JOINT TRANSPORTATION
RESEARCH PROGRAM
INDIANA DEPARTMENT OF TRANSPORTATION
AND PURDUE UNIVERSITY

Design of Educational Material and Public Awareness Campaigns for Improving Work Zone Driver Safety

Ricardo Chahine, Prince Adu Gyamfi, Nandhesh Subash,
Wonsang Cho, Krista O. Kelley,
Stacey L. Connaughton, Konstantina Gkritza

SPR-4522 • Report Number: FHWA/IN/JTRP-2022/13 • DOI: 10.5703/1288284317375

RECOMMENDED CITATION

Chahine, R., Adu Gyamfi, P., Subash, N., Cho, W., Kelley, K. O., Connaughton, S. L., & Gkritza, K. (2022). *Design of educational material and public awareness campaigns for improving work zone driver safety* (Joint Transportation Research Program Publication No. FHWA/IN/JTRP-2022/13). West Lafayette, IN: Purdue University. https://doi.org/10.5703/1288284317375

AUTHORS

Ricardo Chahine
Graduate Research Assistant
Lyles School of Civil Engineering
Purdue University

Prince Adu Gyamfi
Graduate Teaching Assistant
Brian Lamb School of Communication
Purdue University

Nandhesh Subash
Communications Specialist
Purdue Policy Research Institute
Purdue University

Wonsang Cho
Undergraduate Research Assistant
Lyles School of Civil Engineering
Purdue University

Krista O. Kelley
Senior Operations Manager
Purdue Policy Research Institute
Purdue University

Stacey L. Connaughton, PhD
Director of the Purdue Policy Research Institute and Professor of Communication
Brian Lamb School of Communication
Purdue University

Konstantina Gkritza, PhD
Professor of Civil Engineering and Agricultural and Biological Engineering
Lyles School of Civil Engineering
Department of Agricultural & Biological Engineering
Purdue University
(765) 494-4597
nadia@purdue.edu
Corresponding Author

JOINT TRANSPORTATION RESEARCH PROGRAM

The Joint Transportation Research Program serves as a vehicle for INDOT collaboration with higher education institutions and industry in Indiana to facilitate innovation that results in continuous improvement in the planning, design, construction, operation, management and economic efficiency of the Indiana transportation infrastructure. https://engineering.purdue.edu/JTRP/index_html

Published reports of the Joint Transportation Research Program are available at http://docs.lib.purdue.edu/jtrp/.

NOTICE

COVER IMAGES

L. McGrannahan-Roberson, personal communication, September 20, 2021.

TECHNICAL REPORT DOCUMENTATION PAGE

1. Report No. FHWA/IN/JTRP-2022/13	**2. Government Accession No.**	**3. Recipient's Catalog No.**
4. Title and Subtitle Design of Educational Material and Public Awareness Campaigns for Improving Work Zone Driver Safety		**5. Report Date** May 2022 **6. Performing Organization Code**
7. Author(s) Ricardo Chahine, Prince Adu Gyamfi, Nandhesh Subash Babu, Wonsang Cho, Krista O. Kelley, Stacey L. Connaughton, and Konstantina Gkritza		**8. Performing Organization Report No.** FHWA/IN/JTRP-2022/13
9. Performing Organization Name and Address Joint Transportation Research Program Hall for Discovery and Learning Research (DLR), Suite 204 207 S. Martin Jischke Drive West Lafayette, IN 47907		**10. Work Unit No.** **11. Contract or Grant No.** SPR-4522
12. Sponsoring Agency Name and Address Indiana Department of Transportation (SPR) State Office Building 100 North Senate Avenue Indianapolis, IN 46204		**13. Type of Report and Period Covered** Final Report **14. Sponsoring Agency Code**

15. Supplementary Notes
Conducted in cooperation with the U.S. Department of Transportation, Federal Highway Administration.

16. Abstract

This project aims to help improve work zone driver safety in Indiana through driver education and public awareness campaigns. The project focused on two specific objectives: (1) to design a public awareness campaign to increase drivers' knowledge and influence positive attitudes about work zone driver safety practices; and (2) to prepare educational materials to be incorporated into driver's education or training curriculum prior to taking a driving test and getting a driver's license issued. The campaign was informed by formative research and conducted using a survey to assess public knowledge and attitudes. Based on these results, campaign messages were designed. The team also designed an education curriculum which consists of three modules and fourteen knowledge questions. This report concludes with recommendations to INDOT for the successful implementation of the public awareness campaign and educational materials that might be applicable to other states as well.

17. Key Words work zone safety, traffic safety education, communication, awareness, attitudes	**18. Distribution Statement** No restrictions. This document is available through the National Technical Information Service, Springfield, VA 22161.

19. Security Classif. (of this report) Unclassified	**20. Security Classif. (of this page)** Unclassified	**21. No. of Pages** 97 including appendices	**22. Price**

Form DOT F 1700.7 (8-72)

EXECUTIVE SUMMARY

Introduction

Four out of five fatalities in work zone crashes across the nation involve drivers and passenger instead of highway workers. The most common type of work zone crash, fatal or not, is a rear-end crash in a work zone's advance warning area. In particular, the areas where traffic is entering or exiting work zones are often more dangerous because drivers may be changing lanes and merging. Compounding the risks is driver inattention (or distraction), which is reported as the most common issue and a major contributing factor to work zones entry and exit crashes.

Considering this context, the project, Design of Educational Material and Public Awareness Campaigns, was developed to improve work zone driver safety in Indiana through driver education and public awareness campaigns. Building on the findings of the public opinion survey from SPR-4441 and inputs from INDOT Statewide Safety and INDOT's Back-of-Queue Task Force, the project focused on two specific objectives (Adsit et al., 2021). The first objective was to design a public awareness campaign. The target population/audience were drivers who already had their licenses. The objectives of the campaign were to (1) increase drivers' knowledge and (2) influence positive attitudes about work zone driver safety practices. The campaign was informed by formative research and a survey was conducted to assess public knowledge and attitudes. Then, based on the survey results, campaign messages were designed. To test the effectiveness of the campaign messages, a pilot test was conducted on a sample of the target population through an online survey. The pilot test provided feedback to improve the effectiveness of materials and messages.

The second project objective involved preparing educational materials for incorporation into education and training curriculums that drivers use prior to taking a driving test and getting a driver's license. The target population includes people who are going for their drivers' licenses for the first time and drivers who are renewing their vehicle registration online. The aim of the educational material was to increase the target audience's knowledge about work zone driver safety practices, such as maintaining proper speed through work zones.

First, formative research was conducted using a survey that was part of project SPR-4441 (Adsit et al., 2021). The survey was administered to approximately 1,000 adults residing in Indiana during the summer of 2020, prior to the official start of this project. The survey solicited information about driver awareness of current and emerging traffic engineering practices and explored public preferences around topics such as mobility, construction scheduling, and travel time reliability. Most importantly, the survey assessed public opinion regarding specific, current work zone traffic control practices and sought to understand driver work zone speeding behavior. The survey also provided insight into communication habits and preferences for both project-related news and real-time driver information. All of this information taken together with demographic, travel behavior, and driver history data allowed us to not only gain a clearer picture of the average Hoosier driver but to better understand how behaviors and opinions about work zone safety vary across a wide variety of groups.

Second, the team conducted secondary research using document analysis. This task focused on examining current research on work zone safety problems, behaviors, and public outreach best practices, and current educational materials produced by organizations nationwide regarding work zone safety. Preparatory documents for driver's tests that implemented work zone safety campaigns and other relevant materials were analyzed. Public campaign messages were designed based on the results of the survey. The efficacy of the public campaign messages was tested using an online survey. The sample of the target population was recruited through the survey platform, Prolific. Additionally, participants were recruited through the Brian Lamb School of Communication's Research Participation System. The survey included both closed and open-ended questions, and extra credit was offered to student participants. Lastly, public awareness campaign messages were edited based on the results from the survey.

Finally, the team designed an education curriculum with three modules and 14 knowledge questions. Module 1 included six knowledge questions that focused on safe driving behaviors in and around work zones. Module 2 included five knowledge questions that focused on safety signs and laws about Indiana work zones. Module 3 included three knowledge questions about merging in work zones with a focus on zipper merge and early merge. The efficacy of the education curriculum was tested using an online survey. The sample of the target population was recruited through the Brian Lamb School of Communication's Research Participation System.

Findings

A public awareness campaign disseminating the top five most effective messages via multiple outlets is recommended. Although each of the 15 campaign messages tested were perceived to be effective at encouraging safe driving behaviors in Indiana work zones, the team recommends that the five messages which received the highest favorable mean scores be used for the campaign's implementation. The messages were designed for each of the targeted driving behaviors using at least one of the four theoretical frameworks. The behaviors targeted in the messages are speeding, distracted driving, tailgating, and unsafe lane moving and failure to yield the right of way. Additionally, three messages utilized the fear appeal strategy.

To measure the overall effectiveness of the campaign, the team recommends that an outcome evaluation be conducted 3 months after the campaign implementation. This outcome evaluation study could utilize a survey design to examine whether the campaign positively influenced safe driving behaviors among drivers in Indiana work zones.

Based on the education curriculum survey results, the team recommends that more images be used in both the driver's manual and the education curriculum to explain safety signs and how to merge in work zones. This would help drivers better visualize and understand merging in work zones. The team also recommends that the driver's manual and the education curriculum include short sentences to encourage easier information retention and recall. Finally, the team recommends that key points in both the driver's manual and the education curriculum be highlighted for greater emphasis and easier information recall.

Implementation

To implement the campaign, several factors should be considered.

1. INDOT should identify the locations of construction projects planned for August 2022 to July 2023.
2. INDOT should identify roadways in Indiana with a history of work zone crashes.

3. INDOT should consider the media consumption habits of drivers who use roadways with a history of work zone crashes.
4. INDOT should consider the cost and budget for all campaign activities.
5. INDOT should identify and coordinate with other organizations and agencies who may have roles to play in the campaign implementation.
6. INDOT should consider who will produce the campaign messages and the amount of time they may need to complete message production.
7. Finally, the campaign should be implemented in two phases.
    a. Phase 1: A pilot test should be run at one of the identified locations that are prone to work zone crashes to test how the implementation would go.
    b. Phase 2 (targeting all the locations): Process and outcome evaluations should be carried out to determine how the campaign is being implemented and whether the campaign has achieved its specific objectives.

CONTENTS

LIST OF TABLES

LIST OF FIGURES

1. INTRODUCTION

1.1 Overview

The Indiana Department of Transportation (INDOT) is a public state-level agency responsible for transportation across the state. INDOT administers safety programs that work on reducing the severity and frequency of crashes in the state, and hence meet state safety goals. To meet these goals, a better understanding of the trends associated with crashes on the roads is needed. This provides insight into the main countermeasures to mitigate the rising numbers of crashes.

On the roadway, work zones are among the areas with a high number of crashes. Of the fatalities incurred in work zones, most, about four out of five, are those of drivers and passengers rather than highway workers (INDOT). Particularly troublesome, are the areas of work zones where drivers must merge or change lanes as they enter or exit. In the work zone, rear-end crashes are the most common type of crash and driver inattention, or distraction, is a frequent contributing factor to these work zone crashes. As warning signs and technologies for alerting drivers approaching the back of a queue already exist, educating drivers when they are obtaining/renewing their license would be a good opportunity to further improve work zone safety.

In view of the above, INDOT is interested in addressing the issue of work zone crashes through enhancing driver education and awareness. A major review of the existing literature, national driver's manuals, and crash data provides a way to understand work zone crash trends, and the best practices to help increase the work zone safety. Ultimately, the review helps identifying key gaps in public awareness and points out misconceptions and potential educational opportunities. Educating drivers when they are obtaining/renewing their license coupled with public outreach campaigns disseminated via different media provides an additional opportunity to improve work zone driver safety.

1.2 Study Objectives

The overall goal of this project was to improve work zone driver safety in Indiana through driver education and public awareness campaigns. This project builds on the findings of the public opinion survey under SPR-4441 and inputs from INDOT Statewide Safety and INDOT's Back-of-Queue Task Force (Adsit et al., 2021). The project goal was broken down into two specific objectives and is accompanied by the respective tasks.

The first objective was to prepare educational materials to be incorporated into driver's education or training curriculum prior to taking driving test and getting a drivers' license issued. The target population or audience include people who are going for their drivers' licenses for the first time and drivers who are renewing their vehicle registration online. The aim of the design of educational material was to increase target audience's knowledge about work zone driver safety practices. For example, maintaining proper speed through work zones will be one of the knowledge items focused on in the learning/exam process. Both formative/primary and secondary research will inform the design of the educational material. The research was conducted by reviewing documents on best practices of work zone driver safety across the nation and identify material that needs to be taught during the learning phase prior to taking the exam and getting a license issued.

Moreover, the project aimed to design a public awareness campaign. The target population/audience was drivers who already have their licenses. The objectives of the campaign were to increase drivers' knowledge and influence positive attitudes about work zone driver safety practices. The campaign was informed by formative research, conducted using the same survey to assess public knowledge and attitudes. Then, based on the survey results, campaign messages were designed and will be delivered via appropriate channels. To test the effectiveness of both educational materials and campaign messages, a pilot test was conducted on a sample of the target population through an online survey. This pilot test provided feedback to improve the effectiveness of materials and messages.

To achieve the research objectives, the following tasks were proposed.

1.3 Formative Research—Survey

This task was conducted as part of a past INDOT-funded project. That project had slightly differing goals from this one. The survey was administered to approximately 1,000 adults residing in Indiana during the summer of 2020 prior to the official start of this project. The survey solicited information regarding awareness of current and emerging traffic engineering practices, explored public preferences around topics such as mobility, construction scheduling, and travel time reliability. Most importantly, it sought to assess public opinion regarding specific current work zone traffic control practices and understand driver work zone speeding behavior.

The survey also provided insight into communication habits and preferences for both project-related news and real-time driver information. All of this information taken together alongside demographic, travel behavior, and driver history data allowed us to gain a clearer picture of not only the average Hoosier driver, but to better understand how behaviors and opinions change across a wide variety of groups.

1.3.1 Secondary Research—Document Analysis

This task focused on examining current research regarding work zone safety problems and behaviors, current research regarding public outreach best practices, and current educational materials regarding work zone safety produced by organizations nationwide. The educational materials analyzed included drivers test

preparatory documents, previously implemented work zone safety campaigns, and other relevant materials.

1.3.2 Design Educational Materials and Public Campaign Messages

The research team built on the results of both survey and document analysis to prepare the educational materials and design public campaign messages.

1.3.3 Pilot Testing of Educational Materials and Public Campaign Messages

An online survey was conducted to pilot test the effectiveness of educational materials and campaign messages. The sample of the target population was recruited through the Brian Lamb School of Communication's Research Participation System. Extra credit was offered to participants. The survey included both closed and open-ended questionnaires. Given the COVID-19 pandemic situation where less physical contact is recommended, using an online survey was practical, cost effective, and efficient. Feedback from the survey participants helped to improve the effectiveness of educational materials and campaign messages.

1.3.4 Final Educational Materials and Public Awareness Campaign Messages

Following the results from the previous task, the final educational materials and public campaign messages were drafted. Recommendations are included on appropriate channels through which campaign messages are delivered to the target population.

1.3.5 Recommendations and Final Report

Based on the study results, the research team offers recommendations to INDOT about how to measure or evaluate the outcome of the public campaign including timelines.

1.4 Organization of the Report

Following this introduction, the focus of the report will first turn to the literature review pertaining to work zones (Chapter 2), the systematic procedure of analyzing the literature and adopting an approach (Chapter 3), campaign message design (Chapter 4), findings and results of the formative study (Chapter 5), and finally, conclusions (Chapter 6).

2. REVIEW OF WORK ZONE-RELATED LITERATURE, DRIVERS' MANUALS, AND CRASH DATA

An extensive literature review was carried out to provide a foundation of existing knowledge on areas of work zone safety, work zone behavior, communication practices in these areas as well as work zone crashes trends. The literature review consisted of an extensive document analysis as well as crash data analysis. The document analysis was conducted on relevant peer-reviewed articles and driver's education materials from Indiana and elsewhere in the United States. The crash data analysis consisted of performing descriptive analyses on crash data from many sources namely the Automated Reporting Information Exchange System (ARIES) and the National Highway Traffic Safety Administration (NHTSA). In other words, the analyses focused on examining current research regarding work zone safety problems and behaviors, current research regarding public outreach best practices, and current educational materials regarding work zone safety produced by organizations nationwide. The information was used to establish a better understanding of the type of tones and appeals used to deliver a certain piece of information and provided the groundwork to prepare the educational materials and design the public campaign messages later detailed in Chapter 3.

2.1 Document Analysis

2.1.1 Peer-Reviewed Articles

Different sources of literature were reviewed to identify the effect of various countermeasures on the reduction of crashes in work zones. The research team excluded any countermeasure involving new technologies such as connected vehicles and autonomous vehicles as this was outside the study scope.

2.1.1.1 Primary factors leading to work zone crashes. Identifying the primary cause of work zone-related crashes is crucial for determining the appropriate countermeasures. Hence, many researchers investigated the pre-crash behaviors in and around work zone areas. The driver's behavior, vehicle types, demographics, and other factors in work zone crashes are subsequently discussed.

Driver Behavior. The most common type of work zone crash was shown to be rear-end crashes, and hence many studies investigated behaviors involving rear-end crashes. A study conducted by Daniel et al. (2000) found that rear-end collisions are the type of crashes that occur the most frequently. They found that the main factors leading to fatal crashes around work zones included losing control of the vehicle, failing to yield to other vehicles, and speeding. Additionally, a work zone study by Weng et al. (2015) examined the link between rear-end crash risk and the driver's merging behavior. The study revealed that rear-end crash risk does not monotonically increase as the merging vehicle speed increases. However, the crash risk would increase if the vehicle merges at a close distance from the work zone. Another study by Wang et al. (2008) indicated that careless driving behavior, speeding, and driving in urban areas increase the risk of rear-end crashes in work zones. Other factors included absence of daylight and poor pavement conditions. The authors also stated

that roadway components highly influence the probability of work zone fatal crashes. For instance, work zone fatal crashes were more likely to occur around intersections, bridges, ramps, and road access points.

Additional studies associated work zone crashes with speeding and careless driving. Liu et al. (2016) revealed that the speed before a crash was positively correlated with the severity of the driver's injuries. It was found that head-on collisions were the most severe crash types in work zones. Debnath et al. (2015) found that the probability of speeding was highly influenced by the speed of surrounding vehicles in work zones. The study noted that more vehicle tended to speed if surrounding vehicles were speeding as well. Another study by Nahidi and Tighe (2019) found that careless driving highly influenced fatal crash risk in work zones. Similarly, Wang et al. (2008) indicated that careless driving was the most predominant contributing factor for work zone fatal crashes.

Vehicle Type. Vehicle type was also found to influence the risk and severity of work zone crashes. Weng et al. (2014) examined rear-end crash risk for four main following-leading scenarios. It was found that the car-truck scenario had the highest rear-end crash risk among all vehicle following patterns. The study suggested that rear-end crash risk, in all four scenarios, increased with the increase in lane traffic flow, as well as the heavy vehicle percentage. Additionally, Nahidi and Tighe (2019) found that heavy truck involvement increased the probability of fatal crashes. Similarly, Liu et al. (2016) found that truck or bus involvement was likely to be associated with more severe crashes. Also, Daniel et al. (2000) found that fatal crashes in work zones are more likely to involve another vehicle. The study also found that trucks were involved in a higher proportion of fatal crashes. The study explained that heavy vehicles can block passenger vehicle's visibility affecting other drivers to increase their speeds or change their merging behavior. Weng et al. (2014) found that crash risk during a merging increases if merging or neighboring vehicles are heavy vehicles.

In view of the above, it can be concluded that the presence of heavy vehicles highly influences work zone crash risk. This has influenced the research team's choice to look at private and commercial vehicles separately when analyzing crash data from ARIES. The detailed analysis can be found in the crash data analysis in Section 2.2.

Demographics. Additional studies found that demographics, including age, of drivers highly influence work zone crash risk. Overall, studies showed that young and elderly drivers were more likely to be involved in work zone fatal crashes. Nahidi and Tighe (2019) stated that drivers aged between 25 and 50 years old were more likely to be involved with fatal collisions. It was also found that a higher number of lanes increases the risk of fatal crashes in work zones. Additionally, Wang et al. (2008) found that 64% of all fatal crashes involved middle-aged drivers (25–64 years old). Younger drivers (less than 24 years old) came second by being involved in 23% of fatal work zone crashes. The study also noted that crashes involving young drivers are more likely to occur on narrow roads and during the night. Another finding from the study showed that middle-aged drivers are more likely to be involved in fatal crashes when both heavy vehicles and alcohol are involved. Understanding the demographics of drivers who are involved in work zone crashes is crucial before selecting the target audience for campaign messages. In this regard, the research team further analyzed age and gender by creating corresponding graphs in the crash data analysis section.

Other Factors. Other factors were associated with work zone crash risk in the literature. While they may not be directly related to the scope of our study, we found it is important to mention them. Nahidi and Tighe (2019) showed that fatal crash risk increased between 8 pm and 6 am. The study also noted that poor visibility was associated with higher fatal crash risk. Ghasemzadeh and Ahmed (2019) also found that lighting and weather conditions highly impacted work zone crash severity. The study showed that severe crashes are more likely to occur during dusk and dawn. This was linked to drivers' sleepiness, inattention, and lack of alertness during these times. The type and location of the work zone were also found to influence the work zone crash risk. Liu et al. (2016) revealed that the interstate work zone crashes were found to be more severe than other work zone types. Rista et al. (2017) found that single and multilane closures showed higher crash rates than other construction types. Crash rates were significantly higher where lane shifts were utilized. They also noted that crash risk was highest for short-duration work zones.

These studies gave insight on the importance of lighting and signage in work zones. Work zone crash risk was found to increase during the dark. Implementing some measures might be necessary to enhance the drivers' visibility, and alert drivers before entering work zones.

2.1.1.2 Countermeasures. Numerous studies investigated countermeasures that were utilized in work zone areas and their effect on the reduction of work zone-related crashes. In this section, different sources of literature were reviewed to identify the effect of various countermeasures on the reduction of crashes in work zones. The research team excluded any countermeasure involving new technologies such as connected vehicles and autonomous vehicles as this was outside the study scope.

Work Zone Signage. One of the most intuitive countermeasures is work zone signage. It is considered to be the easiest and most common method to alert drivers ahead of a construction zone. Signage is often used to instruct drivers about their behavior ahead of an intersection, including speed and merging. However, the effectiveness of work zone signage is often questionable as some drivers fail to follow the corresponding instructions. Thus, a big part of the literature examined

the effectiveness of work zone signages. The literature also sought to understand the effect of different types of signages, the number of signs, and their location, on reducing drivers' speeds is investigated.

The literature often categorizes work zone signage under text, graphic-aided, and graphic. This stems from the fact that the effectiveness each was found to be significantly different (Bai et al., 2011). The study performed field experiments and driver surveys to determine the effectiveness of different forms of Portable Changeable Message Signs (PCMs) on reducing vehicle speed. It was found that graphic PCMs were most effective for reducing speed compared to text PCMs and graphic-aided PCMs. When showcased on graphic-aided PCMs, 88% of drivers were able to interpret the meaning of a work zone sign. Hence, the authors concluded graphic-aided and graphic PCMs were effective in reducing vehicle speeds in the upstream of work zones. Ukkusuri et al. (2017) also revealed that the use of graphic-aided CMSs reduced the mean speed by up to 17% in the speed limit of 65 mph. The authors mentioned that graphics were quicker to interpret by drivers which resulted in a greater reduction of mean speeds.

Additionally, the location and number of work zone signage were determined to have a significant effect on the reduction of driver's speed. Mekker et al. (2016) evaluated the impact of variable speed limit (VSL) signage and found that 50% of passenger vehicles significantly dropped their speed after observing three variable speed limit signs. Also, Banerjee et al. (2019) revealed that the initial VSL sign was effective only if subsequent signs followed it. It was also found that speed photo enforced signs were found to be the most effective compared to both a dynamic speed display sign and a reduced speed limit sign. Ukksuri et al. (2017) found that the location of the text changeable message signs (CMSs) had a significant impact on its effectiveness. The authors suggested placing multiple text CMSs in advance of work zone for maximum effectiveness.

