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Taxi Service Characteristics and Involvement in Road Traffic Accidents in Riyadh

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Abstract. Riyadh, the capital of the Kingdom of Saudi Arabia, is a modern fast growing city of some three million people. While some elements of the transport system have developed to a modern, up-to-date standard, other elements are still in a state of transition. Taxi service, while always an important part of the transportation system, has experienced many changes over the past decade. Available information seems to indicate that taxis are involved in a disproportionate number of traffic accidents, when compared with other vehicles operating on the same roadway system. This study, however, found that this is not true when a measure of exposure is taken into account. This paper presents some of the basic characteristics of the taxi service operating in Riyadh and analyzes the types of accidents in which taxis are involved. The study is based upon a survey sample of both taxi drivers and taxi companies, as well as reported traffic accidents in which taxis were involved. The paper concludes with several recommendations for actions that would help reduce the number of taxi related traffic accidents.

Introduction

Before the oil boom, in the early 1970's, a conventional taxi service (called yellow taxis) was available within the cities and inter-cities. The conventional taxi driver was only required, by regulations, to have a valid driving license for the type of vehicle. Thus, all taxis followed an owner-operator scheme. These taxis offered both exclusive ride and shared ride services. Fares were unregulated (no meter system) and were set by bargaining between the driver and the passenger. This conventional service satisfyied the market needs for that period of time [1,2].

At the end of seventies and early eighties, and as a result of the massive and rapid development in the country after the oil boom, a large number of expatriates had entered the country to participate in the construction of huge infrastructure projects. As a result,

many of the major cities in the Kingdom of Saudi Arabia (KSA) witnessed a rapid growth in public transportation service. The conventional taxi service appeared unable to satisfy the expanding demand and besides it provided a low-quality service [1,2].

Accordingly, the Ministry of Communications (MOC) was assigned [1,2] to organize taxis in a manner to assure the coordination between taxi service and other public transportation modes. In 1984, the MOC introduced a new form of taxi service, which was called limousine at that time but now is referred to as public taxi. This service is a mode of transportation that caters to people needing transport within the city, and also, to and from the airport, which is located a short distance outside the city. Such services are similar to taxi services which exist in developed countries, except that drivers in the KSA all wear uniforms and do not accept phone-in requests for rides. That is, taxi drivers cruise the streets, looking for passengers. In the KSA, there are no official pick-up-zones. Passengers merely wave their hand from any place at the side of the road and hope to be spotted by a taxi driver.

The new service was able to perform very successfully in its first few years. Passengers preferred it to the yellow taxis because of its superior quality of service. Hence, this business has become a profitable industry and many investors were attracted to enter this business. As a result, the number of taxi vehicles in the cities, particularly in Riyadh, dramatically increased. This triggered MOC to conduct a study in 1990 to evaluate the existing policy regarding the taxi industry. The study recommended freezing the number of taxis in Riyadh at that time (118 firms with a total of 4,288 vehicles). MOC adopted a policy that restricts new firms from entry into the business, but at the same time did not control the existing firms from expanding their fleets. Besides that, there was no strict implementation and enforcement of policies and regulations. In 1997, there were 255 firms with a fleet size of 9,930 vehicles along with 1,123 licensed taxis owned by individuals (owner-operators). In 1997, MOC released a new policy to give taxi-operating licenses to individuals (owner-operators) in order to incorporate yellow cabs and include them under the control of the ministry. Table 1 presents a summary of the number of taxi firms and vehicles for Riyadh and the Kingdom. The result was not only an over-supply problem but also safety-related problems.

Table 1. The number of licensed taxi firms and vehicles (1997)

Item	Kingdom	Riyadh
Firms	651	255
Vehicles operated by companies	24,532	9,930
Vehicles operated by individual owners	4,605	1,123
Number of licensed vehicles	29,137	11,053
Average fleet size per firm (vehicles)	37.7	38.9
Ratio of taxi vehicles per 1,000 inhabitants	1.7	3.7

Source: [4].

According to official traffic-police statistics [3], involvement of taxi vehicles in traffic accidents (accidents per 1,000 vehicles) is approximately 3.3 times higher than that for other vehicles. Such statistics support the need for special attention to safety activities, by both the research community and public officials.

This study aims at analyzing operating and revenue characteristics and traffic-related safety problems associated with taxi services in Riyadh, in order to determine the major contributing factors to such problems. To achieve this objective, taxi drivers and taxi-related accidents were investigated. For analyzing operating characteristics, a field survey of taxi drivers was conducted. To understand the taxi-related accident characteristics, a random sample of reported accidents was collected and anlyzed. After describing the methodology of the study, this paper presents an evaluation of operating characteristics of the taxi business in Riyadh, followed by an analysis of taxi-related accidents. In addition, a limited questionnaire survey was conducted on a small scale with taxi-company owners. The data gathering methods and the analysis of collected data are described below. It should be mentioned that the main thrust of this paper is based on the driver survey and the taxi-accident data. At the end of the paper, a brief discussion of major findings is given and the paper concludes by proposing several recommendations.

