original article

Outcomes of road traffic injuries before and after the implementation of a camera ticketing system: a retrospective study from a large trauma center in Saudi Arabia

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BACKGROUND: Road traffic injuries (RTIs) are the third leading cause of death in Saudi Arabia. Because speed is a major risk factor for severe crash-related injuries, a camera ticketing system was implemented countrywide in mid-2010 by the traffic police in an effort to improve traffic safety. There are no published studies on the effects of the system in Saudi Arabia.

OBJECTIVE: To examine injury severity and associated mortality at a large trauma center before and after the implementation of the ticketing system.

DESIGN: Retrospective, analytical.

SETTING: Trauma center of a tertiary care center in Riyadh.

PATIENTS AND METHODS: The study included all trauma registry patients seen in the emergency department for a crash-related injury (automobile occupants, pedestrians, or motorcyclists) between January 2005 and December 2014. Associations with outcome measures were assessed by univariate and multivariate methods.

MAIN OUTCOME MEASURE(S): Injury severity score (ISS), Glasgow coma scale (GCS) and mortality.

RESULTS: The study included all trauma registry patients seen in the emergency department for a crash-related injury. All health outcomes improved in the period following implementation of the ticketing system. Following implementation, ISS scores decreased (-3.1, 95% CI -4.6, -1.6) and GCS increased (0.47, 95% CI 0.08, 0.87) after adjusting for other covariates. The odds of death were 46% lower following implementation than before implementation. When the data were log-transformed to account for skewed data distributions, the results remained statistically significant.

CONCLUSIONS: This study suggests positive health implications following the implementation of the camera ticketing system. Further investment in public health interventions is warranted to reduce preventable RTIs.

LIMITATIONS: The study findings represent a trauma center at a single hospital in Riyadh, which may not generalize to the Saudi population.

Road traffic injuries (RTIs) are the third leading cause of death in Saudi Arabia, representing 11.7% of total mortality.[1] RTIs are also the leading cause of years of potential life lost (YPLL), according to the global burden of disease study.[2] YPLL is a popular public health measure that puts more weight on deaths occurring at younger ages, where individuals are expected to live long and healthy lives. Furthermore, RTIs are estimated to cost the country a staggering $7 billion in annual medical and property losses.[3] This figure is equivalent to about 16.2% of the country's total budget for health services in 2015.[4] Clearly, RTIs have a substantial negative effect on population health in Saudi Arabia and drain the country's resources.[5]

Developed countries like the US have made tremendous progress in reducing traffic fatality and morbidity in recent decades.[6] In fact, traffic deaths were 25% lower in 2013 than they were in 1975.[7] This decline provided undisputable evidence that injuries, motor vehicle in particular, are not "accidents" and that they are predictable, preventable, and treatable.[8] The decline in the United States was made possible for several reasons. Of significant importance was the successful dissemination and execution of prevention strategies aimed to decrease the frequency, severity and mortality due to RTIs.[9] Therefore, the role prevention plays in reducing public health problems deserves important attention and acknowledgment.

Driver behavioral factors, such as speeding, are associated with a major proportion of traffic crashes.[10] Speed has been found to be one of the major risk factors for high injury severity and mortality.[11] In Saudi Arabia, it is estimated that over 45% of crashes involve speeding.[12] Preventative interventions intended to modify drivers' behavior to reduce the incidence of RTIs, include strict traffic regulations, incentives, and educational programs.[13,14] Camera ticketing systems are one of the forms of strict regulations and focus mostly on deterring drivers from speeding and neglecting traffic signals.

Because RTIs are mostly attributed to speeding in Saudi Arabia, camera systems became an attractive approach to traffic police to curb the burden of RTIs and associated fatalities.[12] As a result, the automated traffic control and management system known as Saher was introduced nationwide in May of 2010.[15] Nevertheless, little is known about whether the introduction of this new system has had an impact on RTIs or fatalities. Anecdotal reports in newspapers about Saher's effects varied substantially from large reductions[16,17] in fatality and the frequency of crashes to increases in RTIs and deaths.[15,18] Therefore, examining the effects of this system on health outcomes using scientific methods should provide an important tool to evaluate the effectiveness of such interventions and would inform policymakers, researchers, and the public. As such, this study aims to evaluate the impact of implementing Saher on reducing the severities and fatalities associated with traffic crashes managed in a major trauma center in Riyadh, Saudi Arabia.

