Road Safety Policy & Practice

Improving guardrail damage reporting and responding to promote injury prevention in motor vehicle crashes

Meghna Iyer[1], Suzanne Garverich[1] and Alisa Lincoln[1]

[1]*Institute of Health Equity and Social Justice Research, Northeastern University, 360 Huntington Avenue – 314 IV, Boston, MA, USA 02115*

Corresponding Author: Meghna Iyer, 450 Chestnut Street, North Andover, MA 01845, USA. iyer.m@northeastern.edu; ORCID: 0000-0002-1412-6259; Ph: (+1) 978-614-5618.

Key Findings

- Unreported and damaged guardrails are a public health concern.
- Reporting crashes is needed to ensure guardrail maintenance.
- Challenges to reporting crashes causing damaged guardrails exist and include lack of quality data, inaccurate and incomplete reports, and lack of reporting from first responders.

Abstract

Guardrails along roadsides can alleviate the severity of crashes if they function as intended. When guardrails are damaged or not maintained they can contribute to injury and death. There has been an exponential number of lawsuits pertaining to fatalities sustained from guardrails. Research on guardrail maintenance and performance is needed to improve safety. Much of the research on this topic is outdated, does not include sufficient data, or has reporting issues that impact results. To address this gap, a mixed-method sequential study, where quantitative analysis of administrative data informed qualitative inquiry, was conducted to better understand the processes by which damaged guardrails are reported to a state's Department of Transportation. Administrative data from the Federal Highway Administration were analysed to assess factors associated with reporting of guardrail damage. Ten qualitative interviews were conducted with key informants to increase understanding of reporting. Only 26% of crashes involving guardrails were reported to the state's Department of Transportations for repairs. Out of the number of crashes that went unreported, 92% of them had severe guardrail damage. Emerging themes were identified as issues in data quality, variety in reporting forms, and a reluctancy by first responders to report guardrail damage. These results demonstrate the need for greater attention to reporting of infrastructure damage including education for first responders on the importance of reporting crashes and guardrail damage to the Departments of Transportation as well as policy to develop a standardised way for first responders to collect information after a crash.

Keywords

guardrail, infrastructure, prevention, reporting, repairs

Introduction

Transportation policies in the United States (U.S.) have improved public health and contributed to a significant increase in life-expectancy (Boston University School of Public Health, 2015). Eighty seven percent of people 16 and older, or of driving age, are licensed to drive and use this as their primary method of daily transportation (U.S. Department of Transportation/Federal Highway Administration, 2014). Prior to the passage of the Highway Safety Act and the National Traffic and Motor Vehicle Safety Act (1966) which allowed national regulations for motor vehicles and the roads they are driven on, there were 50,894 deaths due to a car crash each year (Bureau of Transportation Statistics, 2016). Improvements have continued to highway safety. However, most recently in

Received: 11/02/2022; **Received in revised form:** 02/05/2022; **Accepted:** 26/07/2022; **Available online:** 10/08/2022

Suggested citation: Iyer, M., Garverich, S., and Lincoln, A. (2022). "Improving guardrail damage reporting and responding to promote injury prevention in motor vehicle crashes" *Journal of Road Safety, 33*(3), 55-60. https://doi.org/10.33492/JRS-D-22-00007

2020 while people drove less due to the pandemic, 38,680 people died in car crashes yielding the highest number of car crashes that included a death in the U.S. since 2007 (National Highway Traffic Safety Administration, 2021). Roadway departure (RD) crashes are known as the "most severe type of crashes" and have been noted to "account for more than one half of the traffic fatalities in the United States" (Li et al., 2017). Although greater than one half of road fatalities in the U.S. are caused by RD crashes, how many occurs through vehicles striking damaged and undamaged guardrails is not known. Similarly, any differences between injury severities, like what may be considered minor or requiring hospitalisation, when vehicles collide with a damaged or undamaged guardrail is also not known.

The Federal Highway Administration (FHWA) has defined a RD crash as a "non-intersection crash in which a vehicle crosses an edge line, a centreline, or otherwise leaves the travelled way" (Li et al., 2017). Guardrails along roadsides and other relevant traffic barriers have the ability to alleviate the severity of crashes and injuries containing and redirecting a vehicle leaving the travelled path. In recent years, there has been an increase in the number of lawsuits related to guardrail functioning and injuries (Li et al., 2017). Few states and organisations have a system in place to monitor the conditions of barriers or guardrails (Howell et al., 2019).

