Risk Exposure and Factor Effect Study of Selected Car Accident Parameters on Accident Severity

Khalid Alzoubi
Department of Industrial Engineering
Jordan University of Science and Technology
P.O. Box 3030, Irbid 22110, Jordan
kalzoubi@gmail.com

Sharaf Alkheder
Department of Civil Engineering
Kuwait University
P.O. Box 5969, Safat 13060, Kuwait
sharaf.alkehder@ku.edu.kw

Abstract

Traffic accidents have been very costly to individuals and societies over long decades, motor vehicle collision may cause serious injuries or even deaths to drivers, passengers, or pedestrians. Vehicle collision also causes car and property damage. However, there are some factors, which contribute more to the risk of car accidents that includes the vehicle itself, speeding, road conditions, and driver skills and behavior. In this work, a factor effect study using design of experiment tools has been performed to study the effect of some factors on the severity of car accidents in a city in the Gulf area over a year. Actual data was gathered and statistically analyzed, the factors considered in this study were basically; speeding, driver's skills and attention during driving, and driving under alcoholic condition besides studying the effect of using seatbelts on accident's severity level. The effect of the main factors and the factor interaction was analyzed. The study has revealed that 80% of the accidents were caused by low attention and poor skills of drivers; it was also found that fastening seatbelts was very effective in reducing medium-severity accidents.

Keywords
Risk, Severity, Car accidents, Factor effect, Statistics

Introduction

Car accidents have been increasingly bringing worries to societies because of their economic and social impact, which could be disastrous in some instances. Car accident is a daily practice on most road and highways worldwide that affects safety level on such highways and represents a challenge for governments. Developed and developing countries are both suffering from such life-threatening problem with developing countries being the most affected by this problem especially as related to the increasing number of fatalities, Esmael (2013).

Car accidents are becoming a major contributor to human deaths, injuries, and property damage resulting in huge losses in lives, economy, and quality of life, Toroyan and Peden (2007) and Peden et al. (2004). Causes of car accidents are numerous. However, they are mainly grouped into three categories: human, vehicle and environment. The accident can result from a single factor of the previously mentioned factors or a combination of these factors. Studies, AUSTROADS (1994) and Treat et al. (1979) showed that human (as a single factor or in combination with other factors) is responsible in the first place for accidents occurrence.

Road accidents can result from a wide spectrum of causes such as negligence and speed, Al-masaeid (2009). Taking speeding as an example; Mclean and Kloeden (2002) have shown that driving by 5 km/hr above 60 km/hr would

double the risk of accident involvement. Thus, enforcement of tough penalties on speed violation will contribute significantly at accidents reduction, Constant et al. (2008) and Rijkka and Mikko (2008).

Lucidi et al. (2013) have assessed seven sleep-related risk factors on the diurnal car accidents, the factors considered in their study were poor sleep, changes in habitual sleeping patterns, prolonged wakefulness, self-reported acute sleepiness and daytime sleepiness, night-shift jobs, and insomnia. Geber et al. (2016) presented a tailoring strategy for anti-speeding communication among 1168 young German drivers to reveal different types of risk drivers according to their motivational profiles, communication habits and media use. Eboli et al. (2017) work focused on identifying the accident risk level based on subjective factors depending on experiences with accidents as well as objective measures consisting in kinematic parameters defining the driving style. Li et al. (2017) have studied the effect of the shape of the passenger-car front on the injury level of pedestrian's head, thorax, pelvis and leg. The study of Horswill and Helman (2003) on the behavioral comparison between motorcyclists and a matched group of motorcycling car drivers in behaviors related to accident risk has revealed that motorcyclists choose faster speeds than car drivers do, they overtook more, and pulled into a smaller gaps in traffic.

