,000 population was noted. This could reflect the increase in the

severity of the RTA and be attributed to the presence of areas in or around the cities where there is no speed monitoring as speed was previously recognized as the most common reported cause of RTAs.[11]

Saher system was introduced to the country in 2010. The current study shows a substantial decline in the rate of RTAs mostly in Riyadh and Eastern regions between 2010 and 2014. It has been shown that Saher had reduced road traffic injuries nevertheless, while Riyadh region had the least RTA related injuries and mortalities, this rate stared to increase between 2010 and 2018.[12]

On the other hand, Dubai, a city in a nearby country with similar culture, has shown admirable efforts which reflected on their RTA reports, where RTAs per 100,000 population were significantly lower than all the mentioned regions in Saudi Arabia. Dubai had only 1,053 RTAs between the years 2005-2009, and 677 accidents between the years 2010-2014.[13] The lowest rate of accidents in this time span among the regions in Saudi Arabia was in Makkah, accounting for almost 15,000 RTA. A camera ticketing system similar to Saher was applied in Dubai in 2008 and serious modifications in the penalty regulation was implemented including suspension of licenses.[14] Generally, recommendations for improving education awareness, road engineering, and medical care are made to reduce the severity of accidents and injuries rather than the number of RTAs per se.[14]

Injury and mortality rates in Riyadh have increased in the last ten years, although Makkah had the highest rates of RTAs related injuries and mortalities throughout the previous years. Furthermore, only a slight decrease in the rate of RTAs was detected after the application of Saher. This could be attributed to the constant transportation of employees and families between the nearby cities such as Altaif which has steep roads that are difficult to drive on.

Riyadh has always had the least fatalities due to RTAs. Among all three regions, Riyadh showed a weak positive relationship between RTAs and mortalities and RTAs and injuries. This is because of the variety of medical specialists, and presence of highly prepared medical centres in the region. Overall, all regions showed an increase in the mortality from 2010-2014 with the highest being in Riyadh. The relation between the size of population and RTAs represents a strong positive linear relationship indicating that these variables fluctuate together, so whenever there is an increase in the population, accidents will rise. Increase in population mostly reflects the increase in number of vehicles especially in Saudi Arabia where, as income increases the number of vehicles increase.[15] Rates in general, for all the included variables, are expected to increase by the year 2030.

To be able to control the increase in RTAs and their consequences, further research could look at factors related to RTAs and RTAs severity. This could be broadly categorized into several major categories such as: driver's related, vehicle related, and environment and road related. Qualitative methodology could also be utilized to understand drivers' behaviours and decision-making process on the roads. More analysis could be done to understand the phenomena, if data, such as time of the accidents (day or night) and place of accidents (in city or highway), was available.

Negative drivers' attitude should be controlled to reduce the possible rise of RTAs consequences predicted by 2030. More efforts should be directed toward reducing the number as well as the severity of accidents.

Decreasing the number of RTAs always lies within controlling external factors that influence drivers and their judgement while on the road, including studying driver's behaviours and psychology according to regions and applying appropriate measures accordingly.

## CONCLUSION

Decision makers in Saudi traffic and transportation department should continue monitoring accidents prevention strategies and their effect. Reasons behind high injury and mortality rates, despite the decrease in the rate of RTAs, should be investigated.

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