To conclude, multiple signs preceding the work zone drew more attention and motivated drivers more to reduce their speed. Additionally, multiple graphic-aided work zone signages, when implemented head of the work zone, were shown to cause a greater reduction of drivers' speed. This resulted finally in a reduction of work zone crashes.

Law Enforcement. The presence of police in the work zone was determined to have a significant effect on reducing work zone crashes and speed control. Sommers and McAvoy (2013) performed a simulator experiment to evaluate the effectiveness of different countermeasures. They found that the presence of police resulted in a 12.78 mph reduction in driver's speed. This also found that the speed photo enforcement led 12.63 mph reduction in driver's speed. The authors suggested that the physical form of enforcement was significantly effective in the reduction of speed through work zones. On a similar note, Chen and Tarko (2012) found that police enforcement resulted in a 41.5% reduction in the frequency of work zone crashes. Ravani and Wang (2018) also revealed that the presence of police led to major reduction in the overall and 85th percentile speeds. The authors suggested that the police lights, as well as CMS provided by police, encouraged drivers to merge earlier in the case of a lane closure. Additionally, Ukkusuri et al. (2017) showed that police enforcement helped reducing vehicle speeds by 4.4 mph and truck speed by 5 mph in 45 mph speed limit. This eventually contributed to a 41.5% reduction in the frequency of crashes. It was also found that the intensive static enforcement encouraged more higher-speed drivers to reduce their speeds. Brewer et al. (2006) noted that drivers tended to travel faster without the threat of enforcement. It was also found that unless there were indications that active work is taking place, drivers were more likely to maintain their initial speed prior entering the work zone. Similarly, Domenichini et al. (2017) found that the increase of temporary speed limits did not change the mean driving speed in work zones. The study, however, indicated that speed was influenced mainly by the perceived characteristics of the field of view. The presence of police helped reducing speed in work zone areas. The study also found that drivers' perception that their driving behavior is being observed by the police led to a reduction in their speed.

It is important to note that law enforcement is crucial to reducing work zone crashes. However, considering the cost and halo effect of police, the presence of police in work zones might not be adequate for the long term.

2.1.1.3 Main takeaways. Based on the literature review, the research team discovered that rear-end crash was the most frequent collision manner in work zones. It was found that the main contributing factors were careless driving and speeding. Moreover, the literature hinted that the presence of heavy vehicles significantly influenced the work zone crash risk. This led the research team to analyze the passenger and commercial driver's manuals across all states. Also, the research team identified that a graphic-aided message was the most efficient method to encourage the driver's speed. Hence, the research team decided to design campaign messages with graphics to target careless driving and speeding.

2.1.2 Driver's Manuals

The driver's manuals in all states were reviewed. The main aim was to examine the best practices for public outreach regarding work zone safety education. Since driver's manuals are among the primary driver education sources, it was considered appropriate to examine these documents.

The length of the driver's manual was in the range of 40 to 243 pages with Colorado and Virginia's driver's manual being the shortest and New Jersey's driver's manual being the longest. Indiana's driver's manual had 80 pages (Indiana Bureau of Motor Vehicles,

2022), which was considered as short manual compared to other states. The research team specifically focused on the work zone contents in each manual, and the information relevant to the work zone was searched through a word such as "work zone" and "construction." All states except Mississippi contained the information relevant to the work zone in the manual. Hence, driver's manuals from 50 states were reviewed.

2.1.2.1 Organization style. In the manuals, work zone-related materials were presented following two main different style, consolidated, and split. In a *consolidated style* manual, information relevant to the work zone is presented in a single section. Differently, a *split style* indicates that work zone-related information is scattered along different sections of the manual. There are 37 driver's manuals who use a consolidated style to present the information about work zone, whereas the 13 driver's manuals use a split style. Indiana's driver's manual utilized a split style to organize the work zone-related content. The information regarding highway work zone speed limit is located separately with speed limits on different types of roads such as school zone and rural interstate highway. Other work zone-related contents placed in different pages forming a solid section.

2.1.2.2 Use of graphics. The presence of graphics in driver's manuals was also examined. The driver's manual from 40 states uses graphics including diagrams to illustrate the work zone signs, flagger gestures, and work zone equipment. Figure 2.1 illustrates how graphics are used to aid the understanding of work zone-related information. In contrast, 10 states did not include graphics and only used text to address work zones. Indiana's driver's manual included graphics on flashing arrow boards, flagger signals, and construction signs. However, it did not include a graphic on work zone equipment, which needs to be considered.

2.1.2.3 Tones. Two main tones are used in the driver's manuals across the states when presenting work zone-related information. First, we found manuals who utilize an *informational tone*. This type of driver's manual focuses on the description of different work zone-related elements. Hence, these manuals include how each work zone equipment or sign can guide drivers safely though the work zone. Second, driver's manuals utilized an *advisory tone* to present work zone-related information. This type of manuals often uses words, "remember" and "you," to acknowledge the readers about the behaviors to follow such as "you should remember to slow down." Compared to driver's manuals with informational tone, these manuals directly guide readers to follow appropriate behaviors to avoid potential crashes. Also, the driver's manual with advisory tone mentions about the safety of drivers and workers more frequently. Indiana's driver's manual utilized advisory tone to present the work zone-related information. As mentioned in prior, Indiana's driver's manual directly tell what readers should follow in work zone. Sentences such as "you must stop" or "you should proceed slowly" are used in the manual to emphasize what drivers should do while traveling through the work zone.

2.1.2.4 Persuasive tactics. The persuasive tactics of driver's manuals were investigated. The two main types of persuasive tactics used in the driver's manuals were *appeal to safety* and *appeal to enforcement*. The former emphasized the potential danger of drivers, pedestrians, and workers in the work zone. The work zone crash statistics were offered from some states to acknowledge the importance of work zone signs and guidelines that drivers should follow. In contrast, the latter emphasizes on potential punishment that drivers might encounter when drivers do not follow the guidelines. These driver's manuals generally emphasize that fines are double when violating the speed limit or disobeying instructions. For Indiana's driver's manual, the appeal to safety was utilized. The manual indicated that work zone poses danger, and driver should be respectful of dangers and exercise caution. Also, the manual provided the safety tips to emphasize what drivers need to follow while in work zone to avoid any potential danger.

2.1.2.5 Guidance levels. The amount of information in driver's manual varied among different states. There were three broad approaches from the driver's manual, which are limited guidance, moderate guidance, and full guidance.

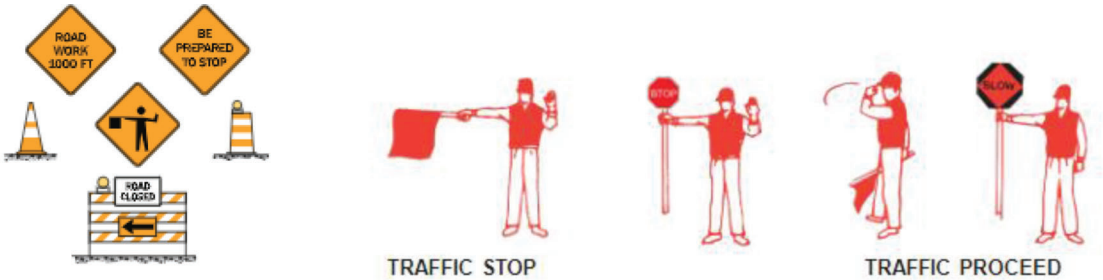


Figure 2.1 Excerpts from (a) Nevada's driver's manual and (b) Alaska's driver's manual (Alaska Department of Administration, 2019; Nevada Department of Motor Vehicles, 2021).

Limited Guidance. The driver's manual with limited guidance offers brief information on the work zone. Generally, these driver's manuals include graphics and description on work zone equipment, work zone signs, and flagger movement. The safety tips provided in these manuals are limited, which only include "slow down" and "pay attention." The description of the work zone is also limited, and thus the information often does not cover every aspect of the work zone. Figure 2.2 is extracted from New Mexico's driver's manual. This is a great example of limited guidance as it does not provide detailed information on available work zone signs and flagger movement.

Moderate Guidance. In contrast, the driver's manuals with moderate guidance offer more descriptions of the work zone compared to the limited guidance. Hence, more safety tips regarding what drivers should follow in work zones are included in these manuals such as "minimize distraction," "merge early," and "do not tailgate." These manuals cover most of the information related to work zones, and therefore most states, including Indiana, fall in this category. The driver's manual from Maine is a great example of moderate guidance, and the section dedicated to the work zone is shown in Figure 2.3.

Work Area Signs—These construction, maintenance or emergency operations signs are generally diamond or rectangular shaped, orange with black letters or symbols and warn you that people are working on or near the roadway. These warnings include reduced speed, detours, slow moving construction equipment and poor or suddenly changing road surfaces. In work areas, traffic may be controlled by a person with a sign or flag. You must obey these people.

Figure 2.2 Excerpt from New Mexico's driver's manual showing an example of limited guidance (New Mexico's Motor Vehicle Division, 2019).

Construction and Maintenance Work Zones

You probably have noticed construction and maintenance projects on the state's public road system, work that is being done to improve and repair our roadways. Because closing a road and detouring traffic adds expense and travel time, the work must go on while traffic passes through the work site or in nearby lanes.

Flashing Arrow Panels: Large flashing or sequential arrow panels are used when a lane is closed on a multi-lane road. Prepare to slow down and merge into the lane indicated.

Construction Warning Sign: These signs are posted to alert drivers of road construction or maintenance activity ahead. They also serve to guide a motorist safely through or around the work site. These signs are black symbols or lettering on an orange background and are often diamond shaped.

Channeling Devices: Barricades, vertical panels, concrete barriers, drums and cones are the commonly used devices to guide drivers safely through the work zone. When driving near these devices, keep your vehicle in the middle of the lane and maintain a responsible speed. As you leave the work zone, stay in your lane and maintain your speed-don't change lanes until you are completely clear of the work zone and have checked the traffic behind you.

Flaggers: Flaggers wear high visibility vests, shirts or jackets and use a stop/slow paddle and hand signals to control traffic through the work zone. Usually a flagger is stationed on each end of the work zone to let the two directions of traffic alternately travel past the work zone. Be patient and always obey their signals. They normally wear orange vests, shirts or jackets and use stop/slow paddles to direct traffic safely through the work zone, and to let workers or construction vehicles cross the road. It's very important to be patient and obey their signals.

The most important thing to do when you are approaching a work zone is to "SLOW DOWN." This helps protect you as the driver and the workers who are working in a dangerous location.

Figure 2.3 Excerpt from Maine's driver's manual showing an example of moderate guidance (Maine BMV, 2022).

Full Guidance. The driver's manual with full guidance offers detailed information on the work zone. Similar to moderate and limited guidance, these driver's manuals contain graphics to illustrate different types of work zone signs, work zone equipment, and flagger movement with descriptions. In addition, these manuals include statistics on work zone crashes to inform the readers to acknowledge the potential danger in work zone. The statistics include the number of deaths in work zone, the most frequent pre-crash behaviors, and crash type information. More pages are dedicated to work zone-related information, and thus additional information such as zipper merge and teen driving are included in the manual. Figure 2.4 extracted from Delaware's driver's manual. Appendix A contains additional examples and excerpts from full guidance manuals.

2.1.2.6 Indiana's driver's manual. Indiana's driver's manual consists of 80 pages with a split section dedicated to the work zone. The first section indicates the speed limit on the highway work zone. The manual postulates that the "worksite speed limits are always at least 10 mph below the maximum established speed limit for the area. Drivers must adhere to the posted speed limit in a worksite." Additionally, it provides a brief description of flashing arrow boards and flagger signals with graphics on a different section. However, the information on work zone signs and equipment is not provided in the manual. The safety tips for drivers are provided in the manual, and the manual emphasizes "stay alert," "merge early," "slow down," "do not tailgate," "minimize distractions," and "plan ahead."

2.1.2.7 Main takeaways from the driver's manual. To summarize, the driver's manuals in all states were reviewed. The analysis provided a better understanding of one of the primary driver education sources across the nation. It was found that the driver's manuals format varies between states. While some manuals are as short as 40 pages, other can get to up to 243. It is important to mention that Indiana's driver's manual had 80 pages.

The manuals follow two main organization styles in the context of how they present work zone-related information, a consolidated and a split style. A consolidated style indicates that work zone-related information is presented in a single section, whereas in a split style information is scattered along different sections of the manual. Indiana's manual is an example of a split style manual. Additionally, the amount of graphics usage varied among manuals. Only 10 states did not include any work zone-related graphics. Moreover, the manuals followed two main tones, informational and advisory tones, when presenting work zone-related information. The first tone focuses on describing the different work zone elements whereas the other one directly guides readers to follow appropriate behaviors to avoid crashes. The persuasive tactics were finally examined, and two main types were identified, appeal to safety and appeal to enforcement.

All the factors that were mentioned above were used to conclude three guidance levels, limited, moderate and full guidance, which were followed in each manual to deliver the work zone-related information. A driver's manual with limited guidance offers brief information on work zones. the driver's manuals with moderate guidance offer more descriptions of the work zone compared to the limited guidance. Finally, the driver's manual with full guidance offers detailed information on the work zone. Table 2.1 shows what factors were following in Indiana's driver's manuals.

To conclude, this section examined the conventions followed across the various manuals. This information provided insight about the best practices for public outreach regarding work zone safety education. The different tones and persuasive tactics, for instance, were eventually considered when designing the educational materials and messages. Additionally, the findings

Figure 2.4 Three pages from Delaware's driver's manual showing an example of full guidance (Delaware DMV, 2021).

TABLE 2.1
Summary of all analyzed criteria in Indiana's drivers manual

	Organization Style	Use of Graphics	Tones	Persuasive Tactics	Guidance Levels
Indiana's Driver's Manual	Split style	Included graphics on flashing arrow boards, flagger signals, and construction signs Did not include a graphic on work zone equipment	Advisory	Appeal to safety	Moderate

provided insight on how Indiana's manual compares to other manuals and highlights the potential information that can be added to enhance the public outreach process. To that end, the team ended up recommending changes to Indiana's driver's manual. Further discussion can be found in Sections 6 and 7 as well as Appendix B. Additionally, examples of full guidance manuals are presented in Appendix A along with excerpts showing the level of details in each document.

2.1.3 Commercial Driver's Manuals

After reviewing the driver's manuals, the SAC also recommended reviewing the commercial driver's manuals. The goal was to find additional tactics and outreach techniques that can be used to develop the new educational messages.

Hence, the commercial drivers' license (CDL) manuals across all states were closely reviewed as well. All of these manuals were based upon a unified version provided by the support of the Federal Motor Carrier Safety Administration (see Figure 2.5). An exception to the rest was Minnesota's manual which included additional information compared to the rest. Thus, only two CDLs to be discussed below are Indiana's and Minnesota's, since the rest of the manuals offer similar content.

2.1.3.1 Indiana's CDL manual. Indiana's manual is 164 pages long and contains overall 13 sections. The searching process was approached by skimming through the table of contents. Chapter 2 titled "Driving Safely" hinted about a relation with safety/work zones. Then, the chapter was searched for words related to work zones such as "work zone," "construction," and "safety."

It was found that two subsections in the second chapter discuss work zones. The first one is titled "Roadway Work Zone" and mentions work zones in the context of controlling speed. The section is as follows (Indiana Bureau of Motor Vehicles, 2017).

> Speeding traffic is the number one cause of injury and death in roadway work zones. Observe the posted speed limits at all times when approaching and driving through a work zone. Watch your speedometer, and don't allow your speed to creep up as you drive through long sections of road construction. Decrease your speed for adverse weather or road conditions. Decrease your speed even further when a worker is close to the roadway (pp. 2–15).

Figure 2.5 Cover page of the unified CDL manuals (AAMVA, 2005).

The paragraph starts off with an informational tone and an emphasis on the potential danger of speeding in work zones. Then, the emphasis changes to what drivers should do in a work zone to prevent speed related problems around work zones. The second paragraph is titled "Hazardous Roads" and enlists work zones as one of the examples. The paragraph is shown as follows (Indiana Bureau of Motor Vehicles, 2017).

> When people are working on the road, it is a hazard. There may be narrower lanes, sharp turns, or uneven surfaces. Other drivers are often distracted and drive unsafely. Workers and construction vehicles may get in the way. Drive slowly and carefully near work zones. Use your four-way flashers or brake lights to warn drivers behind you (pp. 2–19).

The overall tone in this paragraph is also informational with an emphasis on what drivers should do around work zones. The two paragraphs are short, and do not offer much guidance compared to what is discussed in the drivers' manuals. Overall, work zones are briefly touched upon with only three related matches found.

2.1.3.2 Minnesota's CDL manual. While mostly similar to the rest of the manuals, Minnesota's included additional material. This is potentially due to fact that the document had been updated in 2019. In the context of work zone safety, the manual includes two paragraphs similar to the ones discussed previously. Additionally, the document contains the following paragraph about zipper merge.

> When most drivers see the first "lane closed ahead" sign in a work zone, they slow quickly and move to the lane that will continue through the construction area. This can cause dangerous lane switching that is unexpected to other drivers, serious crashes and road rage. When you see the "lane closed ahead" sign and traffic is backing up, stay in your current lane up to the point of merge. Then take turns with other drivers to safely and smoothly ease into the remaining lane (p. 9).

The overall tone is informational with some emphasis on others' safety, and largely what drivers should do when they encounter a zipper merge.

2.1.3.3 Main takeaways from the commercial driver's manuals. To summarize, the commercial driver's manuals in all states were reviewed. The review helped gaining insight on how other educational materials approach driver's education. It was found that almost all commercial driver's manuals follow the same federally issued format except for Minnesota's. Generally, the manuals offered very limited guidance for commercial vehicle drivers. Work zones were mentioned only three times, and briefly, across the manual and in the context of other topics such as controlling speed and hazardous road. On the other hand, Minnesota's commercial driver's manual included a paragraph about zipper merge explaining for drivers how to deal with a closed lane. This type of information is crucial especially that most work zone crashes happen around lane closures (as explained subsequently in the Crash Data Analysis section).

Hence, the commercial driver's manuals lacked explicit work zone educational information which is crucial given that commercial vehicles are as involved in crashes as private vehicles are. Minnesota's manual is a good start to improve and add to the manual but is not enough. It is then important to communicate this matter to stakeholders and push for an update of these manuals. The update should aim at including detailed information about work zones and should consider other important matters.

2.1.4 Motorcycle Operator's Manuals

The SAC also recommended reviewing the motorcycle operator's manuals (MONs). After reviewing both driver's and commercial driver's manuals, MONs were closely reviewed. The analysis aimed at finding additional educational approaches and tactics that can be exploited to develop our own educational materials. It was found that similar to CDL's manuals, motorcycle operator's (MO) manuals offer similar content across the states with some exceptions.

2.1.4.1 The majority of MO's manuals. Overall, work zones were briefly mentioned/touched upon. The following excerpts were from Indiana's MO (Motorcycle Safety Foundation, 2017).

> As you search, focus on finding potential escape routes, especially in or around intersections, shopping areas and school and construction zones (p. 17).

> In potential high-risk areas, such as intersections, shopping areas and school and construction zones, cover the clutch and both brakes to reduce the time you need to react (p. 18).

In these paragraphs, work zones are mentioned as potential hazard sections of the road but not much emphasis is placed on them.

2.1.4.2 MOs exceptions. Several other manuals included more information about work zones. For instance, manuals of Georgia, Michigan, South Carolina, and South Dakota contain a section about construction signs. Additionally, Massachusetts, Rhode Island, and Wyoming include sections about work zones specifically. These manuals include sections dedicated to work zones along with couple construction signs as shown in Figures 2.6 and 2.7.

Additionally, Rhode Island's manual includes the most information about construction zones compared to others. The section starts by giving specifics about construction signs. Then bulleted instructions are given on how to act in a work zone. The instructions start off with an advisory tone mentioning "fines double" to emphasis potential consequence for violating speed limit. The second piece of instruction is informational using facts to emphasize on the danger of high speed in work zones. The rest of the bullet points are only instructions to guide drivers through the zones.

2.1.4.3 Main takeaways from the motorcycle operator's manuals. Similar to the CDL manuals, the

Figure 2.6 Construction and maintenance warning signs, Georgia's MO.

Figure 2.7 Construction and maintenance warning signs, Massachusetts's MO (Massachusetts Registry of Motor Vehicles, 2015).

MONs were almost similar across all states. Almost all of them offered very limited guidance regarding work zone behavior. Work zones were briefly mentioned alongside other "hazardous sites" such as schools and intersections. However, several manuals included more information about work zones. Examples of states that utilized manuals having detailed work zone information are Georgia, Massachusetts, Michigan, Rhode Island, South Carolina, South Dakota, and Wyoming. The level of guidance in these manuals varied between only including work zone signs and providing detailed instructions on how to behave in a work zone area.

To conclude, most MONs still lack important information regarding work zones. More tactics and techniques are needed to be implemented in these manuals especially that motorcycle's crashes are one of the most fatal ones. Hence, it is recommended that more material be included in Indiana's MON. Information can have either safety or enforcement appeal but should be clear to those reading the manuals and preparing for the test. It is also important to present the drivers with detailed instructions about how behave around work zone areas as well as information on the different work zone signs.

2.1.5 Training Curricula

Drivers' training curricula for all 50 states were also reviewed. Most training curricula only list modules and expected learning outcomes that need to be met. Figure 2.8 is an example from Indiana's training curriculum.

Training curricula do not get into the details of the driving education programs since third parties—driving education schools—usually take care of the training and assess the driver's skills before BMV approves. Since the material is not publicly available, only training curriculum standards were screened for information regarding work zone driving. Two training curricula exceptions are the states of New Mexico and New York. The two documents offered detailed information about work zone-related hazards and used different types of appeals. For instance, New Mexico's curriculum used statistics and fear appeal to emphasize on the dangers of violating the rules around work zones. The document mentioned that fines are doubled for speeding in construction zones, it also warned about a risk of imprisonment in case of violation. New York's curriculum started off with statistics about work zones being high crash risk areas on the roadways. The document also alluded to the most common crash manner in work zones that is rear-end crashes. After that, the tone switched to advisory and fear appeal was used to emphasize on the enforcement in these zones and how drivers are fined in case of violation.

To conclude, most training curricula are comprised of learning outcomes that need to be satisfied during the training process. Indiana's training curriculum, for instance, gets into details to ensure trainees have the needed driving skills and techniques. However, it does not explicitly include a work zone-related standard. The closest standard is named "Driving techniques for different types of roads and road surfaces...."

Classroom Training Curriculum Standards

Driver Training School Name:	
Address *(number and street, city, ZIP)*	

Instructions: Driver training schools shall provide a minimum of 30 hours of classroom training that includes the below standards in accordance with 140 IAC 4-4-1.1. Indicate the format for instruction (i.e. workbook, video, demonstration, etc.) and the source document (i.e. textbook name, PowerPoint author, name of video, etc.). Submit this form along with all other required documents for new and renewal driver training school licensing applications. **Attach additional sheets if necessary.**

	Standard	Format for Instruction	Source Document and Publication Date
1	Knowledge of Indiana motor vehicle statutes and administrative rules related to the operation of a motor vehicle.		
2	Railroad-highway grade crossing safety.		
3	Safe driving practices, including how to avoid drivers who display aggressive and unsafe behavior.		

Figure 2.8 Classroom training curriculum standards, Indiana BMV.

Hence, adding such standard to the training curriculum might be beneficial and would make sure that new drivers are aware of all the dangers that accompany work zones.

2.2 Crash Data Analysis

After covering all bases in the literature review, the team also looked at crash data and scrutinized previous work zone safety campaigns from Indiana and elsewhere. This was necessary to identify the crash trends in work zones and tailor the messages to address the actual roadway's problems. Reviewed sources were National Work Zone Safety Information Clearinghouse (through workzonesafety.org website), NHTSA website, Criminal Justice Institute documents, and Automated Reporting Information Exchange System (ARIES) collision reports.

2.2.1 National Work Zone Safety Information Clearinghouse

Through its website (workzonesafety.org), the National Work Zone Safety Information Clearinghouse is a comprehensive resource on work zone safety. The website provides a wide variety of parties, ranging from transportation construction industry to general public, with the necessary information to safety in roadway work zones. The website was thoroughly searched and explored for data that was helpful for our project. Two main data sources were found relevant and analyzed from this website: work zones fact sheets and the crashes interactive tables.

2.2.1.1 Fact sheets. The website contained annual fact sheets published by the Federal Highway Administration (FHWA) presented in Figure 2.9.

