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Original Research Paper

The effect of time of day on driver's injury severity at highway-rail grade crossings in the United States

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ABSTRACT

Based on the Federal Railway Administration (FRA) database, there were totally 25,945 highway-rail crossing crashes happened in the United States between 2002 and 2011. With an extensive research, analysis results showed that there were substantial differences by time of day for driver's injury severity at highway-rail grade crossings. However, there is no published study on time of day analysis of driver's injury given that a highway-rail grade crossing crash happens. This study applied ordered probit models to explore the determinants of injury severity for motor vehicle drivers at highway-rail grade crossings. The results show that motor vehicle driver's injury severity in highway-rail grade crossing crashes that happen during a.m. peak, p.m. peak, and p.m. off-peak is extremely higher than other time periods. However, speed control will significantly reduce driver's injury severity. In addition, crashes that happen during early morning, a.m. peak, and p.m. peak are more likely to be influenced by vehicle speed and train speed compared with other time periods. Paved highways will significantly help to reduce driver's injury severity at highway-rail grade crossings. Drivers during peak hours, early morning and p.m. off-peak are more likely to be influenced by unpaved roadway compared with other time periods.

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1. Introduction

Vehicle-train crash collisions are the most dangerous traffic crashes at highway-rail grade crossings because the average weight ratio of a train to a motor vehicle is about 1–4000 (Yan et al., 2010). Based on the Federal Railway Administration (FRA) database, there were 25,945 highway-rail crossing crashes in the United States between 2002 and 2011. Although the annual average collision rate for highway-rail grade crossings is relatively lower compared with highway crossings, these highway-rail crossing collisions result in higher fatality rates making the study of them critically important.

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There are approximately 25,945 highway-rail grade crossings in the United States. Among these crossings, approximately 39 percent are privately owned and the other 61 percent are publicly owned. Although the number of collisions at highway-rail grade crossings has bean reduced, it is still high and needs to be further reduced.

The initial dataset obtained from the FRA database included 25,945 highway-rail grade crossing crashes that occurred in the United States from 2002 to 2011. In addition, these crashes have been distributed differently by time of day, as shown in Fig. 1. Based on previous studies, time of day is classified into the following times: (1) early morning (midnight–6:30 a.m.); (2) a.m. peak (6:30 a.m.–9:00 a.m.); (3) a.m. off-peak (9:00–noon); (4) p.m. off-peak (noon-4:00 p.m.); (5) p.m. peak (4:00 p.m.–6:30 p.m.); (6) evening (6:30 p.m.–midnight) (Stead and Bhat, 2000; Okola, 2003).

1.1. *Research objectives*

Limited previous studies on crash modeling at highway-rail grade crossings aimed to explore the factors that are likely to increase the crash frequency. However, in recent years, modeling driver's injury severity at highway-rail grade crossings has received numerous scholars' interests. With an extensive research, analysis results showed that there were substantial differences by time of day for driver's injury severity in highway crashes (Bougard et al., 2008; Reimer et al., 2007; Qin et al., 2006). However, there is no published time of day analysis on driver's injury severity given that a crash happened by time of day characteristics. In the following sections, a literature review and a description of the data will be provided, followed by a discussion of the model estimation results.

1.2. *Literature review*

Previous studies have been performed to examine the time of day as an influence factor on highway crashes instead of developing separate models by time of day.

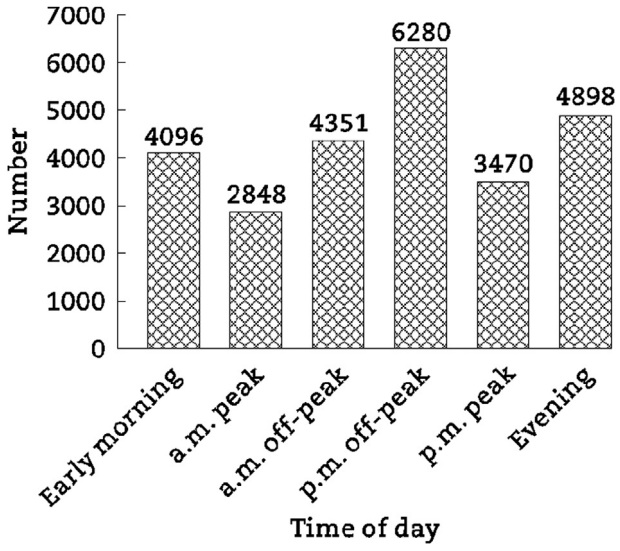

Fig. 1 – Highway-rail grade crossing crash distribution by time of day.

Motorcycle-driving performance by time of day and sleep deprivation was studied by Bougard et al. (2008). Twelve male participants voluntarily took part in four test sessions, starting at 6 a.m., 10 a.m., and 6 p.m., following a night either with or without sleep. The results indicated that motorcycle control at low speed was impacted by time of day, with an improvement in performance throughout the day.

Driving performance by time of day was examined by Reimer et al. (2007). Data were pooled from two driving simulation studies, yielding 79 participants. All subjects were English-speaking active drivers with a minimum of one year driving experience. In the first study, participants were between the age of 18 and 52. In the second study, participants were required to be either younger than 25 or older than 55. The results showed that drivers in the late afternoon consistently drove significantly slower than drivers in other time periods. Time of day had an effect on reaction time and on speed variability measures.

Young driver crashes in the UK were studied with consideration of the influence of age, experience, and time of day (Clarke et al., 2006). A sample of over 3000 crash cases was collected from midland British police forces, involving drivers aged 17–25, and covering a two-year time period (1994–1996). This method relied on the human interpretation of road crash case reported by a special team of researchers with driving experience in several types of vehicle. "Time of day" analysis suggested that the problems of crashes in darkness were not a matter of visibility, but a consequence of the way young drivers used the roads at night. As a result, the crash rate for all drivers that travelled per unit of distance was much higher during darkness than during the daylight.

A study investigated the relationship between crash occurrence and hourly volume for highway segments in Michigan and Connecticut (Qin et al., 2006). The data in this study were collected from different agency resources in the states of Michigan and Connecticut. Hourly traffic volumes from automatic traffic recorders (ATR) were gotten requested from each state's department of transportation, with crash records and road segment characteristics gathered for contiguous highway segments to ensure hourly volume consistency. The study period for Michigan ran from 1995 to 1997 and a total of 32 road segments were used. Compared with the Michigan sample, Connecticut had a smaller sample size of 17 segments along with a longer time period between 1995 and 2000. The author selected time periods of 7 a.m.–3 p.m., 3 p.m.–11 p.m, and 11 p.m.–7 a.m., in order to be consistent with commonly defined work shifts and typical definitions of morning and afternoon peak periods. The binary regression model was used to conduct Bayesian estimation of hourly exposure functions by crash type and time of day. The results revealed how the relationship between crashes and hourly volume varied with time of day, which improved the accuracy of crash occurrence predictions.

The effect of age and time of day on sleepiness for professional drivers was investigated by Otmani et al. (2005). Thirty-six young and middle-aged professional male drivers, free from any sleep disorder, took part in two simulated driving sessions; one was carried out in the afternoon

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