PATIENTS AND METHODS

The dataset used in this study was part of a trauma registry collected at King Abdulaziz Medical City (KAMC). This hospital is one of the largest hospitals in Riyadh with a capacity of over 700 beds and an additional 132 beds in the emergency department (ED). KAMC is one of the most advanced trauma centers in the country. It serves primarily the eastern part of Riyadh's metropolitan area. In fact, the capacity and standards of KAMC make it equivalent to a level I trauma center in the United States.[19]

The trauma registry was established in 2001 to help monitor, facilitate, and plan injury prevention programs.[20] To be included in the registry, patients have to meet at least one the following criteria: (1) presenting to the ED after an acute injury requiring admission to the hospital ward or at least one day in the intensive care unit (ICU); (2) transfer to surgery from the ED; (3) indirect admission (patient discharged from ED and asked to return later); or (4) declared dead after initial evaluation in the ED or prior to arrival. The KAMC registry includes patient demographic, anatomic, physiologic, and outcome variables.[21] The checklist used for data collection is completed by a nurse. A trained research coordinator then enters the information into the registry using Microsoft Access software. There is no information on patient outcomes following discharge or details about their co-morbidities in the trauma registry.

To be included in the study, patients had to be seen in the ED due to a crash-related injury (automobile occupants, pedestrians, or motorcyclists) between January 2005 and December 2014. Patients that were treated in the ED and then discharged were excluded. To achieve the objective of the study, an indicator variable was created to compare the periods before and after the implementation of the Saher system in May of 2010. The period of 2005-2010 was the pre-implementation period while the period of 2011-2014 was the post-implementation period. We chose the post-implementation period to be six months after its May initiation to allow sufficient time for its potential effects to show.

Saher camera ticketing system

The ticketing system uses a network of digital cameras connected to the National Information Center (NIC), which is part of the Saudi Ministry of the Interior.[22] In this automated system, both a stationary and mobile camera were installed in several areas in Riyadh. Mobile units are sometimes hidden behind trees or electricity units on roads with speed limits over 40 miles per hour.

Once a driver commits a speeding violation, the camera automatically takes a photo of the car. The NIC then processes the plate information to identify the owner. A text message is sent to the vehicle's owner within 24 hours with the type, place and the cost of the violation. Failure to pay a traffic violation within a month results in further financial penalties.

Outcome measures

The two outcomes in this study were severity measures at admission and death (defined as any death that occurred before or after hospital admission including deaths upon arrival). Measures of severity included the injury severity score (ISS) and the Glasgow coma scale (GCS). ISS is a measure of anatomical severity of an injury and it is calculated from abbreviated injury scale (AIS) codes.[23] Only the highest AIS score in each area of the body is used to compute the ISS. The areas of the body considered in scoring this measure include the head and neck, face, chest, abdomen, extremities, and external structure. ISS scores range from 0-75, with higher scores indicating a more severe injury; this measure has been validated.[24,25] GCS is a measure of physiological severity of an injury based on the level of consciousness on an ordinal scale ranging from 3 (deep coma) to 15 (normal). It is obtained by adding three individual scores corresponding to motor response, verbal response, and eye opening.[26]

Statistical analysis

All statistical analyses were performed using STATA 14 software for Mac (STATA Corp., College Station, TX). Descriptive statistics of patients before and after the implementation of the camera ticketing system were summarized, including demographics and outcome variables. Mortality (percentage of patients with death discharge status) and severity scores (ISS, GCS) before and after system implementation were compared using the *t* test for continuous variables and the chi-square test for categorical variables. A *P* value of <.05 was used to indicate statistical significance.