A major problem in traffic safety research is data collection and availability due to the large costs associated with data collection process, Lord and Mannering (2010). Even in the case of data availability, the data format might be unsuitable. Most accidents data are published by police in the form of paper-based reports, and it takes huge efforts to convert them to digital databases on which proper analysis can be done. Many approaches were adopted in the literature to analyze the accident data. One major direction in the literature focuses on statistical analysis of accident data as represented in Lord and Mannering (2010), extensive review of such models indicating successful and recent application of random-parameter and finite mixture models. Other direction in the literature focuses on spatial modeling of road accidents that enable a better presentation and visualization of the data using GIS, Liu and Jarret (2007) and Schneider et al. (2004). Many initiatives encourage the research direction into developing spatial models of car accidents in Gulf Cooperation Council (GCC) countries where traffic accidents still represent a major problem that need deep study, Miaou et al. (2003) and Maher (1987). Some research, Abbas et al. (2011) and Bener et al. (2011) indicates that GCC countries have higher accident fatality rates compared to other developed countries. The importance of designing proper safety programs for young drivers as well as children and pedestrians was considered in Hammoudi (2014).

There are a number of factors that contribute to the hazard of collision, including; design of the vehicle, road conditions, speed, driver skills, and driving under the effect of alcohol or drugs. In this work, data were analyzed to study the relationship between the cause of the accident and its impact. Design of experiment tools were used with multifactor design. The statistical inference and factor interaction were used to better understand the combined effect of multiple factors on the response.

Methodology

Road accidents data were collected over one year from traffic police records. Accidents data attributes including speed, driver's skills and attention during driving, driving under alcoholic condition, and seat belt status were collected to be used in detailed analysis. Three factors were considered in this study, namely accidents resulting from poor driver's skills and attention during driving, breaking the speed limits, and driving under the effect of alcohols, as shown in Figure 1.

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│    Grouping Road accident data   │
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  Poor driver's skills   Breaking the   Driving under the
  and attention   speed limits   effect of alcohols
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┌─────────────────────────────────┐
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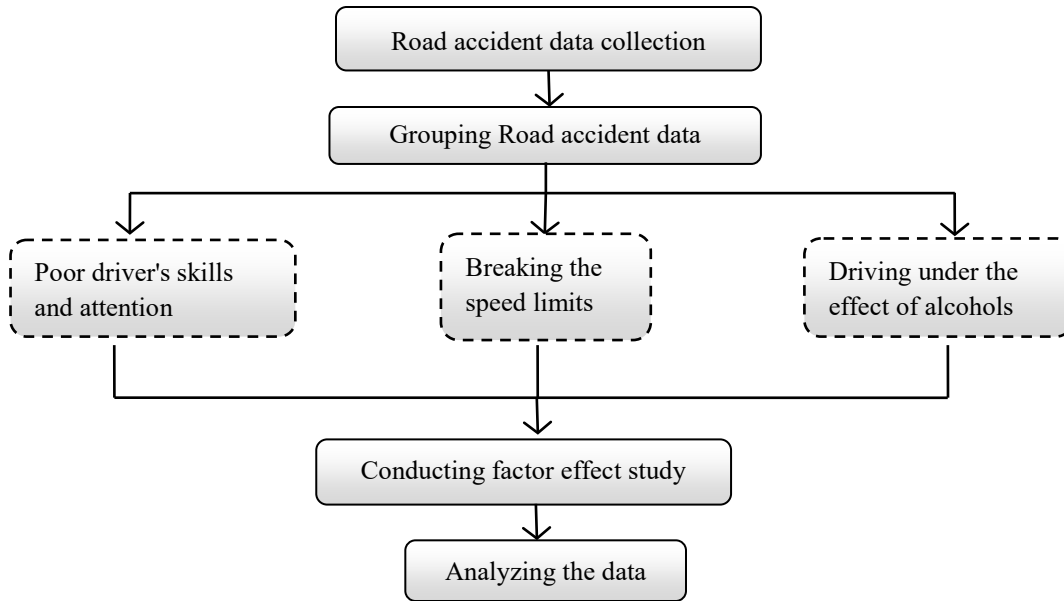
Figure 1. Methodology workflow

Typical forms of accidents caused by driver's poor skills and low attention observed over a year; low level of attention during driving, reckless driving, sudden stop, running the red light, failing to giving priority to other drivers, failing to obey the street rules, and tailgating.