The necessity of maintaining guardrails was first described by the Transportation Research Board (1993) (Michie and Bronstad, 1994). The guardrail type was found to rarely be identified in crash reports as most responding officers were not trained to identify what traffic barrier was used, the guardrail's condition at the time of the impact, or whether it was properly installed (Michie and Bronstad, 1994). The authors noted that this lack of reporting on guardrails may be associated with the increased presence of obsolete systems in guardrails. Obsolete or outdated systems of guardrails may be associated with crashes that included fatalities or injuries (Michie and Bronstad, 1994). Here, patterns of guardrail damage reporting as well as the perceptions of key informants who are experts in the field about guardrail reporting in Massachusetts are examined.

Method

Sequential Mixed Method Study: Quantitative Data Collection and Analysis

Data collected by FHWA and U.S. census data were analysed to examine factors related to under-reporting of guard rail damage as well as subsequent repair. The data from the FHWA consisted of a pilot In-Service Performance Evaluation (ISPE) by the Office of Safety Research and Development on common guardrail end terminals used in four participating states: California, Massachusetts, Missouri, and Pennsylvania (Eigen, 2020). The ISPE data included reports from crashes that involved guardrails.

The reports noted to what extent the guardrails were damaged, the location of the crash, and if the Department of Transportation or a similar agency was notified of the damage. A merged dataset was created with IPSE data and state level census data in the form of median income, the racial demographic, the percentage of individuals living below the poverty line, the level of education, the age breakdown, the percentage of foreign-born individuals, and the percentage of those without health insurance living in the area was added based on the location of the crash.

The necessity of reporting the damage to an agency was quantified through a guide given by the FHWA on what damages warrant immediate repair. First Pearson's Correlations were examined to determine factors associated with frequency of reporting guardrail damages. Once significant factors were determined, three logistic regressions models were built to further examine factors associated with reporting of guardrail damage. All analyses were conducted in STATA 12 (StataCorp, 2021). Once the data were analysed, they informed the development of the qualitative interview guide to capitalise on the strengths of this type of sequential design.

Sequential Mixed Method Study: Qualitative Data Collection and Analysis

Ten qualitative interviews were conducted with key informants in Massachusetts to gain a deeper understanding of guardrail damage reporting. Massachusetts was focused upon since it was one of the states participating in the FHWA pilot study and has made significant efforts to advance motor vehicle safety, resulting in more public data from the state to be used. Participants were identified through snowball sampling and the key informants who ultimately participated in the study had backgrounds as transportation engineers, first responders, trauma doctors, public health professionals, and professors in the field. These characteristics made them experts on transportation and able to share valuable information about the process of reporting and repairing damaged guardrails, including their recommendations on how to best utilise these mechanisms.

The interview guide included seven questions intended to gain a better understanding of the reporting mechanisms for damaged guardrails, the lack of reporting occurring in Massachusetts, socioeconomic factors relating to reporting, and participant recommendations to improve reporting. As noted above, these questions were generated after analyses and review of the quantitative analyses of the administrative data. Interviews continued until saturation was achieved. All interviews were conducted and recorded using Health Insurance Portability and Accountability Act compliant Zoom and later transcribed for analyses.

Transcripts were then reviewed for accuracy and analysed using NVIVO (NVIVO, 2020). An iterative coding process was used starting with summary tags to create a preliminary code list. Codes were refined to be more

concise and then applied to all the transcripts. Every fifth transcript was reviewed by a second coder and revisions were made until consensus was achieved. Code reports were then analysed to identify patterns, themes and concepts to give meaning to the data and memos were written on each code to further explain the meanings. Emerging themes of the key informant interviews were analysed to gain a better understanding of the processes used to report guardrail damages.

Results

Quantitative Results

The FHWA maintains data on guardrail damage as reported from 4 states: Massachusetts, Pennsylvania, California, and Missouri (Eigen, 2021). These states consented to partaking in the pilot ISPE study run with the FHWA (Eigen, 2021). In total, four years of data were examined. Across the four states, this included 517 crashes (Eigen, 2021). The analyses found that only 26% of crashes involving guardrails were reported to the Department of Transportation (DoT) for repairs. Among crashes that went unreported to the DoT, 92% of them included severe damage to the guardrail. It was also found that 50% of reports of crashes involving guardrails did not list enough information for them to be classified as damaged or not, as determined by the reporting guidelines of the FHWA. Although 90% of guardrails had damage warranting repair, again determined by the FHWA guidelines, 22% of them were not reported at all. Lastly, no associations were found among the census data (sociodemographic factors) used and reporting frequency.

