Transportation Research Part F 55 (2018) 314–324

Contents lists available at ScienceDirect

Transportation Research Part F

journal homepage: www.elsevier.com/locate/trf

Are gates at rail grade crossings always safe? Examining motorist gate-violation behaviors using path analysis

Jun Liu *, Asad J. Khattak

Department of Civil & Environmental Engineering, The University of Tennessee, Knoxville, United States

ARTICLE INFO

Article history:
Received 29 September 2017
Accepted 19 March 2018
Available online 5 April 2018

Keywords:
Highway-rail grade crossing
Gate configuration
Gate-violation
Injury severity
Path analysis

ABSTRACT

Gates are installed at highway-rail grade crossings to prevent collisions between highway users and trains. However, sometimes motorists may intentionally go around or through the lowered gates and this behavior often causes severe crashes. The behavior of violating gates is one of the most dangerous actions a motorist might take at gated crossings; it may compromise the intended safety improvement made by adding gates at crossings. This study answers an important research question – what factors are associated with gate-violation at rail grade crossings. Answering this question extends the understanding of correlates of injury severity in rail grade crossing crashes. This study uses path analysis to explore the contributing factors to the gate-violation behavior and the correlation between gate-violation and injury severity. This study investigated 7129 crashes that occurred at gated crossings between 2005 and 2014 in the United States. Results show there is a 9.92% greater likelihood of gate-violation in crashes at crossing with two quadrant gates (compared with four quadrant gates), and gate-violation is associated with a 7.47% larger chance of being killed in a gated crossing crash. Therefore, through the path analysis, the crossings with two quadrant gates is related to a higher possibility of fatality given a crash, owing to the greater likelihood of gate-violation at such crossings. The study identifies the issue of gate-violation at gated crossings, and contributes to enhancing the understanding of gated crossing safety by incorporating pre-crash behaviors at highway-rail grade crossings.

1. Introduction

Gates at highway-rail grade crossings, when activated and fully lowered, provide physical barriers between highway users and trains, and inhibit highway users from illegally entering the crossing zone as a train approaches the crossing (Lenné et al., 2011). Gates are believed to be more effective in reducing the chance of motorists colliding with trains at a grade crossing than other traffic control devices at crossings such as flashing lights, bells and signs. Gates have been widely equipped at highway-rail grade crossings, especially crossings with high-speed train operation, limited sight distance, and/or high-volume highway and rail traffic (Ogden, 2007). According to the current Highway-rail Grade Crossing Inventory provided by the U.S. Federal Railway Administration (FRA), out of 129,469 documented public crossings in 2015, 36% (46,850) have been gated. A small portion of gated crossings (0.6%) have been equipped with four-quadrant gates which block all highway entrance and exit lanes at crossings.

* Corresponding author.
E-mail addresses: jliu34@vols.utk.edu (J. Liu), akhattak@utk.edu (A.J. Khattak).

https://doi.org/10.1016/j.trf.2018.03.014
1369-8478/

Researchers consistently revealed a lower crash frequency or rate at gated crossings compared with other crossing without gates (Austin & Carson, 2002; Park & Saccomanno, 2005; Elvik, Vaa, Erke, & Sorensen, 2009; Raub, 2009). However, it is uncertain that crashes that occurred at gated crossing are less or more severe. Gates provide physical barriers to prevent motorists from colliding with a train, but some motorists may risk themselves by going around or through the lowered gates. Such gate-violation behavior may compromise the intended safety improvement by installing gates. Gate-violation might be the most dangerous behavior a motorist might take at highway-rail grade crossings (Cooper & Ragland, 2012; Liu, Khattak, Richards, & Nambisan, 2015), and it only occurs at gated crossings. It remains unclear what correlates of gate-violation contribute to the severity of crash injuries sustained by a motorist in gate-violation crash. In other words, the behavioral pathway (factors → gate-violation → injuries) that leads to injuries is under-explored. This study develops an integrated framework of path analysis to untangle the behavioral pathway. The objective of this study is to uncover the correlates of gate-violation with associated factors, and link the correlates to the injury severity through rigorous path analysis. The results of this study help transportation researchers and practitioners understand what factors are associated with gate-violation and develop countermeasures to prevent gate-violation at gated crossings.