In addition to bivariate analyses, a multivariate analysis was conducted using multiple regression techniques. First, a linear regression model was constructed using ISS as the dependent variable and time period variable (pre-post implementation) as the independent variable. Second, a linear regression model was constructed using GCS as the dependent variable and time period variable (pre-post implementation) as the independent variable. as the independent variables. Because of skewed data, we transformed the dependent variables (ISS and GCS using the natural logarithm). Finally, a logistic regression was constructed using death as the dependent variable and pre-post variables as the independent variable. The logistic regression results are presented as odds ratios (OR) with 95 percent confidence intervals. The Hosmer-Lemeshow goodness-of-fit statistic was used for calibration of the logistic regression model. The regression models were adjusted for the variables age, gender, injury mechanism, trauma team activation, and the number of vehicles per year in Riyadh. We also adjusted for the type of injury (motor vehicle occupant as the reference, pedestrian, or motorcyclist) because this may confound the association of interest. The type of accident qualifies as a potential confounder because some types of accident are associated with higher severity[27] and mortality and could be affected by the intervention (i.e., reducing occupant injuries after implementation of the system). Because new criteria for trauma team activation in the ED were implemented in 2010, we adjusted for whether the patient was attended by a trauma team, which may be associated with better outcomes. Finally, the number of vehicles per year was included in the model as this may be associated with reduction of speed due to factors such as traffic congestion. Unfortunately, only data for the years 2008-2012 were available from the traffic police;[28] thus, estimates for the remaining years were obtained using the forecast function in Microsoft Excel. Because the camera ticketing system is mostly installed on roads with relatively high speed limits, it may have little or no effect on pedestrian injuries. Thus, the same analyses were repeated excluding pedestrian injuries.

To examine the change in injury severity and associated fatalities throughout the study period, we plotted the coefficients from the regression models by the outcome measures (ISS, GCS and death). However, instead of only comparing before and after implementation, we treated years as a categorical variable (2005, 2006, etc.). The year 2010 was used as the reference category. Microsoft Excel for Mac was used to produce the plots. To explore if there was any significant change in severity and mortality across years 2005-2014, we performed a trend test.[29]

The KAMC trauma registry includes other types of injuries, such as falls, burns or violent injuries. Therefore, we hypothesized that any positive pattern of improved patient outcome associated with the camera ticketing system would not be observed for other types of injuries. Between 2005-2014, there were 5558 patients included in the registry due to injuries other than RTIs. As a sensitivity analysis, we constructed the same regression models described previously (without covariates), but using the sample of patients sustaining non-RTIs.

RESULTS

During the study period, 6196 patients met the inclusion criteria of KAMC's trauma registry and were included in all analyses. Patients who were seen in the period following the implementation of the Saher camera ticketing system were slightly older (mean age=27.6 vs. 26.5, *P*<.01) than those from the pre-implementation period (**Table 1**). While there were no differences in the proportion of males between the two periods, pedestrians were less represented in the post-implementation period (14.6% vs. 20.3% pre-implementation, *P*<.01). Head injuries declined significantly from 44.4% prior to implementation to 36.3% after implementation (*P*<.01). Mixed findings were observed when examining healthcare utilization. A higher proportion of patients were admitted to the intensive care unit (34.4% vs. 28.2%, *P*<.01) and a higher proportion of patients required activation of the trauma team (18.7% vs. 33.6%, *P*<.01) in the post-implementation period (years 2011-2014). However, hospital length of stay and the proportion of patients undergoing surgeries were not significantly different between the two periods. Injury severity measures and mortality improved significantly after implementation. While the mean ISS declined from 16.0 to 13.5 (*P*<.01), the mean GCS increased from 11.8 to 12.2 after implementation. Similarly, overall deaths and deaths upon arrival declined from 13.2% and 5.2% to 8.2% and 1.8%, respectively (both *P*<.01).

Regressions analyses confirmed the reductions in injury severity and the odds of mortality. Following implementation, the mean ISS score was reduced (-3.1, 95% CI -4.6, -1.6; *P*<.01) from the pre-implementation period adjusting for type of injury, trauma activation and the number of vehicles per year (**Table 2**). Regression models with ISS and GCS transformed using natural logarithms also showed significant association between implementation and improved outcomes. While the mean ISS score declined approximately 20% following implementation, GCS score increased 7% follow-

Table 1. Descriptive statistics of traffic-related injuries treated at King Abdulaziz Medical City by admission periods: pre-implementation (2004-2010) and post-implementation of the camera ticketing system (2011-2014).

