Impact of vision 2030 on traffic safety in Saudi Arabia

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ABSTRACT

Background and objectives: Road traffic accident (RTA) in the Kingdom of Saudi Arabia (KSA) is the first and major cause of death. The primary objective of this paper is to investigate the impact of Saudi Vision 2030 on road traffic safety. The Vision 2030 programs lead to the implementation of two crucial steps. The first step was to introduce value-added tax (VAT), and the second step was to increase fuel prices. The effect of these two steps on RTAs, injuries, and fatalities is determined and evaluated in this study.
Research methods: The data of RTAs, injuries, and fatalities in the last three decades before implementing VAT and before increasing fuel prices were collected and analyzed. A short-term effect of fuel prices was evaluated using the data of 3 months after each increase in fuel price. The results of RTA before the increase in fuel prices were compared with those of RTAs after the increase in fuel prices. Time series autoregressive and *t*-test were used to analyze the significant differences in the results.
Results and discussion: The results show that RTAs have increased continuously during the last 30 years until the increase in fuel prices. A short-term effect of Vision 2030 and economic transformation were evaluated using RTA data before and after the increase in fuel prices. The remarkable decline in the number of RTAs, injuries, and fatalities after fuel prices increased was recorded.
Conclusion: Despite all the core issues implementing to reduce RTAs, such as traffic law enforcement, RTAs in the KSA increase and become the first cause of death in the country. Vision 2030 leads to an increase in gasoline prices and the implementation of VAT. The increase in gasoline prices contributes to a short-term decrease in RTAs, injuries, and fatalities by 22.4%, 21.9%, and 14.1%, respectively, while intermediate-term decrease in RTAs and road traffic fatalities is by 72892 and 1842, respectively. The decrease in RTAs may be attributed to the reduction in unnecessary trips and slower and careful driving by people to decrease fuel consumption. Statistical analyses performed using time series and *t*-test confirmed the significant effect of fuel prices on reducing RTAs.

1. Introduction

The Kingdom of Saudi Arabia (KSA) is one of the largest Arab countries in West Asia with an area of 2,149,690 km^2 and a population of 32,552,336 million in 2017 [1]. The population in the KSA in the year 2000 was 20,846,884, and just before economic transformation, the population reached 31,742,308 in the year 2016 [1,2]. The population almost increased more than 0.8 million per year according to the General Authority for Statistics. The per capita income of the KSA during the past decade has increased significantly and exceeded 120,000 Saudi Arabia Riyal (SAR) per year in 2017 [2]. The KSA is a high-income nation and is part of the Group of Twenty (G20) of major economies. According to the average per capita income, the KSA ranked on the 18th position globally [3]. The per capita GDP of the KSA during the third quarter of 2017 at current prices was 19600 SAR [2]. During the 1980s, the number of vehicles in the KSA was approximately 2 million, whereas the population was approximately 10 million. During 2015–2016, the number of vehicles in the KSA reached 18 million, whereas the population exceeded 30 million. The increase in the total number of vehicles shows that the proportion of vehicles per capita has increased from 0.2 vehicles per capita to approximately 0.6 vehicles per capita. The development of paved and rural roads in the KSA in the last 5 years indicates that the number of paved roads in the year 1432H (2011) was 59,143 and increased to 64,632 in the year 1437H (2016) [4]. In other words, in the past three decades, unprecedented urbanization in the KSA has been a phenomenon of modernization

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that involves social, economic, and environmental transformations. With the modernization of societies, these movements are increasing and moving toward automatic transport routes. The larger the population of a country and the higher the income, the higher is the demand for transport [5]. Population growth maximizes aggregate transport demand [6]. Economic growth leads to an increase in the ownership and mobility of vehicles, thus increasing consumption of transport energy and capacity [7–9]. Despite the positive effects of these changes on economic development, they have many negative effects on individuals and communities, such as traffic congestion, accidents, noise, land use, energy use, and air pollution [5].