The fact sheets are published annually during the National Work Zone Awareness Week. This campaign aims at bringing more attention to the critical issue of safety in and around work zones. The statistics in these facts sheets are national and are mainly about work zones fatalities and crashes grouped by type of highway (class) and transportation mode.

An example about the information found in these documents is there have been 11% increase in work zone fatalities versus only 0.3% increase in highway construction spending and 0.8% increase in vehicle miles travelled (VMT).

In essence, reviewing the fact sheets helped identify trends pertaining to different highway classes and transportation modes, but on a national scale. The sheets helped highlighting certain aspects that were considered during the subsequent analyses. For instance, it was kept in mind that commercial and private vehicles are associated with different trends, which led to analyzing the two modes separately in the subsequent chapters (i.e., ARIES).

2.2.1.2 Interactive tables. The website also offered a variety of interactive tables on crashes. However, the extent of granularity varied depending on the criteria that were sought for. Tables on fatal crashes and fatalities were offered on both the national and state scale (i.e., Indiana) as shown in Figure 2.10(a). However, crash data with detailed crash severity information (property damage and injury) was only available on a national scale. Additionally, yearly values for truck-involved fatal crashes were obtained from these tables. They were utilized to build another table, represented in Figure 2.10(b). The table indicates that, in Indiana, the average annual fatal crashes (4-year average) that are truck-involved nearly doubled during the last 10 years.

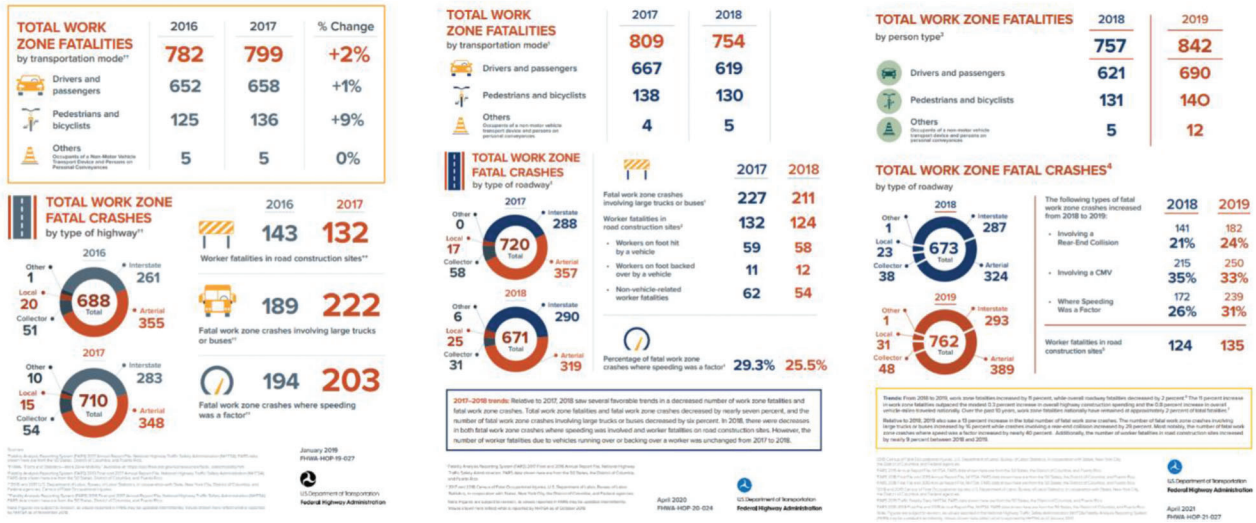


Figure 2.9 Fact sheets about work zone safety published by the FHWA in 2019, 2020, and 2021.

Year	Truck-Involved Work Zone	
	Fatal Crashes	Fatalities
2010	2	2
2011	11	12
2012	4	5
2013	3	3
2014	7	7
2015	6	10
2016	6	6
2017	11	13
2018	9	10
2019	11	16

4 years average = 5.0 fatal crashes

4 years average = 9.25 fatal crashes

(a)

(b)

Figure 2.10 Interactive table: (a) 2019 Indiana work zone fatal crashes and fatalities and (b) truck-involved work zone fatalities and fatal crashes (from workzonesafety.org).

The tables provided more insights on the trend associated with trucks and fatalities in Indiana specifically. This also led to considering these factors when analyzing the ARIES data. Findings also influenced the development of the campaign messages by linking them to other tactics and types of appeals, namely emotional.

2.2.2 National Highway Traffic Safety Administration (NHTSA)

The NHTSA website included plenty of resources related to crashes and safety. For the purposes of this project, the Fatality and Injury Reporting System Tool (FIRST) was used. A snapshot of the tool is presented in Figure 2.11. This tool was utilized to build queries relating work zone crashes to potential crash-related variables. The most relevant variables that were used to build the query were speed, age, vehicle type, and collision manner.

The tool was used to generate several tables and graphs. One limitation of the tool is that only fatal crashes were provided on the state level. Injury and property damage crashes were only aggregately available. The data helped exploring trends associated with speeding, young driver-involved crashes, vehicle type, and collision manner, etc. Figure 2.12 for instance, shows the distribution of fatal crashes over age groups 2011 and 2020.

Figure 2.12 shows that the distributions of fatal crashes around work zones compared to elsewhere are fairly similar. The two curves peak at the 25–34 age group, indicating that this group has the highest share of crashes, and then gradually decreases as age increases. One difference between the two curves is that older adults (older than 35) are slightly more likely to get involved in work zone crashes than elsewhere. This means that the campaign should lean more towards targeting these age groups.

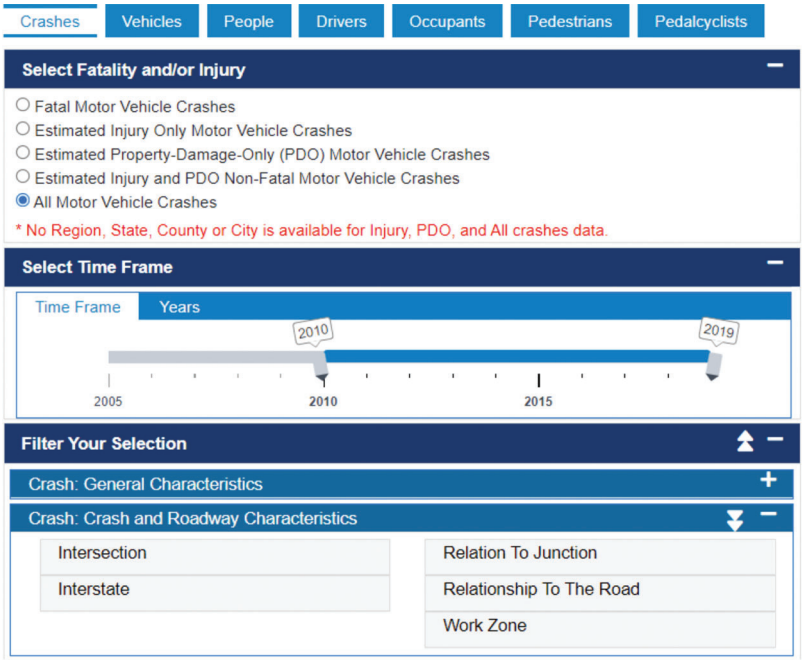


Figure 2.11 Fatality and Injury Reporting System Tool (FIRST) for crash data queries.

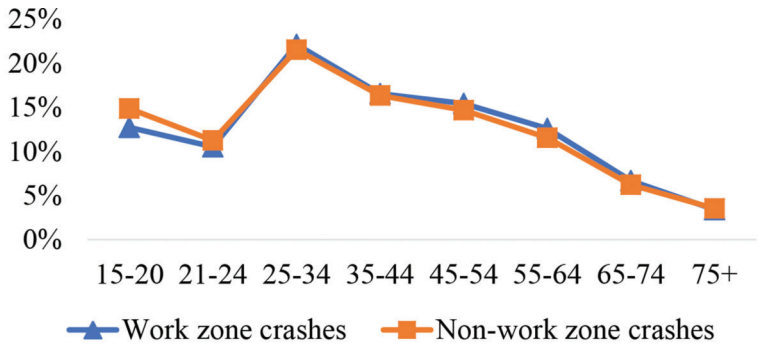


Figure 2.12 Total number of fatal crashes between 2011 and 2020 distributed over age groups (in percentages).

As mentioned earlier, the tool was utilized to generate more plots which were eventually included in Appendix C. However, key takeaways from these query reports are bulleted below.

- Correlation between young drivers and their involvement in speeding is not strong.
- Most speeding-related crashes do not involve young drivers.
- Large trucks are most likely to be involved in rear-end crashes that would lead to fatal crashes.
- Cars have seen an unsteady increase in the number of rear-end fatal crashes.
- Rear-end collisions constitute 38% of speeding-involved fatal incidents.
- Large trucks are involved in nearly 35% of fatal crashes involving speeding and 25% of those that do not.
- Passenger cars are involved in nearly 30% of fatal crashes involving speeding and more than 40% of those that do not.

As a summary, NHTSA's tool offers rich work zone crash data. Granulated data was not available on the state level, but only fatal crashes data was. Nevertheless, many trends were extracted on the national level, namely involving speed and age. These trends were considered while designing the messages and gave more insight on the demographics of the targeted population. However, more granularity was still sought for to identify more underlying trends. This led to subsequently analyzing Indiana's Crash Facts Reports and ARIES data.

2.2.3 Indiana Crash Facts Reports

The Indiana Crash Facts are annual reports developed by Indiana University Public Policy Institute and Center for Criminal Justice Research in collaboration with the Indiana Criminal Justice Institute (ICJI). The reports contain data that was tabulated from the Automated Reporting Information Exchange System (ARIES) database, maintained by the Indiana State Police.

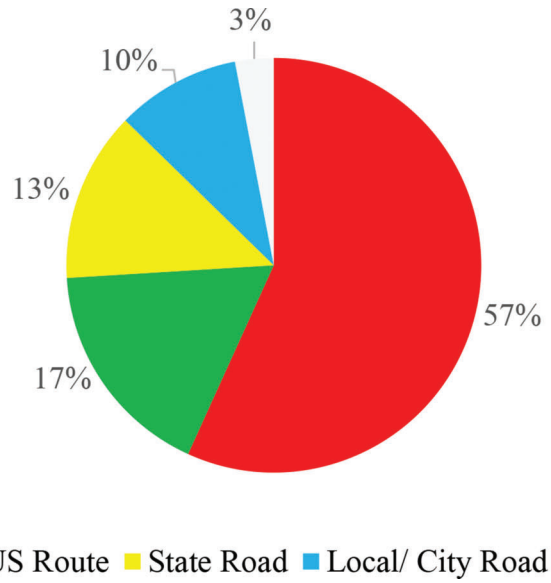


Figure 2.13 Distribution of average yearly work zone collisions by road class (between 2011 and 2019).

The reports covered details pertaining to crashes and collisions in Indiana. The group was able to retrieve nine yearly reports from 2010 until 2019 each having more than 170 pages. Thus, a comprehensive table was developed from the report. The table comprised of information relevant to our study (i.e., information on work zones). Due to page size constrains, the table was split into four smaller tables, which were all eventually included in Appendix C.

Instead, three graphs were selected from these tables and are shown in Figure 2.13. Figure 2.13 shows that the majority of work zone crashes occurred on interstates. On average, 57% of work zone collisions happened on interstate roads whereas 17% happened on US routes.

Additionally, another graph, shown in Figure 2.14, sows that only 15% of collisions occur in rural locales. This indicates that most collisions happen in urban and suburban locales which might be explained by the high exposure in such locales.

Moreover, the number of collisions (regardless of the severity) was found to be increasing over the years. It was also found that deaths were increasing around work zones over the years (Figure 2.15).

In summary, it was found that most work zone crashes happen on interstates and urban locales. Results, for instance, would influence the decision of road messages and billboards' placement. Additionally, it was established in the previous section that private and commercial vehicles exhibited different trends, hence the next section aimed at examining such trends more closely in the context of road class and locale.

2.2.4 Automated Reporting Information Exchange System (ARIES)

ARIES is the electronic crash reporting system for the state of Indiana. It contains data about road crashes

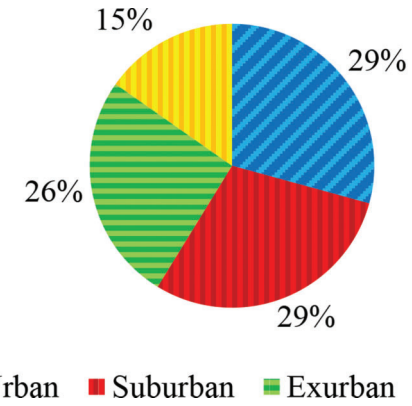
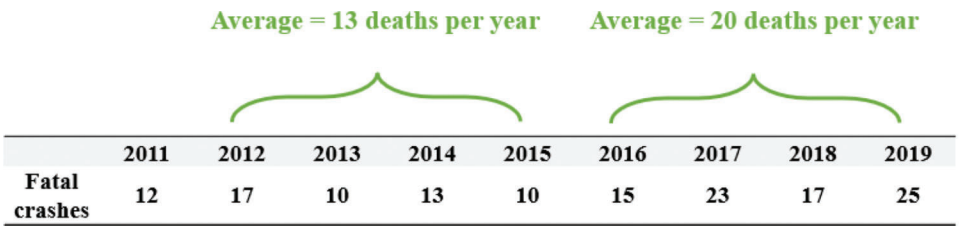


Figure 2.14 Distribution of average yearly work zone collisions by census locale (between years 2011 and 2019).

in the state and offers granulated information about each entry. While the preceding data offered great insight into the work zone-related crash trends, some granularity was still missing. Hence, it was recommended by the SAC that the group looks and analyzes the ARIES data. Access was requested and granted in July 2021 as per the SAC's recommendation.

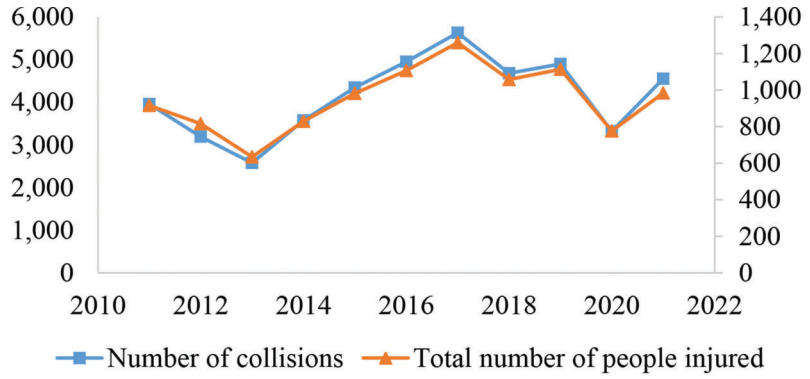
The dataset was filtered to include crashes occurring only at or around work zones; crashes in this section refer to work zone-related crashes. Also, data was downloaded as Excel files. The sheets were large and are not publicly available. Hence, only key takeaways were presented in the report. Additionally, since it was established in the antecedent analysis that private and commercial vehicles exhibit different trends around work zones, two separate comparative analyses were performed for the two modes.

2.2.4.1 General statistics. Different trends and analyses were performed on the dataset. First, general trends about collisions were explored such as injuries

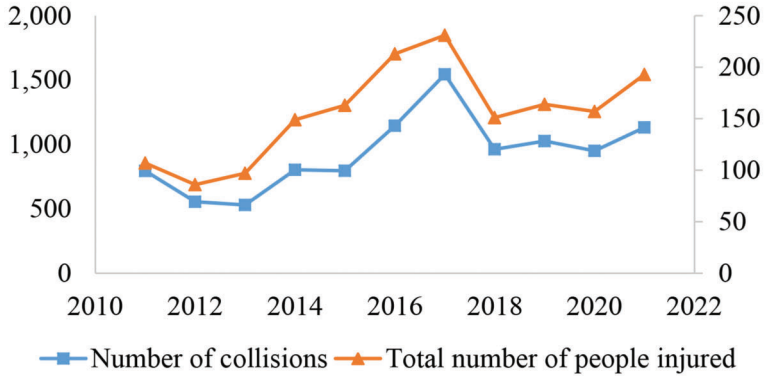


	2011	2012	2013	2014	2015	2016	2017	2018	2019
Fatal crashes	12	17	10	13	10	15	23	17	25

Figure 2.15 Trend in fatal crashes from 2011 to 2019.



(a)



(b)

Figure 2.16 (a) Number of collisions and people injured per year in private vehicles and (b) number of collisions and people injured per year in commercial vehicles.

and fatalities. Figures 2.16(a) and (b) show that the number of injuries was proportional to the number of collisions for both private and commercial vehicles. The number of injuries reached a low in 2013 and started increasing to reach a peak in 2017. After 2017, numbers started decreasing again to reach a minimum in 2020 (mainly due to COVID-19) and then went back up in 2021.

Moreover, the number of deaths was analyzed in parallel with the number of collisions. The graphs are shown in Appendix C. The trend was different for deaths as the numbers fluctuated and were not as proportional to the number of collisions as injuries were. For instance, the number of deaths pertaining to private vehicles-related collisions peaked in 2019 and not 2017. Additionally, the number of deaths caused by commercial vehicles-related collisions peaked in 2020, the year of COVID-19, where number of collisions were at a minimum. Hence, the number of deaths caused by work zone-related collisions was influenced potentially by other factors. Also, the death rate per collision for commercial vehicles was much higher than that of the private vehicles.

2.2.4.2 Primary factors leading to collisions and related collision manner. Designing the public awareness campaign and messages required good understanding of the primary factors associated with collisions, and the corresponding top collision manner. This stems from the fact that messages needed to target behaviors

TABLE 2.2
Ranking of the primary collision-causing factors around work zones and the resulting collision manner

	Private Vehicles		Commercial Vehicles	
Rank	Primary Factors of Collision	Top Associated Collision Manner (%)	Primary Factors of Collision	Top Associated Collision Manner (%)
1	Following closely	Rear-end (97%)	Unsafe lane movement	Side-swipe (84%)
2	Unsafe lane movement	Side-swipe (75%)	Following closely	Rear-end (92%)
3	Failure to yield right of way	Right angle (34%)	Unsafe speeding	Rear-end (66%)
4	Distracted driving	Rear-end (74%)	Distracted driving	Rear-end (55%)

that are associated with a high number of collisions. Table 2.2 ranks the primary collision causing factors around work zones. The table also lists the resulting collision manner associated with each factor.

It was found that the different modes exhibit different trends in the context of factors leading to a collision. While following closely was the top primary factors for private vehicles, commercial vehicles had unsafe lane movement. Failure to yield right of way was ranked third for private vehicles whereas it was unsafe speeding for commercial vehicles.

Moreover, rear-end and side-swipe crashes were ranked as the most and second most frequent collision manner in work zones, for both private and commercial vehicles. However, death/injury rate of commercial vehicles was found to be 10 times higher than that of private vehicles (6 deaths per 100 injuries compared to 5 deaths per 1000 injuries). It was found that most primary factors led to rear-end crashes and side-swipes collisions for both private and commercial vehicles. In general, more than 20% of rear-end collision manners involved more than two vehicles (tailgating) every year. Also, rear-end crashes and unsafe speed were the number one collision manner and primary factor, respectively, that caused death around work zones for both modes. The corresponding tables are shown in Appendix C.

2.2.4.3 Road class. Another variable that was examined was road class. Different factors influence the distribution of collisions across road class, namely traffic volume and number of construction projects per each road class. However, it is important to identify which road class experiences the highest number of collisions to decide on the channel preference (i.e., where to place the public education billboards).

The pie charts in Figure 2.17 show the distribution of collisions over different road classes. Overall, most collisions happened on interstates for both modes. For private vehicles, work zone-related collisions on local/city roads were as frequent as interstate collisions, as opposed to commercial vehicles. The explanation behind the difference is because most commercial vehicles drive on interstates which increases the exposure on that road class. It was also found that most deaths (more than half on average for private vehicles) happen on interstates.

Additionally, the literature review suggested that lighting conditions affected the number of work zone crashes. In this context, the trend of collisions in the dark was examined. For private vehicles, it was found that less than 20% of all collisions happened in the dark. Almost one quarter of interstate collisions happened in the dark. The trend was not different for commercial vehicles where one quarter of collisions happened in the dark. Almost one third of interstate collisions happened in the dark which was much higher compared to other classes.

Regarding the primary factor of collision and collision manner, data is presented in Table 2.3. Following too closely was the top primary factor of collision on all road classes for private vehicles. For commercial vehicles, however, there were different trends on different road classes. The top primary factor leading for a collision was unsafe lane movement. Moreover, the top manner of collision for private vehicles was rear-end which was different from commercial vehicles' sideswipe.

In summary, most collisions happen on interstates. For private vehicles, local and city roads also have a high percentage of collisions. Additionally, results showed that there were different trends on different road classes. For private vehicles, following too closely was the main and only top primary factor of collision, whereas for commercial vehicles the trend was different among different road classes.

2.2.4.4 Construction type. The database categorizes construction works into four types: intermittent or moving work, lane closure, work on shoulder, and x-over/lane shift. Each type necessitates different road setup and considerations. For instance, drivers would need to change lanes when there is a lane closure but might not need to do so when there is work on shoulders. This leads potentially to different collision manners, and it would be important to identify which manner would be associated with each construction type.

It was found that more than half of collisions happen in lane closures, for both private and commercial modes (shown in Figures 2.18(a and b)). Additionally, lane closures had the highest number of yearly deaths on average for both modes (please refer to Appendix C for more information). In fact, more than half deaths around work zones happened during lane closures.

Moreover, no specific trends were detected for both modes in the context of collisions in the dark. On average, one fifth of all collisions happened in the dark across all construction types. There was a higher chance

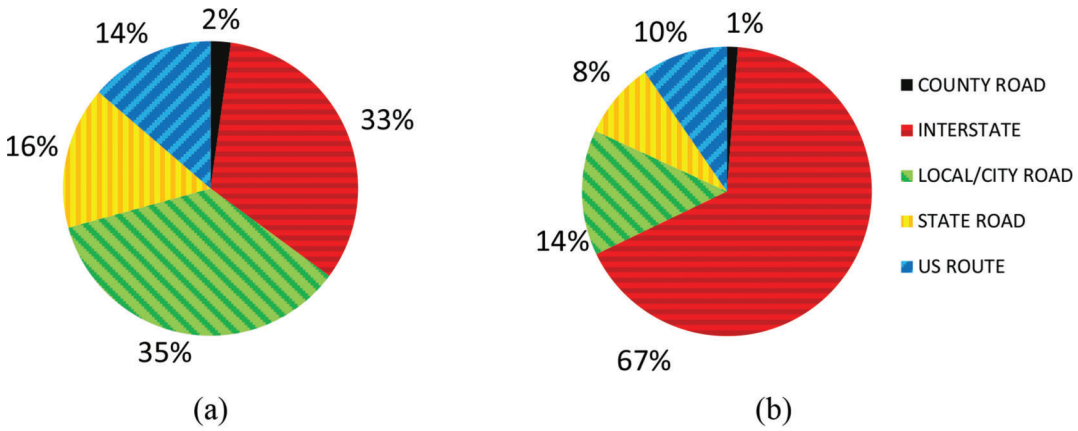


Figure 2.17 Distribution of collisions over different road classes: (a) private vehicles and (b) commercial vehicles.

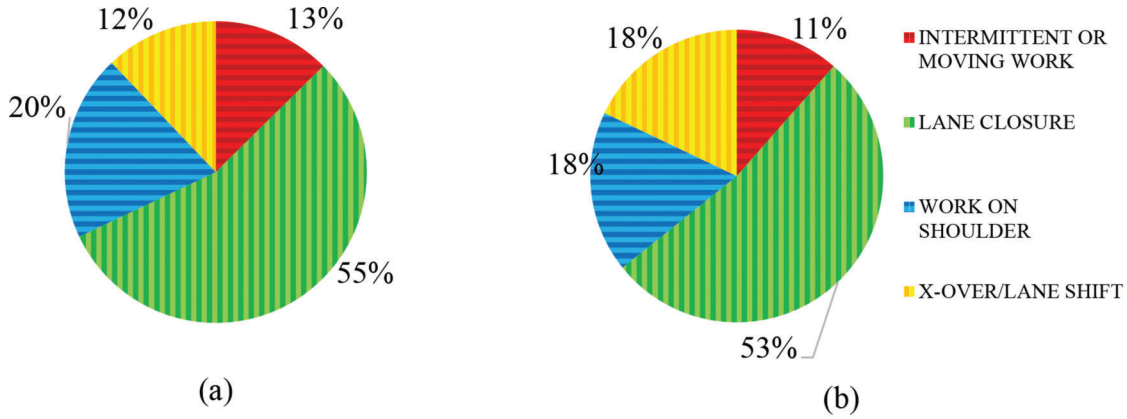


Figure 2.18 Distribution of collisions over different construction types: (a) private vehicles and (b) commercial vehicles.

