

## **CIVIL ENGINEERING**

### **Traffic Safety at Night: An Analysis of Recent Trends in Riyadh, Saudi Arabia**

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**Abstract:** Nighttime traffic accidents pose a more serious problem than daytime accidents, especially when fatal and injurious road accidents and traffic volumes during the two periods are compared. This research paper represents the first attempt to identify the characteristics of nighttime road accidents in Riyadh, the capital city of Saudi Arabia. Records of every road traffic accident (7721) occurring during the year 1984 are analyzed and nighttime and daytime trends are compared. The roles of human factors, the road network, and vehicle components are incorporated in these comparisons. A  $\chi^2$  test of significance was also performed to verify the existence of a significant proportional difference between daytime and nighttime accidents. Finally, conclusions and recommendations for the improvement of road safety after dark in the Kingdom are made.

#### **Introduction**

The problem of road traffic safety is an ever present and critical dilemma worldwide. This is particularly true of nighttime collisions. In developing nations data on the extent and magnitude of night accidents is missing or at best sketchy. It was this informational gap which prompted the undertaking of this study. Statistics show that accidents after dark claim a much higher proportion of fatalities and injuries than do daytime collisions. This difference is even more dramatic when considered in the context of contrasting day and night traffic volumes. Although, the traffic flow is less at night the accident rate is much higher [1].

In the western industrialized nations, for example, between 30 to 60 percent of traffic accident fatalities occur during the hours of darkness, despite the fact that the volume of traffic during this period is substantially lower than that of day-time hours [2]. The percentage of nighttime fatal accidents in Europe ranges from a low of 25% to a high of nearly 60% [3]. The reasons for such variations in the percentage of severe nighttime accidents are not clearly known. Factors such as the geographic locations of the country, the degree of motorization, the state of the economy, climate, population density, and the extent and characteristics of the road network, however, undoubtedly play a causative role.

Nighttime road accidents are found to be more severe than those occurring during the day [4]. Reasons for this include lower traffic volume: higher speed, higher vehicle occupancy, reduced visibility, low seat-belt usage, alcohol/drug intake, driver fatigue, the higher proportion of young drivers, the presence of more snow, ice, and fog and longer first-aid and ambulance service times [3,5].

Until recently research in the area of nighttime road safety has been insufficient even in developed industrialized nations. Also, past measures to improve road traffic safety have usually given priority to daytime accidents. In developing nations, despite the magnitude and complexity of the night accident problem, detailed information concerning the who, where, why, and when of such mishaps is rare or non-existent. In the Kingdom of Saudi Arabia, the only information available is the percentage distribution of road traffic accidents by day and night [6,7]. More recently, however, authorities in the Kingdom of Saudi Arabia have directed serious attention towards the area of road safety. Higher penalties for traffic violations, establishment of vehicle inspection program, improvements in the transport of accident victims to emergency service facilities are few of the measures taken to improve road safety in the Kingdom.

The specific aims of this research paper are to determine the various characteristics of nighttime road accidents in Riyadh, and to identify factors which may be important in the development of counter-measures to improve road safety at night in the Kingdom.

### **The Data**

Records of every road accident (100 percent sample size) in metropolitan Riyadh reported by traffic police officials during the 12-months period Moharram-Zilhijjah, 1404H (1984), were obtained from the General Traffic Directorate (GTD), Department of Planning, Ministry of Interior. A total of 7721 records of road accidents were analyzed. Reported accident forms contained information on data, time, day-of-week, month, location, cause, type, and results of accidents as well as on the age, nationality, education and marital status of drivers, passengers and pedestrians. Also, included were data on the type, year, and make of vehicles involved in road accidents. However, a large percentage of reported accident forms contained missing information. Particularly sketchy were details concerning exact locations, the cause of the accident, and the sex and age of pedestrians involved. In Table 1, the percentage of missing data for some of the important variables are shown. As can be seen, missing data rates are quite high for some variables.

An attempt was made to investigate whether missing data might differ significantly from the reported data. In a person-interview of traffic police officials, it was revealed that accident reports involving only minor property damages may contain missing data on some variables. Limitation on the number of accident-investigating

officers is the main reason for the absence of data in some accident reports. Severe accidents involving a fatality, an injury or a major property damage are reported comprehensively by investigating officers.

Accident information was taken directly from the traffic police accident files, coded and compiled in the memory of the IBM computer system of the College of Engineering. The Statistical Analysis System (SAS) was utilized to analyze the data.