2. Vision 2030 in the KSA

All countries of the Gulf Cooperation Council (GCC) including the KSA are among those countries that were greatly affected by the decrease in petroleum prices. Revenue from oil contributed between 50% and 90% to the government revenues before 2014 [10]. Most economic systems and events in the KSA depend heavily on oil consumption, and the Saudi government is the main player in all economic activities [11]. The oil reserves in the KSA account for approximately 25% of the world's total oil reserves. The KSA is the world's leading oil exporter and plays a pivotal role in OPEC. The contribution of the oil sector in the Kingdom constitutes 45% of the annual budget revenues and GDP and 90% of the export revenues [12]. However, Saudi officials and economists acknowledged the need to diversify the economy away from dependence on oil revenues and government spending. Therefore, the Saudi Vision 2030 was presented by the godfather of the vision Prince Mohammed bin Salman in response to the urgent need to chart the way to the future of the KSA.

Saudi Vision 2030 represents a serious attempt to address a future in which oil plays a less role in the Kingdom's economy. As a result of the implementation of Saudi Vision 2030 projects, the KSA witnessed a significant development in all fields, especially economy. These changes coincided with changes in gasoline prices and the introduction of value-added tax (VAT). An essential factor in the economy is the increase in gasoline prices to reduce waste of energy and help optimize its use.

The KSA had implemented an economic reform before 2 years. Economic reform includes VAT and increase in gasoline price. With the increase in gasoline prices, road traffic accidents (RTAs), road traffic injuries (RTIs), and road traffic fatalities (RTFs) declined significantly. This paper presents and analyzes the impact of the gasoline prices on RTAs in the KSA.

3. Road traffic safety

Road traffic safety is a global challenge in several aspects including society, economy, and health. RTAs, RTIs, and resulting RTFs are significant problems worldwide [13]. Globally, The estimated number of fatalities resulting from RTAs and crashes each year is approximately 1.25 million, while the number injured could be as high as 20–50 million. RTAs are a leading cause of death globally and ranked the first as the primary cause of death among individuals aged 15 to less than 30 years. Almost 60% of RTFs occur among people aged 15–44 years [14]. According to the World Health Organization (WHO), RTFs occurring due to RTAs in the KSA reach 27.4 for every 100,000 people in 2013. RTFs due to RTAs in other countries such as USA, Canada, UK, and UAE were 10.6, 6.0, 2.9, and 10.9 for every 100,000 people, respectively [15].

The WHO proposed the 2030 Agenda for Sustainable Development targeting to improve traffic safety and reduce RTAs, RTIs, and RTFs by 50% by 2020. Consequently, WHO suggested Save-LIVES

plan and provided five important issues to enhance traffic safety. The issues of this plan are controlling and managing speed, leadership on road safety, improving road and highway design, enhancing the safety standard of the vehicle, implementing the traffic laws strictly and improving actions after accidents [16]. Several countries including the KSA have adopted DARS and implemented some of the core components of the Save-LIVES plan. Despite the implementation plan in the KSA, the RTAs, RTIs, and RTFs continue to increase during the last decade.

4. Research methods

In this study, the impact of implementing the Saudi Vision 2030 programs on traffic safety was evaluated in three different ways. In the first section, the impact of fuel prices on traffic safety worldwide is reviewed from published papers in refereed journals. In the second section, the percentage of fuel prices is determined during each variation in the fuel prices in the KSA. In the third section, the effect of fuel prices and implementation of VAT on traffic safety is assessed in the short term (during the first 3 months after the increase in fuel prices) and the intermediate term (for 1 year of fuel price change). Time series autoregressive analyses were conducted. In addition, t-test and one-way ANOVA for RTA were performed before and after increase in fuel prices using SPSS packages.