Qualitative Results

Three primary themes emerged from the qualitative data examining guardrail practices in Massachusetts that provide further knowledge related to the reporting processes for damaged guardrails: involvement of first responders, databases of guardrail information, and report forms used for the crashes and damages. While other factors were raised in the interviews, such as the framework of the transportation industry focusing on blame as opposed to safety, here the focus is on the top three emerging themes.

First Responders

The role of first responders such as police officers, in car crashes and reporting of guardrail damage was discussed by 80% of informants. Many described how when a crash occurs, a police officer or Emergency Management Team (EMT) responds to the scene. They are required to fill out a report on information about the crash. Massachusetts has additional issues compared to other states because "there's at least nine vendors that have systems with which police departments can enter their crash data" and each is unique. Each report has different fields that are required to be filled out, leaving the officer filling out the form to receive "different and inconsistent messages" about what information is important to write a detailed report. Two informants mentioned that many officers are not motivated to fill out the reports because they believe it is purely "for the benefit of insurance companies", but it is actually used to determine what may have caused the crash in order to prevent it in the future.

In addition, police are required to submit crash reports for crashes with injuries and over $500 of damage. Officers are asked to determine what crashes meet this threshold, which is not something they are appropriately trained to do. Police reporting was described as "behind the times" by one of the informants. Similarly, other agencies have difficulties getting reports from the police. If a guardrail repair company is trying to examine the report to determine what to fix, they are often not able to because they are not listed as the owner of the damaged property by the police officer when writing the report. In these cases, it takes a while for repairs to be made. As a whole, traffic safety initiatives have been known to "take a back seat to major crimes" throughout the country and are dependent on "how high of a priority it is within a department".

Databases of Guardrail Information

Data collection is one of the major sources of errors and contributes heavily to how damaged guardrails get repaired. Ninety percent of informants reported on data collection. As noted above, the majority of data on damaged guardrails is collected through crash reports that are filled out by first responders at the scene. There are several fields that police officers have difficulties with filling out. For example, respondents described that the "Massachusetts State Police has no [method] of tracking locations accurately into [their] system", meaning that police departments are not able to accurately determine where a crash occurred to fill out the location field of the report. The Registry of Motor Vehicles (RAMS) can kick back reports that do not have certain data fields filled and the record management system specific for the Massachusetts State Police where all crash reports are housed does not always talk to other programs, like a Global Positioning System (GPS). There are "five fields or so that are poor and that's one of them" on RAMS.

Another perspective participants had was that many officers feel as though some fields are unimportant based on the situation or do not have enough expertise on crashes to fill out, so they get left blank. The crash report is "saturated with the amount of fields" present and there must be a balance in the number of data points on the field, so that it does not overwhelm officers because "if it takes too long, people aren't going to want to [fill] it" out.

Participants also highlighted the importance of collecting accurate data because it "helps [one] elicit whether or not this was preventable and [if] there's anything [that] can [be done] about it to fix these" crashes.

Another important data collection challenge is related to the number of groups/organisations that have independent

databases gathering related data including insurance companies, roadside service providers, and other agencies. Crash reports also provide beneficial data that "everybody has an interest in from law enforcement to car seat manufacturers". Many key informants believe these databases are "very fragmented".

Report Forms

A second theme related to data on guardrails relates to the forms required to gather data. Seventy percent of informants discussed the impact of report forms. Participants indicated there are approximately 14 different vendors providing a version of the Massachusetts crash report form with different approvals and checks for data in place for each system. Participants described how officers will take some notes when at the scene of the crash and later input them into their software vendor to automatically complete the Massachusetts crash report form. There is some "degradation in the overall [data] quality because of some of the nuances of the different capabilities or fields within the vendors" and people are not always aware of that.

In addition to this, participants described how certain police departments refuse to use the standard state forms. They instead use a general report for any police action, not just for car crashes. The Registry of Motor Vehicles cannot input this data into their system and due to difficulties in this process, informants noted that large cities under-report crashes related to the many demands on their time and effort. As there are multiple vendors, "the people who develop these systems with the police have a right to business". Participants described the ways that these report forms have become a business enterprise, which contributes to the confusion between forms in Massachusetts. Other challenges in the forms and reporting relate to requirements to redact identifying information before they are shared with other parties, which is often done by hand and is time consuming.