Data Assembly

Three sets of data were collected in this study. The first set was for taxi drivers. A sample of 416 taxi drivers (6% of population) from Riyadh was selected at random. For example, a survey observer would stand on the side of the road, wave at perhaps every other taxi (systematic sampling) which passed, and then ask the driver to respond to the questionnaire. This process was conducted at randomly selected locations throughout Riyadh. The sampled drivers belonged to different taxi firms.

The second data set was for taxi-related accidents that occurred in Riyadh in 1996. A sample of 314 reported accidents (in a systematic randomly manner) was obtained from the Riyadh Traffic Department (RTD). The police accident records in the RTD are kept manually in archived folders. Searching for any type of accident reports must be done manually since a computerized system is not yet available. Therefore, looking for the taxi-related accident reports was not an easy process because of the need to go through all the reports in the folders and select such accidents.

The third data set was collected through a limited questionnaire survey for taxi firms. Data from twenty taxi companies were collected. Although this sample of firms accounts for about 13% of all taxi companies in Riyadh and it was enough for the purpose of the study, the intention was to cover at least 50% of the companies. However, most of them were very conservative and did not cooperate. Even the twenty companies that were surveyed did not respond fully to all the questions. Thus, the analysis of this data set is limited for this study.

Subsequently, data were reduced, coded, and tabulated to be in a consistent format for computer entry and test statistics used in the study.

Drivers Characteristics

Using the questionnaire survey, driver characteristics, such as nationality, age, marital status, and education were analyzed. The type of driver license carried by taxi drivers in Riyadh was also investigated. These characteristics are presented in the following sections.

Nationality

The study revealed that taxi drivers in Riyadh are scattered among eleven nationalities, as presented in Table 2. However, four nationalities were found to be dominant—Pakistan (57.69%), Bangladesh (14.90%), India (11.77%), and Egypt (8.41%). The majority of the taxi drivers in the study sample came from Pakistan. Although the regulations urge taxi firms to have at least 25% percent Saudi drivers, no Saudi driver was observed during this study.

Table 2. Drivers' nationalities in the study sample

Nationality	Count	Percentage
Pakistan	240	57.69%
Bangladesh	62	14.90%
India	49	11.77%
Egypt	35	8.41%
Sudan	12	3%
Somalia	8	2%
Other	10	2.4%
Total	**416**	**100%**

Age

The mean age of the sampled drivers is 33.9 years with a standard deviation (st. dev.) of 6.48 years. The distribution of drivers by age, given in Table 3, shows that the largest age group is between 31 and 35 years. More than two thirds of the drivers (67.07) are of age 35 years or below.

Table 3. Distribution of drivers by age group

Age group	Count	Percent	Lower limit	Upper limit
20-25	42	10.1	7.2	13
26-30	101	24.28	20.16	28.4
31-35	136	32.69	28.18	37.2
36-40	88	21.15	17.23	25.07
41-45	28	6.73	4.32	9.14
46-50	8	1.92	0.6	3.24
>=50	13	3.13	1.46	4.8
Total	**416**	**100**		

Education and marital status

Illiterate drivers account for 15%, while 5% have a higher education (Bachelor Degree). With respect to marital status, 84% of drivers are married. Typically, their wives are living in their home countries.

Type of driving license

There is a clear government regulation concerning the type of driving license that the taxi driver should carry. This rule states [1]:

The taxi driver must carry a General Driving License (GDL) while driving a taxi vehicle, and it is illegal to drive such a vehicle with a Private Driving License (PDL).

The GDL requires specific driving skills. The traffic rules require that heavy-vehicle and taxi drivers obtain this type of license before sitting behind the wheel. Yet, the study found that 43% (the 95% confidence limits for this percent is 35.8%~50.28%) of the sampled drivers did not carry GDL, but rather a PDL (this type is for private-vehicle drivers). Therefore, about half of the taxi drivers violate this rule. Based on the responses of both drivers and the firms' owners, two main reasons causing this illegal situation are the following:

1. Most drives working in this type of service do not originally enter the Kingdom for this type of job (i.e., their entering visas are not driving-type).
2. Law enforcement is not sufficient to get them off the road.

