



Non-crossing rail-trespassing crashes in the past decade: A spatial approach to analyzing injury severity



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ABSTRACT

Transportation professionals have long recognized the harm of trespassing along railway rights-of-way. However, the non-crossing rail trespassing issue has received less attention compared with highway–rail grade crossing crashes, despite the fact that nearly 8800 rail-trespassing crashes occurred on non-crossing rail tracks during the past decade with a large number of them resulting in fatality. Also, geographic and socio-demographic diversity within the US implies that trespassing crash severity and its correlates may vary across geographic entities or regions. The purpose of this paper is to investigate these issues using rail-trespasser crash data maintained by Federal Railroad Administration ($N = 8794$ over 2004–2013). The unique aspects of the study are the development of a framework that explores correlates of injury severity in crashes and applies appropriate analysis methods. Specifically, using rigorous spatial modeling methods (Geographically Weighted Regression), the study uncovers spatial variations in correlates between rail-trespassing injury and revealed contributing factors. The factors include personal attributes of individuals, environmental and location attributes, time of crash and pre-crash behaviors. The results show that non-crossing trespass crashes are generally severe with 52.1% involving a fatality. Pre-crash behaviors were found to be key factors showing significant associations with the probability of rail-trespassing injury, especially lying or sleeping (on or near tracks). Fundamentally, the basic assumption of spatial stationarity in traditional regression models does not fully hold in the situation explored. Correlates of injury severity are found to be non-stationary across space. Therefore, regional considerations in specific situations should guide the implementation of treatments and policies.

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1. Introduction

While crashes at highway–rail grade crossings with vehicles, pedestrians, bicyclists and other users are a continuing societal concern, a growing concern is train crashes with trespassers on railroad rights-of-way other than designated grade crossings. Railway trespassers are individuals who commit the act of trespassing on the railway property without the permission of the property owner, costing billions of dollars annually in injuries and fatalities. USDOT/FHWA guidance recommends that non-motorist-crossing safety should be considered at all rail grade crossings to minimize pedestrian crossing time and avoid trapping pedestrians between sets of tracks. But there is no such safety guidance at non-crossing trails. Safety at non-crossings is lightly researched and needs to be investigated further. Trespassers not only endanger themselves but also expose railway staff and

passengers to unnecessary delays and strain public services. Rail-trespasser crashes are particularly problematic, as they are associated with more fatalities than any other form of railway-related crashes (Lobb, 2006). In addition, individuals are more likely to be killed or irreparably injured in crashes with trains, compared to the crashes with highway vehicles (Evans, 2003). With rail-trespasser crashes a key concern in the future (due to a resurgence in goods movement through trains in the US), the problem may get worse, if appropriate actions are not taken, e.g., adding surveillance and enhancing public education.

Little is known about people who violate/trespass by crossing, walking or taking other actions along tracks at places other than a designated level crossing. Most trespassers are pedestrians, but some can be people who driving or riding a bike, ATV, dirt bike, snowmobile, vehicles, etc. Investigation into the characteristics of trespassers as well as their pre-crash actions could help in the development of countermeasures to reduce the number of crashes.

To provide valuable information to decision-makers and take advantage of the expansion in computation power, availability of

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geo-referenced data, and geographic information systems, this study investigates injuries in rail-trespassing crashes that occur along railway tracks. It explores (1) how rail-trespassing crashes are distributed spatially in the United States; (2) the correlates of injury severity to trespassers that include personal attributes, environmental and location attributes (e.g., railroad yard), time of crash and trespasser actions, i.e., pre-crash behaviors; (3) how such associations are distributed across the country, given the geographical and social diversity.

2. Literature review

Much of the previous research has focused on rail–pedestrian/bicyclist crashes, especially on crashes at highway–rail grade crossings (Khattak and Luo, 2011; Metaxatos and Sriraj, 2013). The motivations for trespassers to cross railway tracks at improper locations or their presence in other railroad right-of-way areas vary substantially. Taking the shortest or most convenient route by crossing tracks is one of the most common reasons for pedestrian trespassing; people in one of the study reported that the safe, legal route via an overbridge took more time and effort and hence they decided to trespass (Lobb et al., 2001).

A macabre motivation may be the desire to commit suicide. In European countries, most of the rail–pedestrian crashes turned out to be suicides (Van Houwelingen and Beersma, 2001; Silla and Luoma, 2012a,b). In the United States, there is also strong speculation that a substantial amount of rail–pedestrian crashes may be suicides (Savage, 2007). But perhaps lower than in some of the other countries that restrict access to firearms.