Discussion

Results indicate a three-pronged approach of the three E's of public health – engineering/environment, education, and enforcement – are key to fixing both issues in reporting damage to guardrails and adequately maintaining them.

To start with engineering and fixing the environment, different states' policies regarding guardrails require several updates from when they were originally written. Not only have designs and research evolved over the years, but other motor vehicle initiatives have contributed to change the environment of these rails over time (Li et al., 2017). An example of this is how speed limits have changed in certain areas. In Kentucky, the "current guardrail rating program (GRP) was established in 1989 to identify and prioritise guardrail needs and last updated in 2009, but the current "program no longer meets the transportation industry's safety guidelines and policies (Howell et al., 2019). In lieu of this, the Kentucky Transportation Center (KTC) reviewed the literature surrounding motor vehicle safety practices nationwide to determine where the existing rating program could evolve and how to implement it (Howell et al., 2019). There is a need for this considering the impact guardrails have on a state. For example, "the Virginia Department Transportation (VDOT) has installed in recent decades a total length of more than 7,000 miles of guardrail systems with an asset replacement value of close to $1 billion" (Li et al., 2017).

However, many of these traffic barriers are not in working condition and "many [are] approaching or exceeding their service life [as well as] no longer meeting the new U.S. federal and VDOT standards" for guardrails (Li et al., 2017). An important aspect to managing motor vehicle safety "is the allocation of resources [and] prioritising where and when to invest in maintenance and upgrades [which could be] informed by the real-world performance" of guardrails (Li et al., 2017). Each state in the study done alongside Kentucky's system had their own plan detailing the installation of barriers at specific locations and when they should occur (Howell et al., 2019). As a result, the environment and engineering of guardrails are highly variable and must be manipulated to reflect the state's needs.

Education is necessary for first responders in order to maintain a safe environment. There is much to be added to the system of the states to make up for the lack of information on installations and qualities of guardrails. First responders, namely police officers, were an important theme in the qualitative study, being described as having reluctancy to report crashes and damage to guardrails due to a lack of understanding of the importance of this process, thus leaving reports incomplete and unusable.

Having additional training on reporting mechanisms and how crash data can help prevent future crashes has the potential to expedite repairs to damaged guardrails and advance reporting. However, it would be challenging for first responders to forensically examine guardrails to understand if the guardrail in question had been subjected to a past crash and how severe the damage is. In addition, first responders must manage the crash shortly after it occurs and attend to any injuries that may have occurred, ensure the crash site is safe, manage traffic, take statements, assist ambulances at the site, and many other important duties. First responders may not be able to manage guardrails to this extent, but they must create a report immediately following a crash with enough details that someone else, like a traffic engineer, is able to promptly forensically examine the site and repair the guardrail as needed.

Enforcement of these recommendations can be implemented in a multitude of ways to ensure compliance. First, states could create and enforce policies that

would ensure a standardised system of report forms with optimised fields and a centralised database for this information. Second, they could enact checks and balances for first responders and agencies conducting the repairs to prevent issues such as under-reporting from occurring. While other crimes may be more important than traffic safety, it does not mean traffic safety can be ignored. Some departments have separate teams for each crime to prevent this from occurring, but it is entirely dependent on the police department. Lastly, states can initiate ISPEs to continually assess roadway safety and update policies as environments change. Implementing a more encompassing reporting system for guardrail damage and crashes is a national issue and each state has a unique environment that sets the stage for different numbers and types of motor vehicle crashes which requires the necessity of policies and enforcement to ensure appropriate reporting is occurring, which will allow for needed repairs to increase road safety. Some states have been trying to engage these strategies. In addition, there are several unrecorded guardrail strikes with resulting damage, like unreported property damage only or minor injury crashes, which should be reported.

To ensure damaged guardrails are not present on roadsides, there is a need to identify processes, like themed guardrail Road Safety Audits along key routes that have demonstrated RD crash histories and routes with extensive lengths of guardrails, to identify the location and extent of damage of these guardrail strikes. Once a process and program for guardrail reinstatement has been established, enforcing the procedure and following it would be of high importance. The process should be monitored and evaluated for effectiveness after it is implemented.