4.1. Fuel prices and VAT

The KSA has witnessed a tangible growth in economy, education, industry, and several other fields supported by its large oil industry and large revenues. During 1979–2015, the GDP of the KSA increased from approximately 1.26 trillion in 2010 to 2.52 trillion in 2016 [11]. The vision of Saudi Vision 2030 is a serious attempt to address a future in which oil plays a less role in the Kingdom's economy. Energy reform can be another effective way to improve financial sustainability and resource efficiency in the Saudi economy. The Kingdom does not impose full market prices for energy as a traditional way to share the benefits of its natural resources, support social welfare, and enhance competitiveness.

To achieve the objectives of the Saudi Vision 2030, the KSA decided to increase fuel prices and to start implementing VAT. The KSA government announced the implementation of 5% VAT and an increase in electricity and gasoline prices at the beginning of 2016 [11]. Fuel prices increased twice during the past 2 years following the start of Saudi Vision 2030. First, at the end of 1437H (2016/217), an increase in fuel prices led to the increase in nominal prices for ordinary gasoline-91 and unleaded gasoline-95 from 0.45 to 0.60 SAR per liter to 0.75 and 0.90 SAR per liter, respectively. Second, at the beginning of 1439H (2017/18), an increase in fuel prices led to the increase in nominal prices for ordinary gasoline-91 and unleaded gasoline-95 from 0.75 to 0.90 SAR per liter to 0.75 and 2.04 SAR per liter, respectively. Table 1 shows variations in fuel prices and the percentage during the two times that fuel prices have increased. Although the Kingdom has increased fuel prices twice with the percentage reaching 126.7%, the price of fuels in the KSA is still lower than that in the international market. The Kingdom remains among the top five countries in the world with regard to fuel prices. Price increases have been designed to provide better efficiency in energy use and economy in the KSA. This also could decrease the vital growth in domestic fuel use and consumption [11,12].

This correction in the gasoline prices in the KSA is due to the enormous waste in energy resources, which holds the Kingdom in support of the energy field up to 300 billion annually where the Kingdom also consumes 35% of its oil production, and this is a very high rate [17]. This corrective action is instrumental in controlling

Table 1
Fuel price variation in KSA.

Fuel Type	Price in the Year 1437H (2015−2016)	Price in the Year 1438H (2016−2017)	Percentage Change	Price in the Year 1439H (2017−2018)	Percentage Change
Ordinary Gasoline-91	0.45 SAR	0.75 SAR	66.7%	1.37 SAR	82.7%
Unleaded Gasoline-95	0.60 SAR	0.90 SAR	50.0%	2.04 SAR	126.7%

the use of energy and reducing it. People's behavior with regard to fuel consumption will change because of the increase in gasoline price and the introduction of VAT. The change in people's behavior will affect traffic volume and distance traveled, and consequently, this will reduce RTAs and improve the environment.

4.2. Data of road traffic accidents

The data of RTAs, RTIs, and RTFs were collected for the last three decades before implementing VAT and before increase in fuel prices, and these data were analyzed. A short-term effect of fuel prices was evaluated by using the data of 3 months after each increase in fuel price and was compared with the same 3 months of the year before the increase in prices. An intermediate-term effect was assessed by collecting RTA data 2 years before increase in fuel prices and was compared with the results obtained with the RTA data 2 years after the increase in prices.

5. Results and discussion

Fuel prices and VAT are found to negatively affect RTAs. Higher fuel prices tend to decrease RTAs, RTIs, and RTFs. The decrease in RTAs leads to high traffic safety. The following sections present the impact of fuel prices and VAT on traffic safety globally, in general, and in the KSA, in particular.

