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Presence of passengers: Does it increase or reduce driver's crash potential?

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ABSTRACT

This study examines the impact of passengers on the driver's crash potential on freeways. To estimate the impact, a set of bivariate probit models were developed using the 5-year (1999–2003) crash records on a 36.3-mile stretch of Interstate-4 freeway (I-4) in Orlando, Florida. Bivariate probit models identify the correlation between potentially inter-related choices of three passenger characteristics and three crash characteristics. The analysis using bivariate probit models showed that there exist strong correlations between passenger and crash characteristics. It was found that drivers generally display safer driving behavior when they are accompanied by passengers, and more passengers reduce driver's crash potential. It was also found that younger driver's crash potential increases with the presence of a younger passenger only. In addition, the analysis of crash type using traffic flow parameters at the time of crashes showed that young drivers with only younger passengers are more likely to be involved in single-vehicle crashes in high-speed and low-volume conditions. The findings in this study provide insight into how the presence of passengers has an impact on driver behavior and traffic safety in various conditions.

1. Introduction

There have been debates whether the presence of passengers positively or negatively affects driver behavior leading to crash occurrence. While some studies suggested that passengers prevent drivers' risky driving behavior, some studies suggested that passengers distract drivers and consequently increased crash potential. These contradictory effects take place depending on the characteristics of drivers and passengers such as age and sex. For instance, crash potential is reduced when middle-age passengers accompany teenage drivers as guardians whereas crash potential increases when teenage passengers accompany teenage drivers. Thus, it is important to identify the correlation between passenger characteristics and crash characteristics to evaluate the effect of passengers on crash potential.

In this regard, some studies have shown that passengers may reduce driver's risky behavior (Isaac et al., 1995; Vollrath et al., 2002; Hing et al., 2003; Rueda-Domingoa et al., 2004) while others have shown that they distract and increase driver's crash potential (Doherty et al., 1998; Cooper et al., 2005; Simons-Morton et al., 2005). The latter findings have been focused on teenagers and younger drivers. In fact, these contradictory effects depend on driver's and passenger's demographic factors (e.g. age, gender). For instance, Rueda-Domingoa et al. (2004) found that the presence of passengers had more protective effect for older drivers than younger drivers in Spain. However, they found that the protective effect of passengers differ by the age of passengers. Some studies focused more on the specific high-risk driver age group (e.g. teenage drivers) and their crash risk associated with the presence of passengers. Doherty et al. (1998) found passengers have a negative effect on crash rates for particularly teenage drivers. Similarly, Cooper et al. (2005) observed that younger drivers are distracted, rather than being protected, when they are accompanied by younger passengers. They observed that restricting teenage passengers who accompany new teenage drivers significantly reduced the crash involvements of teenagers in California. Similar findings were also reported in Lam et al. (2003). Williams and Shabanova (2002) also found that teenage drivers are less likely to wear seatbelts when they are carrying more teenage passengers. Some researchers suggested that passenger's gender also has influence on risky driving. For example, Simons-Morton et al. (2005) observed that teenage drivers displayed more aggressive driving behavior (indicated by mean speed higher than posted speed limit and shorter headways) when they were accompanied by male teenage passengers than female teenage passengers.

In some cases, injury severity of crashes was also related to the presence of passengers. Preusser et al. (1998) reported that the young drivers (younger than 24) are more likely to be involved in

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fatal crashes than older drivers when they are accompanied by passengers. Similarly, Lin and Fearne (2003) found that the presence of passengers increases the likelihood of a fatal injury of young drivers. On the other hand, Isaac et al. (1995) reported that alcohol-impaired drivers are less likely to be fatally injured when they are accompanied by passengers. They suggested that this is because unimpaired passengers can reduce the risk of alcohol-involved crashes. Some studies focused on the injury severity of passengers involved in crashes. Williams and Wells (1995) observed that the death rate of teenage passengers relative to older passengers is higher than the death rate of teenage drivers relative to older drivers. They also reported that two-thirds of total teenage passengers killed in crashes were driven by teenage drivers. In particular, the passenger's seat (e.g. front or back/driver-side or passenger-side seat) in vehicles is also closely related to the injury severity of child passengers (Glass and Graham, 1999).

The number of passengers is also a significant factor affecting crash risk. Keall et al. (2004) found that the crash risk of driving with more than one passenger is higher than the risk of driving alone or driving with a single passenger. Doherty et al. (1998) suggested that the number of passengers should be restricted for novice/young drivers to prevent the distraction from passengers. Hing et al. (2003) found that older drivers (75 or older) were more involved in crashes when they carried two or more passengers. They suggested that this may be because drivers are more likely to be distracted by more passengers.