The second factor considered is accidents caused by driving under alcoholic conditions that took the forms of driving under the effect of alcohol or drugs, or driving under the effect of sleepiness, tiredness, or fatigue. The third factor considered in this study was speeding which took the form of breaking the speed limits. On the other hand, the effect of fastening the seat belt on the severity of the accident is studied.

Factor effect study -using design of experiment tools- was conducted. Three factors were considered in this study besides the status of the seatbelt on the degree of severity of the accidents. Four levels of severity were selected based on actual observations; very high if the accident has resulted in deaths, high if the accident has resulted in severe injuries, medium if the accident has resulted in moderate injuries and low if the accidents have resulted in simple injuries. Three different cases were observed for the cause factor; driver's skills and attention, speed, and driving under the effect of alcoholic conditions. The two cases considered for the seatbelt were (YES) if the seatbelt is fastened and (NO) if it is not fastened. The factors and levels are summarized in Table 1.

Table 1. Factors and levels

Factor	Level		
Cause of accident	Speed	Driver's attention and skills	Driving under alcoholic conditions
Seatbelt	Fastened (YES)		Not fastened (NO)

Results

In analyzing the results of the different types of accidents considered, the total number of accidents is grouped according to the degrees of severity resulted from the accident as shown in Figure 2. It can be noticed 60.7% of the accidents (have low severity level, and 3.0% of the accidents have resulted in deaths. The data was obtained from actual accident numbers took place over one year.
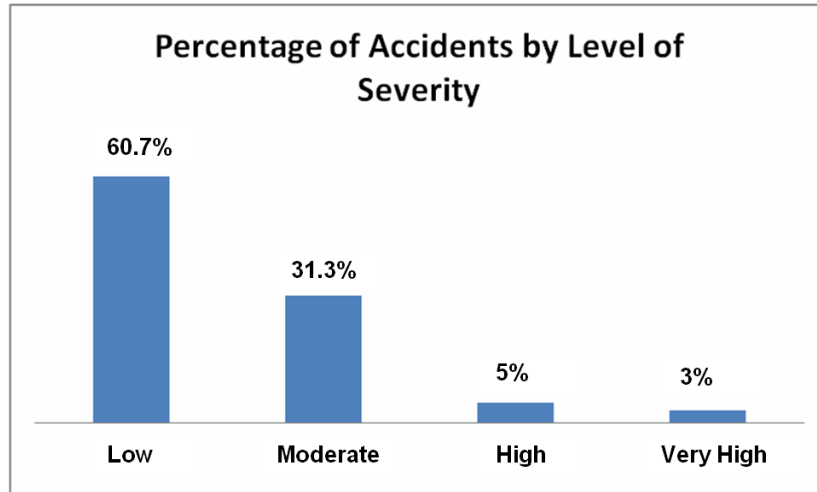
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Figure 2. Percentage of accidents by level of severity

On the other hand, A Pareto chart was constructed as shown in Figure 3. As can be directly noticed from the chart, about 80% of the accident happening were because of driver's skills and attention during driving. The least percent was for accidents caused by driving under alcoholic conditions which is quite expected in such country in which alcoholic drinks in general is religiously prohibited.
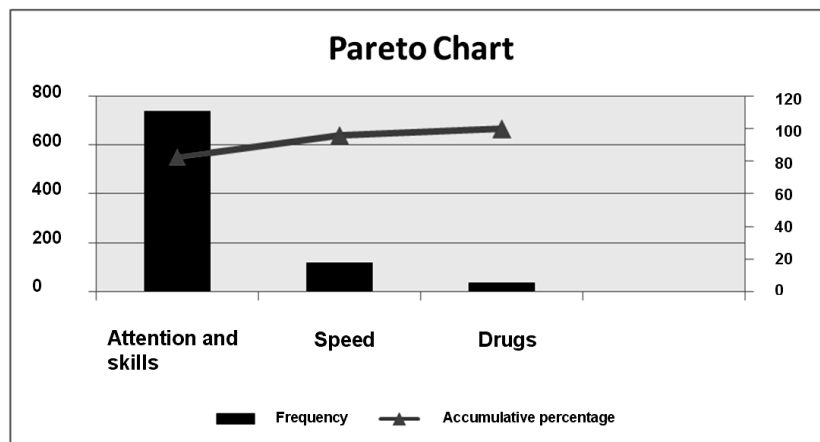