5.1. Effect of fuel prices worldwide

There is a negative relationship between the economic conditions of the country and traffic safety. Several economic factors significantly affect traffic safety; these factors include income, unemployment, and gasoline prices. Gasoline price is the primary factor that affects traffic safety and has a tangible effect on the low-income and unemployed people [18]. Increase in fuel prices may affect the traffic safety in different ways such as mode of traffic, resuces the volume of traffic, reduces the trip frequency, reduces distance trips, reduces vehicle ownership, reduces frequent single trips, increases multipurpose trips, and reduces work-related trips. Increase in fuel prices may also decrease the amount of driving time and distance, thereby changing driver behavior to drive in a more safer way and in a high fuel-efficient way as well as to reduce other trips not related to work and change from personal trips into car-sharing and carpooling or increase the use of public transportation [19−23]. A review study stated that gasoline price and income of drivers are the significant factors that lead to a change in the driver's behavior to drive in a way that reduces gasoline consumption and traffic volume, which may further reduce RTAs and make roads safer [24]. A study was conducted in the USA to determine the impact of increasing gasoline prices on traffic safety. The study showed that higher gasoline prices reduced driving, especially among the risk-seeking younger drivers, which in turn leads to higher traffic safety [19]. The effects of increasing gasoline prices on reducing crashes among younger drivers occur immediately, but the effects on reducing crashes among older drivers occur across an intermediate term. Another study found a positive

association between higher gasoline prices and safer roads. Overall, gasoline prices affected crashes in short-, intermediate-, and long-term change [18]. A study conducted in Malaysia showed that the increase in gasoline price influenced the shift in preference from private to public transports, and this may reduce traffic congestion and traffic volume. Therefore, RTAs and air pollution are also reduced [25].

5.2. History of road safety in the KSA

Data of RTAs, RTIs, and RTFs were analyzed for the last 30 years in the KSA until the launch of the Saudi Vision 2030 programs, which include two significant steps, namely, start of the VAT by 5% and an increase in fuel prices. Fig. 1 shows the total number of RTAs in the last three decades before Saudi Vision 2030. The results in Fig. 1 present data of RTAs in 1986, 1996, 2006, and 2016, before increasing the fuel price and economic transformation. The results indicate that RTAs increase continuously. The RTAs increase during 2016 by approximately 100% compared to RTAs in 2006. The increase in RTAs may be attributed to the high income in the KSA, a large number of vehicles, a massive number of roads developed in the last 10 years, and the low price of fuel. Fig. 2 presents the number of RTAs, RTIs, and RTFs in 1986, 1996, 2006, and 2016, before increasing the price of fuel and economic transformation. The results indicate that during the last decades, RTAs were increased by 60%, whereas RTFs due to RTAs increased by 235%.

Results of the analysis of RTAs according to the age of the drivers involved in these accidents and the cause of road accidents in 2016 just before implementing Saudi Vision 2030 are given in Figs. 3 and 4, respectively. The majority of RTAs involved young drivers, of whom 49% were less than 30 years old. These results are in line with those reported by WHO in 2017, with RTFs accounting for approximately 60% of drivers aged between 15 and 44 years [14]. Most drivers of this age are unemployed people, students, or those newly joined to the labor market and earn a low income; this makes them more affected by the increase in fuel prices as evidenced by other studies [18].

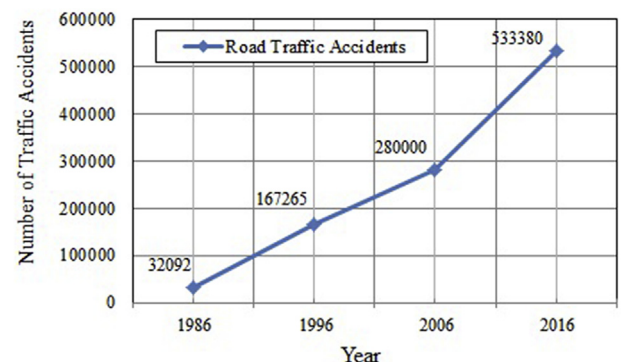The causes for RTAs in 2016 presented in Fig. 4 indicate that the