TABLE 2.3
Top primary factor of collision and the associated collision manner per road class

Private Vehicles					
Road Class	**County Road**	**Interstate**	**Local/City Road**	**State Road**	**US Route**
Top primary factor of collision	Following too closely	Following too closely	Following too closely	Following too closely	Following too closely
Commercial Vehicles					
Road Class	**County Road**	**Interstate**	**Local/City Road**	**State Road**	**US Route**
Top primary factor of collision	Unsafe backing	Unsafe lane movement	Failure to yield right of way	Following too closely	Following too closely

that collisions in the dark would happen during lane shifts. Regarding primary factor of collisions, following closely was the highest leading factor for private vehicles across all construction types, associated with rear-end crashes. For commercial vehicles, however, it was mainly unsafe lane movement across all construction types with different collision manners, namely sideswipes and rear end.

2.2.4.5 Locality. Locality was examined since private and commercial modes were found to exhibit different trends across the different localities. The analysis showed that indeed the different modes had different collision trends across localities (presented in Figure 2.19). For private vehicles, there was on average a 30% to 70% split of collisions occurrence between rural and urban locales. For commercial vehicles, on the other hand, the number of collisions was distributed equally across the two locales.

Additionally, death rate was calculated for both locales and it was found that rural roads had higher death rates involving private vehicles than urban roads (please refer to Appendix C). For commercial vehicles, death rate was found to be the same across the two locales.

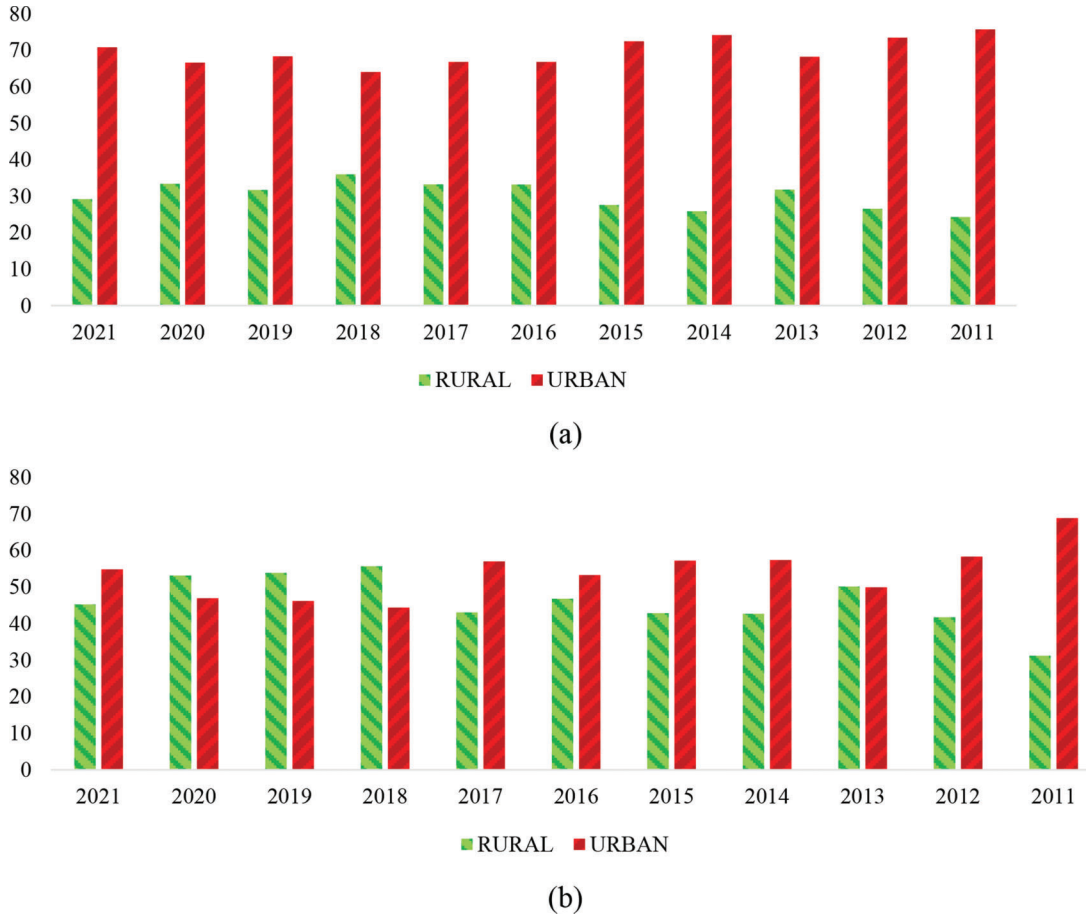


Figure 2.19 Proportion of collisions per locality: (a) private vehicles and (b) commercial vehicles

2.2.4.6 Individuals. Finally, characteristics and trends pertaining to individuals involved in collisions were examined. Figure 2.20 shows that males were more likely to be involved with collisions for both private and commercial modes. Around 60% of private vehicles' collisions involved males. The gap was bigger for commercial vehicles where more than three quarter of all collisions involved males.

Additionally, the number of pedestrians involved in collisions was explored. The dataset did not provide information on whether pedestrians involved in collisions were workers or not. Hence, no distinction was made between workers and other pedestrians. It was found that the number of pedestrians involved in collisions with private cars peaked in 2016 and kept on decreasing after that. For commercial vehicles, on the other hand, there was not a specific trend. The number of pedestrians involved in collisions peaked in 2020 during which traffic volume was at a low. Figure 2.21 presents the aforementioned results.

2.2.4.7 Main takeaways. Information provided by this dataset was most helpful with developing the campaign message. Insights regarding factors leading to collisions and collision manners, for instance, widely influenced the language and the focus of the messages. A notable difference was found in the trends of private and commercial vehicles. This necessitates addressing both audiences differently by updating both manuals and designing different messages. Collisions involving commercial vehicles were found to be more dangerous. This supports the idea of enhancing the means of reaching out for these types of drivers.

Additionally, findings from this section shed light on the different primary factors leading to work zone crashes. This helped emphasizing on several driver behaviors when designing the campaign messages. It also provided statistics and influenced the statements that were eventually written in the messages. For instance, one message stated, "Avoid unsafe lane movements, check your blind spots." The message focused on the top collision causing factors for commercial vehicles. Additional details about the message design process are provided in the subsequent chapter. Findings also enforced the necessity of targeting these behaviors in the manuals, as well as other educational materials in the context of work zone safety.

Interstates were found to be associated with the highest numbers of collisions compared to other road classes. For private vehicles, local and city roads also had a high percentage of collisions. Additionally, results showed that there were different trends on different

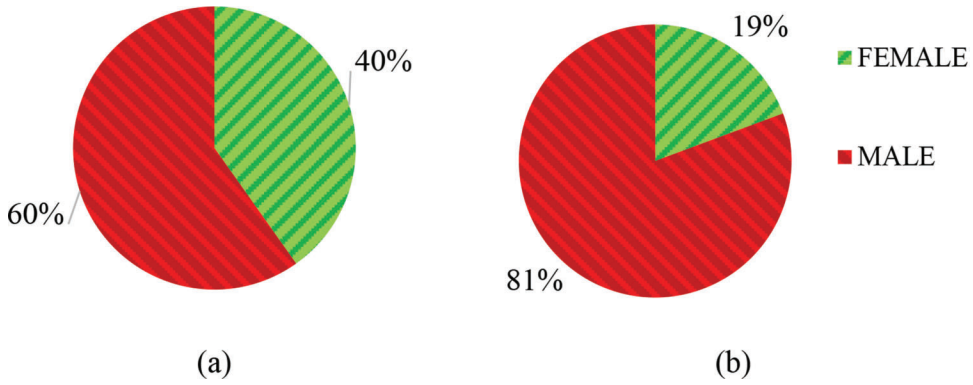


Figure 2.20 Gender distribution: (a) private vehicles and (b) commercial vehicles.

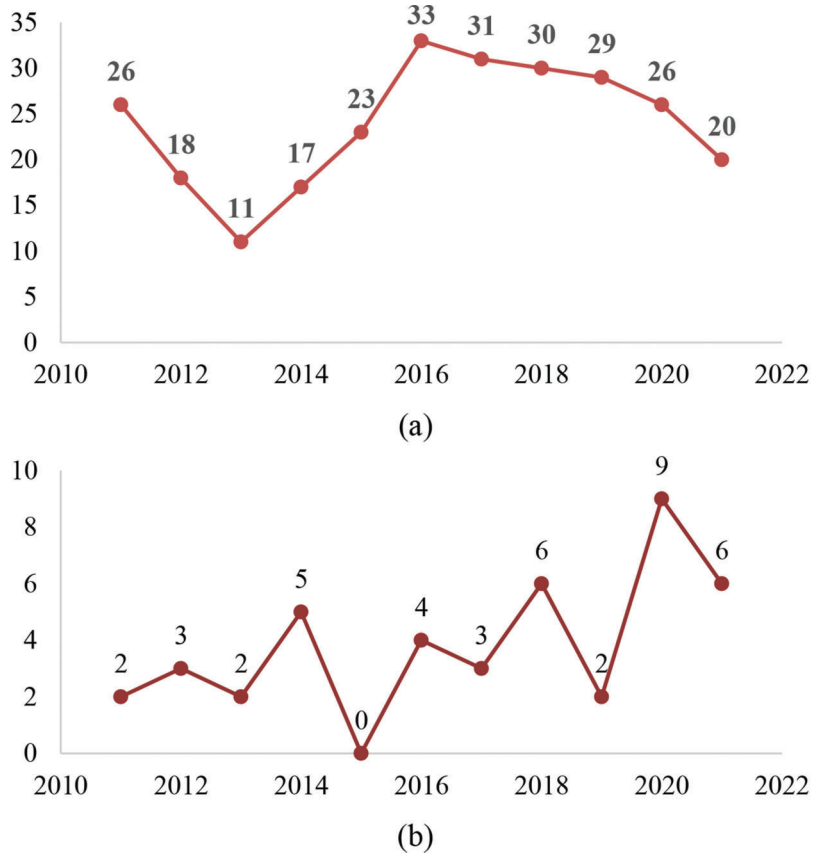


Figure 2.21 Number of pedestrians involved in collisions per year: (a) private vehicles and (b) commercial vehicles.

road classes. For private vehicles, following too closely was the main and only top primary factor of collision, whereas for commercial vehicles the trend was different among different road classes. Insights will help deciding on the channel preference (i.e., where to place the public education billboards). They will also help address those behavior by adding related information to the educational materials.

Regarding construction type, it was found that trends also vary between different construction projects. Lane change and work on shoulders were found to be the most problematic. The factors leading for collisions were found to be following too closely and unsafe lane movement. This helps directing the effort towards preventing such behavior potentially by enhancing driver education or by modifying the work zone signage to cater for that.

Finally, findings on locality stated that more private vehicles collisions happen on rural roads and that the death rate on rural roads is higher as well. This information will eventually help deciding on the placement of the messages. Additionally, most drivers were found to be males. This can be targeted by putting special emphasis on this issue in the driving education process and providing statistics to raise awareness of this audience.

3. CAMPAIGN MESSAGE DESIGN

To develop the communication campaign messages, the grant team engaged in seven systematic processes. First, the team analyzed the crash data from different sources (i.e., National Work Zone Safety Clearing House, National Highway Traffic Safety Administration, Indiana Crash Fact Reports) to learn more about the driving behaviors that most often cause crashes in highway work zones. This analysis identified five driving behaviors that most often cause crashes: distracted driving, speeding, tailgating/following too closely, unsafe lane moving, and failure to yield right of way.

Second, the team conducted a content analysis of previous campaign messages about work zone safety to learn more about the target audiences of these message, the conceptual frameworks guiding these messages, and driving behaviors the messages were seeking to influence. The analysis revealed, for example, that the messages sought to influence speeding, distracted driving, and tailgating behaviors in highway work zones.

Third, the team reviewed the road safety campaign literature to learn more about the best practices for effective persuasive message designing strategies and theoretical frameworks guiding these designs. The literature suggests, for instance, that campaigns using explicit theoretical frameworks are more effective than those that do not (Adamos & Nathanail, 2016; Delhomme et al., 2009).

Fourth, the team identified four theoretical or conceptual frameworks that guided the message design. These frameworks included fear appeal, positive appeal, social norms, and source credibility. Fear appeal uses scare tactics to threaten individuals to adopt protective behaviors (Sampson et al., 2001; Witte & Morrison, 1995). Positive appeal seeks to provoke good feelings and values (e.g., pride) in the target audience to motivate them to adopt recommended behaviors (Delhomme et al., 2009). Social norms refer to the rules and standards of acceptable behaviors that are understood and shared by a group of people (Cialdini & Trost, 1998). Source credibility relies on the expertise (e.g., working experiences, job title); attractiveness (e.g., physical appearance, social status, personality, etc.); and trustworthiness (e.g., honesty, fairness) of the message source as the persuasive technique to motivate an audience to adopt recommended behaviors (Delhomme et al., 2009).

Fifth, the team developed 15 messages informed by the identified theoretical frameworks and targeted behaviors. Specifically, the messages were designed for each of the targeted driving behaviors using at least one of the four theoretical frameworks. For example, the source credibility messages used testimonials from highway workers such as, "By slowing down in work zones, you can help keep workers safe. It's that simple! – Jayson Abraham, senior construction technician."

Sixth, the team tested the efficacy of the 15 messages through a formative study. The goal of this formative study was to test the effectiveness of these messages in influencing safe driving behaviors among the target audience. The target audience were drivers in Indiana.

Finally, based on the findings of the formative study, recommendations about enhancing message effectiveness and dissemination/implementation are provided. The crash data analysis process was discussed in the first part of this final report. The next six processes are discussed in the subsequent sections of this report.

3.1 Analysis of Previous Campaign Messages

Previous road safety communication campaign literature suggests that campaigns based on past research conducted via a meta-analytical and/or descriptive review are most successful (Delhomme et al., 2009). Guided by this recommendation, a content analysis was conducted on previous campaign messages on highway work zone safety. This analysis had the following three objectives.

1. Objective 1: learn more about the target audience of previous campaign messages.
2. Objective 2: identify the specific safety driving behaviors previous campaign messages were encouraging in highway work zones.
3. Objective 3: unearth the theoretical/conceptual frameworks guiding previous campaign messages.

Guided by these objectives and Delhomme et al.'s (2009) recommendations on a campaign message strategy, a coding scheme was developed to content analyze 146 campaign messages on highway work zone safety from 35 states. The other 15 states were excluded because some did not have messages specifically for highway work zone safety, and others had work zone safety messages that were the same as those among the selected states. This coding scheme was theoretically driven and consisted of targeted driving behavior, recommended action/behavior, message sources, message target audience, consequences for adhering to or not adhering to the message recommendation (i.e., motivation), graphics and their relevance to the text, and theoretical framework. These 146 safety campaign messages were retrieved from the official websites and social media platforms (i.e., Facebook and Twitter) of the transportation departments of the 35 states. The criterion for message selection was that the message must focus on highway work zone safety. The initial search produced 180 messages, but 34 were excluded from the final analysis because these messages were duplicates—as in, they were used by two or more states.

The systematic content analysis revealed that the campaign messages mostly targeted drivers (76%) with 24% of messages making no reference to a specific target audience. The analysis also revealed that the messages targeted three behaviors: speeding, distracted driving, and tailgating. The speeding behavior was the most frequent which was followed by distraction and tailgating behaviors, respectively (see Table 3.1).

TABLE 3.1
Targeted behaviors

Targeted Behaviors	Number of Messages (% of total)
Speeding	69 (47.3)
Distracted driving	46 (31.5)
Tailgating	8 (5.5)
No stated behavior	36 (24.7)

Interestingly, a large percentage of the messages did not target any behavior.

Again, literature suggests that campaign messages are considered effective when they are recommending some specific actions audience members can take. The analysis revealed that these messages recommended some specific actions that drivers should take while driving through highway work zones. These recommended actions included slow down, pay attention, move over, stop, put phones away, avoid tailgating, follow posted speed limits, etc. Slowdown in highway work zones was the most frequent recommendation, which was followed by pay attention, move over, and stop, respectively (see Table 3.2). Interestingly, a large percentage of the analyzed messages did not provide any recommended action for drivers.

Additionally, literature suggests that the perceived credibility of message sources is an important factor that can influence audience members' attitudes and behaviors (Delhomme et al., 2009). Our analysis revealed that the messages focused on two types of sources: organizations (i.e., the logo of the state department of transportation) and individual or group testimonials (i.e., coming from workers and/or their families). The organizational sources appeared more frequently in the messages than the testimonials (see Table 3.3). Unfortunately, a large percentage of the messages did not have any sources.

Prior research suggests that messages on road safety that utilizes visual images are more effective at influencing safety attitudes and behaviors than text only messages (Huang & Bai, 2014, 2019). Specifically, Huang and Bai (2012) found that most drivers prefer graphic aided portable changeable message signs to text-only portable changeable message signs. The analysis revealed that most messages contained some graphics (see Figure 3.1). The analysis also revealed that of the 118 messages that utilized visual images, 90% of the graphics were relevant to the accompanying texts (see Figure 3.2). In other words, the graphic reflected what the text was saying or added contextual meaning to the text.

Moreover, literature suggests that messages are more likely to be effective when target audiences feel motivated to process those messages (Cyr et al., 2018; Delhomme et al., 2009; & Li et al., 2021). Our analysis operationalized motivation as the consequence of not adopting the recommended actions in the campaign messages. The analysis revealed that most messages did not articulate a specific motivation. This was followed by crashing/killing or injuring a worker, saving/protecting lives, and paying fines, respectively (see Figure 3.3).

TABLE 3.2
Recommended action

Recommended Action	Number of Messages (% of total)
Slow down	60 (41.1)
Pay attention	27 (18.5)
Move over	23 (15.8)
Stop	14 (9.6)
Put phones away	14 (9.67)
Avoid tailgating/follow at a safe distance	10 (6.8)
Follow posted speed limit	5 (3.4)
Patience	4 (2.7)
Obey signs	3 (2.1)
Obey flaggers	3 (2.1)
Watch out for workers	2 (1.4)
Use alternate route	2 (1.4)
Maintain traffic flow	2 (1.4)
Plan ahead	2 (1.4)
Avoid eating while driving	1 (0.7)
Turn on headlight	1 (0.7)
No recommendation	22 (15)

TABLE 3.3
Message sources

Message Sources	Number of Messages (% of total)
Organization (logo)	78 (53.4)
Testimonial (workers or their families)	21 (14.4)
No source	51 (34.9)

Finally, the road safety campaign literature suggests that theories are important for designing messages because they provide a framework through which attitudes and behaviors can be influenced (Guttman, 2016; Hoekstra & Wegman, 2011; Nathanail & Adamos, 2013). Our analysis revealed that while 86% of the messages had some theoretical/conceptual bases, 14% did not have any theoretical/conceptual bases. The frameworks used were emotional appeal, framing, efficacy beliefs, and credibility/trustworthiness (see Table 3.4).

3.2 Road Safety Communication Campaign Literature Review

A communication campaign generally uses promotional strategies to purposefully inform, persuade, and motivate a specific audience to change its knowledge, attitudes, or behaviors. Specifically, a road safety communication campaign seeks to improve safety among road users by influencing their attitudes and behaviors. The campaign literature suggests that communication campaigns about road safety are mostly effective at influencing safety attitudes and behaviors among road users. For example, a meta-analysis of 67 studies evalu-

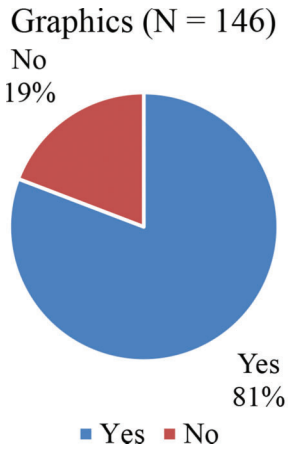


Figure 3.1 Frequency of graphic message.

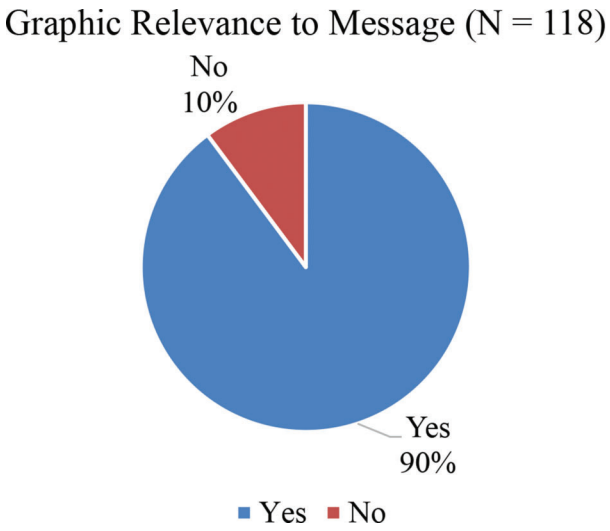


Figure 3.2 Graphic message relevance.

ating the effect of road safety campaigns on crashes found that road safety campaigns were associated with a 10% reduction in crashes (Phillips et al., 2011). However, the effectiveness of these campaigns largely depends on eight important factors (Delhomme et al., 2009; Friemel & Bonfadelli, 2016). These factors are discussed in the subsequent paragraphs.

First, campaigns using explicit theoretical frameworks are more effective than those that do not (Adamos & Nathanail, 2016; Delhomme et al., 2009; Friemel & Bonfadelli, 2016; Shiwakoti et al., 2020). According to Guttman (2016), theories or models help to explain the reason behind people's behaviors and identity underlying factors influencing those behaviors. Second, campaigns using emotional appeals are more effective than those using rational or informative appeals (Adamos et al., 2013). Third, campaigns that are combined with other ongoing supportive activities such as enforcement and/or education are more effective than those without such supportive activities (Adamos et al., 2013; Faus et al., 2021; Zatoński & Herbeć, 2016).

Fourth, campaigns that have clear objectives with specific target audiences are more effective than those without clear objectives and specific target audiences (Delhomma et al., 2009; Elder et al., 2004; Mikusova, 2015). According to Delhomme et al. (2009), the identification of specific target audience should be informed by data (i.e., statistics) and past research. Fifth, campaigns based on prior research are more effective than those that are not based on prior research (Delhomme et al., 2009). In other words, meta-analytical and qualitative or descriptive reviews can be conducted on past road safety campaigns to learn what works and what does not work.

Sixth, campaigns with persuasive intent are more effective than those with informative/educational intent

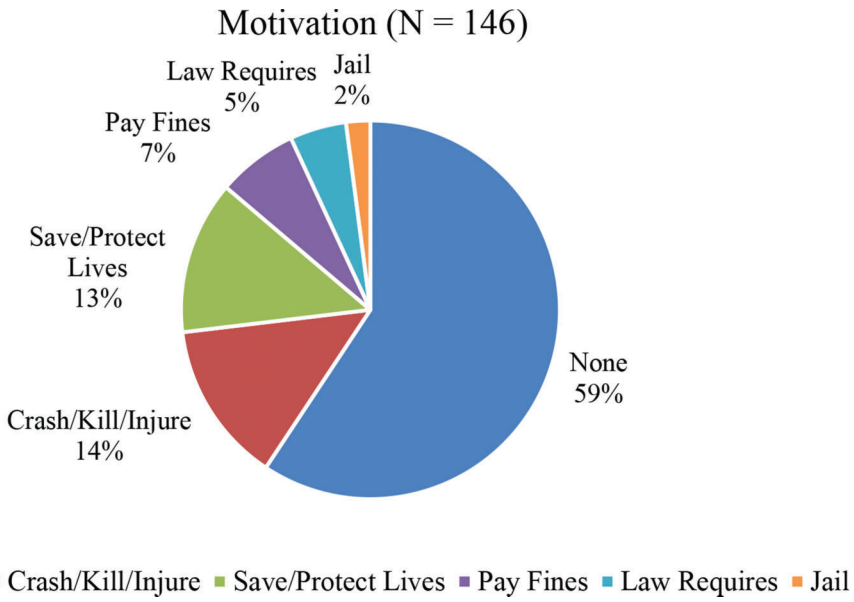


Figure 3.3 Audience motivation.