The general traits of road traffic accidents occurring in metropolitan Riyadh are presented in Table 2. Nearly 8000 road accidents resulting in 91 fatalities and 1520 injuries occurred during the study year. A total of 14,982 drivers, 479 passengers, and 467 pedestrians were involved in these accidents. Also shown are the numbers of fatalities and injuries for each category of road-users.

**Table 1. Distribution of available and missing data for selected road accident variables**

Variable Name	Records available	Percent missing
No. of traffic accidents	7721	---
Accident hour	6873	11.0
Accident location	6293	18.5
Accident result	7051	8.7
Accident cause	5480	29.0
Pedestrian age	274	41.3
Pedestrian sex	309	33.8
Driver education*	8775	41.4
Driver marital status	9575	35.9

\* Total number of drivers involved = 14,982.

**Table 2. General characteristics of road traffic accidents in Riyadh**

Characteristics	Value
Total No. of traffic accidents	7,721*
Total No. of drivers involved	14,982
Total No. of passengers involved	479
Total No. of pedestrians involved	467
Total No. of fatalities	91
Driver fatality	33
Passenger fatality	26
Pedestrian fatality	32
Total No. of injuries	1,520
Driver injury	664
Passenger injury	453
Pedestrian injury	403

\* For four days during the month of Moharram (September) accident statistics were not available.

Based on the information in Table 2, the likelihood of serious injury and fatality for the various groups of road users involved in traffic accidents were calculated. Fatality rates, for example, were calculated as 2.2 for drivers, 54.3 for passengers, and 68.5 for pedestrians. When compared to drivers, the respective likelihoods of passengers and pedestrians being killed when involved in accidents, are 25 and 31 times greater. A possible reason for the higher death rate among passengers as opposed to drivers may be due to a higher degree of missing data on non-injured passengers as well as the high vehicle occupancy, especially for non-work trips, resulting from the generally large family size characterizing most households in the Kingdom. This data for passengers and pedestrians dramatically underscores the need for the travel safety of passengers and for the improved protection of pedestrians against motorized traffic.

The day and night distribution of Riyadh road traffic accidents by type revealed that the proportion of nighttime accidents increases from 31.5 percent for all accidents to 34.1 percent for injurious and 36.6 percent for fatal accidents. It is important to consider that, while approximately 1/4 of the daily (24-hours) traffic volume in Riyadh occurs during the hours of darkness [8], nearly 37 percent of fatalities resulting from traffic accidents takes place during this period. It is also interesting to note that, these percentages of nighttime traffic accidents in Riyadh compare with the lowest figures recorded in western industrialized nations, despite the extremely low level of seat-belt usage [9] and the inferior level of driver behavior which is commonly observed throughout the developing world [3].

The consumption of alcohol and drugs is highly prohibited in the Kingdom for both Moslems and non-Moslems. Jail (for all) and deportation (for expatriates) would apply, without exception to any individual consuming these substances and arrested for traffic violation or accident involvement. Because of these stiff penalties involved in violating the law, drunk-driving is practically non-existent in the Kingdom. In fact, statistics show that during the 7-year period 1974-1981, an average of only 0.8 percent of road accidents in Riyadh were associated with the use of these substances [6].

Western developed nations, especially those experiencing a high percentage of alcohol/drug-related traffic accidents may consider policies and measures to restrict both the availability as well as the consumption of these substances, particularly when the performance of night driving is involved.

### **Road-User Involvement**

A category analysis was performed on the data to determine the extent of driver, passenger, and pedestrian involvement in accidents taking place during night hours. Results indicated that, while disproportionately high percentages of both injurious and fatal accidents occurred during the hours of darkness, nearly 1/2 of fatal accidents involving pedestrians were concentrated within this time period. Separation

and better illumination of pedestrian crossing points, stricter nighttime enforcement of speed limits in these areas and improvements in driver education may substantially improve traffic safety for pedestrians.

Analysis of the age distribution of pedestrians revealed that young pedestrians ( $\leq 15$ ) and elderly pedestrians ( $\geq 65$ ) were not highly represented among those involved in fatal accidents at night. However, nearly 1/2 of all accidents involving pedestrians in the age category 16-64 occurred during the hours of darkness (Table 3). The existence of a very large number of low-income working expatriates, concentrated mostly in the congested central area of the capital city, combined with reduced visibility during the hours of darkness, may be the main factors contributing to the high nighttime accident involvement of this age group.