Fig. 1. The number of road traffic accidents during the last three decades.
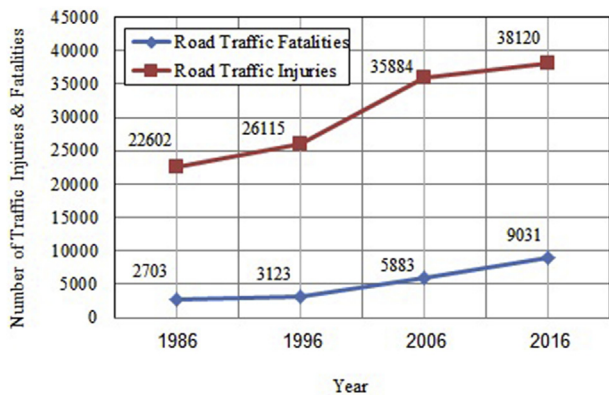
Fig. 2. The number of road traffic injuries and fatalities during the last three decades.
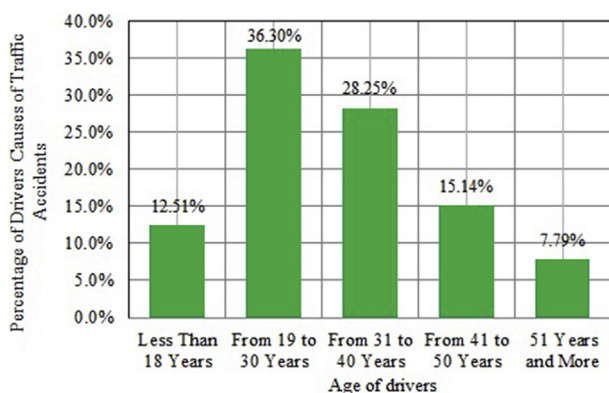

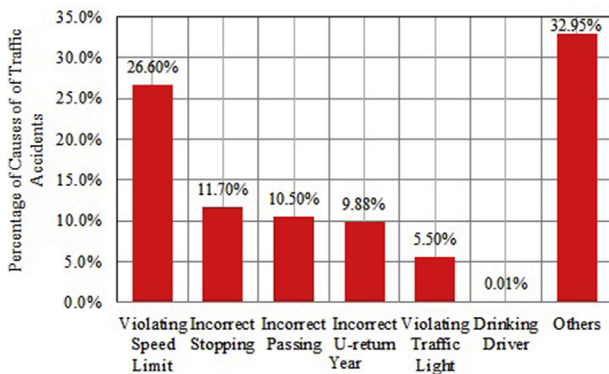**Fig. 3.** Distribution of drivers involved in road traffic accidents according to age.

Fig. 4. Distribution of road traffic accidents according to accident cause.

five major causes are violation of speed limit, incorrect halting, incorrect overtaking, incorrect U-turn, and violation of traffic signals. However, 70% of the total RTAs involve the use of a cellular phone, which is in addition to the causes of accident listed in Fig. 4. Exceeding the upper speed limit is the most common cause of RTAs after mobile use. Many previous studies conducted in the KSA have also attributed RTAs to these five causes [26–29].

5.3. Effect of fuel prices in the KSA

Despite all measures taken to reduce RTAs in the KSA, including informant of traffic laws, RTA continues to increase remarkably. The results of the analysis of RTA data obtained in the last 30 years in the KSA indicate that RTAs, RTIs, and RTFs continued to increase annually and reached its maximum numbers during 2015–2016 just before implementing Saudi Vision 2030 programs, which lead to an increase in fuel prices. The total number of RTAs, RTIs, and RTFs was 533,380, 38,120, and 9031, respectively.

5.3.1. Time series autoregressive analysis

Time series autoregressive analyses were performed for RTA from 1986 until 2018 before and after the increase in fuel prices and the implementation of VAT. The results of RTA, autoregressive model forecasting, upper and lower limits of the model are presented in Fig. 5. The autoregressive model showed a significance R-squared equal to 0.995. The results showed that there was a significant change after implementing VAT and increasing fuel prices. This indicates the importance of performing the interrupted time series analysis with one sample, but it was divided into two samples: before and after increase in fuel prices. This analysis could provide different models before and after increase in fuel prices and provide a clear picture about the effect of fuel price on RTA similar to the one studied herein [30,31].