TABLE 3.4
Theoretical/conceptual framework

Theoretical Frameworks	Dimensions	Number of Messages (% of 126)
Emotional appeal = 38 (30.2%)	Negative (fear) appeal	35 (92)
	Positive appeal	3 (8)
Framing = 42 (33.3%)	Positive (gain) frame	38 (90.5)
	Negative (loss) frame	4 (9.5)
Efficacy	Self/response efficacy	21 (16.7)
Credibility/Trustworthiness = 25 (19%)	Yes	20 (80)
	No	5 (20)

(Delhomme et al., 2009). Seventh, campaigns focusing on specific behaviors are more successful than those focusing on general behaviors (Delhomme et al., 2009). Finally, the campaign literature suggests that all campaign messages should be pretested on a sample of the specific target audience (Hoekstra & Wegman, 2011). These reviewed factors influenced the design of the current work zone safety communication campaign.

3.3 Theoretical/Conceptual Frameworks

Theories are important in designing campaign message because they help to identify and explain underlying factors influencing people's attitudes and behaviors (Guttman, 2016; Hoekstra & Wegman, 2011). Most successful road safety campaigns have well-structured theoretical frameworks (Nathanail & Adamos, 2013). Informed by the results of the previous campaign message analysis and the road safety campaign literature review, our campaign project identified four theoretical frameworks to guide the design of messages. These frameworks include fear appeal (or loss frame), positive appeal (or gain frame), social norms, and source credibility.

Fear appeals utilize scare tactics by threatening individuals to adopt recommended behaviors (Sampson et al., 2001; Witte & Morrison, 1995). Fear appeals are considered powerful persuasive strategies for designing campaign messages (Diegelmann et al., 2020; Witte, 1993). An effective fear appeal message highlights the threat or danger of a particular health problem or safety issue and provides recommendations for dealing with such a threat (Carcioppolo et al., 2013). Extended parallel process model (EPPM), an influential theory for fear appeal message designs, argues that a fear arousing message initiates two appraisals—threat appraisal (evaluation of perceived severity and susceptibility) and efficacy appraisal (evaluation of perceived response efficacy and self-efficacy) (Witte, 1992, 1994, 1996, & 1998). When individuals receive fear appeal messages, they evaluate the threat in the message to determine their vulnerability to the threat as well as the seriousness of the threat. If they perceive no threat, they will not initiate the efficacy appraisal; that leads to no response. However, when they perceive a threat, they will initiate the second appraisal by evaluating the effectiveness of the recommended behavior to avert the threat (response efficacy) and their ability to perform the recommended behavior (self-efficacy).

According to EPPM, people will adopt the recommended behavior when they believe that the recommendation is effective and that they can perform it. They will reject the recommended behavior when they believe that the recommendation is not effective and that they do not have the ability to perform the recommended behavior. EPPM has received empirical support across contexts such as road safety campaigns (Diegelmann et al., 2020), HPV (Carcioppolo et al., 2013), HIV/AIDS (Sampson et al., 2001), electromagnetic fields (McMahan et al., 1998), safe sex (Witte & Morrison, 1995), and breast cancer (Totzkay et al., 2022). A meta-analysis suggests that fear appeals generally influenced changes in attitudes, intentions, and behaviors; but the effect was greater when efficacy was included in the fear appeal messages (Tannenbaum et al., 2015). Diegelmann et al. (2020) recommend that efficacy in fear appeal messages can be enhanced by highlighting personal stories of drivers who found a better way (effective strategy) of changing their behaviors from using mobile phones while driving to encourage campaign message recipients. Fear appeal has three features: message structure, message style, and extra-message (Witte, 1993). Fear appeals are structured by first presenting the threat which is then followed by the recommended behavior (efficacy) to avert the threat. The style pertains to the words, audios, and visuals of fear appeal messages. The extra-message feature pertains to variables (such as source credibility, message sidedness, message duration, repetitions, medium, etc.) outside the content of message that can influence message persuasiveness. Message sidedness refers to the nature of the arguments within a persuasive appeal, e.g., one-sided message (i.e., a message that presents one side; it is in favor of or is against the topic) or two-sided message (i.e., a message that presents both sides).

The second framework is positive appeals which seek to provoke good feelings and values (e.g., pride) in the target audience to move them to adopt recommended behaviors (Delhomme et al., 2009). Positive appeals can serve as a persuasive message strategy to promote safety attitudes, intentions, and behaviors. Specifically, persuasive appeals may be more persuasive over time compared to fear appeals (Lewis et al., 2008). One of

the approaches to developing positive appeal messages is using gain frames in prospect theory. According to prospect theory, people are more willing to avert risk when faced with gain frame information (Tversky & Kahneman, 1981). Gain frame (positive) appeals highlight attaining the desirable outcome and are more persuasive for prevention behaviors (Rothman et al., 2006). For example, Harrington and Kerr (2017) found that people avoided taking adverse risks when they received a gain frame message in a severe consequence condition.

The third framework is social norms. Social norms are a persuasive communication strategy that can influence changes in attitudes, intentions, and behaviors (Yun & Silk, 2011). Three conceptually distinct types of social norms have been identified and extensively studied in the broad literature on normative influences: subjective, injunctive, and descriptive norms. Subjective norms refer to the individual's judgment of the opinions of important others (e.g., family or friend) about a given behavior (Ajzen, 1988; Ajzen & Fishbein, 1980). Injunctive norms refer to the individual's perception of what ought to be done (Lapinski & Rimal, 2005; Rimal & Real, 2005). Descriptive norms refer to the individual's perception of what most others are doing (Lapinski & Rimal, 2005). Empirical evidence suggests that social norms are effective in influencing positive attitudes and behaviors. For example, Merrikhpour and Donmez (2017) found that social norm feedback performed better than real-time feedback at influencing positive driving behaviors among teen drivers. While a social norm feedback provided information that compared teen driving behavior with that of their parents, a real time feedback alerted teen drivers after spending more than 2 seconds on a secondary task while driving.

The fourth framework is source credibility which relies on the expertise (e.g., working experiences, job title), attractiveness (e.g., physical appearance, social status, personality, etc.), and trustworthiness (e.g., honesty, fairness) of the message source as the persuasive technique to motivate an audience to adopt recommended behaviors (Delhomme et al., 2009). A critical review of the effect of source credibility on persuasion over a span of five decades suggested that a message of higher source credibility had a greater influence on attitude and behavior than that of a lower source credibility (Pornpitakpan, 2004). The review study also indicates that other variables (such as characteristics of the message, channel, audience, or source) can affect the impact of source credibility. For example, when consumers have a positive attitude towards the brand, a low-credibility source will be more persuasive than a high-source credibility (Pornpitakpan, 2004). Thus, the characteristics of the source (trustworthiness, expertise, attractiveness) and message (style and structure) should be considered when designing messages that utilize source credibility as a persuasive strategy.

3.4 Development of Campaign Messages

Our communication campaign message development was informed by the work zone crash data analysis, previous campaign message analysis, and road safety communication campaign literature review. Both crash data and previous campaign message analyses suggested five common driving behaviors to target in the current campaign messages. These driving behaviors include distracted driving, speeding, tailgating/following too closely, unsafe lane moving, and failure to yield right of way. The road safety campaign literature review suggested four theoretical frameworks to guide the design of the current campaign messages. The frameworks include fear appeal, positive appeal, social norms, and source credibility.

Based on this information and best practices, 15 messages were developed. The messages were designed for each of the targeted driving behaviors using at least one of the four theoretical frameworks. Eight messages targeted speeding behaviors. Three messages targeted distracted driving behaviors. Two messages targeted tailgating behaviors, and one message each for unsafe lane moving and failure to yield right of way behaviors, respectively. All these messages have the logo of Indiana Department of Transportation (INDOT) to add credibility to each message. INDOT is perceived as a credible state institution, and prior research suggests that the credibility of an organization can influence changes in attitudes and behaviors (Delhomme et al., 2009).

Additionally, three messages utilized the fear appeal strategy. The fear appeal messages were structured by first presenting the threat of crashing in work zone which then was followed by providing a recommended action to prevent crashing in work zones. Statistical information was used to indicate perceived susceptibility and severity. An example is, "At least 3 out of every 10 fatal crashes in Indiana work zones involve speeding." The recommended action told drivers to slow down in work zones. Seven messages utilized the positive appeal strategy. The gain frame messaging approach of prospect theory was used to develop the positive appeal messages. Specifically, such messages told drivers the good or positive things/consequences that would happen to them if they drove safely in work zones. An example is, "Keep a safe distance! Save a life."

Three messages utilized the social norm strategy. Specifically, the injunctive and descriptive norms were utilized for these messages. The descriptive norm message suggested that most people drive safely in work zones. An example is, "Make sure everybody makes it home safe and sound. Slowdown in work zones." The injunctive norm message told drivers that the law required them to drive safely in work zones. An example is, "Slow down! It's the law!" Lastly, two messages utilized the source credibility strategy. The source credibility messages employed testimonials from highway workers. Their names and job titles were included in the messages to increase the perceived

trustworthiness, attractiveness, and expertness of their testimonials. An example is, "By slowing down in work zones, you can help keep workers safe. It's that simple! – Jayson Abraham, senior construction technician."

Past research on message design suggests that messages on road safety that utilizes visual images are more effective at influencing safety attitudes and behaviors than text only messages (Huang & Bai, 2012, 2014, & 2019). All fifteen messages contain graphics. The graphics were mostly photos of workers working on the road and work zones. The majority of these photos were provided by INDOT, while the remainder were sourced from copyright-free public domain image databases.

4. FORMATIVE STUDY OF CAMPAIGN MESSAGES

The road safety campaign literature and best practices recommend that campaign messages should be pre-tested through a formative study on the target audience before actual implementation of the communication campaign (Delhomme et al., 2009; Hoekstra & Wegman, 2011). This helps to determine how the messages work to select the messages that will most likely lead to attitudinal and behavioral changes. According to Delhomme et al. (2009), the pre-testing should seek to address the following issues: message appropriateness for target audience, message clarity, message relevance, message recall, and message comprehension (easy to understand). This formative study has two objectives.

Objective 1: Test the effectiveness of the campaign messages in influencing safe driving behaviors among a sample of the target audience.

Objective 2: Determine the channels (i.e., social media, portable changeable message, billboard, rest place, etc.) most appropriate for the target audience.

4.1 Survey Design

This formative study utilized online survey designs to test the effectiveness of all 15 campaign messages using both a college student population and an Indiana population. The survey incorporated both close- and open-ended questions. The close-ended questions helped to measure whether each campaign message was perceived to be effective at encouraging work zone safety driving behaviors among sampled participants. The open-ended questions helped to gather participants' suggestions about ways to improve each message to make them more effective and appropriate. The survey also included questions about participants' channel uses and preferences for how to receive work zone safety messages.

4.2 Study Participants

Participants included colleges students from Purdue University and residents of Indiana. A total of 135 college students were recruited through the Brian Lamb School of Communication's research participation system (i.e., SONA). To participate in the survey, participants had to be at least 18 years old, be currently registered students, and hold a valid US driver's license. Extra credit for a communication course was offered for participation. Data cleaning was conducted on 135 recorded responses from students. First, 29 responses were removed due to missing values. Second, 5 respondents did not have valid US driver's licenses, and those responses were removed. In total, 34 responses were removed. The remaining 111 responses passed the attention check (items incorporated into the survey to determine whether participants were paying attention as they were completing the survey) and were used for the analysis. Also, 399 residents of Indiana were recruited through Prolific, an online private research participation platform. To participate in the survey, participants had to be at least 18 years old, be current residents of Indiana, and hold a valid US driver's license. Each participant received $4.75 for their participation. Data cleaning was also conducted on 399 recorded responses from residents of Indiana. First, 17 responses were removed due to missing values. Second, 24 respondents who did not have a valid US driver's licenses were removed. This resulted in 358 responses which passed the attention check. The total responses for analyses were 469 (i.e., 111 students' responses and 358 Indiana residents' responses).

4.3 Study Procedures

Data collection began in November 2021 and ended in February 2022. After receiving approval from Purdue University's Institutional Review Board, online surveys via Qualtrics were used to collect data through SONA (i.e., Brian Lamb School of Communication's research participation system) and Prolific (i.e., an online private research participation platform). After reading and agreeing to an online consent form, participants read 15 campaign messages and answered questions about the perceived message effectiveness, self-efficacy, and response efficacy for each campaign message. Then, respondents answered questions about channel uses and preferences for receiving and reading safety driving messages about Indiana work zones. After that, they answered demographic questions about their age, gender, education, race, income, and driver's license status. Participants were debriefed by providing them information about the purpose of the study and other resources to read more about the study. The survey took approximately 30 minutes to complete.

4.4 Study Measures

4.4.1 Perceived Message Effectiveness

This scale assessed the perceived effectiveness of each of the 15 campaign messages by using four items

adapted from Niederdeppe et al.'s (2011) study. Items included "This message made me stop and think," "This message grabbed my attention," "This message was believable," and "This message made me want to quit unsafe speeding." These items were rated on a five-point Likert scale ranging from 1 = strongly disagree to 5 = strongly agree.

4.4.2 Perceived Self-Efficacy

This scale assessed participants' level of confidence to perform the recommended safety driving behaviors being depicted in each of the 15 campaign messages. Three items adapted from Witte (1996) were used. Items included "I am able to slow down while driving through an Indiana highway work zone," "Slowing down while driving through an Indiana highway work zone is an easy thing to do," and "Slowing down while driving through an Indiana highway work zone is convenient for me." These items were rated on a five-point Likert scale ranging from 1 = strongly disagree to 5 = strongly agree.

4.4.3 Perceived Response Efficacy

This scale assessed participants' belief that performing the recommended safety driving behavior depicted in each of the 15 campaign messages could prevent crashing in an Indiana highway work zone. Three items adapted from Witte (1996) were used. Items included "Slowing down while driving works for preventing a crash in an Indiana highway work zone," "Slowing down while driving is effective for preventing a crash in an Indiana work zone," and "If I slow down while driving through an Indiana highway work zone, I am less likely to crash." These items were rated on a five-point Likert scale ranging from 1 = strongly disagree to 5 = strongly agree.

4.4.4 Channel Uses and Preferences

Participants were asked to choose up to three channels they most frequently used to read messages about driver safety in Indiana work zones. The options to choose from included Facebook, Twitter, Instagram, INDOT website, portable message changeable signs, billboards, and others (by specifying). Participants were also asked to choose up to three channels they would prefer to receive or read messages about driver safety in Indiana work zones. The options included Facebook, Twitter, Instagram, INDOT website, portable message changeable signs, billboards, rest areas, and others (by specifying).

4.4.5 Demographics

Participants were also asked demographic questions about their gender, age, income, race/ethnicity, education, and driver's license status. See Appendix D.

4.4.6 Attention Checks

Four attention check items were incorporated into the survey to determine whether participants were paying attention as they were completing the survey. An example included "Please choose 'strongly agree' for this statement." Items were rated on a five-point Likert scale ranging from 1 = strongly disagree to 5 = strongly agree.

4.5 Data Analysis

The close-ended responses were extracted from Qualtrics into SPSS file, and analyses were conducted using SPSS. Descriptive analyses such as means, standard deviations, and frequencies were conducted. The open-ended responses were extracted from Qualtrics into Excel file and were manually analyzed to identify recurring trends and themes.

5. RESULTS OF FORMATIVE STUDY

The result section is divided into three subsections. The first subsection presents results for the Indiana resident sample. The second subsection presents results for the college student sample. The third subsection presents results from the qualitative data analysis.

5.1 Results from the Indiana Resident Sample

The age of participants was determined using five categories: 18–24 years (n = 127, representing 35.5% of total participants), 25–34 years (n = 108, representing 30.2%), 35–44 (n = 55 representing 15.4%), 45–59 (n = 46, representing 12.8%), and 60 years and older (n = 21, representing 5.9%). This suggests that a majority of participants from the Indiana resident sample were young adults with ages ranging from 18 to 34 years. This result is representative of the demographic of Indiana as a state (i.e., about 54% of residents' ages range between 18 and 64 years). See Figure 5.1 for age of Indiana resident participants.

Also, the results revealed a majority of participants were females (n = 241, representing 67.3%), with 106 male participants representing 29.6%, 6 non-binary participants representing 1.7%, 3 transgender participants representing 0.8%, and 2 participants preferred not to disclose their gender representing 0.6%. Non-binary, transgender, and preferred not to disclose categories were collapsed into other for the chart. This result is, however, not representative of the demographic of Indiana as a state (i.e., 50.7% of residents are females). This should not be a concern because almost all participants perceived all 15 messages to be effective at influencing safe driving behaviors. It could, however, be a concern if some participants had perceived the messages to ineffective. See Figure 5.2 for the gender of Indiana resident participants.

Regarding level of education, a majority of participants had college degree (n = 137, representing 38.3%),

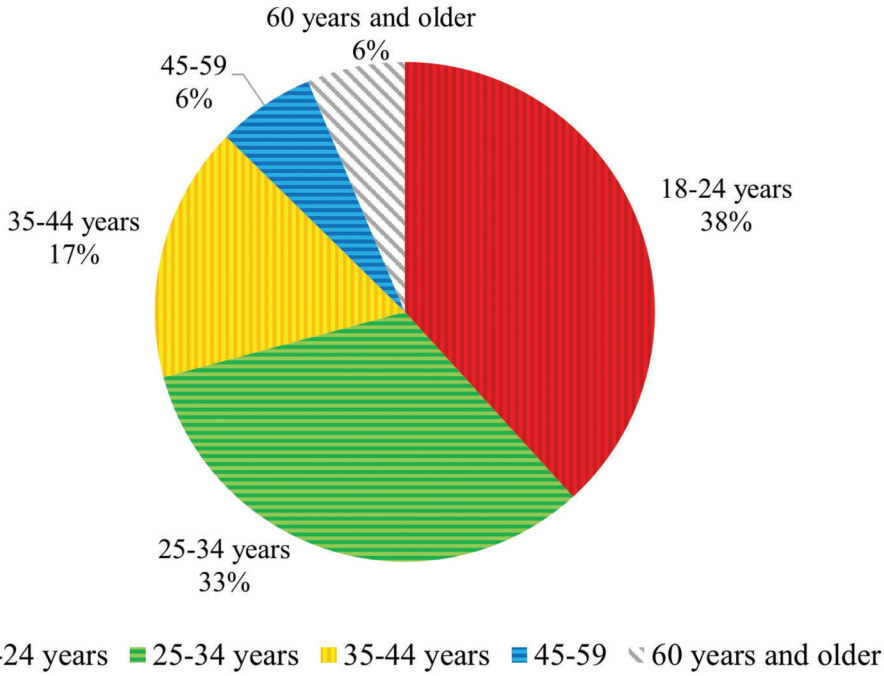


Figure 5.1 Age of Indiana resident participants (n = 358).

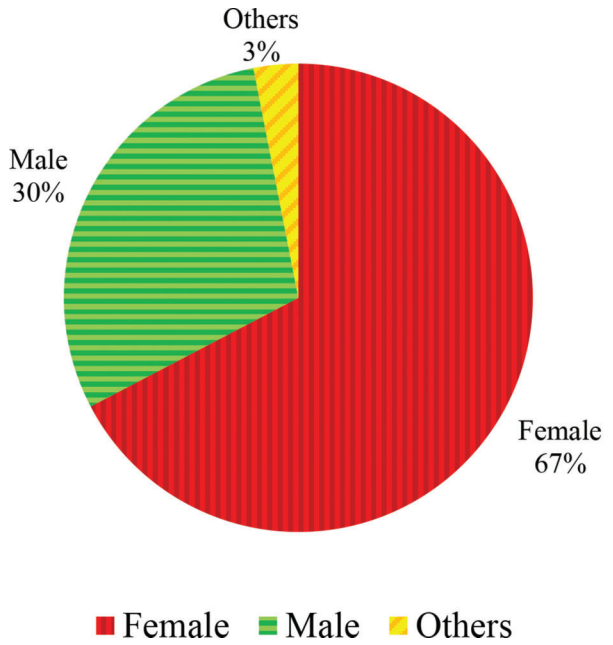


Figure 5.2 Gender of Indiana resident participants (n = 358).

followed by some college (n = 114, representing 31.8%), graduate degree (n = 50, representing 14%), high school graduate or GED (n = 34, representing 9.5%), some graduate school (n = 17, representing 4.7%), and some schooling but no diploma or degree (n = 6, representing 1.7%). This result is, however, not representative of the demographic of Indiana as a state (i.e., 88.7% of residents are high school graduates or GED). See Figure 5.3 for education of Indiana resident participants.

Regarding the level of income, a majority of participants had an annual household income of $50,000 and above (n = 204, representing 57%), followed by participants with an annual household income of $49,999 and below (n = 154, representing 43%). This result is representative of the demographic of Indiana as a state (i.e., median household income is $56,303). See Figure 5.4 for income of Indiana resident participants.

Regarding race/ethnicity, an overwhelming majority of participants identified as Caucasian (n = 340, representing 85%), followed by Black or African American (n = 18, representing 5%), Latinx (n = 17, representing 4.7%), Asian or Asian American (n = 14, representing 3.9%), multi-ethnic/race (n = 11, representing 3.1%), and Native American (n = 1, representing 0.3%). This result is representative of the demographic of Indiana as a state (i.e., 84.8% of residents are whites). See Figure 5.5 for race/ethnicity of Indiana resident participants. These demographics were not representative of the demographics of Indiana as a state.

Analyses revealed that participants perceived all 15 campaign messages to be effective (with mean scores above 3 out of 5) because the messages grabbed their attention, were believable, made them think about work zone safety, and made them want to engage in safety driving behaviors in Indiana work zones. Each campaign message was assigned a code name to aid in the analysis and report writing. The analyses also revealed that six campaign messages (i.e., SSN3, TFA1, SSN2, DCS1, DFA1, and SFA1) received highest favorable scores (with mean scores above 4 out of 5). This suggests that these six messages were perceived to

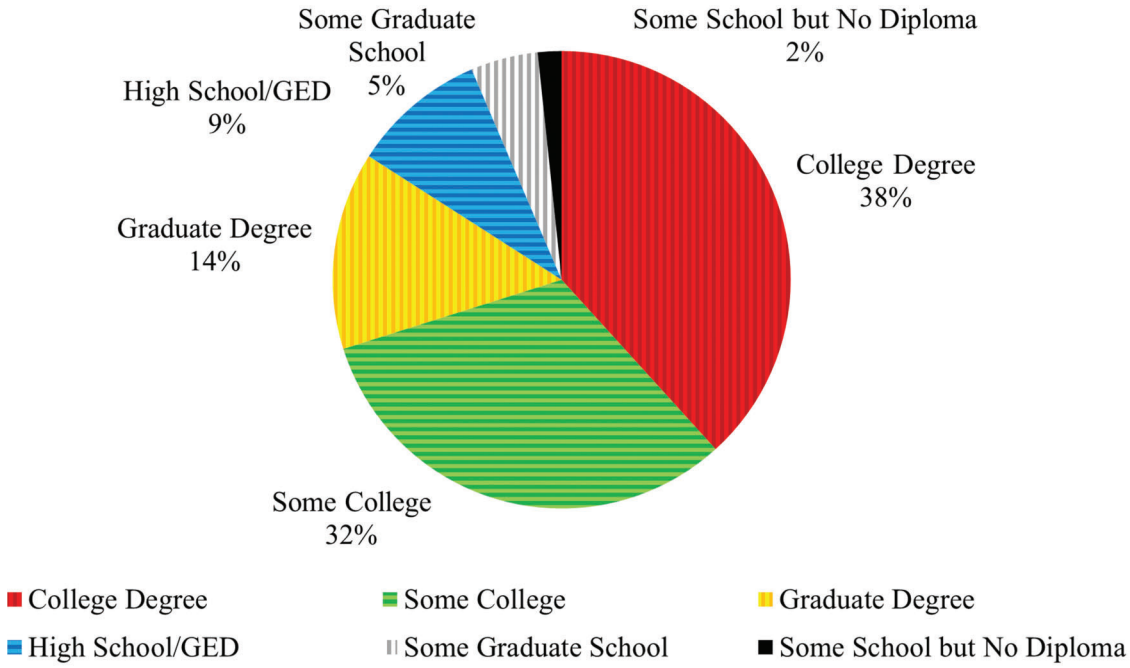


Figure 5.3 Education of Indiana resident participants (n = 358).