Socio-demographics are usually used to draw the picture of train–pedestrian crashes, based on the possibility that people belonging to certain socio-economic groups may be more likely to be involved in trespassing crashes. Children and senior trespassers are vulnerable, though relatively few such crashes involved children under the age of 10 or seniors above the age of 60 (Pelletier, 1997; Silla and Luoma, 2012a). Summarizing a decade of train–pedestrian crashes in Charleston, South Carolina, Cina et al. found that young males accounted for a majority of rail–pedestrian crashes in their data (Cina et al., 1994). They further found that 80% of such crashes involved blood alcohol levels greater than 99 mg/dL. Pelletier reported that trespasser fatalities typically involved unmarried males with less than a high school education (Pelletier, 1997). He also pointed out the problem of alcohol intoxication in such trespassers. Lobb et al. conducted a self-reported survey to investigate the behaviors of individuals crossing the railway (Lobb et al., 2001). Their findings suggested that teenagers and males have more dangerous attitudes and are more likely to walk across railroad tracks.

The time of rail–pedestrian crash occurrence is also a concern in the literature. Silla and Luoma, analyzed documented rail–pedestrian crashes on the Finnish railway network and reported a large portion of crashes occurred in the afternoon and evening and a great number of crashes occurred on weekends. Also summer and winter time had more such crashes than spring and fall months (Silla and Luoma, 2012a). Pelletier found that fatality-involved crashes typically occurred at night at the end of a week (Pelletier, 1997). Lerer and Matzopoulos, report that rail–pedestrian crashes occurred at peak commute times in Cape Town, South Africa (Lerer and Matzopoulos, 1996). Investigations of crash locations have revealed that rail–pedestrian crashes typically occurred in areas with dense population and train activity. Such places included the vicinity of residential communities and train stations and rail yards (Silla and Luoma, 2012a).

Researchers also have found that trespasser pre-crash behaviors have a strong connection with the severity of injury. Pre-crash

behaviors include walking, running, standing, sitting, lying, etc. in railroad rights-of-way. A study based on three-year rail–pedestrian crash records revealed that walking and lying were the two major pre-crash behaviors associated with trespassers (Savage, 2007). Another study found that pre-crash behaviors are helpful in revealing the reasons of the crash occurrence—a large portion of sitting or lying behaviors were strongly suspected to be suicides or intoxicated individuals (Savage, 2007; Silla and Luoma, 2012a).

Prevention of the rail–pedestrian crashes through treatments has been investigated in the literature (Pelletier, 1997; CDCP, 1999; Lobb, 2006; Savage, 2007; Liu et al., 2011; Silla and Luoma, 2011, 2012b,a). Mohanty et al. suggested surveillance and public education as useful ways to decreasing the frequency of rail–pedestrian crashes (Mohanty et al., 2007). Surveillance in particular places that include typical trespassing crash locations, rail yards and highway–rail grade crossings can help. However, it is impractical and cost-prohibitive to monitor all such places. Public education may help people realize the danger of crossing tracks illegally (Lobb et al., 2001). Studies by Mok and Savage indicated that increasing the amount of public educational activities on railway safety can be effective in reducing the number of train-motor vehicle crashes at highway–rail crossings, through investigating crash reductions after a campaign called Operation Lifesaver initiated in the 1970s (Mok and Savage, 2005; Savage, 2006). However, a follow-up study by Savage did not show a relationship between trespassing crashes and the implementation of Operation Lifesaver, owing to two potential reasons: (1) there was simultaneous growth in Operation Lifesaver programs and railroad abandonments (which would decrease train activity and crashes), and (2) Operation Lifesaver mainly focused on risks at grade crossings rather than non-crossings (Savage, 2007). Savage further discussed the associations of educational activities with trespassing behaviors and suggested Operation Lifesaver to redirect some of their activities to places (school and civic groups) located close to the tracks (Savage, 2007). Studies have investigated the effects of three countermeasures (landscaping, building a fence and prohibitive signs) on the frequency of trespassing, and found that fencing can reduce frequency of trespassing by 94.6% (Silla and Luoma, 2011).

Nearly all the above mentioned studies have focused on trespassing crash frequency instead of the crash severity (harm suffered by the trespasser) given a crash, except a study conducted by Pelletier (1997). While a few previous studies have investigated non-crossing trespassing crashes, even fewer have taken advantage of the available computation power that allows more data-intensive spatial analysis of rail–pedestrian crashes. While widely used to assess highway crashes (Levine et al., 1995; Loo, 2009; Plug et al., 2011), spatial analysis has not received a large application in rail trespassing studies. This is partially due to the limited availability of geo-coded rail-trespassing data. However, this situation has improved considerably because the Federal Railroad Administration (FRA) now includes geocode information in its rail-trespassing data, making it possible to apply location-aware modeling methodology to help demonstrate the spatial patterns of rail-trespassing and understand the factors associated with rail-trespassing crash outcomes. Given that rail-trespassing is a national issue, it is of particular interest to use robust spatial visualization and state-of-art modeling methods to analyze relevant data.

3. Methodology

After obtaining the relevant data, the study first conducted univariate analyses for exploring the distribution of variables and descriptive statistics. They provided information about outliers in the data. Data were visualized using spatial statistics methods.

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