5.3.2. Short- and intermediate-term effect

The effect of increasing the price of fuel on RTAs in the short term was studied using RTA data for 3 months after each increase in fuel prices, and the results were compared with those of RTA data for the same 3 months before the increase in fuel prices. The results of the number of RTAs before and after each increase in fuel price are shown in Fig. 5, and the number of casualties and deaths due to RTAs before and after the increase in fuel prices is shown in Fig. 6.

It is clear from the short-term results that RTAs, RTIs, and RTFs decline significantly after each increase in fuel prices. The number of accidents decreased from 138,724 to 127,988, a decrease of 10,736 accidents in 3 months resulting from the increase in fuel prices for the first time, thus constituting a decrease of 7.74%. There was also a decrease in the number of accidents from 138,724 to 107,637, a decrease of 31,087 accidents in 3 months due to the increase in fuel prices for the second time. The number of accidents decreased by 22.4%. These high and unprecedented rates of decline in the number of accidents have not been observed in the Kingdom for 30 years despite the efforts attempted in many ways in many parts of the Kingdom to reduce RTAs, especially amendments and the implementation of strict traffic regulations by the traffic department.

Similarly, the number of injuries and fatalities decreased from 9953 to 8299 injuries and from 1920 to 1591 fatalities. This forms a decrease of 1654 injuries and 329 fatalities in 3 months resulting from the increase in fuel prices for the first time, thus constituting a decrease of 16.6% and 17.1% for injuries and fatalities, respectively. There was also a decrease in the number of accidents from 9953 to 7776 injuries and from 1920 to 1649 fatalities, a decrease of 2177 injuries and 271 fatalities in 3 months resulting from the increase in fuel prices for the second time. The number of injuries and fatalities decreased by 21.9% and 14.1%, respectively. These high and unprecedented rates of decline in the number of injuries and fatalities have not been recorded before in the KSA. The results show a decrease of approximately 24 injuries every day, and hence, the lives of 3.7 Saudi people are saved every day. The increase in the fuel price leads to a range of changes including a decrease in gasoline demand and the distances traveled by passenger cars. These changes, in turn, result in many benefits including additional welfare by reducing air pollution, greenhouse gas emissions, congestion, and RTAs.

The intermediate-term effect of the increase in fuel prices on traffic safety was determined by collecting and analyzing RTA data
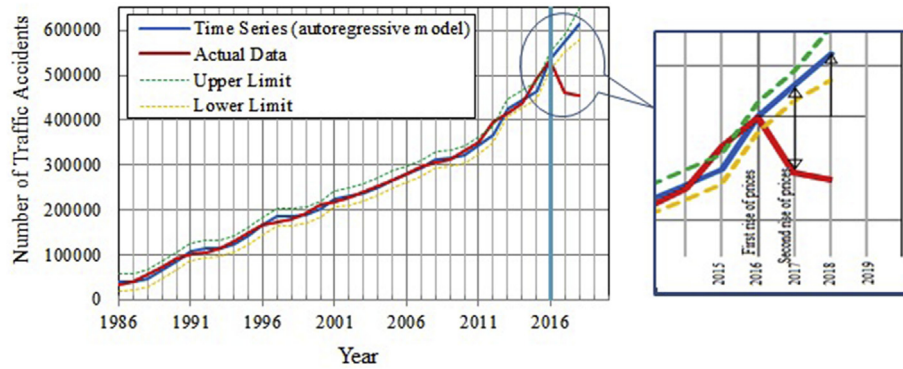
Fig. 5. Time series autoregressive analysis of RTA before and after fuel price increases.
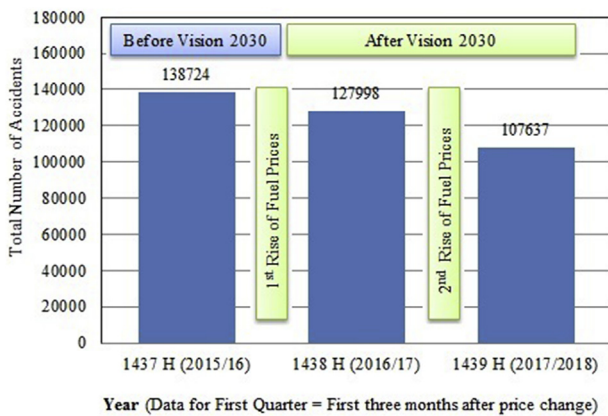