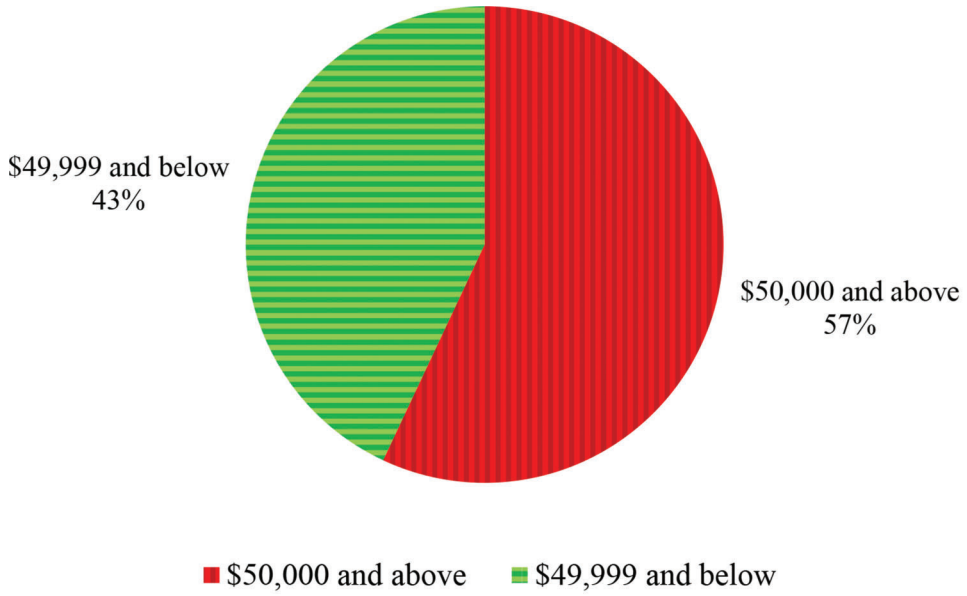


Figure 5.4 Income of Indiana resident participants (n = 358).

be the most effective. See Table 5.1 for mean scores out of 5 and standard deviations for each message. See Appendix E for all 15 messages. These campaign messages are briefly described in the following list.

1. DFA1 is a fear appeal message targeting distracted driving behavior. It encourages drivers to avoid using their phones while driving through work zones.
2. DPA1 is a positive appeal message targeting distracted driving behavior. It encourages drivers to avoid texting while driving through work zones.
3. DSC1 is a source credibility message targeting distracted driving behavior. It features a male construction worker who is encouraging drivers to avoid all forms of distracted driving in work zones.
4. FYPA1 is a positive appeal message targeting failure to yield right of way behavior. It encourages drivers to always yield right of way to avoid crashes in work zones.
5. GPA1 is a positive appeal message encouraging drivers to maintain traffic flow in work zones.
6. SFA1 is a fear appeal message targeting unsafe speeding behavior. It encourages drivers to slow down in work zones.

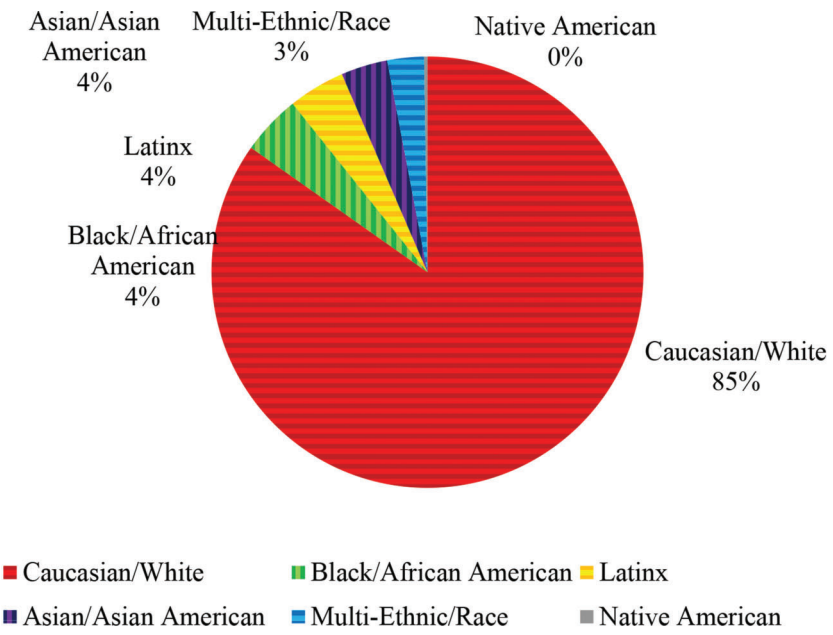


Figure 5.5 Race/ethnicity of Indiana resident participants (n = 358).

7. SFA2 is a fear appeal message targeting unsafe speeding behavior. It encourages drivers to slow down in work zones to protect a life.
8. SPA1 is a positive fear appeal message targeting unsafe speeding behavior. It encourages drivers to obey posted speed limits in work zones.
9. SSC1 is a source credibility message targeting unsafe speeding behavior. It features a male construction worker who is encouraging drivers to slow down in work zones.
10. SSN1 is a social norm message targeting unsafe speeding behavior. It encourages drivers to obey posted speed limits in work zones because the law requires them to do so.
11. SSN2 is a social norm message targeting unsafe speeding behavior. It encourages drivers to slow down in work zones because their families expect them home safe and sound every day.
12. SSN3 is a social norm message targeting unsafe speeding behavior. It encourages drivers to do their parts by slowing down in work zones.
13. TFA1 is a fear appeal message targeting tailgating behavior. It encourages drivers to leave a plenty of room for large trucks operating in work zones.
14. TPA1 is a positive appeal message targeting tailgating behavior. It encourages drivers to maintain a safe distance while driving through a work zone.
15. ULMPA1 is a positive appeal message targeting unsafe lane moving behavior. It encourages drivers to check their blind spots when changing lanes in work zones.

The analyses also revealed that participants believed they could perform the safe driving behaviors recommended by each campaign messages because those recommendations were easy to perform while driving in Indiana work zones and convenient. See Table 5.2 for mean scores out of 5 and standard deviations for each campaign message. See Appendix E for all campaign messages.

TABLE 5.1
Perceived effectiveness of 15 campaign messages (Indiana residents' sample)

Messages	Mean	Standard Deviation
SSN3	4.26	.746
TFA1	4.22	.759
SSN2	4.20	.724
DSC1	4.18	.770
DFA1	4.09	.774
SFA1	4.08	.573
SFA2	3.97	.703
TPA1	3.91	.811
SSC1	3.80	.811
SPA1	3.73	.875
ULMPA1	3.72	.854
FYPA1	3.64	.889
DPA1	3.63	.920
GPA1	3.62	.957
SSN1	3.38	.821

The analyses also revealed that participants believed that the safe driving behaviors recommended would be effective in preventing crashes in Indiana work zones. See Table 5.3 for mean scores out of 5 and standard deviations for each campaign message. See Appendix E for all campaign messages.

Additionally, the analyses revealed that a majority of participants most frequently read Indiana work zone safety messages on billboards (n = 255, representing 62.8%), followed by portable changeable message signs (n = 185, representing 51.7%), Facebook (n = 147, representing 41.1%), Indiana Department of Transportation's website (n = 87, representing 24.3%), Instagram (n = 58, representing 16.2%), Twitter (n = 54, representing 15.1%), and other channels (n = 26, representing 7.3%). The analyses also revealed that a

TABLE 5.2
Perceived self-efficacy of 15 campaign messages (Indiana residents' sample)

Messages	Mean	Standard Deviation
DFA1	4.41	.648
TFA1	4.32	.754
TPA1	4.30	.669
SFA1	4.26	.615
DPA1	4.25	.730
ULMPA1	4.25	.720
DSC1	4.23	.743
SSN3	4.20	.718
SSC1	4.20	.717
SSN2	4.18	.688
SFA2	4.17	.670
FYPA1	4.11	.804
SPA1	4.05	.758
GPA1	4.01	.816
SSN1	3.98	.763

TABLE 5.3
Perceived response efficacy of 15 campaign messages (Indiana residents' sample)

Messages	Mean	Standard Deviation
DFA1	4.55	.611
SFA1	4.49	.535
TFA1	4.48	.634
DSC1	4.46	.653
SSN3	4.43	.673
DPA1	4.42	.670
TPA1	4.42	.622
SFA2	4.39	.616
ULMPA1	4.37	.756
SSC1	4.36	.640
SSN2	4.35	.720
SPA1	4.26	.703
FYPA1	4.23	.777
GPA1	4.21	.751
SSN1	3.98	.986

majority of participants would still most prefer to receive and read safety message about Indiana work zone on billboards (n = 246, representing 68.7%), followed by portable changeable message signs (n = 204, representing 57%), rest areas or welcome centers (n = 146, representing 40.8%), Facebook (n = 127, representing 35.5%), INDOT's website (n = 87, representing 24.3%), Instagram (n = 58, representing 16.2%), Twitter (n = 50, representing 14%), Email (n = 39, representing 10.9%), and other channels (n = 11, representing 3.1%). See Figure 5.6 for channel preference for Indiana resident participants. It is worth mentioning that participants were asked to choose up to 3 channels. Therefore, the results should be interpreted within this context.

5.2 Results from the College Student Sample

Almost all participants were within the 18–24 years category (n = 110, representing 99.1%). This result is representative of the demographic of Indiana as a state (i.e., about 54% of residents' ages range between 18 and 64 years). There were a majority of female participants (n = 60, representing 54.1%) with 49 male participants representing 44.1%, and 2 non-binary participants representing 1.8%. This result is representative of the demographic of Indiana as a state (i.e., 50.7% of residents are females). See Figure 5.7 for gender of college student participants.

Regarding race/ethnicity, a majority of participants identified as Caucasian (n = 87, representing 78.4%), followed by Asian or Asian American (n = 21, representing 18.9%), Latinx (n = 3, representing 2.7%), Black or African American (n = 2, representing 1.8%), multi-ethnic/race (n = 1, representing 0.9%). This result is representative of the demographic of Indiana as a state (i.e., 84.8% of residents are white). See Figure 5.8 for race/ethnicity of college student participants.

Regarding level of income, a majority of participants had an annual household income of $50,000 and above (n = 77, representing 69.4%), followed by participants with an annual household income of $49,999 and below (n = 32, representing 28.8%). These are most likely their parents' household incomes. This result is representative of the demographic of Indiana as a state (i.e., median household income is $56,303). See Figure 5.9 for income of college student participants.

Data analyses, similar to those from the Indiana resident sample, revealed that participants perceived all 15 campaign messages to be effective (with mean scores above 3 out of 5) because the messages grabbed their attention, were believable, made them think about work zone safety, and made them want to engage in safety driving behaviors in Indiana work zones. The analyses also revealed that five campaign messages (i.e., TFA1, DSC1, SSN3, DFA1, and SSN2) received highest favorable scores (with mean scores above 4 out of 5). Interestingly, these messages also received the highest favorable scores among the Indiana resident sample, suggesting that these five messages were perceived the most effective of all the 15 campaign messages among both participant samples. See Table 5.4 for mean scores out of 5 and standard deviations for each message. See Appendix E for all 15 messages.

The analyses, similar to those from the Indiana resident sample, also revealed that participants believed they could perform the safe driving behaviors recommended by each campaign message because those recommendations were easy to perform while driving in Indiana work zones and convenient. See Table 5.5 for mean scores out of 5 and standard deviations for each campaign message. See Appendix E for all campaign messages.

The analyses revealed that participants believed the safe driving behaviors recommended by each campaign would be effective in preventing crashes in Indiana work zones. See Table 5.6 for mean scores out of 5 and standard deviations for each campaign message. See Appendix E for all campaign messages.

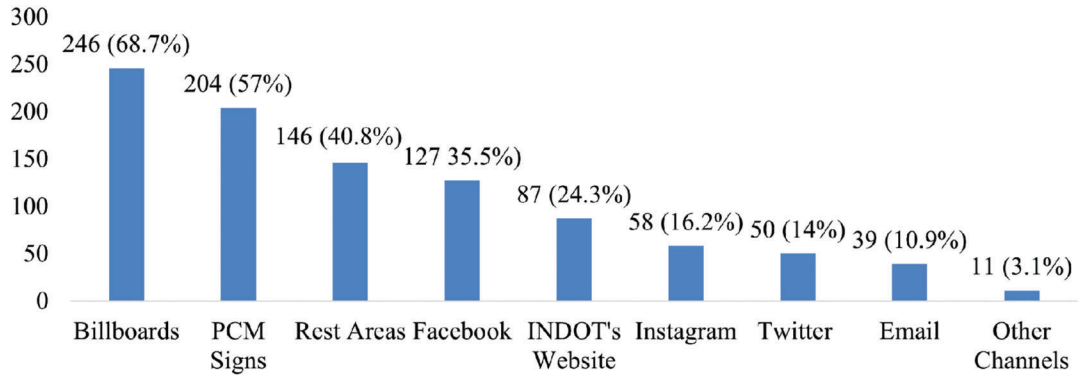


Figure 5.6 Channel preference for Indiana resident participation (n = 358).

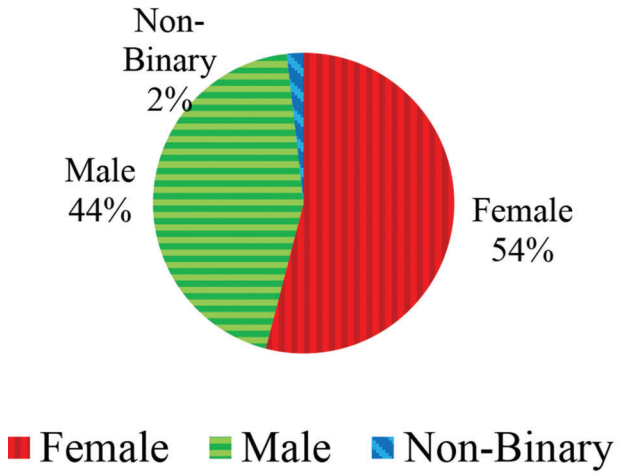


Figure 5.7 Gender of college student participants (n = 111).

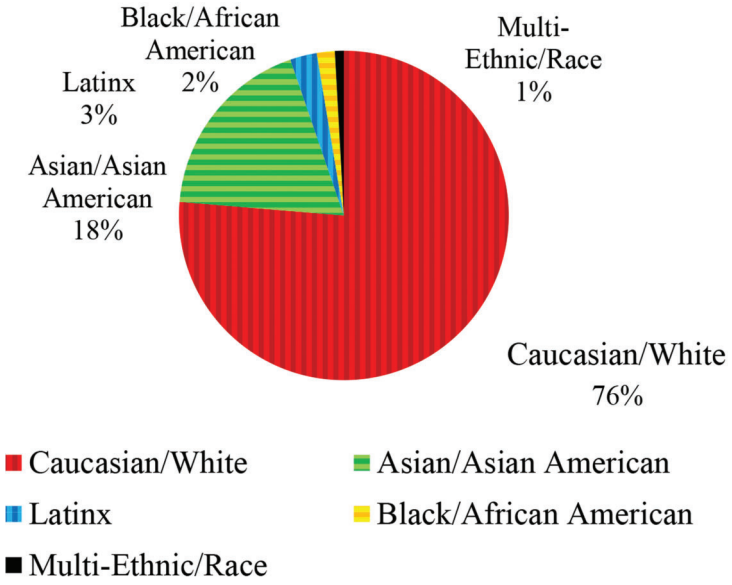


Figure 5.8 Race/ethnicity of college student participants (n = 111).

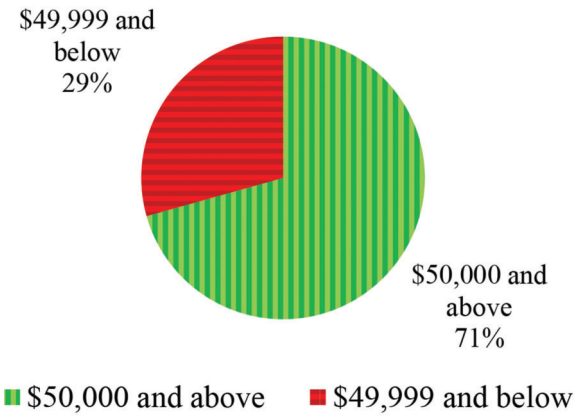


Figure 5.9 Income of college student participants (n = 111).

TABLE 5.4
Perceived effectiveness of all 15 campaign messages (college students' sample)

Messages	Mean	Standard Deviation
TFA1	4.37	.654
DSC1	4.15	.723
SSN3	4.13	.824
DFA1	4.12	.784
SSN2	4.10	.774
SFA2	3.91	.704
SFA1	3.82	.581
TPA1	3.81	.813
SPA1	3.78	.820
ULMPA1	3.75	.913
SSC1	3.73	.915
DPA1	3.70	.870
GPA1	3.70	.930
FYPA1	3.68	.879
SSN1	3.46	.921

TABLE 5.5
Perceived self-efficacy of 15 campaign messages (college students' sample)

Messages	Mean	Standard Deviation
DFA1	4.41	.631
TFA1	4.38	.638
ULMPA1	4.28	.705
DFA1	4.28	.624
TPA1	4.23	.668
FYPA1	4.23	.665
SSN2	4.20	.630
SSN3	4.18	.736
SFA1	4.17	.719
DSC1	4.17	.673
SFA2	4.16	.572
GPA1	4.16	.702
SSC1	4.12	.718
SPA1	4.10	.705
SSN1	3.99	.743

TABLE 5.6
Perceived response efficacy of 15 campaign messages (college students' sample)

Messages	Mean	Standard Deviation
DFA1	4.53	.555
TFA1	4.45	.626
ULMPA1	4.44	.593
DFA1	4.42	.673
DSC1	4.39	.579
SFA1	4.36	.578
SFA2	4.35	.567
TPA1	4.35	.633
SSN2	4.32	.600
GPA1	4.32	.618
SSN3	4.31	.644
SPA1	4.24	.615
SSC1	4.23	.684
FYPA1	4.23	.698
SSN1	4.01	.899

Lastly, the analyses revealed that a majority of participants most frequently read Indiana work zone safety messages on billboards (n = 84 representing 75.7%), followed by portable changeable message signs (n = 45, representing 40.5%), Instagram (n = 40, representing 36%), Facebook (n = 36, representing 32.4%), Twitter (n = 27, representing 24.3%), Indiana Department of Transportation's website (n = 19, representing 17.1%), and other channels (n = 7 representing 6.3%). The results also revealed that a majority of participants would still most likely prefer to receive and read safety message about Indiana work zones on billboards (n = 74, representing 66.7%), followed by rest areas or welcome centers (n = 48, representing 43.2%), Instagram (n = 46, representing 41.4%), portable changeable message signs (n = 39, representing 35.1%), INDOT's website (n = 25, representing 22.5%), Facebook (n = 24, representing 21.6%), Twitter (n = 21, representing 18.9%), Email (n = 21, representing 18.9%), and other channels (n = 6, representing 5.4%). See Figure 5.10 for channel preference for college student participants. It is worth mentioning that participants were asked to choose up to 3 channels. Therefore, the results should be interpreted within this context.

In summary, the results indicate that the demographics of the college student sample are more representative of the demographics of Indiana as a state than those of the Indiana resident sample. This implies that the results from the college student sample are more generalizable to the population of Indiana as a state. Also, the results indicate that participants from both Indiana residents and college student samples perceived all the 15 campaign messages to be effective at encouraging safe driving behaviors in Indiana work zones. Specifically, five of the campaign messages (i.e., TFA1, DSC1, SSN3, DFA1, and SSN2) received the highest favorable mean scores from both samples, suggesting that these messages are perceived to be the most effective. The results also indicate that partici-

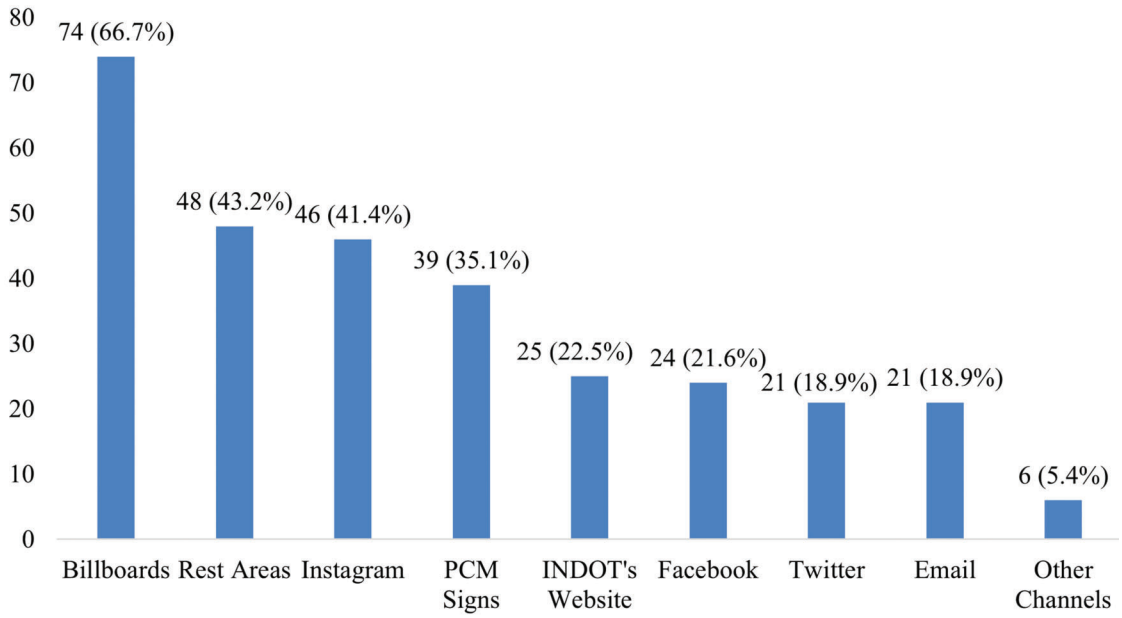


Figure 5.10 Channel preferences for college student participation (n = 111).

pants from both samples believed that they could perform the safe driving behaviors recommended by each message. The results indicate that participants believed the recommended safe driving behaviors would be effective in preventing crashes in Indiana work zones. Finally, the results indicate that participants from both samples would prefer to receive and read work zone safety campaign messages on billboards, portable changeable message signs, Instagram, Facebook, INDOT's website, and at rest areas.

5.3 Results from the Qualitative Data Analysis

The open-ended responses from both Indiana resident and college student samples were analyzed for each campaign message. The responses were mainly suggestions to improve each message. These recommendations were subsequently accounted for to make modifications to the campaign messages where applicable and feasible to do so. See Appendix E to view the edited versions of the 15 campaign messages. Also, see Appendix D for the campaign survey questions.

5.3.1 Speeding Fear Appeal #1 (SFA1)

The campaign message in Figure 5.11 received several suggestions centering around the background photo, amount of text, and content of the message. For example, some participants commented about poor quality of the background photo. They suggested that using another photo of higher quality that clearly depicts the consequences of speeding in a work zone would be effective and persuasive. In terms of the text, other participants suggested adding a trim or border around the words might help "pop" the color between the two blocks. The second block of text should be enlarged or treated with a

Figure 5.11 Speeding fear appeal #1.

different color to stand out as the primary note. The messaging was agreeable, albeit a bit wordy in the first block of text. They also suggested the statistic should be rephrased as a whole number or ratio/proportion because 36% could be dismissed by some as insignificant. Rewording the message to include potential fines or penalties for speeding may also be feasible.

5.3.2 Speeding Fear Appeal #2 (SFA2)

The suggestions for improving the message in Figure 5.12 centered around background photo and content of this message. Specifically, some participants suggested that the background photo should be made a little more transparent, so as to appear less busy. It is also unclear if the photo reflects a work zone environment. They also commented that although the stick figures at the top do a fine job visually representing the 3/10 statistic, the 3 fatal crashes would be the ones better served being

Figure 5.12 Speeding fear appeal #2.

opaque, rather than faded. From a messaging perspective, 3/10 comes across for some as a weak statistic, so the copy could be trimmed and reframed for both brevity and noteworthiness.