Figure 3. Pareto chart for the causes of accidents

Design of experiments tools were used to study the effects of the main factors and their interactions on the severity of accidents. An experimental matrix was set as shown in Table 2. Figure 4 shows the main effect plot for the factors considered, as can be noticed that driver's attention and skills is the factor responsible for the majority of the accidents. The majority of the accidents are among the low-severity category, and the difference in the mean number of accidents between the two cases of having the seatbelt fastened or not fastened is not statistically significant.

Table 2. Experimental matrix

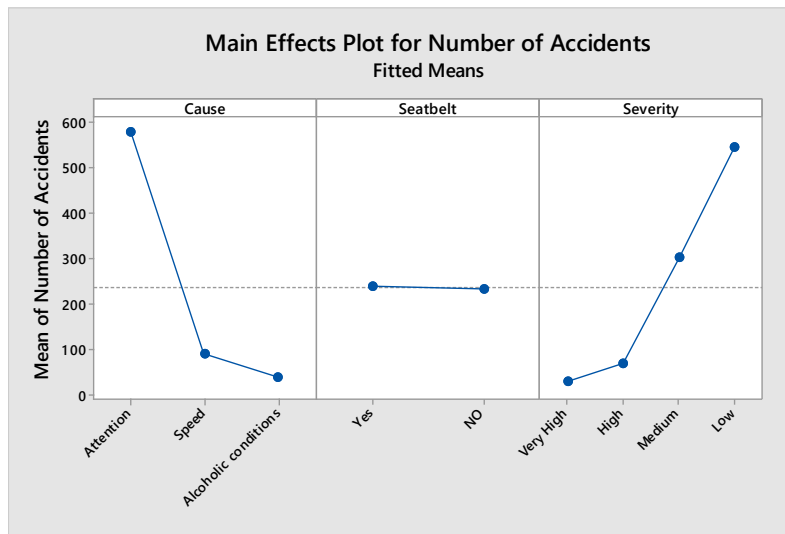| Severity	Speed		Driver's attention/ carelessness		Driving under alcoholic conditions	
	Seat belt		Seat belt		Seat belt	
	YES	NO	YES	NO	YES	NO
Very High	16	54	22	66	5	12
High	29	62	113	173	12	17
Moderate	91	181	630	820	40	41
Low	130	155	1889	1153	116	68