Characteristics of Taxi Service

Operating characteristics

Operating characteristics investigated in this study include: number of daily trips, daily traveled distance, and daily working hours. According to the taxi company questionnaire, the ratio of driver to vehicle in the taxi firms in Riyadh is 1. That is, only one driver for each vehicle. The driver survey revealed that each taxi driver, on average, travels 407 (st. dev is 93.7) kilometers, works 14.65 (st. dev. is 1.86) hours, and completes 18.64 (st. dev. is 5.4) trips every day. Figure 1 shows that the 95^{th} percentile for working hours is 16.75 hours. According to the taxi firms sampled in this study, drivers travel 357.9 Km in 12.42 hours, on average, every day. Testing the difference in means for both the traveled distance and time data from firms and drivers shows that the difference is statistically significant at 5% level, as presented in Table 4. This indicates that figures given from the two parties, firms and drivers, are not consistent; however, both parties agree on the fact that taxi drivers spend much more than 8 working hours on daily basis. The government regulations restrict working hours to 8 hours maximum per day, but the data indicates that taxi drivers in Riyadh actually work nearly twice as long as officially allowed. This excess in working hours can lead to several problems, such as

physical and mental pressure on the driver which in turn leads to increased stress and less concentration on the road.

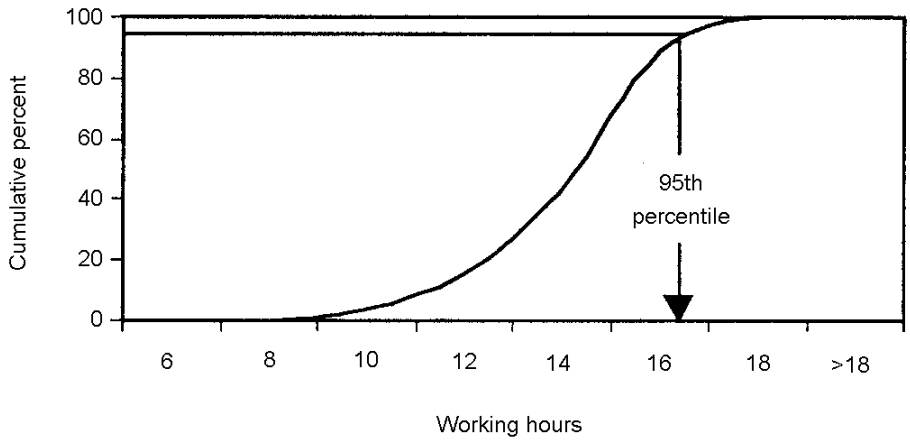

Fig. 1. Cumulative percent for working hours.

Table 4. Number of daily working hours and kilometers per driver

Item	Firms surveyed		Drivers surveyed	
	Mean	**Std. dev.**	**Mean**	**Std. dev.**
Traveled distance (km)	357.9*	60.7	407*	93.68
Working hours	12.42**	2.78	14.7**	1.85

* The difference is significant at 0.05 level by using t-test.
** The difference is significant at 0.05 level by using t-test.

Revenue characteristics

This part of the study describes the financial relationship between the driver and the taxi firm for which he works. Although the regulations require a monthly payment for the taxi driver, the majority of companies have “an under the table” agreement with their drivers by which the driver must pay a fixed amount of money to the company at the end of the day. According to the drivers, there are three types of agreements identified in this study:

1. The driver receives a monthly payment + takes home any surplus of daily revenue (60% of drivers).
2. The driver takes home any surplus of daily revenue (37% of drivers).
3. The driver takes home about 15% of daily revenue (3% drivers)

Surplus of revenue is the extra money from the total daily revenue collected by the driver after a certain fixed amount of money that he must pay to the firm. Surplus money cannot be achieved every day. Sometimes the daily revenue is equal or less than the

fixed amount of money specified by the firm. In mathematical language the surplus of revenue can be represented as follows:

$$r = m \pm h$$

where

r = daily revenue (SR).
m = a fixed daily amount of money specified by the firm (SR).
h = surplus or loss for +ve or –ve sign, respectively (SR).

The above relationship implies three cases:

Case I: If $r > m$ surplus = $(h > 0)$
Case II: If $r = m$ no surplus and no loss ($h = 0$)
Case III: If $r < m$ loss ($h < 0$) (the driver must balance from his pocket)

The study data indicates that 97 percent of the taxi drivers depend on the surplus policy to make their own money. In other words, the higher revenue a driver gets the higher profit he can make. This kind of agreement may lead to the following safety-related problems:

- the taxi driver is put under tremendous pressure to achieve case *I*. This pressure pushes him to work most of the day (more than 14 hrs as the survey indicated) resulting in tremendous stress and exhaustion.
- many drivers claim that, for several days a month, the daily revenue does not reach what the firm asks (case *III*). Accordingly, the drivers must balance from other days profit (46% of drivers say they work the off-day (Friday is the off-day in Saudi Arabia) just to balance the fixed amount of money). This again puts the driver under more pressure.