Variable	Pre-implementation n=3541	Post-implementation n=2655	All patients N=6196	*P* value
Age (mean, SD)	26.5 (16.4)	27.6 (16.8)	26.9 (16.5)	<.001^
Male	3016 (85.2)	2265 (85.3)	5281 (85.2)	.93*
Mechanism of injury				<.001*
Occupant	2632 (74.4)	2028 (76.4)	4660 (75.2)	
Motorcycle	187 (5.3)	238 (9.0)	425 (6.8)	
Pedestrian	721 (20.3)	389 (14.6)	1110 (17.9)	
Transport to hospital				.27*
EMS	2329 (65.8)	1799 (67.7)	4128 (66.6)	
Private vehicle	1174 (33.1)	830 (31.2)	2004 (33.3)	
Other (missing or police)	37 (1.0)	26 (1.0)	63 (1.0)	
GCS (mean, SD)	11.8 (4.5)	12.2 (4.2)	12.0 (4.4)	<.001^
ISS (mean, SD)	16.0 (17.5)	13.5 (12.6)	14.9 (15.7)	<.001^
Length of stay (days), median	8	10	9	.09^
Hypotension	221 (6.2)	155 (5.8)	376 (6.0)	.51*
Head injury	1575 (44.4)	965 (36.3)	2540 (41.0)	<.001*
Surgery	891 (25.1)	666 (25.0)	1557 (25.1)	.94*
ICU admission	1010 (28.5)	913 (34.4)	1923 (31.0)	<.01*
Trauma team activation	665 (18.7)	894 (33.6)	1559 (25.1)	<.01*
Deaths upon arrival	184 (5.2)	50 (1.8)	234 (3.7)	<.01*
Overall deaths	467 (13.2)	218 (8.2)	685 (11.0)	<.01*

Values are number (percent) unless indicated otherwise. *Chi-square test; ^ *t* test

SD: Standard Deviation, ISS: Injury Severity Score (higher indicates worst injuries), GCS: Glasgow Coma Scale (lower indicates worst injuries) ing implementation and adjusting for other covariates (**Table 2**). The logistic regression model suggested that patients from the post-implementation period had 46% lower risk of death than those from the pre-implementation period adjusting for whether the patient was an occupant of a vehicle, a motorcycle or pedestrian (*P*<.01). The model showed no evidence of lack of fit (Hosmer-Lemeshow statistic 4.3, [*P*<.05]).

Other regression covariates were also associated with the outcomes examined in this study. Activating the trauma team was associated with an increase in ISS score of 9 and an over threefold increase in the odds of mortality (OR=3.7, 95% CI=3.1-4.4). Compared to car occupants, those who sustained RTIs in motorcycles had an ISS score that was a mean of 1.1 higher and had a 40% higher odds of death. A lower magnitude of effect was found between age and ISS score, where each increase in age of one year was associated with 0.05 increase in ISS score (*P*<.01). When the same analyses were repeated excluding pedestrian injuries, the findings remained unchanged.

Findings from the trend tests indicated significant changes in patient outcomes throughout the study period (all *P*<.01). This was also observed in the plots of ISS, GCS and odds of deaths (**Figures 1-3**). However, severity and associated mortality showed the opposite trend in 2014 than earlier years in the post-implementation period. Regression models that examined injury severity and associated mortality among those without RTIs suggest no significant difference between the period before and after implementation (**Table 3**).

DISCUSSION

We found significant reductions in injury severity and mortality among patients seen in KAMC following the implementation of the Saher camera ticketing system in Riyadh. RTIs account for over 80% of all trauma admission in the country.[5] Moreover, about half of the population of Saudi Arabia is under the age of 25.[30] Therefore, preventable deaths due to RTIs in particular remain a major threat to population health. Our findings may provide some reassurance to the public and policymakers that public health interventions may facilitate improvement of population health. In addition, the study findings can support further investments in traffic safety interventions to reduce the burden of traffic crashes on health and reduce healthcare utilization.

The positive effects of electronic enforcement systems found in our study are consistent with literature from developed countries.[31–33] A systematic review by Wilson et al found speed cameras to be associated with reductions of between 11% and 44% in traffic fatalities.[14] A similar finding was reported by Jones et al when they examined the impact of speed cameras in rural areas of England and found as much as 19% and 44% reduction in fatal and serious crashes, respectively.[34] Another study conducted in the US examined the effects of removing speed cameras on admissions to a

Table 2. Multiple regression analyses of differences in severity measures and mortality after implementation of the camera ticketing system (n=6196 patients).