2. Literature review

Numerous previous studies focused on safety issues at highway-rail grade crossings (Horton et al., 2009; Raub, 2009; Rudin-Brown, Lenné, Edquist, & Navarro, 2012; Khattak, 2013a,b; Russo & Savolainen, 2013; Fan, Kane, & Haile, 2015; Hao et al., 2016; Liu et al., 2015; Liu, Bartnik, Richards, & Khattak, 2016; Liu, Khattak, & Wali, 2017). The frequency of collisions between motor vehicles and trains at grade crossings had substantially dropped during 2005–2009, followed by a relatively stationary number between 2009 and 2014. Researchers attribute the decrease to active traffic control devices installed at grade crossings (Lenné et al., 2011; Liu et al., 2015). Active devices include gates, flashing lights, and bells. They are associated with lower a crash rate at crossings that passive or static control devices that include stop, yield, and crossbuck signs. Further, gates are often associated with an even smaller crash rate relative to other active devices (Austin & Carson, 2002; Park & Saccomanno, 2005; Ogden, 2007; Elvik et al., 2009; Raub, 2009).

However, whether crossings at gated crossings are less severe is uncertain. A study by Witte and Donohue (2000) implied an increased likelihood of fatality in crossings at a gated crossing. As reported, 10–20% of drivers are likely to go around lowered gates and such gate-violation actions often cause severe injuries if a crash occurs. Cooper (2012) found 20.6% of crashes where drivers went around gates were fatal.

Many researchers have explored the FRA crash databases (http://safetydata.fra.dot.gov) to understand the correlates of injury severity with associated factors (Eluru, Bagheri, Miranda-Moreno, & Fu, 2012; Khattak, Clarke, Liu, Wang, & Zhang, 2014; Fan et al., 2015; Hao et al., 2016; Liu et al., 2015; Ghomi, Bagheri, Fu, & Miranda-Moreno, 2016; Haleem & Gan, 2015; Liu et al., 2016; Zhao & Khattak, 2015; Zhang, Khattak, Liu, & Clarke, 2018). The injury severity in a crossing crash was found to relate to various factors including crash features, driver and vehicle characteristics, crash environment, and the intersecting track and highway characteristics.

Some studies (Fan et al., 2015; Haleem & Gan, 2015) clearly showed that traffic controls at crossings are not significantly related to the injury severity in crashes. A study by Liu et al. (2015) linked the injury severity to controls through their influences on driver behaviors, and found significant indirect links between injury severity and controls at highway-rail grade crossings. Gate configurations are possibly related to the gate-violation behavior, i.e., driving around or through the lowered gates at crossings, and therefore may have an indirect association with the injury severity in crashes. This study specifically examines the role of gate-violation behaviors at gated crossings. Gate-violation behaviors may be associated with various factors including gate configurations, and aggravate the injury severity sustained by the motorist involved in a crash at gated crossings.

3. Methodology

3.1. Data preparation

This study used two Federal Railway Administration's (FRA) databases: highway-rail grade crossing accidents/incidents and highway-rail grade crossing inventory. The database of highway-rail grade crossing accidents/incidents documents all reported crossing crashes in United States. This study pulled ten years of crash data (2005–2014) from the database for analysis. This study focuses on the behavior of gate-violation at crossings, and this behavior is only present at crossings equipped with gates. Therefore, the crashes that occurred at gated crossings were particularly identified with respect to the scope of this study.

These crashes the database were originally reported by investigators filling up the form - FRA Form 6180.57. The Form allows investigators to provide details about individual crashes at highway-rail grade crossings, including highway user information, crossing control devices (of the day), crash contexts (weather, time of day, etc.), train speeds, and highway vehicle speeds. In particular, Form 6180.57 documents motorists' actions prior to a crash. Actions include "Went around the gate", "Went through the gate", "Stopped and then proceeded", "Did not stop", "Stopped on crossing", and other behaviors (such as suicide or attempted suicide, went around or through temporary barricade, and unclassified behaviors). This study treats the actions of "Went around the gates" and "Went through the gates" as gate-violation.