As presented in Table 5, the daily revenue of the majority of the drivers (57.69%) is between SR100 ($27) and SR200 ($54). More than a third have a daily revenue of SR300 ($81) to SR400 ($98). It is apparent from the table that the revenue per working hour ranges, on average, between SR10 ($2.7) and SR24 ($6.4). Considering the daily revenue kms as calculated (28%), the daily revenue hours would be:

$$14.65 \times 0.28 = 4.1 \text{ rev hrs}$$

Hence, the daily revenue per revenue hour (mean value) ranges between SR37 ($9.75) and SR85 ($22.75).

Table 5 . The drivers' daily revenue

Daily revenue (SR)	Rev. per working hour (SR)	Count	Percent	Lower limit	Upper limit
100-200	10	240	57.69	52.94	62.44
200-300	17	156	37.5	32.85	42.15
300-400	24	20	4.81	2.75	6.87

Supply and demand characteristics

A common measure of supply is the ratio of licensed taxis to population (A more sophisticated ratio can be used, based not only on the local population, but also on the number of commuters and air passengers). The population of Riyadh is estimated to be three million in 1997 [5]. The current supply of taxis presented in Table 1 is 11,053 vehicles. Accordingly, the current supply of taxis in Riyadh is about 3.68 vehicles per 1,000 inhabitants, which is more than twice that of the entire Kingdom (nationwide), as shown in Table 1. Compared with similar international measures (U.K=0.80, USA=0.40, France=1.80, Germany=1.70, Turkey=2.80, Greece=1.60 [6]), the rate for Saudi Arabia is somewhat higher than some of these countries but the citywide rate is higher than the rates in all these countries, even though, unlike these other countries, Saudi Arabia is not an attractive place for tourists. Thus, it can be said that there is an over-supply of taxi vehicles in Riyadh. Limiting the number of taxi licenses is a common measure in Western cities [7]. Doing so (a) reduces crowding and pollution problems related to heavy traffic; (b) ensures a degree of profitability for operators; (c) avoids ruinous competition; (d) reduces taxi waiting time; and (e) facilitates public-safety controls, consumer protection, and service quality. Failure to limit the number of licenses, particularly if combined with a lack of operator selection criteria, can lead to a massive influx of new operators, reduced profits in general, lower taxi occupancy rates, higher fares, degraded service quality, and heavy traffic problems on the roads. However, it must be said that limiting the number of taxis is highly controversial [7]. Regulations that limit the number of licenses can, however, have insidious effects. For example, the limit can prevent the creation of new taxi services for use by the public.

Study data show that the number of revenue trips served daily is 18.64 per taxi vehicle. The average occupancy per trip is 1.40 passengers (MOC study [8] found this occupancy 1.20 and Al-Gadhi study (1994) found it 1.52). In addition, this study found that, on average, the taxi vehicle operates 6.7 days per week. Therefore, the annual mean number of trips made by a taxi in Riyadh is 6,744 trips serving 9,442 passengers (a total of 288,439 passengers per day served by all taxis in Riyadh). MOC indicates that the total daily number served by all buses (public transit and private buses) in Riyadh is 97,000 passengers [8]. Compared with 288,439 passengers, the taxis serve about three times (2.97) more passengers.

As a result of long daily driving distance, a taxi driver travels most of the day without a customer. That is, a large portion of daily distance is wasted in cruising streets looking for a customer. This study found that the daily revenue kilometers account for only 28% of the daily distance traveled. (See appendix). Accordingly, more than 70% of

the kilometers driven are non-productive. This suggest that there is a problem of over-supply.

Meter usage

Although the MOC regulations require the use of a meter for determining the passenger fare, only 44% of the drivers use the fare meter system. Thus, 56% report that the majority of the trips are charged by bargaining (flat fare). Those drivers claim that the flat fair (due to the passenger preference) is less than what would be charged if the meter was used. This claim was investigated by Al-Gadhi (1994) and found to be true. He found that the revenue per km for metered trips is significantly greater than that for flat fares and concluded that the non-use of the fare meter system benefits the passenger. It should be mentioned that one primary goal of setting fares is to prevent abuse when clients are unable to negotiate the cost of service. The driver's name and vehicle number must also be posted in plain view so that clients can complain above violations.

On-call service

From the above analysis, it is obvious that the primary dilemma of the taxi service in Riyadh is the relatively long distances traveled on a daily basis. The taxi driver travels, on average, 407 kms, while the drivers of other vehicles in Riyadh travel 86 kms per day [10]. This long travel distance lowers his revenue per working hour since the revenue kms account for only 28% of this distance. The majority of the taxi-firm owners (95%) say that they ask the driver for a daily fixed amount of money. Although it is illegal, they justify this practice due to the lack of wireless communications with their drivers. They blame the MOC for not providing this type of communication by which they can dispatch trips based on in-coming calls. That way, they could monitor the driver and locate his position at any time.