Fig. 6. The number of road traffic accidents in the same first 3 months before and after each increase in fuel price.
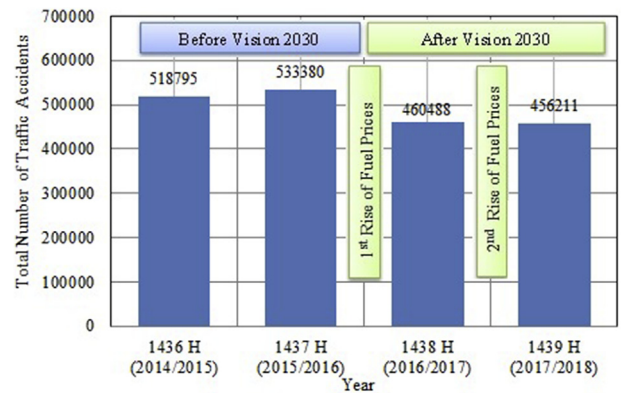

Fig. 8. Yearly data of road traffic accidents before and after fuel prices increase.

for a whole year before and after each increase in fuel prices. Because the data were still not available for the year after the second increase in fuel prices, the effect was analyzed only for the first increase in fuel price. Details for yearly RTAs before and after the increase in fuel price are given in Fig. 7 and those for RTIs and RTFs are given in Fig. 8.

It is clear from the intermediate-term results that RTAs, RTIs, and RTFs decline significantly after each increase in fuel prices (see Fig. 9). The yearly number of accidents decreased from 533,380 to 460,488, a decrease of 72,892 accidents in 1 year resulting from the increase in fuel prices for the first time. This decrease in RTAs constitutes a decline by 13.67%. Similarly, the number of injuries and fatalities decreased from 38,120 to 33,199 injuries and from 9031 to 7489 fatalities, a decrease of 4921 injuries and 1542 fatalities in 1 year resulting from the increase in fuel prices for the first time, thus constituting a decrease of 12.91% and 17.1% for injuries and fatalities, respectively. The results show that the decline in RTAs, RTIs, and RTFs continues for a long term owing to the lag of time the people need to rearrange their trips, reduce unnecessary trips, and shift to live near their workplace. The finding is in agreement with the results presented in a study conducted in the USA [18,19]. Further studies may be needed to evaluate the long-
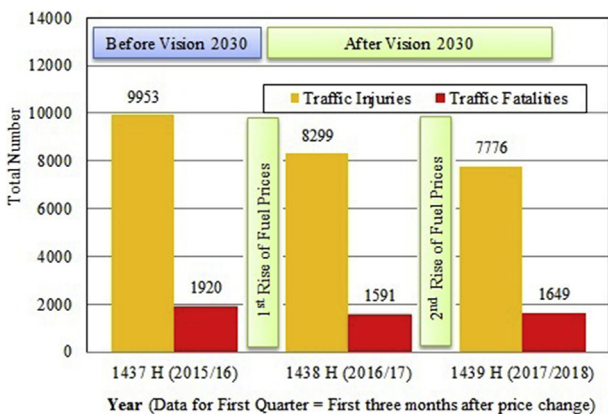