Limitations of the Study

There are several limitations of this exploratory research. First, there is a lack of research available on the social environment of guardrails. There are many reasons that states have not begun this needed evaluation including, but not limited to: "limitations of data systems, lack of arrangements with the police for timely receipt of crash reports, lack of funding and staff, and lack of perceived benefit [meaning that] agencies are unlikely to invest in evaluation capabilities without evidence that the results can be useful for guiding decisions on selection, maintenance, and replacement" of roadside safety devices (Committee on In-Service Performance of Energy-absorbing W-beam Guardrail End Treatments, Policy Studies, Studies and Special Programs Division, Transportation Research Board, and National Academies of Sciences, Engineering, and Medicine, 2018). This has been noted in a number of the studies regarding traffic barriers to conclude that the "quantification of the effects of guardrails reducing crash severity has been surprisingly limited due to the lack of roadside details in the police crash report and the difficulty with matching the roadside departure crash data with corresponding guardrail inventory" (Li et al., 2017). The pushback in such work is found in both the state and federal levels as the testing being needed is not required by the current system (Schafer-Wilson, Kane, 2015).

Finally, while qualitative interviews were conducted until data saturation was achieved, future qualitative efforts might examine a wider group of stakeholders as the small study sample may limit the robustness of the study findings. In particular, the survey of ten key informants included a range of several professions, meaning that the representation of each profession is small, limiting the ability to draw conclusions across professions or groups of stakeholders.

Future Directions and Implications

The problems in motor vehicle crash reporting and guardrail repairs could be remedied with a monitoring system that is an effort of both entities. The environment/engineering practices of each state should be addressed. States would have the means to adapt to their environments through policy and update engineering processes through conducting ISPEs. Implementing a national monitoring system to document where and how many installations of a guardrail are present would help to track results of ISPEs as well as monitor crash sites. Motor vehicle crash dashboards currently exist in many states, and these practices can be built upon to allow for stricter watch over the trends that result in a gap in safety. Being able to note in the dashboard which traffic barriers are outdated or damaged and where they are located could help track damage and facilitate quick repairs.

To address education, campaigns to teach first responders the importance of collecting information through the crash report and how to identify guardrail damage will help increase efforts by first responders. Programs and policies to provide training and encouragement for police officers to increase necessary reporting could be useful in this effort. Data from past reports submitted can be examined to see if an extremely different number of reports was submitted year to year. A department that submitted well below their expected number of reports could then have a system of being kept in check.

This leads into enforcement, the final approach to focus on. Data quality checks for the number of report forms submitted and for the codes on the crash report would be valuable. Under-reporting of infrastructure or guardrail damage could be reduced through data quality checks, mandatory fields, and a GPS function that automatically fills out locations while saving work for the first responder. Massachusetts can serve as a leader in improving motor vehicle safety by incorporating a reformed reporting system based on the three E's by utilising the perspectives of key players in the reporting and maintenance process through opportunities for growth building upon good efforts already happening.

Conclusions

Combining the three-pronged approach of engineering/environment, education, and enforcement to change policy to yield a centralised system, these components of reporting can work together on the common goal of preventing crashes from occurring to alleviate most issues seen in the motor vehicle crash reporting process as it relates to guardrails and infrastructure. More research is also necessary to further understand the ways in which reporting systems operate and develop new strategies to continually improve them to decrease the number of motor vehicle crashes.

Acknowledgements

We would like to thank the Northeastern University Office of Undergraduate Research and Fellowships for their support in this research.

Author Contributions

MI contributed to the research study development and design, implementation and analysis, and wrote the manuscript. SG and AL contributed to the research study development and design, analysis, and revised the manuscript. All authors have read and agreed to the published version of the manuscript.

Funding

This work was supported by the Northeastern University Office of Undergraduate Research and Fellowships. This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Human Research Ethics Review

The study was fully approved by the Northeastern University Institutional Review Board, performed in compliance with relevant laws and institutional guidelines, and informed consent was obtained from participants. All subjects gave their informed consent for inclusion before they participated in the study. The study was conducted in accordance with the Northeastern University Institutional Review Board, and the protocol was approved by the Ethics Committee of Northeastern University on October 9, 2020 (Project identification code: 20-09-26).

Conflicts of interest

The authors declare that there is no conflict of interest.

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