Accident Characteristics

Taxi accident data was obtained from the Riyadh Traffic Department (RTD). Unfortunately, the taxi-related accident reports are not kept separate. Rather, they are kept among all accident records. That is, a taxi report may be found only after searching some accident reports (e.g., sometimes up to 50 accidents). This process of extracting taxi-related accident reports is lengthy and takes a lot of effort. After searching more than ten thousands reports for accidents that occurred in Riyadh over the period from April 1997 to April 1998, a set of 314 taxi-related accident reports was obtained. Afterward, data were reduced, summarized and computerized to fit the needs of the study.

In this study, taxi-related accidents were found to be over-represented when compared with other vehicle accidents. About 15.6 percent of taxi-related accidents were casualty accidents (i.e., ended with either injury and/or death) compared with 10.8 percent of other vehicle accidents occurring throughout the Kingdom [3]. Additionally, it can be seen from Table 6 the higher casualty rate (injury and fatal victims per

accident) for taxi accidents (0.16) compared with other vehicle accidents (0.11) that occurred in Riyadh (citywide) in 1996 [3] indicates the high severity of taxi accidents.

Table 6. A comparison between taxi accidents and other vehicle accidents that occurred in Riyadh

Item	Other vehicle accidents	Taxi accidents
No. of accidents	42,361	1,495
No. of injuries	4,140	225
No. of fatalities	345	12
Casualty per accident	0.11	0.16

Nevertheless, when the average daily distance traveled is used, as a measure of exposure, to make the comparison between taxis and other vehicles as fair as possible, the result is that taxis are under-represented, as presented in Table 7 using the following relationship:

$$\text{Acc. Rate} = \frac{\text{No. of Accid. per year} \times 1{,}000{,}000}{365 \times \text{avg. daily traveled distance per veh.} \times \text{No. of vehicles}}$$

Note that the above formula can be modified for injury rate or fatality rate.

Table 7. Accident comparison considering vehicle kilometers driven

Item	Accident rate*	Injury rate*	Fatality rate**
Taxis	0.92	0.14	0.73
Other vehicles	1.98	0.19	1.61

* per million vehicle kilometers driven.
** per 100 million vehicle kilometers driven.

It is obvious that when the measure of exposure is considered, both involvement and severity rates of other vehicle accidents seem higher than those of taxis. Although, accident involvement of taxis in Riyadh is lower than that of other vehicles, there is room for improvement. Reducing the relatively high daily distance traveled by a taxi driver will improve safety.

Cause of accident

Table 8 presents the distribution of taxi accidents by cause. The major contributing cause of the taxi accidents is Followed Too Closely (FTC) (26.8%) followed by Not Giving Priority (NGP) (25.8%), and Speeding (18.5%). These three causes, accounting for 71.1% of all accidents, can be described as being a category of improper driving behavior in which the driver is the key factor.

Table 8. Distribution of accident causes by those taxi drivers at fault

Cause	Accidents		Driver error	
	Count	%	Count	%
Speed too fast	58	18.5	54	93.1
Disregarded red light	23	7.3	18	78.3
Followed too closely	84	26.8	81	96.4
Drove wrong way	12	3.8	12	100
Flailed to give yield	81	25.8	75	92.6
Unknown	56	17.8	50	89.3
Total	**314**		**290**	

Type of accident

The majority of taxi accidents are a multi-vehicle (90.1%), as shown in Table 9. Fixed-object accidents place second (5.1%), followed by pedestrian accidents (4.5%).

Table 9. Distribution of accidents by type

Type of accident	Count	%
Vehicles	283	90.1
Fixed object	16	5.1
Overturn	1	0.3
Pedestrian	14	4.5
Total	**314**	

Type of collision

The largest number of taxi accidents is sideswipe type (38.2%). Rear-end accidents are second (31.8%), followed by right-angle accidents (21.3%).

Driver error

Table 8 presents the causes of taxi accidents along with the percentages of drivers at fault for each cause. It is clear from the table that the percentages of drivers at fault are very high for all causes, between 78% and 100%. That is, the proportion of taxi drivers being at fault in the study sample is 92% (290/314). Thus, the probability of a taxi driver being at fault in a traffic accident is high. This indicates that the long driving hours and the long distance traveled daily by a taxi driver may put the driver at high risk of being in an accident as well as being at fault.

Comparison with other vehicles

With regard to accident cause, accident type, and collision type, comparison of proportions between taxi-related accidents and other-vehicle-related accidents (other vehicles mean all vehicles excluding taxis) in Riyadh was also determined. This type of comparison gives additional understanding of the magnitude of accident involvement for taxi vehicles, compared with other vehicles in the traffic stream.