In fact, the presence of passengers is more effective in reducing crash risk under certain traffic, environmental and road geometric conditions. For instance, Vollrath et al. (2002) observed that the presence of passengers can help reduce crash risk particularly when traffic is moving slowly and lighting is dark. This finding seems to suggest that passengers help relieve drivers' impatience during traffic congestion and improve drivers' visibility in dark condition (or potentially relieve driver's fatigue during nighttime driving). The positive impact of passengers on reducing crash risk in adverse weather condition, particularly for older drivers, was also found in Hing et al. (2003). This study also found that crash risk is higher with the presence of passengers on curved road sections with higher grade.

From the review of the past studies, driver and passenger characteristics are important factors affecting crash risk and particularly the certain combinations of driver–passenger age groups (e.g. young drivers accompanied by young passengers) have higher crash risk. Also, the effects of traffic, environmental and road geometric factors on crash risk vary with the presence or absence of passengers. The presence of passengers has generally positive effects on reducing crash risk under congested traffic and adverse weather conditions.

However, there exist some limitations in these past studies. First, most statistical models used in the analyses do not properly take into account the potential correlations of inter-related variables such as the presence of passengers and crash potential. In other words, most models only describe the relationship between one dependent variable and a set of explanatory variables, but do not consider the correlation of multiple dependent variables in different equations that are simultaneously estimated. Second, most studies overlooked the combined effect of traffic flow parameters with the presence of passengers in the analysis. Although Vollrath et al. (2002) considered this effect, the parameters used in their study are subjective and qualitative measures of traffic density (e.g. dense, slow traffic) and it is difficult to determine the general quantitative effect of traffic flow on crash potential. Thus, more objective and quantitative measures of traffic flow should be used to identify its impact on crash potential associated with the presence of passengers.

Thus, the objectives of this study are (1) to develop the models that consider the correlation of inter-related choices associated with the presence of passengers and crash potential, and (2) to identify the traffic conditions leading to crashes with the presence of passengers using the short-term traffic flow data at the crash time. From this analysis, we can better understand the complex interactions among driver/passenger characteristics, traffic/environmental conditions, road geometry and crash potential.

2. Data description and preliminary analysis

This study used 5-year crash data that have occurred on a 36.3-mile stretch of Interstate-4 freeway (I-4) in Orlando, Florida. This stretch was chosen since inductive loop detectors were installed in every 0.5 mile on this section of the freeway. These data were extracted from the Florida Traffic Crash Records Database. A total of 2817 crashes occurred on the mainline freeway from 1999 to 2003. Since more than one driver was involved in some of these crashes, one driver was randomly selected from each multi-vehicle crash (regardless of driver citation) to avoid over-representation of crashes where many drivers are involved. For each crash, the information on the selected driver and his/her passenger(s) (if the driver was accompanied by at least one passenger) including driver's age and gender, and passenger's age was collected from the database. Due to the absence of the information on passenger's gender from 1999 to 2001, passenger's gender was not considered in this analysis. In addition, the information on the time of crash occurrence and environmental conditions at the crash time was also collected. It should be noted that since the presence of passengers was only known for the drivers who were involved in crashes, not for driving population, exposure could not be measured. Instead, the sample of non-cited drivers was considered as a comparison group relative to cited drivers in order to estimate the likelihood of individual driver's citation when passengers were present (i.e. the effect of the presence of passengers on driver citation). Thus, the term "crash potential" in this study essentially implies the relative likelihood of crash causation by specific driver group with or without passengers compared to other driver groups.

Given that traffic and road geometric conditions are also important factors affecting crash potential associated with the presence of passengers, traffic flow characteristics prior to the crash time were obtained from loop detectors close to the crash sites, and the curvature of road sections was also obtained. Traffic flow parameters include 5-min average speed, volume and occupancy 5–10 min prior to the time of crashes. The road section is classified into the curved section ($0 <$ radius of curvature ≤ 3000 feet) and the straight road section (otherwise).

Among 2817 crashes, approximately 62% of the selected drivers drove alone and 38% of them were accompanied by at least one passenger. The list of variables related to crashes is summarized in Table 1. Using the data set including all the selected drivers, the composition and behavior of drivers with and without passengers were compared in terms of the following factors (categories in parentheses): driver's age (younger, middle or older), driver's gender (male or female), residence (local or non-local), alcohol/drug use (yes or no), seatbelt use (yes or no), citation for crash occurrence (at-fault or not-at-fault) and day of week (weekdays or weekends). A Chi-square test was performed to compare the proportions expressed as percentages of drivers with and without passengers for the corresponding category. The p-value less than 0.05 indicates that two proportions are significantly different at a 95% confidence level.

As shown in Table 2(a), As shown in Table 2(a), the results of the Chi-square test (i.e. low p-values) indicate that among the drivers involved in crashes, the proportion of the drivers with passengers