Variables	Linear regression (ISS dependent variable)	Linear regression (ISS dependent variable, log transformed)	Linear regression (GCS dependent variable)	Linear regression (GCS dependent variable, log transformed)	Logistic regression(odds ratio for mortality)*
Time Period					
Pre-implementation	Reference	Reference	Reference	Reference	Reference
Post-implementation	-3.1 (-4.6, -1.6)	-0.20 (-0.27,-0.10)	0.47 (0.08, 0.87)	0.07 (0.01, 0.11)	0.54 (0.39, 0.75)
Type of accident					
Occupant	Reference	Reference	Reference	Reference	Reference
Motorcycle	1.1 (.15, 2.6)	0.02 (0.03,0.08)	-0.27 (-0.53,-0.00)	-0.02 (-0.53,-0.00)	1.4 (1.1,1.7)
Pedestrian	-5.0 (-6.6,-3.5)	-0.40 (-0.47, -0.30)	0.95 (0.55,1.35)	0.11 (0.55,1.35)	0.33 (0.16,0.54)
Age (years)	0.05 (0.02,0.07)	0.0 (0.0,0.0)	0.01 (0.00,0.01)	0.01 (0.00,0.01)	1.0 (1.0,1.0)
Gender (male reference)	1.0 (0.01,2.1)	0.10 (0.04,0.16)	-0.56 (-0.84,-0.28)	-0.5 (-0.8,-0.2)	1.1 (0.90,1.5)
Vehicles per year	0.0 (0.0,0.0)	0.0 (0.0,0.0)	0.0 (0.0,0.0)	0.0 (0.0,0.0)	0.99 (0.99,1.0)
Trauma activation	9.0 (8.1,9.9)	0.80 (0.7,0.8)	-4.5 (-4.7,-4.2)	-0.50 (-0.53,-0.47)	3.7 (3.1,4.4)
R-squared	0.08	0.16	0.19	0.16	0.08*

Values are variable coefficients and 95% confidence interval (linear regression) or odds ratios and 95% confidence intervals (logistic regression). Bold is significant. ISS: Injury severity score, GCS: Glasgow coma scale

*Hosmer-Lemeshow: 4.3, (*P*=.84); Pseudo R-squared: 0.08

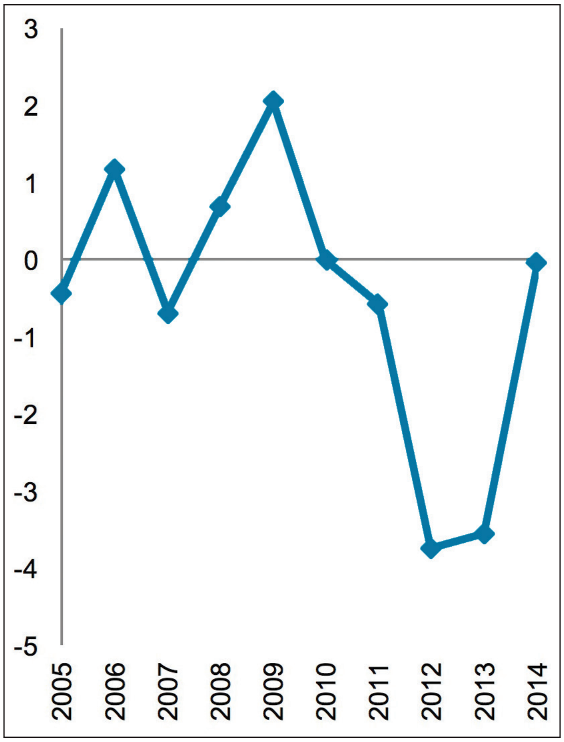

Figure 1. Injury severity scale scores relative to the year 2010.