First, the following hypothesis is stated:

H_o : $p_i - p_j = 0$ (i.e, $p_i = p_j$) (i.e., no difference between the two proportions)

H_a : $p_i - p_j \neq 0$ (i.e., $p_i \neq p_j$) (i.e., difference exists)

Testing the hypothesis was conducted by constructing the lower and upper limits for a confidence interval at 5% level of significance. The formulation of the confidence interval for the two proportions as stated in the null hypothesis above is given as:

$$(\hat{p}_i - \hat{p}_j) \pm t_{\alpha/2}\sqrt{\frac{\hat{p}_i(1-\hat{p}_i)}{n_i} + \frac{\hat{p}_j(1-\hat{p}_j)}{n_j}}$$

where

p_i = proportion for item i in comparison for taxi vehicles.

p_j = proportion for item j in comparison for other vehicles.

n = sample size for *i/j*.

According to the testing hypothesis procedure, the null hypothesis is accepted when the above interval includes zero, otherwise, it is rejected.

The test output in Table 10 shows that the null hypothesis is rejected for speeding, following too closely (FTC), and wrong way (WW) proportions. The proportion of taxi-related accidents due to following too closely (27%) is about twice as high as that for other vehicles (15%) [3]. This might reflect the aggressiveness of taxi drivers.

Table 10. Comparison of causes between taxi accidents and other vehicle accidents for Riyadh

Cause	Other vehicles	Taxis	Lower limit	Upper limit	Test decision
Speed too fast	0.29	0.19	0.05	0.15	reject
Disregarded red light	0.07	0.07	-0.03	0.03	accept
Followed too closely	0.15	0.27	-0.17	-0.07	reject
Drove wrong way	0.07	0.04	0.01	0.06	reject
Flailed to give yield	0.22	0.26	-0.09	0.01	accept

It is clear from Table 11 that the difference in proportions of collisions with other vehicles is statistically significant. Similarly, the fixed-object and pedestrian proportions from both populations are significantly different.

With respect to collision type, presented in Table 12, sideswipe and rear-end collisions are the most frequent type for taxi-related accidents. Since taxi-related accidents due to "following too closely" is about twice as high as that for other vehicles, it is not surprising that the proportion of rear-end collisions is higher by 11% than that for other vehicles. The big difference in sideswipe-collision proportions (16%) might be attributed to the practice of taxi drivers picking up passengers, who waive for a taxi.

Table 11. Comparison of accident types between taxis and other vehicles in Riyadh

Accident type	Other vehicles	Taxis	Lower limit	Upper limit	Test decision

Vehicles	0.69	0.9	-0.25	-0.17	reject
Fixed object	0.09	0.05	0.01	0.07	reject
Pedestrian	0.14	0.05	0.07	0.12	reject

Table 12. Comparison of collision type accidents between taxis and other vehicles

Collision type	Other vehicles	Taxis	Lower limit	Upper limit	Test decision
Right angle	0.34	0.21	0.07	0.17	reject
Sideswipe	0.22	0.38	-0.22	-0.1	reject
Rear-end	0.21	0.32	-0.17	-0.06	reject
Head-on	0.2	0.09	0.08	0.15	reject

Risk index

One way to compare the level of accident-involvement risk of a certain group in a population is by using the Risk Index (RI) measure [11]:

$$\mathrm{RI} = \frac{\text{percent accident involvement in group}}{\text{percent population in group}}$$

This measure is used in this study to investigate the extent of involvement of two factors, namely, nationality and age of driver, in a quantified manner. Although the Pakistani drivers represent the largest portion in the driver population, their risk index is the least, as shown from Fig. 2. It is clear from this figure that the Bangladeshis (Bangalians) and Indian drivers are the most likely groups to be involved in accidents among the four groups of nationalities shown in the figure. The risk indices for these two groups are larger than 1.0, indicating that they are involved in a disproportionate number of accidents relative to their proportion of the driver population.

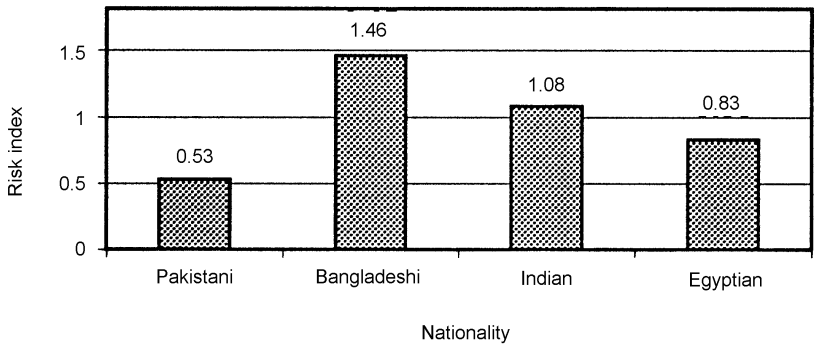

Fig 2. Risk index for driver nationality.