**Table 3: Distribution of daytime/nighttime road accidents by pedestrian age**

Pedestrian age	Accident involvement (%)	
	Daytime	Nighttime
$\leq 15$	74.9	25.9
16-64	53.6	46.4
$\geq 65$	75.0	25.0

Because of the over-representation of young drivers in nighttime accidents in most countries, accident-involved drivers were also analyzed by their age. Results showed that of the accidents befalling drivers under 16 years, more took place between 12 a.m. (midnight) and 6 a.m. than for any other age group. In addition, drivers aged 25 years or less are involved in more than 40 percent of all traffic accidents occurring between 6 p.m. to 12 a.m. (midnight). The reason for this, high presence of young drivers in Riyadh's nighttime accidents may be due to the patterns of night youth social/recreational interaction, which in turn, relate to the extremely high daily temperatures which prevail most of the year. The fact that, these inexperienced drivers do not hold legal driver's licenses also helps explain that their choice of late-night/early morning hours for driving to take advantage of the low levels of traffic volumes as well as the more relaxed traffic enforcement which characterize this period. It was also noted that, the percentage of drivers in the 16-25 years age group involved in evening accidents between the hours of 6 p.m. and 12 midnight was the highest of any age group.

### Vehicle Involvement

Table 4 presents the proportion of night accidents by type of vehicle. For bus transit vehicles, an impressive 45 percent of road accidents took place at night. Again, the large number of nighttime social/shopping trips generated by the captive and low-income workers in Riyadh is perhaps the main reason for this phenomenon. Trucks,

on the other hand, had the lowest proportion of their accident involvement at night, as expected.

**Table 4. Distribution of daytime/nighttime road accidents by vehicle type**

Vehicle type	All accident involvement (%)			
	Daytime		Nighttime	
	Frequency	Percent	Frequency	Percent
Auto	5583	60.6	3630	39.4
Pick-up	2386	63.0	1401	37.0
Minibus	125	54.5	104	45.5
Bus	79	54.4	67	45.6
Truck	670	65.4	355	34.6
Other (Utility services vehicles, Garbage trucks Heavy construction vehicles, etc.)	223	62.9	132	37.1

In order to determine whether nighttime and daytime accidents differ significantly, a  $\chi^2$  test of significance was performed on the data [10]. Utilizing the day and night distribution of traffic volumes [11], the expected proportion of road accidents by vehicles type was determined and a  $\chi^2$  value was computed as shown in Table 5. Results indicated that the proportion of observed daytime and nighttime road accidents was significantly different from those expected for auto, pick-up, minibus and bus at the 99 percent significance level. The opposite was true for truck and the "other" category of vehicle type.

**Table 5.  $\chi^2$  test of significance for daytime and nighttime road accidents by vehicle type**

Vehicle type	Daytime accidents		Nighttime accidents		Computed $\chi^2$
	Observed	Expected	Observed	Expected	
Auto	5583	6265	3630	2948	231.9*
Pick-up	2386	2575	1401	1212	43.4*
Minibus	125	156	104	73	19.4*
Bus	79	99	67	47	12.5*
Truck	670	697	355	328	3.2
Other	223	241	132	114	4.1

\* Signification at the 99% level ( $\chi^2_{0.99} = 6.63$ )

Accidents were also analyzed by the number of vehicles affected and time of day. While percentages of traffic accidents which involved single, two, and multiple vehicles were nearly the same during the period 12 a.m. to 12 noon, those affecting single and two vehicles peaked during the period 12 noon to 6 p.m. High volumes of vehicle

and pedestrian traffic during the early afternoon rush hours (between 2 and 4 p.m.) may be the main reasons for these accidents. Multiple vehicle accidents, on the other hand, reached their peak during the period from 6 a.m. to 12 p.m. (noon) and remained generally constant during the afternoon as well as the hours of darkness.

Multiple-vehicle road accidents in central areas of the city are usually a result of high traffic volume (low travel speeds). These accidents are generally not severe and result in vehicle damages. The opposite may be true for single and two-vehicle accidents. To investigate the relationship between the number of vehicles involved and the severity of accidents, a cross-classification analysis was performed on the data. It was found that, single vehicle accidents (auto-pedestrian and auto-fixed object crashes) constituted 54.7 percent of all fatal accidents. Only 1.6 percent of fatal accidents affected multiple vehicles ( $> 3$  vehicles), with the remaining 43.7 percent resulting from 2-vehicle collisions. Once again, the urgent need for improved protection of pedestrians, who constitute the greatest majority of single-vehicle traffic accident victims, warrants immediate attention.