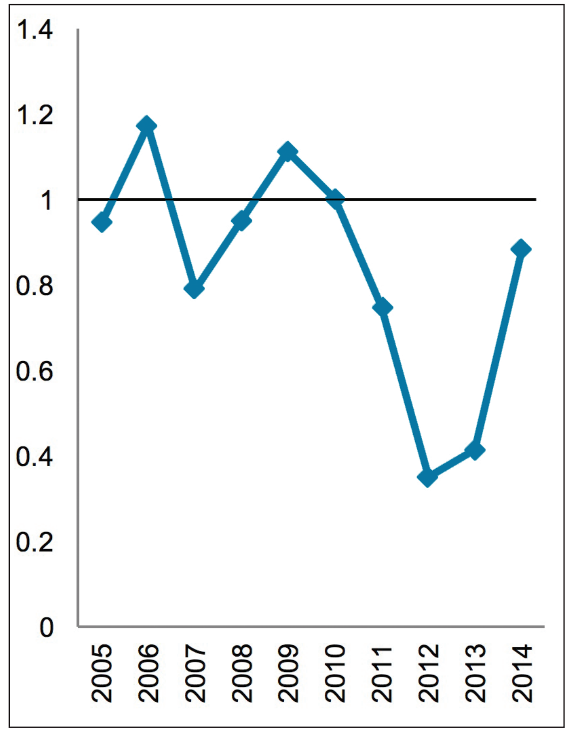

Figure 3. Odds ratio of death relative the to year 2010.

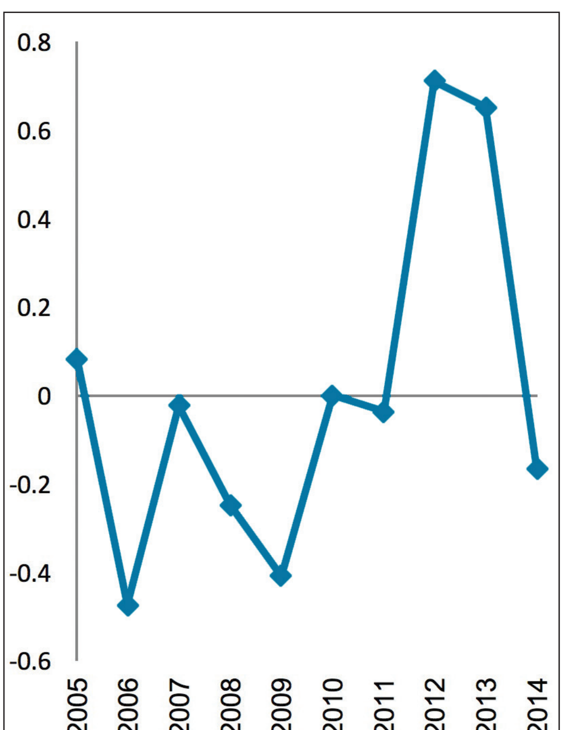

Figure 2. Glasgow coma scale scores relative to the year 2010.

level-one trauma center and found a twofold increase in crash-related trauma admissions.[33] Findings from our study support the positive impact associated with the camera system observed in other countries.

There are a number of potential explanations for the findings presented in this study. One explanation is that high-risk drivers, who are used to speeding, may have reduced their speed due to the fear of citations, leading to safer driving behavior or less severe crashes. Another potential factor is improvement in EMS services (i.e. shorter response time) during the study period, which may have improved patient outcomes. Founded in 1963, the Saudi Red Crescent provides free emergency transport using a fleet of over 1300 ambulances.[35] EMS personnel are trained in basic or advanced life support.[36] However, it is unlikely that our findings are due to improvement in EMS during throughout the study years because there were no major changes in the EMS system in Saudi Arabia.

Trauma care improvement at KAMC over the study period may have played a role in reducing mortality rather than the implementation of Saher. For example, the 2010 change in trauma team activation may have allowed early identification of severely injured patients leading to improved survival. However, it is unlikely that

Table 3. Regression analyses of differences in severity measures and mortality after implementation of the camera ticketing system among patients without road-traffic injuries (n=5778 patients).

Variables	Linear regression (ISS dependent variable)	Linear regression (GCS dependent variable)	Logistic regression (odds of mortality)
Pre-implementation	Reference	Reference	Reference
Post-implementation	-.08 (-0.65, 0.48)	0.00 (-0.12, 0.12)	0.80 (0.61, 1.0)

R-squared for ISS: 0.008, GCS: 0.007. Pseudo-R-squared for mortality model: 0.001

this may explain our findings because reduction in mortality was also observed among patients who died upon arrival. Furthermore, the fact that we did not find the same pattern of improved outcomes among patients injured in non-RTIs provides some assurance that our findings are less likely to be associated with improved hospital care. Finally, the increase in the number of vehicles driven in Riyadh may have played a role in reducing injury severity and mortality. This is because traffic congestion will inevitably lead to reduction in average speed even among high risk drivers. In Saudi Arabia, the number of registered vehicles have increased, substantially rising from 13 million in 2008 to 18 million in 2014.[28]

Few studies that have examined camera systems reported little or no effects[13,37] on traffic crashes or injuries. The possibility remains that the Saher system had no effect on crashes and the findings presented here are due to other factors. Examples of such factors might include improvements in non-speed camera enforcement or engineering. A global study of traffic law enforcement suggests that recent seatbelt and helmet-related safety programs in middle-income countries were associated with reduced fatalities.[38] To rule out this possibility further population-based samples including control populations are needed to provide clearer evidence.