Among age groups, the thirty-five-year and less groups are at higher risk than older groups (> 35 years). It is noticed that the age group of 31-35 is involved in a

disproportionate number of accidents relative to their proportion of the driver population. Figure 3 shows a big drop after the age group 31-35. This might raise a question about the capability of relatively young drivers (35 year or less) to work in the taxi service industry.

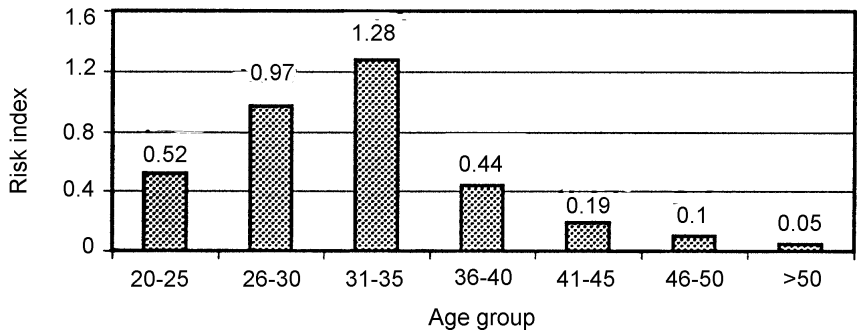

Fig. 3. Distribution of age groups by risk index.

Conclusions and Recommendations

In this study, taxi service in Riyadh has been evaluated from a perspective of operation and safety. Data gathered from taxi companies and drivers, and accident reports were analyzed, and interpretation of such analysis was carried out to reach practical recommendations for improving operational and safety measures (i.e., reduction of accident involvement and severity) of this transport service.

It appears from this study that there is an over-supply problem in taxi-service in Riyadh resulting in about 72% of the daily distance traveled by a taxi being non-productive. As a result, a lower occupancy rate exists.

Although the MOC has set clear regulations for the taxi industry, the study shows that not all of these regulations are being enforced. For example, though national regulations require taxi drivers to have a General Driving License, approximately 43% of the drivers in Riyadh, do not carry this type of license. The violation of daily working hours is another example of how taxi companies are not following existing regulations. That is, the regulations establish the daily working hours to be no more than 8 hours; however, this study found that 95 percent of drivers work 16.75 hours or less. The study shows that the primary cause of this illegal practice is the under-table payment policy set between the firm and the driver. That is, about 97 percent of the companies relate the income of the driver to his daily revenue without any restriction on working hours. Most of these companies ask the driver to pay, on a daily basis, a fixed amount of money, to the firm. The higher the daily revenue is, the more money the driver can make. As a result, the driver is pushed indirectly to work most of the day (on

average 14.65 hours and traveling 407 kms) and almost all the days of week (on average 6.7 days per week). This situation leads to higher accident involvement as well as violation commitment due to fatigue and stress expected from being on the road for long periods of time.

This study also observed that drivers from eleven nationalities work in the taxi service. The predominant nationalities are Pakistani, Bangladeshi, Indian, and Egyptian. Although regulations urge that a taxi firm must have Saudis for at least 25 percent of its driving force, no Saudi driver was observed during this study. About one-fifth of the drivers learned to drive only when they started in this service. Again, this is against national regulations, which require the driver to have a driving career and experience before he can start working in this service.

Although, available information seems to indicate that taxis are involved in a disproportionate number of traffic accidents, when compared with other vehicles operating on the same roadway system, the study found that this is not true when a measure of exposure is taken into account. Yet, the analysis of accident data indicates that there exists room for safety improvement.

The recommendations reached in this study are summarized as follows:

- The gap between the existing regulations governing this service and the actual regulations enforced should be narrowed though strict law enforcement. It is obvious from the findings of this study that the absence of such enforcement contributes substantially to the violation of the regulations which were instituted, in part, to increase safety.
- The operation of this service should be managed on an on-call basis. That is, the taxi vehicle should not be on the road unless a customer calls. This requires a big change in the existing strategy of operation. In other words, each firm should have an operation's room to receive a customer call and respond quickly, by dispatching a vehicle to the customer's location. One useful function of the operation's room would be the ability of the firm to monitor and control the vehicle's movement through a wireless communication with the driver. Hence, the technology of wireless communication should be allowed for this service. This way, the problem of being on the road for a long duration of time would be eliminated, and thus, the risk of being involved in accidents could be reduced.
- The high level of involvement of taxi drivers in improper-driving-behavior-related accidents suggests the need for a safety campaign consisting of educational programs in order to make the drivers aware of traffic rules and to understand their responsibilities towards other road users.
- The high accident risk for the drivers at 35 years or below, compared with those older that 35, needs additional investigation in order to determine their capability of being in this business or the need to be given special training programs.

