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A framework for accident reduction and risk identification and assessment in Saudi Arabia

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Abstract

Purpose – The purpose of this paper is to propose a framework methodology for the assessment and improving accident data collection and analysis in the Kingdom of Saudi Arabia (KSA).
Design/methodology/approach – A proposed framework methodology for accident reduction by an integrated process which includes a risk identification, assessment and reduction process is proposed for Tabuk city in KSA.
Findings – Tabuk city has a high accident rate. The proposed framework can improve the process of accident data collection and analysis and identify hot spot locations and accident severity.
Originality/value – It has been estimated that the annual cost of traffic accidents in Saudi Arabia exceeds six billion US dollars, in addition to other social, health and economic impacts, such as disability, rehabilitation and unemployment due to traffic accident injuries. There are not many studies, if any, in Tabuk in KSA on the investigation and development of a framework for accident reduction.

Keywords Sustainability, Sustainable development, Sustainable environment, Accident, Chronic problems, Tabuk City Saudi Arabia
Paper type Conceptual paper

Introduction

It has been claimed that more than 300,000 traffic accidents occur every year in the Kingdom of Saudi Arabia (KSA). Traffic accidents account for more than 30 per cent of bed occupancy in hospitals, and the Kingdom bears losses of more than SR13 billion as a result of traffic accidents (Arab News, 2013). The World Health Organization found Saudi Arabia to have the world's highest number of deaths from road accidents, which now make up the country's principal cause of death in adult males aged 16-36. First reported by the Saudi daily Arab News, the study found that 6,485 people had died and more than 36,000 were injured in over 485,000 traffic accidents during 2008 and 2009 (Greenprophet, 2010). In 2010, Saudi Arabia recorded four million traffic accidents, leading to 86,000 deaths and 611,000 injuries, 7 per cent of which resulted in permanent disabilities, which is almost a third of traffic accidents in the Saudi capital Riyadh. The main reasons included drivers jumping red lights, and 18 per cent of accidents were caused by illegal U-turns. The most common dangerous driving activities were speeding, sudden stops and speaking on the phone while driving. The driving problems are mostly seen in young people, because driving provides an outlet for them to enjoy themselves. In addition, there is no proper driver training or education in schools regarding driving and respecting the road. Drug use is also a contributing factor. These are the central problems.

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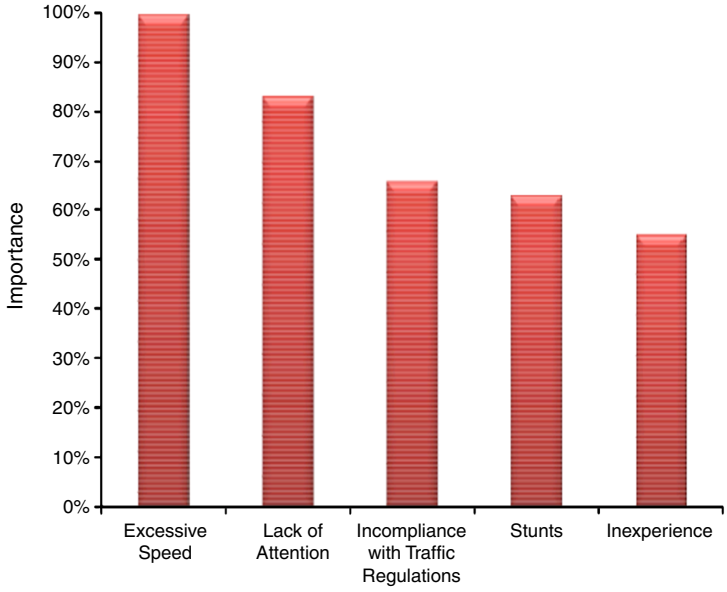
Ansari *et al.* (2000) reported 200 recorded deaths from vehicular accidents, increasing from 570 in 1971 to 4,077 in 1994: a seven-fold increase. Excess speed and violation of traffic signals are major causes of traffic accidents. Gharaibeh and Abdo (2011) conducted user experience research on students at King Faisal University and selected high schools in Al-Ahsa, Saudi Arabia, to rate the causes of accidents. Results showed that excessive speed (100 per cent), lack of attention (85 per cent), incompliance with traffic regulations (65 per cent), stunts (60 per cent), and inexperience (55 per cent) were all important, as shown in Figure 1.