The results of this study have implications for public health policy and practice. Traffic safety initiatives can use these findings to inform public health researchers, policymakers, and the public of the positive impact of traffic safety interventions. Furthermore, our findings may help facilitate investment in other neglected areas of traffic safety such as seatbelt use, which is one of cheapest and most effective interventions to reduce the burden of traffic crashes. While there are no population studies of seatbelts use in Saudi Arabia, a study in the eastern region found compliance to be as low as 43% and 26% for drivers and passengers, respectively.[39] Another study found compliance to be as little as 5%.[40] Unfortunately, it has not received much attention from traffic police, which may explain low compliance among drivers and passengers.

It is not clear why RTI outcomes became worse in the year 2014. One explanation is that risky drivers may have started to adopt new methods to avoid citations from the system. An example of this is using electronic devices that can identify nearby speed cameras. Another example of illegal methods to avoid citation is covering the plates to avoid recognition of vehicle information. Because the traffic police do not post the frequency of these violations, little is known about their prevalence in Riyadh.

The increased use of smartphones and engagement in social media, which have become increasingly popular in recent years, may also have played a role in increasing severity in the year 2014. According to the Saudi Communication and Information Technology Commission, broadband subscriptions (internet plans) for mobile phones increased from 11 million to 29 million (163% increase) between 2011 and 2014. Globally, there is an increased risk of RTIs due to distracted driving that is associated with the use mobile phones.[41] This finding was also consistent with a self-reported survey by Osuagwu et al among Saudi drivers that assessed the association between mobile use and traffic crashes.[42] Clearly, more studies are needed to generate more comprehensive evidence about mobile use and the trend of increasing RTIs in Saudi Arabia.

Automobiles are the main form of transportation in Saudi Arabia. Therefore, reducing dependence on motor vehicles as a means for transportation may also facilitate reducing the burden of RTIs. Investment in public transportation is an example of this and Riyadh is in the process of building its own metro system which is expected to be completed in 2019.[43] Further investigation by future studies are needed to assess the impact of the public transportation system in reducing RTIs in the country.

This study is not without limitations. First, it is retrospective and because patients in the two periods may have differed from each other, we can not rule out unmeasured confounding effects. For example, the study did not include detailed information on seatbelt use or human factors (i.e. driver errors); however, it is unlikely that these factors operated differently across the two periods examined in this analysis. Another concern is that we had no means to identify whether traffic crashes in this study had occurred in areas covered by speed cameras. Second, demographic details are limited (i.e. education, marital status, etc) and the data was collected from a single hospital, and therefore, the results may not generalize beyond the city of Riyadh. To provide more evidence of the impact of the camera ticketing system, further research would need to be conducted using population-based data sources to ensure generalizability of the findings. Third, the study examined the effects on short-term outcomes represented by mortality and injury severity; however, no measures of disability were captured. It is estimated that 7% of RTIs results in permanent disability.[5] Therefore, future studies should aim to examine the role of traffic safety interventions, such as the Saher camera ticketing system, on the prevalence of disabilities due to RTIs.

Nevertheless, our positive findings are independent of police reporting, which may be more inclined to overestimate the effects of safety interventions. A study by Barrimah et al that examined traffic deaths in northern Saudi Arabia compared police data and healthcare data and found major discrepancies.[3] The authors found traffic deaths based on death registration data to be almost twice as high as police estimates and suggested that police reporting data are less reliable.

In summary, this study found positive health implications following the implementation of the Saher camera ticketing system, which was installed to improve traffic safety in Riyadh. These findings may be used to inform the public, policymakers and researchers of the positive externalities associated with the Saher system. Further investment in public health interventions is warranted to reduce preventable RTIs and improve population health.

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Ethical Approval

This study has been reviewed and approved by Institutional Review Boards at King Abdullah International Medical Research Center (KAIMRC).

Conflict of interest

The authors have no conflict of interest to report.

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