Figure 4. Main effects plot for number of accidents

Figure 5 shows the two factor-interactions of the factors considered, it can be noticed that there was almost no interaction between the status of the seatbelt and the cause of the accident. Also, there was no interaction between the status of the seatbelt and the severity of the accident when the accident's severity is high and very high, i.e. The status of the seatbelt has almost no effect on accidents resulted in deaths (very high severity) or accidents resulted in serious injuries (high severity) because of the horrible nature of those accidents. On the other hand, there was some interaction between the two factors of medium and low severity, and also between the speeding and attention factors. Which obviously means that the number of accident which have a low and medium severity degree is highly affected by the levels of the seatbelt factor (YES or NO) and the levels of the cause of accident (attention or speed), i.e. poor skills and low attention besides speeding will highly affect the degree of severity. Driver's attention and skills are responsible of the majority of low and medium severity accidents.
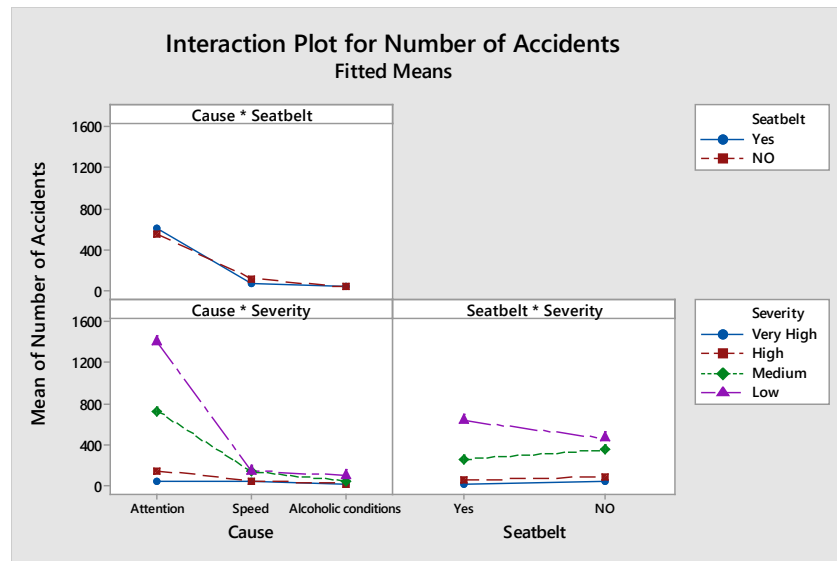
Figure 5. Interaction plot for number of accidents

The results of this study indicate that low and moderate severity accidents composing approximately 80% of total accidents, are related to driver's skills and attention. The vast majority of them were caused by the weak skills and attention of drivers. It was also found that accidents caused by driving under alcoholic conditions are not as important as driver's attention or speed because the study was conducted in a country that prohibits alcoholic drinks from religion point of view.

Conclusion

In this study, accident data were analyzed to understand the effect of some factors on the severity level of the accident as a part of the accident risk management process. Driver's skills and attention, speeding, and driving under alcoholic conditions were considered in this study and the effect of the status of the seatbelt on the severity level was investigated. The majority (about 80%) of the moderate and low severe accidents were caused by the driver's skills and attention. It was also found that the number of accidents resulting from some factors is affected by the levels of the other factors. For catastrophic accidents, the number of accidents observed over a year was not affected by the status of the seatbelt. Therefore, awareness campaigns are very helpful in urging drivers to pay more attention during driving.

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Biographies

Khalid Alzoubi is an Assistant Professor in the Department of Industrial Engineering at Jordan University of Science and Technology (JUST). He received his Ph.D. in Industrial and Systems Engineering from State University of New York at Binghamton, New York, in 2010, and his B.Sc. and M.Sc. in Mechanical Engineering from Jordan University of Science and Technology, Jordan, in 2002 and 2005, respectively. Before joining the Department of Industrial Engineering at JUST, he worked as an Assistant Professor of Industrial Engineering at Yarmouk University, Jordan, between August 2014 and June 2018. He also worked as an Assistant Professor of Engineering Management at Prince Sultan University, Saudi Arabia, between 2012 and 2014. Dr. Alzoubi's research areas of interest are Quality & Reliability, Risk Management, and Design of Experiments. Dr. Alzoubi's research activities thus far have led to many scholastic publications in various refereed journals, and conferences.

Sharaf Alkheder is an associate professor at Civil Engineering Department, College of Engineering & Petroleum, Kuwait University, Kuwait. He holds a PhD in civil engineering from Purdue University. He is part of the transportation research team in Kuwait University to study existing Traffic, Highway, and related transport problems. His research work focuses on solving various traffic safety problems in Kuwait using advanced analytics. He has a strong research publication record in top international referred journals. He worked as a consultant of MPW for different traffic and highway related engineering problems.