5.3.3 Speeding Social Norm #1 (SSN1)

Figure 5.13 Speeding social norm #1.

The suggestions for the message in Figure 5.13 centered around the graphic and amount of text. Some participants said the graphic was a bit jarring, as the speed limit sign utilized was not appropriate. They suggested that a *Reduce Speed* sign more in line with highway construction work zones could have been better opted for use. The simple language in the message was appreciated, although it could be trimmed further. The message also felt impersonal to some participants due to a lack of incentive (fines/penalties?), suggesting that adding an incentive to the message would make it more persuasive.

5.3.4 Speeding Social Norm #2 (SSN2)

The design and messaging of Figure 5.14 were both well-received, as an emotional appeal was a welcome

Figure 5.14 Speeding social norm #2.

change from the previous iterations. Notable suggestions were to reword the message slightly to shorten the text, as well as to move the work zone in between the two text blocks to draw quick attention. To blend in more with the background, a border around the white text box would be ideal. While the photos were of high quality, real images of families and workers could be supplemented to appear less staged and stock-like. Optionally, more diverse types of families (extended, same-sex, single parent, etc.) could be another consideration.

5.3.5 Speeding Social Norm #3 (SSN3)

Figure 5.15 Speeding social norm #3.

The suggestion for message in Figure 5.15 centered around messaging. Although liked overall, the *It's the Law* portion appears condescending in tone to some participants and mixing the statement with the larger message of protecting construction workers feels manipulative, as if they are being used as an emotional pawn. Therefore, the text could be reworked without emphasizing the law, and instead opting for a relevant

fatal accident statistic. Clearer selfies/pictures of a higher quality would be beneficial, as would larger font size and a two-tone color scheme.

5.3.6 Speeding Positive Appeal #1

Figure 5.16 Speeding positive appeal #1.

Participants' suggestions for Figure 5.16 centered around font size, amount of text, and content of the message. Specifically, the font size of graphic could be enlarged, while reducing the size of the image. To that effect, trimming the amount of text used in the image would help. Additionally, a designated work zone speed limit sign would be more applicable in this scenario, in addition to more effective visuals. The message could be slightly rewritten to provide a reason or incentive to slow down, as well as to appeal both to other drivers and the self.

5.3.7 Speeding Source Credibility #1

The choice of image used for Figure 5.17 was easily identified to be a stock image and rather generic, so a more authentic construction worker would lend the message an even greater sense of ethos (credibility). The situation depicted in the image (construction site, rather than work zone) could reflect the message better by being genuine. The text box in the bottom left corner leaves a lot of blank space in the sample, so positioning it higher would be logical. The message content was simple enough, although the amount of text could be trimmed for concision. Alternatively, a more empathetic message for worker safety could be devised for similar versions in the future.

Figure 5.17 Speeding source credibility #1.

5.3.8 Distracted Driving Fear Appeal #1

Figure 5.18 Distracted driving fear appeal #1.

While the image itself in Figure 5.18 was positively commented upon, certain comments were provided to improve its overall perception. For instance, the phone used in the picture was outdated, and the red "X" on the phone was a bit too cartoon-like. The top message of the graphic would look better with a border, or instead it could be removed for greater effectiveness in another sample altogether. The monochrome color scheme did not find favor with every respondent either. From a message perspective, the second paragraph could be reworded and trimmed, as it comes across as ambiguous when talking solely about work zones. Finally, the statistic of 25 lives could be reframed as a ratio or proportion for a higher impact.

5.3.9 Distracted Driving Source Credibility #1

Personal testimonials on the Figure 5.19 message were received well by the majority of participants. In this particular case, respondents felt that a clearer and more professional picture with better lighting would hold more value to the message. Showing the complete *Stop* sign would also lend credence to the construction worker's quote. This could be a feasible way to use up empty spaces in the graphic, although special attention ought to be given to ensure the

Figure 5.19 Distracted driving source credibility #1.

color scheme remains consistent throughout. The message print should be aided by trimming (or even removing) the 1st paragraph, while specifying a distinct type of distraction in the 2nd paragraph for the sake of clarity.

5.3.10 Distracted Driving Positive Appeal #1 (DPA1)

Figure 5.20 Distracted driving positive appeal #1.

In terms of the graphic design of Figure 5.20, the yellow text box could be enlarged to occupy blank space within the sample. From a message point of view however, the copy felt weak and unconvincing in terms of call-to-action, perhaps due to its generic tone and similar graphics already existing in the public domain. The simple language and concision were welcomed, but some participants questioned if the printed text could stand to have more details. Including texting-specific statistics or discussing handsfree/Bluetooth options could be an opportunity to differentiate the message.

5.3.11 Tailgating Positive Appeal #1

While the majority of participants liked the photo in Figure 5.21, some had difficulty distinguishing the text statement overlaid on the image. To that effect, making

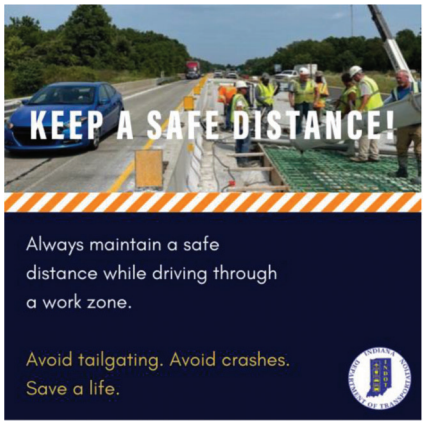


Figure 5.21 Tailgating positive appeal #1.

the print clearer and more distinctive through shadowing or a darker shade should be considered. Some participants also mentioned that a more traffic-packed work zone would be more evocative of a real-life scenario, while others felt that a higher quality photo with brighter colors would also add to its authenticity. Comments regarding the messaging were minimal, although a few suggested the inclusion of what a safe following distance in a work zone actually constitutes.

5.3.12 Tailgating Positive Appeal #2

Figure 5.22 Tailgating positive appeal #2.

The choice to use a photo of a crash in Figure 5.22 was a stylistic choice, and one that resonated successfully with participants. From a design perspective, participants suggested that using a car-on-car crash or a car-on-truck crash would have a more dramatic impact, as the applicability and relatability factors would be higher. Furthermore, illustrating that the image was clearly from a work zone would enhance the credibility of the message. In terms of the message content, trimming and rewording the 1st paragraph, while emphasizing action-specific words would be ideal.

5.3.13 Unsafe Lane Movement Positive Appeal #1

Figure 5.23 Unsafe lane movement positive appeal #1.

Figure 5.23 received minimal feedback from participants. Some participants suggested changing the color of the mirror to a greyscale, while also moving the truck in the photo closer to the car's actual blind spot. Alternatively, using an entirely different photo of a driver physically turning to check their blind spot would be worth considering. Some participants felt the message seemed to lack persuasiveness. Although the statements were clear and concise, they seemed too distinct and disjointed from each other. Participants suggested rewording these statements to make them more coherent and concise.

5.3.14 Failure to Yield Positive Appeal #1 (FYPA1)

Figure 5.24 Failure to yield positive appeal #1.

From both a design and message perspective, this message in Figure 5.24 was not rated as highly as the previous ones displayed. The use of a *Yield* sign rather than an Indiana-specific one (with appropriate font and color) was criticized, as was the fact that it was non-existent in a work zone. The textbox could be enlarged and positioned higher to occupy the abundance of blank space in the graphic. Messaging was notably perceived to be less persuasive as there was ambiguity on what or when to yield to, the meaning of "right of way," and the importance or incentive to yield in a work zone.

5.3.15 General Positive Appeal #1 (GPA1)

Figure 5.25 General positive appeal #1.

Similar to the assessment of FYPA1, both the design and messaging of Figure 5.25 was perceived as less persuasive by some participants. They suggested that a more eye-catching, higher quality picture would be persuasive. In addition, the message would suit a darker background better. These suggestions require an almost complete rewrite, as "Maintain traffic flow" sounds vague in terms of what it entails. Since traffic flow is not always in the driver's control, this could be alleviated by rewording the message to include a statistic related to traffic flow.

5.3.16 Key Takeaways

In summary, the vast majority of campaign messages received largely positive qualitative feedback from participants of both samples. With a select number of easily remediable tweaks to the design and messaging components where applicable, the team believes that these campaign messages are ready for implementation. This qualitative analysis has some limitations. Manually poring through 8,250 comments for suggestions, it was evident that no campaign message received a 100% rate of support. To that end, the quantitative results are a much better indicator of public perception, as opposed to a short-form suggestion box. Additionally, survey fatigue among respondents is a genuine concern, especially within the open-ended format. With a total of 60 questions pertaining to the evaluation of graphic samples alone, it is evident that participants may have felt burnt out towards the latter stages of the survey, opting to write "None" or "N/A" in lieu of more

detailed, specific answers. The results also indicate that participants believed that the photos used in the campaign messages were of low production quality making them less persuasive.

6. EDUCATION CURRICULUM

The second goal of this project was to design educational materials to be incorporated into driver's education or training curriculum prior to taking a driving test and getting a driver's license issued. The design of the educational material was informed by crash data analysis, driver's manual analysis, previous campaign message analysis, and the Oklahoma work zone safety course for teens (https://workzonesafe.com). Specifically, the crash data and previous campaign message analyses helped to identify five driving behaviors that most often cause crashes in work zones. These driving behaviors were distracted driving, speeding, tailgating/following too closely, unsafe lane moving, and failure to yield right of way.

These five driving behaviors were included in the education curriculum. The format and structure of the education curriculum was informed by the driver's manual analysis and the Oklahoma work zone safety course for teens (see https://workzonesafe.com). The education curriculum has three modules and 14 knowledge questions. See Appendix B for all three modules and 14 knowledge questions. Module 1 focuses on safe driving behaviors in and around work zones. This module has six knowledge questions. Module 2 focuses on safety signs and laws about Indiana work zones. This module has five knowledge questions. Module 3 focuses on merging in work zones. The zipper merge and the early merge were the main focus. This module has three knowledge questions.

The main aim of this education curriculum is to increase the target audience's knowledge about work zone driver safety practices. The target audience includes drivers who are going for their drivers' licenses for the first time and drivers who are renewing their vehicle registration online. This education curriculum has the following four specific objectives.

1. Objective 1: Increase learners' knowledge about safe driving behaviors in and around Indiana highway work zones.
2. Objective 2: Increase learners' knowledge about Indiana highway work zone safety signs.
3. Objective 3: Increase learners' knowledge about Indiana laws concerning highway work zone safety.
4. Objective 4: Increase learners' knowledge about how and when to merge in Indiana highway work zones.

6.1 Formative Study of Education Curriculum

This education curriculum was pilot tested through an online survey study to determine its effectiveness in increasing learners' knowledge about highway work zone safety practices and to also gather suggestions on how to improve the curriculum.

6.1.1 Survey Design

This formative study utilized an online survey design. The survey incorporated all three modules and 14 knowledge questions. One open-ended question was included in the survey to gather participants suggestions about ways to improve the curriculum.

6.1.2 Study Participants

Participants were college students from across Purdue University who were recruited through the Brian Lamb School of Communication's research participation system (i.e., SONA). To participate in the survey, participants had to be at least 18 years old, be registered students, and hold a valid US driver's license. Extra credit for a communication course was offered for participation. 248 participants were recruited and completed the survey.

6.1.3 Study Procedures

Data collection began in January 2022 and ended in March 2022. After receiving approval from Purdue University's Institutional Review Board, an online survey via Qualtrics was used to collect data. After reading and agreeing to participate via an online consent form, participants read the instructions for and expectations of the survey. Participants were informed that they would read three modules and answer knowledge questions after each module. Participants read Module 1 on safe driving behaviors in and around highway work zone and answered six knowledge questions. Participant next read Module 2 on safety signs and laws about Indiana highway work zones and answered five knowledge questions. Participants then read Module 3 on merging in highway work zones and answered three knowledge questions. Then, participants provided a written response giving suggestions about ways to improve the curriculum. Finally, participants answered demographic questions about their age, gender, race/ethnicity, household income, and driver's license status.

6.1.4 Data Analysis

Descriptive statistical analyses such as frequencies were conducted on the demographic and knowledge question data. The open-end responses were extracted from Qualtrics into an Excel file and were manually analyzed to identify recurring trends and themes.

6.2 Results of Formative Study

The results section is divided into three subsections. The first subsection presents demographic results. The second subsection presents knowledge question results.

The third subsection presents qualitative results from the open-ended response.

6.2.1 Demographic Results

The majority of participants were female (n = 149, representing 61.1%), with 93 male participants representing 38.1% and 2 non-binary participants representing 0.8%. This result is close to being representative of the demographic of Indiana as a state (i.e., 50.7% of residents are females). See Figure 6.1 for gender of participants.

Almost all participants were within the 18–24 years age category (n = 241, representing 98.8%) with 2 participants within the 25–34 years category representing 0.8% and 1 participant within the 35–59 years category representing 0.4%. See Figure 6.2 for the age of participants.

Regarding race/ethnicity, a majority of participants identified as Caucasian (n = 183, representing 70%), followed by Asian or Asian American (n = 63, representing 24%), Latinx (n = 6, representing 2%), Black or African American (n = 3, representing 1%), multi-ethnic/race (n = 2, representing 1%), Native American/American Indian/Alaska Native (n = 2, representing 1%), and Native Hawaiian/Other Pacific Islander (n = 2, representing 1%). This result is close to being representative of the demographic of Indiana as a state (i.e., 84.8% of residents are Caucasian). See Figure 6.3 for race/ethnicity of participants.

Regarding level of income, a majority of participants had an annual household income of $50,000 and above (n = 177, representing 73.1%), followed by participants with an annual household income of $49,999 and below (n = 65, representing 26.9%). These are most likely their parents' household incomes. This result is representative of the demographic of Indiana as a state (i.e., median household income is $56,303). See Figure 6.4 for income of participants.

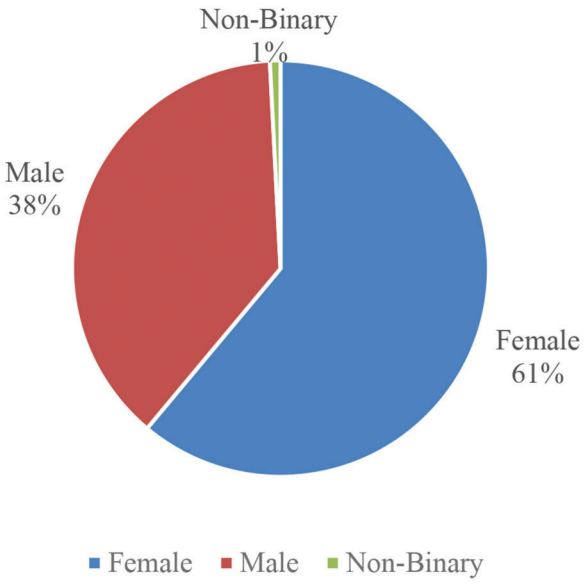


Figure 6.1 Gender of participants (n = 244).

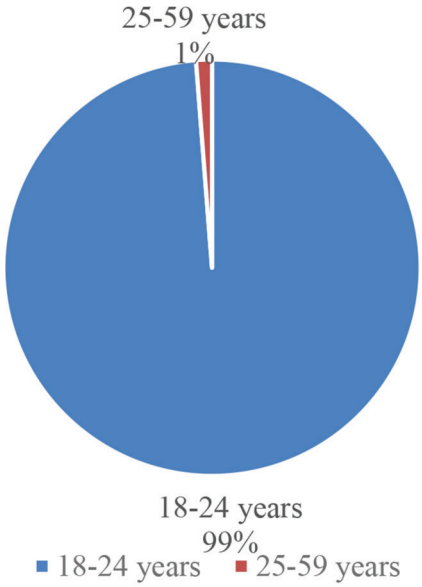


Figure 6.2 Age of participants.

6.2.2 Results for Each Knowledge Question

There were 14 knowledge questions in the education curriculum. Six questions focused on safe driving behaviors in and around highway work zones. Five questions focused on safety signs and laws about highway work zones. Three questions focused on merging in highway work zones. Both multiple choice and true or false questions were used. Nine questions were multiple choice type questions with four answer options, and five questions were true or false type. See Appendix B for all 14 knowledge questions and their corresponding answer choices.

Question 1 asked, "What driving behaviors likely contribute to work zone crashes?" Answer choice "D" (All answers are correct) was the correct answer to this question. A majority of participants answered this question correctly (n = 234, representing 94%). See Figure 6.5 for results for Question 1.

Question 2 asked, "What activity will likely take your attention away from driving or your eyes off the road in a highway work zone?" Answer choice "D" (All answers are correct) was the correct answer to this question. A majority of participants answered this question correctly (n = 236, representing 95%). See Figure 6.6 results for Question 2.

Question 3 asked, "Driving at a higher rate exceeding the posted speed limit in a highway work zone can potentially…." Answer choice "D" (All answers are correct) was the correct answer to this question. A majority of participants answered this question correctly (n = 226, representing 91%). See Figure 6.7 for results for Question 3.

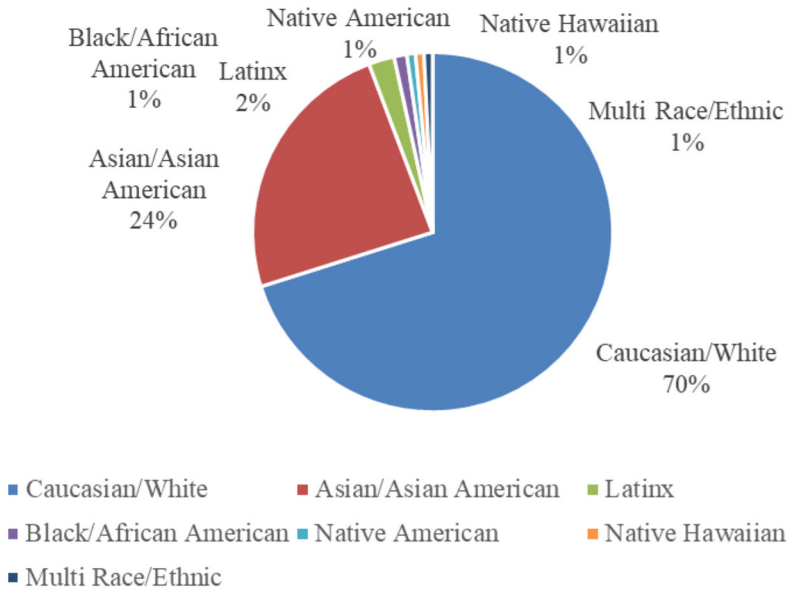


Figure 6.3 Race/ethnicity of participants.

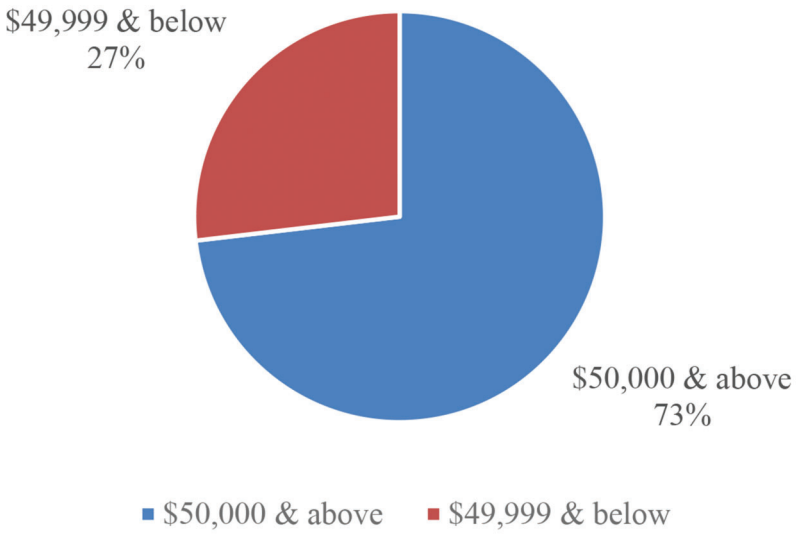


Figure 6.4 Income of participants.

Question 4 asked, "To make safe lane movement in work zones, a driver must…." Answer choice "D" (All answers are correct) was the correct answer to this question. A majority of participants answered this question correctly (n = 242, representing 97%). See Figure 6.8 for results for Question 4.

Question 5 asked, "Driving at 45 mph instead of 55 mph through a 5-mile work zone will only add 1.2 minutes to your trip." Answer choice "True" was the correct answer to this question. A majority of participants answered this question correctly (n = 225, representing 91%). See Figure 6.9 for results for Question 5.

Question 6 asked, "Sending or reading a text while driving through a work zone takes your eyes off the road for 5 seconds." Answer choice "True" was the correct answer to this question. A majority of participants answered this question correctly (n = 221, representing 89%). See Figure 6.10 for results for Question 6.

Question 7 asked, "The Indiana state laws require drivers or motorists to obey all signs in work zones." Answer choice "True" was the correct answer to this question. All participants answered this question correctly (n = 245).

Question 8 asked, "Drivers who injure or kill a highway worker may end up…." Answer choice "D" (Answer B and C are correct) was the correct answer to this question. A majority of participants answered this question correctly (n = 224, representing 91%). See Figure 6.11 for results for Question 8.

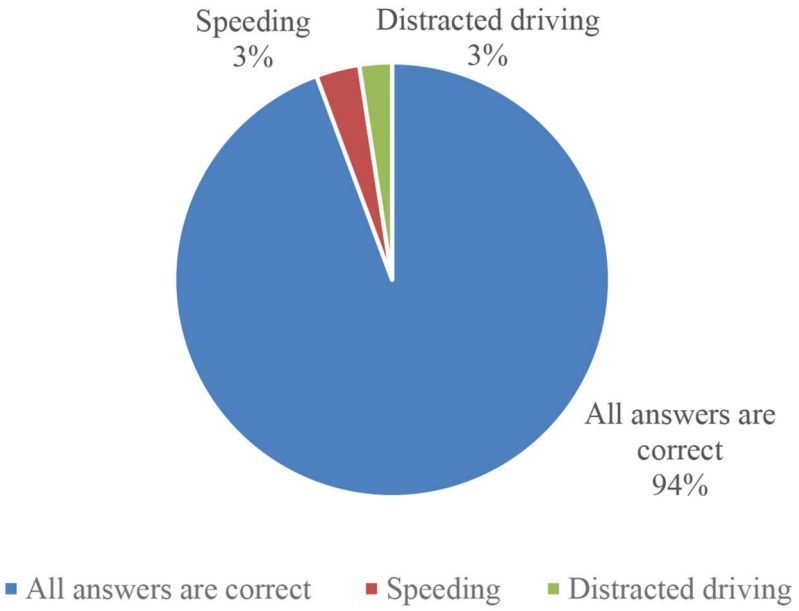


Figure 6.5 Question 1: What driving behaviors are likely to contribute to work crashes?

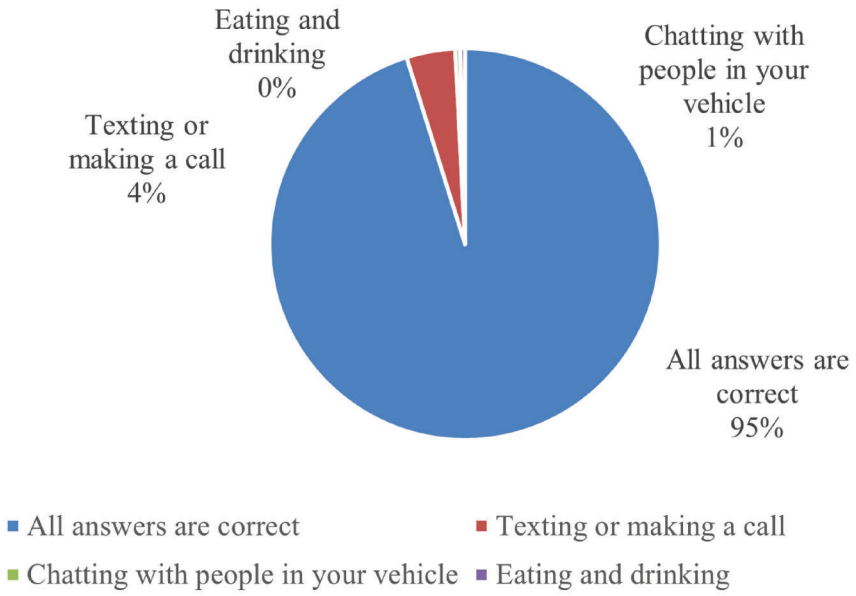


Figure 6.6 Question 2: What activity will likely take your attention away from driving or your eyes off the road in a highway work zone?