- There should be a log-sheet used by a driver to fill out all related-trip information. The data collected from the log-sheet can be very useful for the owner, MOC, and interested researchers in conducting detailed analysis for the purpose of evaluating the performance of the driver as well as the taxi service overall.

- Recently, MOC has introduced some major changes in the regulating policy of the taxi service. A similar future study can be conducted 'after' the new regulating policy is fully implemented. Consequently, the current study can be considered as a 'before' study to evaluate the recent changes through what is called in statistics before-and-after analysis.

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Appendix

Estimating of Non-productive Traveled Distance

Before estimating traveled distance without a passenger (non-productive kms), an explanation of the background on taxi fare policy in Saudi Arabia, which is the responsibility of MOC, should be given. Taxi fare structure in Saudi Arabia follows the meter charge scheme. MOC specifies national rates that must be followed by all taxi firms in the country. Thus, each taxi vehicle must install a fare meter. There are several types of charges that can be placed on meters [2]: (1) flag drop charge (opening door tariff), (2) additional kilometers charge, (3) waiting time charge, and (4) traffic delay (live clock) charge. Only the first three types are adopted by MOC with the following rates [1,8]:

1) Flag drop charge = SR 5.00 (flag drop distance = 2 km)
2) Additional kilometers charge = SR 1.40 for every 1000 meters
3) Waiting time charge = SR 0.50 for every one minute.

The above rates are adopted on the basis of a 15% return on investment in vehicles only.

The aim herein is to use the above fare data along with the observed data to estimate the revenue kms (productive kms) driven daily by a taxi. For this purpose one can formulate the relationship between the average daily revenue trips, and travel distance, as following:

$$y = (n \times t_1) + (d - 2n) \times t_2 \quad (1)$$

where

y = average daily revenue (SR200).
n = average number of daily trips.
D =average daily revenue distance traveled (kms).
t_1 = opening door tariff (SR 5.00)
t_2 = additional kilometer tariff (SR 1.40 per km).

From the driver survey, the average daily distance traveled is 407 kms per day. This distance consists of productive kms (while a taxi is occupied by a passenger) and non-productive kms. Thus, the productive kms can be calculated as follows:

$$d = \frac{y + 2nt_2 - nt_1}{t_2} \quad (2)$$

Substituting the fare and observed data in the right-hand side of the above relationship results in the following:

$$d = \frac{20 + 18.64(2 \times 1.4 - 5)}{1.4} = \frac{158.99}{1.4} = 113.57 \qquad \text{km} \quad \text{(around 114 km)}$$

which is the total daily revenue distance.

Thus, a taxi driver, whose average revenue is SR 200 per day (with the assumption that the fair meter is used), travels about 114 km every day, on average, as revenue distance. This distance represents the actual taxi utilization. Again, we know that the daily travel distance is 407 km, therefore, the non-productive daily distance traveled is

407-114 = 293 km

This distance, during which a driver is cruising the streets looking for a customer, accounts for 72% of the daily distance traveled by a taxi. Hence on average, only 28% of the taxi drivers daily distance is producing revenue. This result is consistent with another study which indicates that the taxi driver makes 69% of daily trips with no passengers [2].

خصائص خدمة سيارات الأجرة وتورطها في حوادث الطرق المرورية في مدينة الرياض

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(استلم في ١٩٩٩/٣/١٥م؛ وقبل للنشر في ١٩٩٩/١٠/١٠م)

ملخص البحث. تتميز الرياض، عاصمة المملكة العربية السعودية، بأنها مدينة عصرية تعايش نموا سريعا، حيث يبلغ عدد سكانها نحو ثلاث ملايين نسمة. عاصرت بعض عناصر نظام النقل في هذه المدينة تطوّرا على أسس ومعايير حديثة، إلا أن ثمة عناصر أخرى يمكن القول إنها مازالت في مرحلة انتقالية نحو التحديث. وفيما تعد خدمة سيارات الأجرة من عناصر النقل المهمة في كل الأحوال، فقد مرت بتغيرات خلال العقد الماضي في هذه المدينة. تشير المعلومات المتاحة إلى أن اشتراك سيارات الأجرة في حوادث المرور لا يتناسب مع عدد هذه السيارات عند مقارنتها بحوادث السيارات الأخرى. كشفت هذه الدراسة غير ذلك حين يؤخذ مقياس التعرض المروري في الاعتبار. تقدم هذه الورقة بعض الخصائص الأساسية التشغيلية لخدمة الأجرة العامة في مدينة الرياض، كما تقدم تحليلا لأنواع الحوادث التي تشترك فيها سيارات الأجرة. تستند الدراسة إلى عينتين من سائقي الأجرة العامة وشركاتها، وأيضا إلى عينة من تقارير الحوادث المسجّلة لسيارات الأجرة. تخلص الورقة إلى توصيات عملية يتوقع أن تسهم في الحد من حوادث هذه الخدمة.