Al-Atawi (2013) analysed the effect of intersection characteristics, such as geometric design, control system and location, on the number of violations in Tabuk city. Data consisted of traffic characteristics and violations, intersection geometric design (road width, number of lanes, speed), and was collected at 38 intersections in Tabuk using video cameras. He found that that the number of approaches, speed, road width, speed on crossroads and width of crossroads significantly affects red light violation. The regression model developed shows that road width, red time and speed are the most important factors affecting red light violation. Another study in the Al-Ahsa region by Gharaibeh and Abdo (2011) found that that youths in the region had knowledge of the wrong driving practices, but lacked knowledge of traffic regulations and signs. Therefore, they recommended that training in traffic regulations and safety awareness should begin at an early stage and age, through TV programmes and school activities. In addition, knowledge of traffic signs should be emphasised with the increase of the enforcement of traffic regulations.

In recent years, Saudi Arabia has developed a taste for expensive cars, and sightings of young Saudis cruising the streets of Jeddah and Riyadh in Maseratis, Ferraris, Porsches and Harley Davidson motorbikes are increasingly commonplace. Saudi Arabia is therefore one of the Middle East's largest car markets. Automobile sales make up



Source: Gharaibeh and Abdo (2011)

Figure 1.
Cause of accidents in Saudi Arabia over the decades

about three per cent of Saudi Arabia's gross domestic product. Although the global recession has seriously weakened the Arab world's largest economy, Saudi car sales are now expected to boom. The Kingdom's car market, including both commercial automobiles and transport infrastructure, is currently worth about $9 billion. The market is expected to grow by 30 per cent in 2010. Now automobile growth is targeting 24 per cent growth over the 2014-2017 period, up from 17 per cent previously. However, the increase in vehicle growth does not impact the reduction in safety and traffic violations. The average level of red-light running in Tabuk is about ten times higher than in the USA or Australia. Characteristics of the drivers who commit such violations because of social factors may be expected to have a role in the causation of this problem in Saudi cities. These levels are unacceptable and therefore indicate that traffic signals are an ineffective way of controlling traffic in the city. The safety of pedestrians and vehicles are compromised and it is found that that the average level of red-light running correlates positively with road width, distance to city centre and total traffic volume on each leg, while it correlates negatively with width of crossed road, length of red interval and speed (Al-Atawi, 2013).

According to the International Road Federation (IRF) (2012), over 95 per cent of road traffic accidents involve some degree of driver behaviour/fault combined with one of the other three factors. Existing accident data record by traffic police in Tabuk city do not reflect the actual cause of road accidents, and are thus less useful for scientific analysis. Some of the common reasons identified by the International Road Federation are the same for the KSA and Tabuk city:

- Accident data are normally collected by the traffic police in most countries – untrained police personnel collect incomplete data.
- The causes of accidents are attributed to driver behaviour/fault only in most cases – which is incorrect.
- Insufficient details such as exact location of the accident and road conditions, etc. leaves many questions unanswered – a separate GPS tracker is required to track the exact location.
- The collection technique is laborious and data are collected for criminal record purposes rather than for modifying incorrect design/inappropriate control/ deficient behaviour – partial information is collected half-heartedly.
- No mechanism exists to share data with other stakeholders, such as road authorities – non-standard data, not made available to actual users.
- A comprehensive data collection system is required to identify exact causes of accidents and to design countermeasures.
- A proper inventory and data collection procedure with accident characteristics and circumstances would greatly help research and guidance in the improvement of road safety in relation to roads, road users, vehicles and traffic movement.
- Local authorities also make extensive use of road accident data. Engineers use it for establishing priority sites for remedial measures and previous experience has shown that even low-cost measures can be extremely effective in reducing or eliminating accidents at particular sites.
- Road safety officers and researchers also gain much of their evidence on which to base national and local educational programmes and training from the data

accruing from local road accident statistics. The police, who collect these data, also use them as a guide to the operational tactical deployment of their patrols in order to fulfil one of their primary roles, the reduction of casualties.