### **Summary and Conclusion**

Statistics show that, traffic accidents after dark claim a much higher proportion of fatalities and injuries than do daytime collisions. In western industrialized nations, 30-60 percent of traffic accident fatalities occur during the hours of darkness. In the Kingdom, this statistic is nearly 37 percent for drivers and 47 percent for pedestrians.

The main reason for Riyadh's relatively low proportion of nighttime traffic fatalities when compared to the majority of western developed nations may be the extremely low level of alcohol and drug consumption in the Kingdom. This is despite the existence of inferior driver behavior and low levels of traffic education and enforcement programs prevailing in most developing countries, the Kingdom included.

Results of the analysis of Riyadh's nighttime accidents by driver age closely agreed with those of other nations. Of the accidents resulting in fatalities of drivers under 16 years of age, more took place during the night hours between 12 a.m. (midnight) and 6 a.m. than for any other age group. Patterns of youth social interaction, their lack of driving experience, reduced visibility, higher travel speed, and more relaxed enforcement at this time period may be responsible for this high rate of nighttime fatal accidents among these young drivers. The percentage of young drivers in the 16-25 years age group involved in traffic accidents between the hours of 6 p.m. and 12 a.m. (midnight) was also the highest of any age group. The promotion of special education and training for night driving, combined with the enforcement of lower speed limits and safety belt usage may substantially improve these young drivers' chances of avoiding accidents at night.

Analysis of the age of pedestrians involved in Riyadh's night fatal accidents revealed two important points. **First**, pedestrian accidents involving children ( $\leq 15$ ) and the elderly ( $\geq 64$ ) were mainly a daytime phenomenon, as might be expected. **Second**, nearly 1/2 of all accidents involving pedestrians in the age category 16-64 occurred during the hours of darkness. Improvements in the design and illumination of pedestrian crossing facilities, encouragement of the use of reflectorized aids and the promotion of pedestrian education may reduce their high nighttime risk of being struck by a vehicle.

Single-vehicle (pedestrian and fixed-objects) accidents constituted nearly 55 percent of all fatal accidents. Crashes with fixed objects and obstacles on the road were responsible for only less than 7 percent of all fatal accidents. The remaining large portion of single-vehicle fatal accidents involved the unprotected pedestrian. The implementation and enforcement of lower speed limits for night driving, especially in areas with heavy volumes of pedestrian traffic is of paramount importance.

Because of the complexity and multiplicity of the factors involved in nighttime traffic accidents, a single-action and piecemeal safety program will, quite obviously, not suffice. A safety system program must be comprehensive in its dimensions, coordinated to encompass all involved parties and factors, and continuous to incorporate the changing patterns of attitudes and behaviours as well as changes in transport technology. A prerequisite to the implementation of any traffic safety program is the establishment of a road safety management information system.

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سلامة السير في الليل : دراسة تحليلية للمعدلات الأخيرة  
في مدينة الرياض بالمملكة العربية السعودية  
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قسم الهندسة المدنية، كلية الهندسة، جامعة الملك سعود، ص. ب. ٨٠٠،  
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ملخص البحث . تشكل حوادث السير التي تحدث أثناء الليل مشكلة أكثر خطورة من تلك التي تحدث أثناء النهار، خاصة إذا أخذ في الاعتبار عدد الحوادث التي ينتج عنها وفيات وإصابات بالنسبة لحجم حركة السير في الفترتين . ويمثل هذا البحث المحاولات الأولى لمعرفة خصائص ونوعيات الحوادث الليلية في مدينة الرياض، عاصمة المملكة العربية السعودية .

لقد تم تسجيل كل الحوادث التي وقعت في مدينة الرياض خلال العام ١٩٨٤م، وتم تحليل ومقارنة معدلات الحوادث في فترتي الليل والنهار، وذلك بإدخال العوامل البشرية، وعوامل شبكات الطرق وحالة السيارة في تلك المقارنة . أيضا تم إجراء اختبار الأهمية أو الجدوى ( $\chi^2$ -test) للتحقق من وجود فروق تناسبية ذات أهمية بين الحوادث أثناء الليل والنهار . وقدم البحث النتائج والتوصيات اللازمة لرفع مستوى السلامة على الطرق في المملكة أثناء الليل .