Fig. 7. The number of road traffic accidents, injuries, and fatalities in the same first 3 months before and after each increase in fuel price.
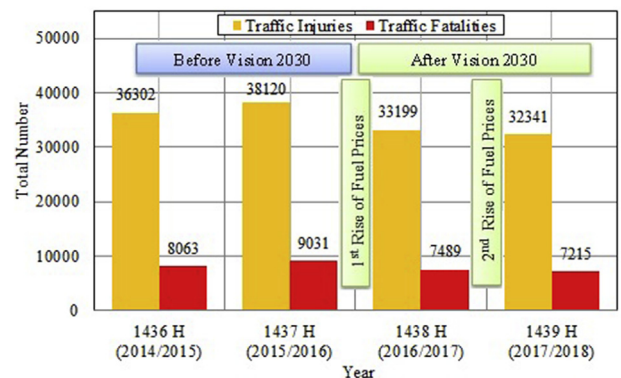

Fig. 9. Yearly data of road traffic accidents, injuries, and fatalities before and after fuel prices increase.

Table 2
Analysis of *t*-test using SPSS package for RTA before and after fuel increase.

Group statistics				
Road traffic accident (RTA)	N	Mean	Std. Deviation	Std error Mean
Before fuel increase	3	5.0199E4	76770.03	44323.20
After fuel increase	3	4.5963E4	71123.80	41063.35

Significant Test − independent samples					
Road traffic accident (RTA)	Levene's test for Equality of Variances		*t*-test equality of means		
	F value	Sig.	t-value	df	Sig.
Equal variances assumed	0.045	0.842	0.070	4	0.946
Equal variances not assumed			0.070	3.977	0.947

term effect after few years of increase in fuel price. RTAs can also be decreased by several other factors such as increased population awareness through TV traffic programs and traffic radio, strict implementation of traffic roles, SAHER, and other monitoring systems. All these factors were considered and implemented several years before increase in fuel price but do not contribute significantly to reduce RTA. The SAHER system and increase in penalty for violating traffic law were implemented for more than 5 years before the increase in fuel prices. An analysis of the contribution of each of these factors in reducing RTA will draw a clear picture for policy makers. If detailed data are available, in the future, further analysis by including all these factors can be conducted, and this may help to reduce RTAs in the KSA.

5.3.3. One-way ANOVA and t-test

To better visualize the significant difference in RTAs before and after increase in fuel prices and implementation of VAT, *t*-test and one-way ANOVA were performed. The results of the *t*-test are given in Table 2. The results show that there is a significant difference and decrease in RTA, RTI, and RTF after increase in fuel prices. The t-value was 0.07, and the significance was 0.947. Similar results were obtained using one-way ANOVA; the F-value was 0.005, and the significance was 0.947.

6. Conclusions

The results obtained from this study show that RTAs, RTIs, and RTFs remarkably increased during the last 30 years before implementing Saudi Vision 2030 programs, which lead to an increase in fuel prices and the implementation of VAT by 5%. Despite all the core issues implementing to reduce RTAs, such as traffic law enforcement, RTAs in the KSA have increased and become the first cause of death in the country. Increased gasoline prices contribute to a short-term decrease in RTAs, RTIs, and RTFs by 22.4%, 21.9%, and 14.1%, respectively, while intermediate-term effects indicate that RTAs decrease to 72,892 and RTFs decrease to 1842. Traffic safety improved because the people tend to reduce any unnecessary trips, drive in a manner to decrease fuel consumption, and convert to use public transport more than owning vehicles. These changes result in reducing traffic volume and traffic congestion and lead to reduce air pollution and RTAs. The result of time series autoregressive analysis and *t*-test analysis confirmed the significant decline in RTAs after implementing the Saudi Vision 2030 in the KSA. Further study is ongoing to determine the long-term impact of gasoline prices and economic reform on road traffic safety in the KSA. Recommendation to analyze other factors that may affect the RTA in the KSA, such as increased population awareness, strict implementation of traffic rules, SAHER, and other monitoring systems, improved overall traffic conditions in the streets, overall individual income, and controlling the nonlegal immigrants as well as

increased governmental activities to capture those immigrants and returning them back, which may have contributed significantly to decrease the road loads and hence decrease the RTA. This analysis may help in determining the effect of these factors and separated from the increase in fuel prices if these data could be available in the near future.

Declarations of interest

None.

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