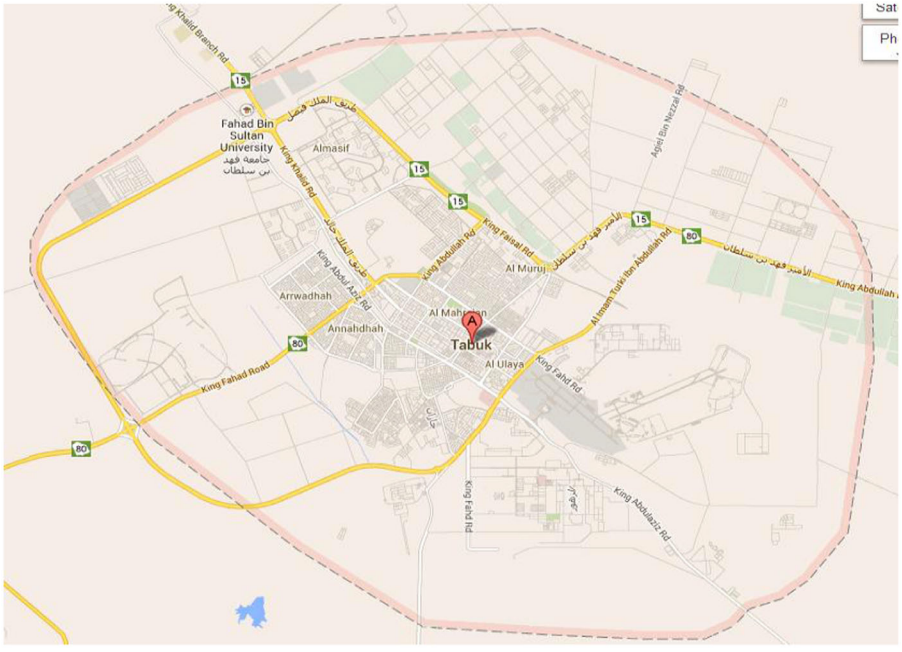
The Ministry of Health in Saudi Arabia (1995) reported that 81 per cent of deaths in hospitals resulted from traffic accidents and one-fifth of hospital beds were occupied by traffic accident casualties. Unfortunately these numbers might be higher, by approximately 60 per cent for Saudi Arabia because of the accidents that go unreported for multiple reasons. This is despite the fact that Saudi traffic laws and regulations state that it is compulsory to report any type of traffic accident. Traffic accidents continue to inflict severe health and economic repercussions worldwide (Ministry of Health, 1995). In addition to fatalities, such traffic accidents also cause disability and are a drain on healthcare resources. The situation is not much improved up to present.

Therefore the main aim of this paper is to present a brief assessment and enhance the accident data collection and analysis methodology in the KSA. In order to carry out this study, Tabuk city has been selected as a case study city with particularly high accident rates. The impacts of other environmental road factors such as the presence of signs and speed cameras, etc. on accident rates and severities will also be investigated in future to develop a risk assessment framework (RAF) for road and traffic accidents in Saudi Arabia. The methodological approach is presented as follows.

Methodology

Identification of study area

Tabuk is one of the largest and most rapidly growing cities in the KSA, as shown in Figure 2. It is situated in the north of the country and is strategically important for its



Source: © Google Maps (2014)

Figure 2.
Study area of Tabuk city in Saudi Arabia

role as the gateway to the Mediterranean countries. Its population is about 0.5 million with annual growth rate of 2.5 per cent. Tabuk is an example of a typical Saudi city that is mainly car dependent. The car ownership rate is about 1.8 cars/household. The urban density of Tabuk is very low (100 person/hac) (Al-Atawi, 2013). There were 22,166 traffic accidents in Tabuk in the year 2012 resulting in 386 deaths. The majority of the accidents involved men in the age group of 18-30 years, and were due to excessive speed. Snowfall in Tabuk also causes traffic accidents. Four people died and 32 were injured in traffic accidents caused by snowfall in the Tabuk region in January 2012 (Saudilife, 2013).

RAF

A RAF is a strategy for prioritising and sharing information about the risks associated with road users which are related to traffic. A good RAF organises and presents information in a way that both technical and non-technical personnel can understand. It has two main important components: consistent assessment methods and a reliable and clear reporting system. A properly organised risk assessment process involves a wide range of areas to be assessed: pedestrians, vehicles, accident at signals, tunnels, highway, city roads, workplaces, commercial and residential complex, specific (dangerous) works and construction-related activity on roads. As a result of an incomplete risk assessment, there is the possibility that the risk reduction measures are not well-focused and high-risk areas are neglected, which in turn can lead to incompliance with legislation and a higher probability of accidents. The common view is that an RAF provides help to cities, local authorities and transport planners to determine low risk and high risk in various components of the transport system, including locations, users and vehicles as well as other environmental (or surrounding) conditions. The developed RAF should provide a useful tool for determining the threats, opportunities, strengths and weaknesses of the data system used to report, analyse and document road and traffic accidents in the city.

There are several RAFs available which have been developed for various problems and context. However, a framework which is developed specifically for a particular problem should be the most suitable and appropriate to meet the targets and objectives of the problem in hand. Any RAF for road and traffic accidents should contain or carry out the following:

(1) An inventory and categorisation of accidents.

(2) Identify threats: these may include factors that represent high risk in terms of accidents.

(3) Identify most vulnerable road users. Data about vulnerabilities can be obtained from the available database.

(4) Prioritise locations in the transport system.

(5) Document risks and determine action.

This will have to be an on-going process, with a pre-determined schedule for issuing reports. The report should document the risk level for all components of the transport system in question. In this paper, it should be noted what level of risk any city is willing to tolerate and accept and identify procedures at each risk level for implementing and maintaining security controls. An overview of the activities is depicted in Figure 3.

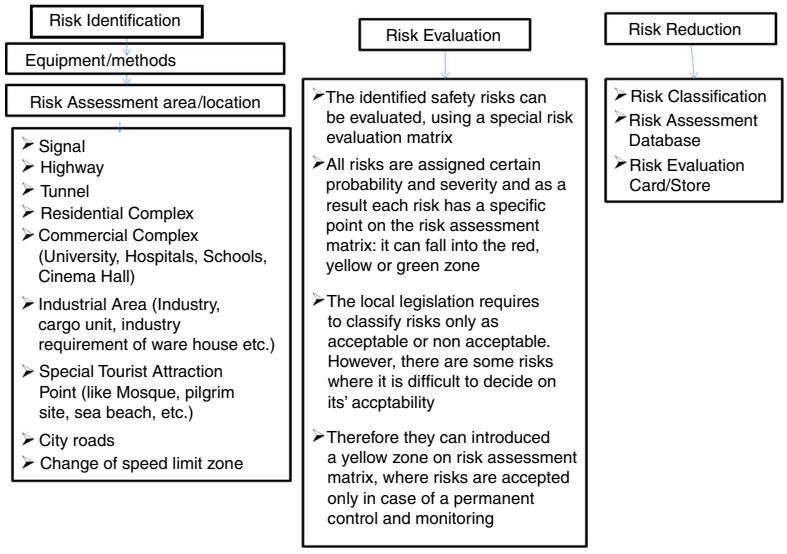


Figure 3.
Risk assessment framework for Tabuk city in KSA

Risk identification. Knowing the "who, where, when, how and why" surrounding road crashes gives fundamental intelligence, which is used to both identify and solve problems of road danger (STATS 19). Factors contributing to road accidents include:

- driver behaviour or fault;
- roadway design or control;
- poor roadway maintenance; and
- vehicle failure.

Factor of risk identification were discussed with the local authority and academic institutions of Tabuk city. In Tabuk, there are three different organisations with access to information and data related to road traffic accidents. These are: traffic police, the hospitals and the Red Crescent. Factors related to accidents and injuries therefore need to be collated and combined from these three organisations. The most important factors associated with accidents include general circumstances, vehicle and driver characteristics at the time of the accident and type of casualty and its severity. The detailed factors are described in Table I.

The International Road Federation (IRF, 2012) proposed a Road Accident Data Recording (RADaR) system, which is a quick and easy automated tool to collect comprehensive road crash data. This system is a user-friendly software application loaded onto a tablet computer working on the ANDROID operating system. The RADaR system is an innovative tool for scientific RADaR, and it is a device-independent supply of the application software for installation in a tablet of Android OS.

Accident/crash data collected at the accident scene and later at other locations will then be transmitted to the central server directly from the tablet by using the menu-driven option given in the tablet application GPS/GPRS facility to record the exact crash.

The RADaR application is supplied in a licensed pen drive, which permits the application to be loaded in 10 or 20 tablets of the user's choice. The RADaR license can

Accident circumstances	Vehicle	Casualty
Accident ID	Accident ID	Accident ID
Police force	Vehicle reference	Vehicle reference ID
Accident severity	Vehicle type	Casualty reference ID
Number of vehicles	Towing and articulation	Casualty class
Number of casualty	Was vehicle left hand drive	Sex of casualty
Date (DD/MM/YYYY)	Violation of traffic rule speed/no priority rule at junction/round about/VIP/school bus/no light in night/	Age band of casualty
Day of week	Speed at time of accident	Casualty severity
Time (HH:MM)	Driving licence type (international/local)	Casualty type
Location easting OSGR (null if not known)	Journey purpose of driver	Casualty ID
Location easting OSGR (null if not known)	Sex of driver	
Longitude (null if not known)	Age band of driver	
Latitude (null if not known)		
Speed limit		
Junction detail		
Junction control		
Light conditions		
Weather conditions: (hot temperature/rains/ desert/snow/fog)		
Urban or rural area		
Did police officer attend scene of accident		
Road signage availability		

Table I.
Factors of risk identification and assessment in Tabuk

be given to a police station, which will be using the tablet application for the collection of road accident/crash data through trained police personnel in its jurisdiction through the use of 10 or 20 tablets, located in a global coordinate system, using Google Maps, and transmits data to a web-based central server. The web-based central server is provided, managed and maintained by the supplier of the RADaR application. It is a completely secured database server with 99.99 per cent reliability through systems of back-up servers. The data for each police station is recorded, managed and maintained separately, so as to provide access to the users hierarchically for their jurisdictions – from a police station to the highest level of the country as a whole. The GSM/GPRS network facility in the tablet and internet access (WAN) for the users of different hierarchies can be arranged and made available by the implementing agency, namely police department, road authority, etc. All users at different levels of hierarchy can use the RADaR reporting tool to generate cross-classified tables of the accident data for a chosen area (jurisdiction of the user) and selected period in months and years.

The following recorded data can be analysed in terms of first, accident identification; second, information on persons involved, site layout, collision type and road characteristics; third, information on vehicles/passengers/pedestrians involved in accident; fourth, location on Google Maps, GPS coordinates of accident location and photographs of accident scene; fifth, recording collision diagram on layout of accident site layout; also saving data in tablet memory or sending to web-based server; sixth, facility to search previous data or export data. The data from RADaR can be analysed for different classification depending on the road type, road surface condition, weather

condition, gender distribution, age distribution, collision type, severity type and many others ways (IRF, 2012).

Risk evaluation process. Traffic analysts and the general public, however, are actually interested in accident concentration areas in terms of specific conditions, such as different time intervals, weather conditions and road surface conditions. For example, a traffic analyst may be interested in an accident concentration area for the downtown area during workday rush hours, so that he can locate the most vulnerable locations for accidents and analyse the reasons behind these accidents to improve road safety. A new driver may be interested in a map of the northwest part of the city during winter weekends, which can help him avoid dangerous areas when practicing driving in the northwest part of the city in winter and during hot periods. These different conditions reflect different requirements from users. Therefore, risk maps that meet users' manifold requirements are necessary. Nevertheless, integration of users' requirements into generating different concentration maps is not an easy task (Hautzinger *et al.*, 2007).

Wang and Wang (2011) proposed an ontology-based traffic accident risk-mapping framework. In the framework, the ontology represented the domain knowledge related to the traffic accidents and supports the data retrieval based on users' requirements. A new spatial clustering method that takes into account the number and severity levels of accidents is proposed for risk mapping. Tailor-made statistical tools can be developed to enable accident researchers to identify whether there is a relationship between a set of potential risk factors and accident involvement or accidental injury to ascertain the cause of an accident. A framework for Traffic Accident Scene Investigation with GPS VRS, Road Database and Stereo Vision Integration was investigated by Qingwu and Haiying (2011). They developed a traffic accident scene-management system which is designed to manage the traffic scene map, with on-site stereo images and accident report documents with a unique geo-reference, which can be used for court evidence, traffic accident statistic analysis and causes.

Laureshyn *et al.* (2010) proposed a framework for the evaluation of traffic safety based on micro-level behavioural data. They proposed a framework for organising all traffic encounters into a severity hierarchy based on some operational severity measures. A severity hierarchy provides a description of the safety situation and trade-off between safety and efficiency in the traffic system. They also suggested automated video analysis as a tool for data collection for evaluation purposes.

Proposed risk reduction process. Using different techniques in accident data collection such as the RADaR System, Video, GPS VRS stereo vision integrated system, automatic video analysis, GIS based risk or hazard mapping, statistical tools can be developed for the study area of Tabuk city using a risk evaluation matrix. Probability and severity of risk can be identified and located. The local authority can take decisions for various levels of implementation. They can frame regulations, redesign traffic road pedestrian systems and/or provide training and awareness campaigns at both local and national levels.

Conclusions

In this paper, the challenges of traffic accidents, barriers and the way forward for Tabuk city is presented and a city-specific risk assessment methodology is proposed. The framework includes identification of the factors associated with risk assessment and enhancement of accident data collection systems as well as the development of a framework for the analysis of these factors in KSA. This framework can reduce the accident risk when it is implemented at city level. This type of framework will raise the awareness of police, academia, researchers, drivers and traffic enforcement

authorities for more vigorous enforcement measures to be implemented in the Kingdom to reduce accidents appropriately.

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