Question 9 asked, "Cones and barricades are used in work zones to…." Answer choice "D" (All answers are correct) was the correct answer to this question. A majority of participants answered this question correctly (n = 227, representing 93%). See Figure 6.12 for results for Question 9.

Question 10 asked, "You must obey all work zone signs only when workers are present." Answer choice "False" was the correct answer to this question. A majority of participants answered this question correctly (n = 181, representing 74%). See Figure 6.13 for results for Question 10.

Question 11 asked, "Work zones pose dangers for…." Answer choice "C" (both drivers and construction workers) was the correct answer to this question. A majority of participants answered this question correctly (n = 148, representing 60%). See Figure 6.14 for results for Question 11.

Question 12 asked, "A zipper merge allows drivers to use both lanes until reaching the merge point." Answer choice "True" was the correct answer to this question. A majority of participants answered this question correctly (n = 232, representing 95%). See Figure 6.15 for results for Question 12.

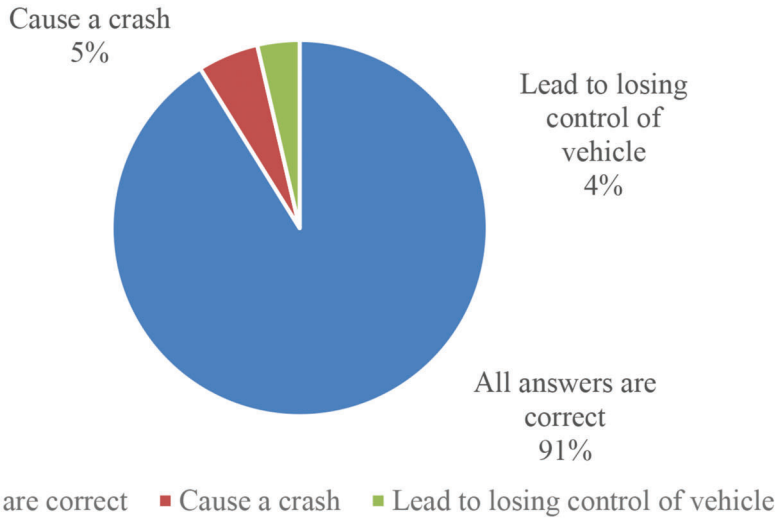


Figure 6.7 Question 3: Driving at a higher rate exceeding the posted speed limit in a highway work zone can potentially lead to what?

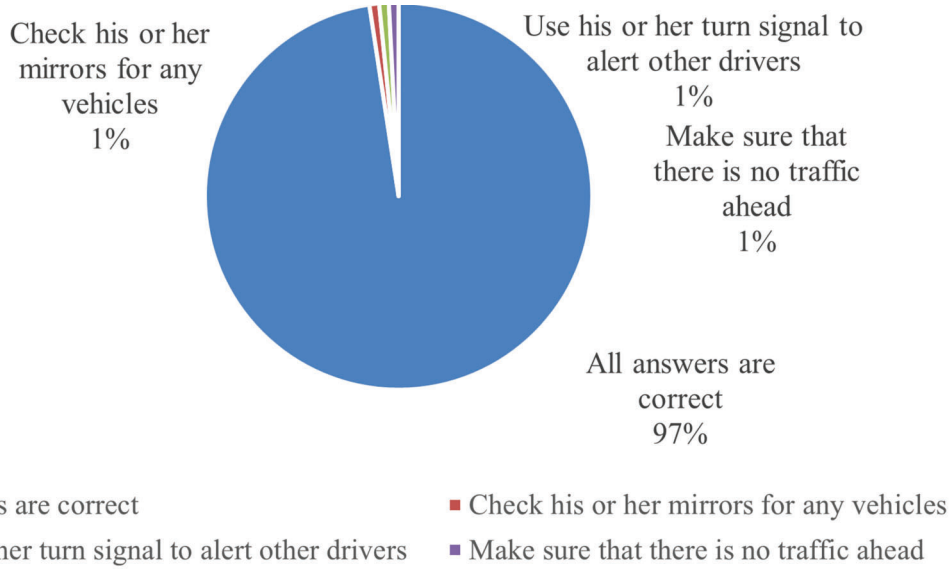


Figure 6.8 Question 4: To make safe lane movement in work zones, a driver must do what?

Question 13 asked, "A zipper merge helps to…." Answer choice "D" (All answers are correct) was the correct answer to this question. A majority of participants answered this question correctly (n = 221, representing 90%). See Figure 6.16 for results for Question 13.

Question 14 asked, "An early merge is…." Answer choice "B" (When you start moving into the open lane at the first sight of a lane closed sign) was the correct answer to this question. A majority of participants answered this question correctly (n = 163, representing 73%). See Figure 6.17 for results for Question 14.

6.2.3 Results for the Qualitative Data Analysis

Overall, participants were impressed with the content of the education curriculum. More specifically, participants felt that the content was well organized, very insightful, and useful, particularly, for new drivers and people who need a refresher on work zone safety. Participants provided some suggestions for improving the education curriculum. These suggestions centered around four broad themes: use more images, use more short videos, vary the question types, and vary the text contrast.

6.2.3.1 Use more images. The majority of participants suggested that more images should be incorporated into the curriculum for better content engagement, more content clarity, easier understanding and recall of content, and making it easier to read the content at a glance. Specifically, they suggested that the zipper merge module (or section) should include more diagrams, gifs, or photos to help learners to better visualize how and

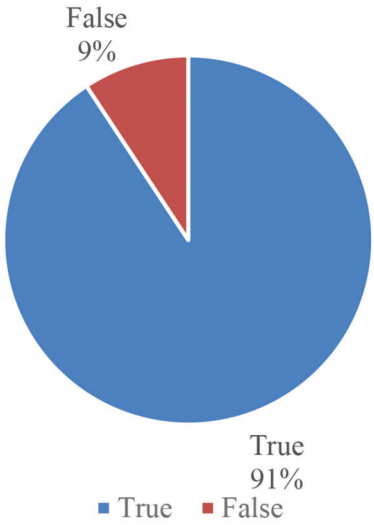


Figure 6.9 Question 5: Driving at 45 mph instead of 55 mph through a 5-mile work zone will only add 1.2 minutes to your trip.

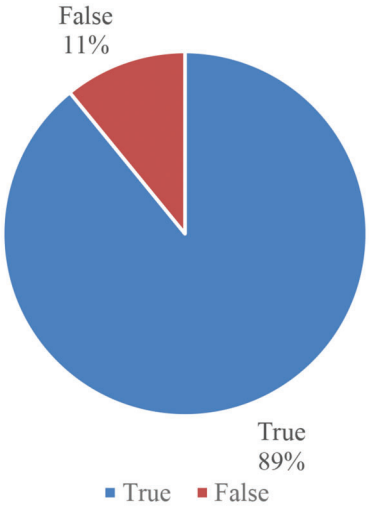


Figure 6.10 Question 6: Sending or reading a text while driving through a work zone takes your eyes off the road for 5 seconds.

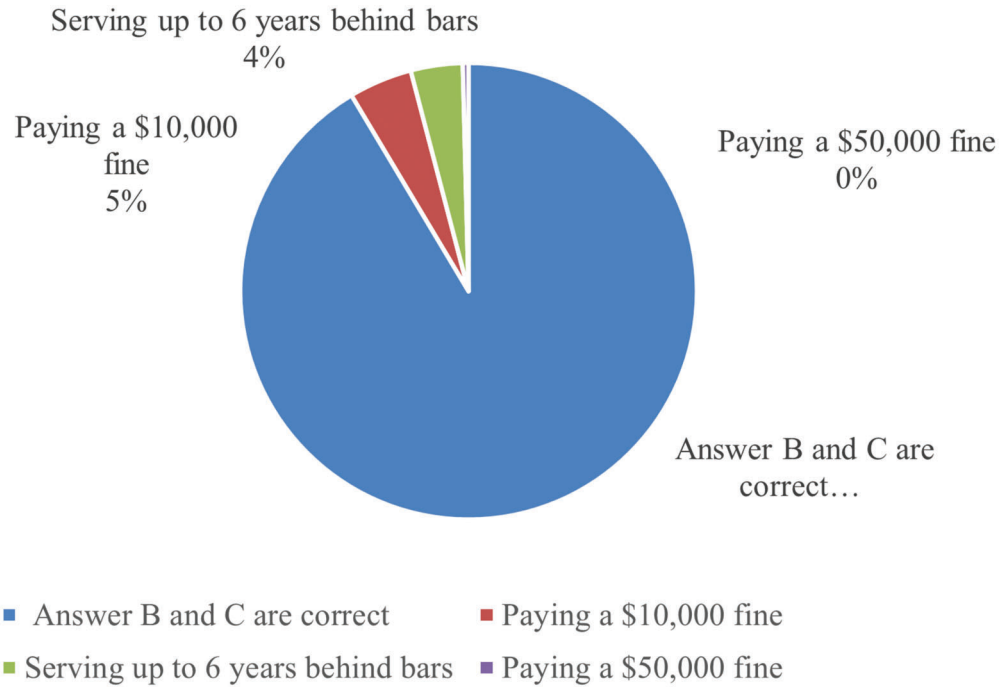


Figure 6.11 Question 8: Drivers who injure or kill a highway worker may end up with what consequence?

when to merge in work zones. Some participants expressed that zipper merge was relatively new to Indiana, so adding some diagrams showing how to merge would be very helpful for drivers.

6.2.3.2 Use more short videos. The majority of participants suggested using more short videos to explain some of the signs and how to merge in work zones. They suggested that these videos should be animated to enhance information recall and understanding.

6.2.3.3 Vary the question types. Participants suggested that the knowledge questions and answer choices should be varied to increase learners' attention. Specifically, some participants felt that the questions were too easy to answer, which could encourage learners not to actually engage/read the content. They suggested adding more difficult questions to encourage learners to read the content of the curriculum. They also suggested adding open-ended questions (i.e., questions that required written responses) to encourage learners to read the content. Other participants also

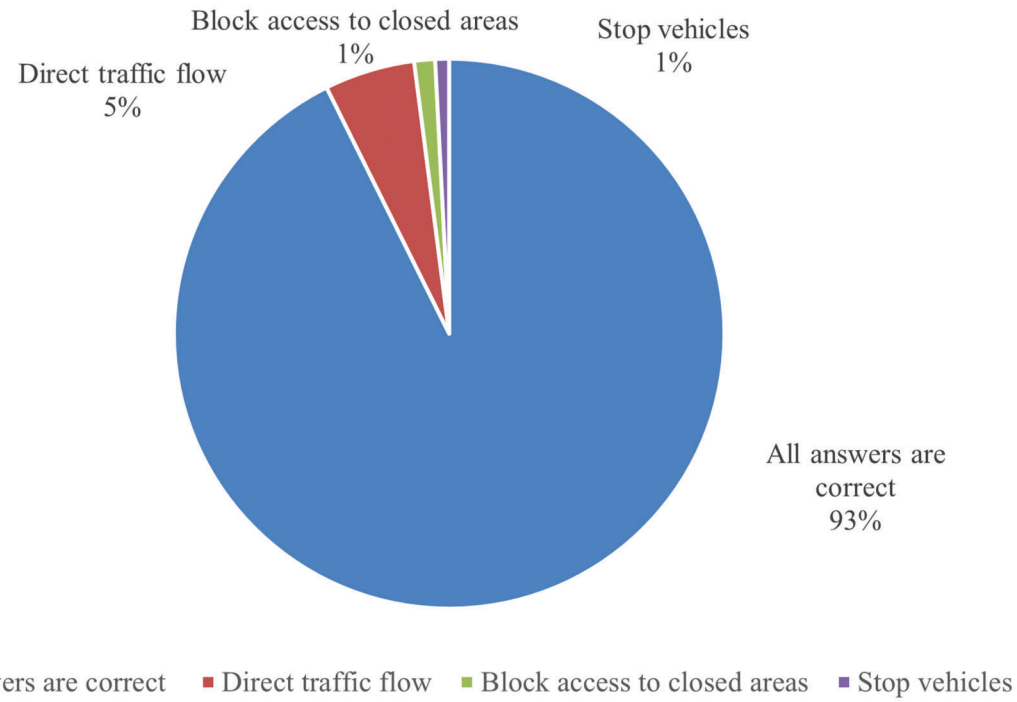


Figure 6.12 Question 9: Cones and barricades are used in work zones to do what?

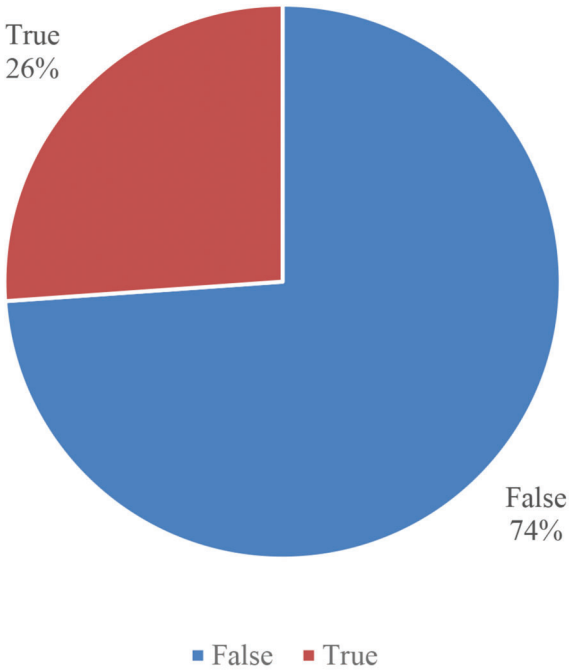


Figure 6.13 Question 10: You must obey all work zone signs only when workers are present.

expressed that too many similar answer choices (such as "All the above are correct," "A and B are correct," etc.) did not make a lot of sense and could discourage learners from reading or engaging with the content. They suggested minimizing such answer choices.

6.2.3.4 Vary the text contrast. Some participants suggested varying the text of the content. Specifically, they suggested using shorter sentences more often to facilitate greater information retention and recall. They suggested that less text should be used because they felt that reading

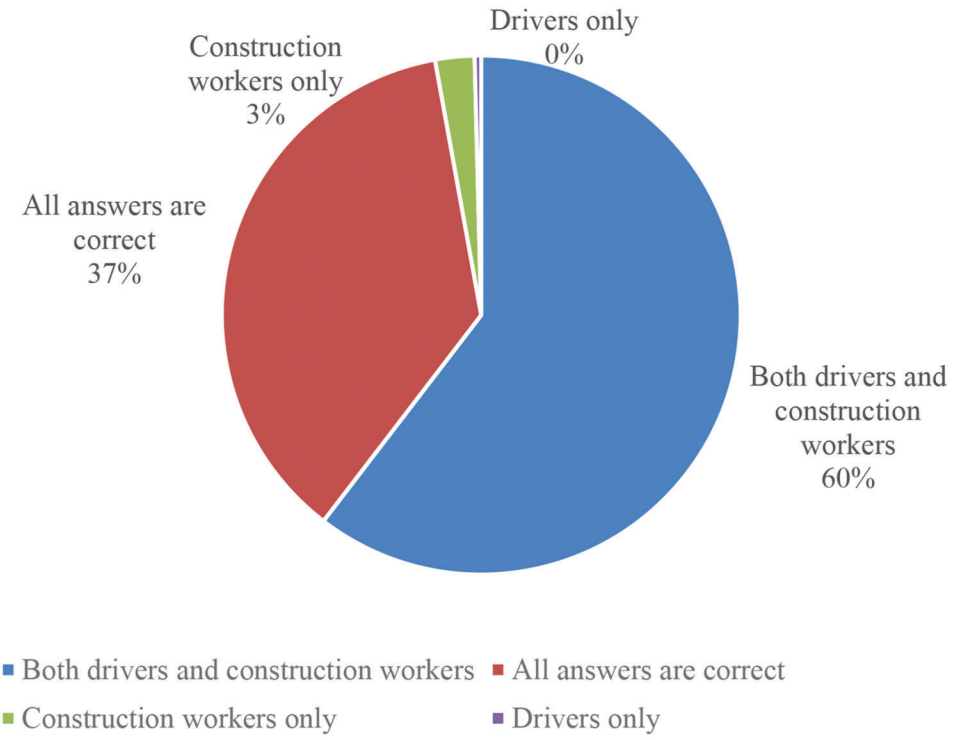


Figure 6.14 Question 11: Work zones pose dangers for who?

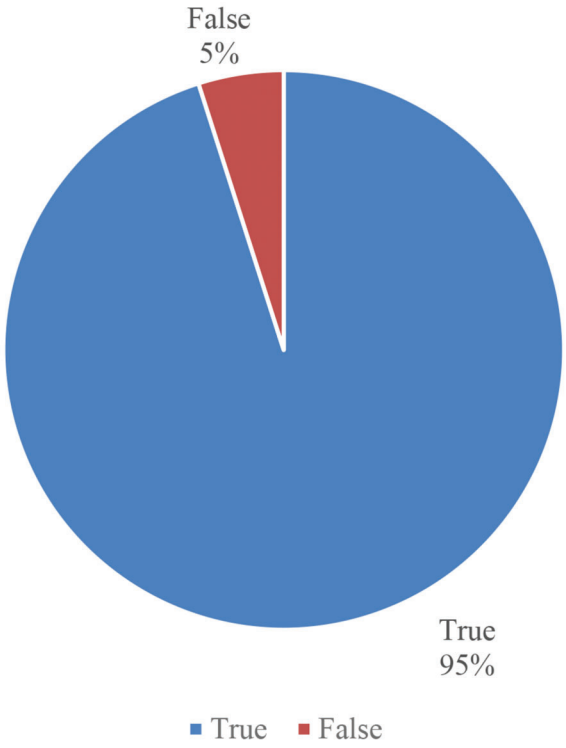


Figure 6.15 Question 12: A zipper merge keeps traffic by allowing drivers to use both lanes until reaching the merge point.

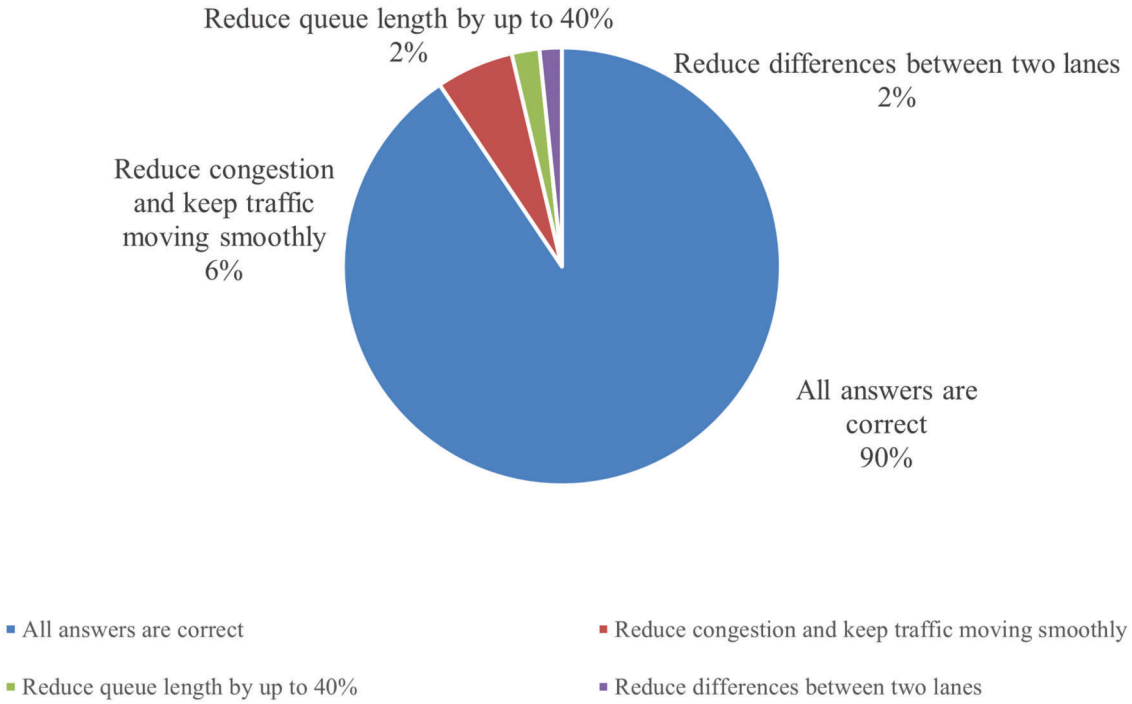


Figure 6.16 Question 13: A zipper merge helps to do what?

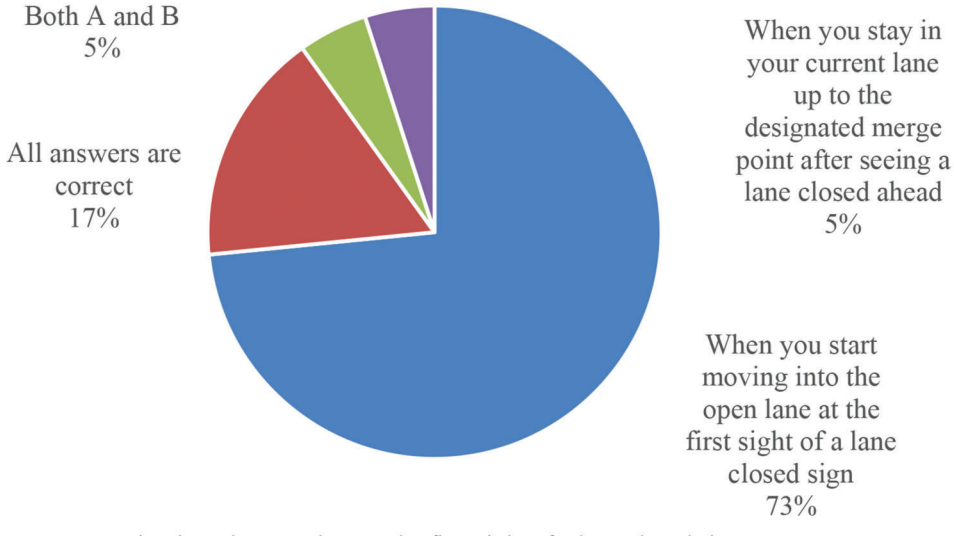


Figure 6.17 Question 14: An early merge is what?

text heavy content was uninteresting and discouraging. They also suggested bolding/highlighting key points for greater emphasis and easy recall. They suggested that the content should be formatted in a manner that enhances the overall learner educational experience.

7. CONCLUSIONS

7.1 Summary of Key Findings

This project provided a strong understanding of the trends associated with work zone crashes. It also uncovered several practices to target public education and understanding regarding behavior in work zones. Ultimately findings will help improve work zone driver safety in Indiana through driver education and public awareness campaigns.

The literature almost unanimously shows that rear-end crashes are the most frequent collision manner in work zones. The main contributing factors related to work zone crashes are careless driving and speeding. Heavy vehicles are found to increase work zone crash risk. Additionally, graphic-aided messages are among

the most efficient methods to encourage drivers to lower their speed in work zones.

After reviewing driver's manuals across all states, the research time found that manuals follow different conventions. With different tones and persuasive tactics used among the manuals, three levels of guidance are specified in the context of work zone information. Indiana's manual follows a moderate guidance and additional information can be potentially added to enhance the public outreach process. As for the commercial driver's manuals, they lack explicit work zone educational information. A couple of states are in the exception and offer additional information in this regard, but major updates are still needed to add detailed work zone-related information. Similarly, to commercial driver's manuals, motorcycle operator's manuals lack important information on work zones. More information is needed to be implemented in these manuals especially that motorcycle's crashes are one of the most fatal ones. It is also important to present the drivers with detailed instructions about how behave around work zone areas as well as information on the different work zone signs, and this applies to Indiana's manual as well.

The crash data analysis also uncovered important trends pertaining to work zone crashes. Most drivers that are involved in work zone-related crashes are males. The majority of work zone crashes happen on interstates and urban locales. For private vehicles, local and city roads also have a high percentage of collisions. More private vehicles collisions happen on rural roads and that the death rate on rural roads is higher as well. Overall, a notable difference is found in the trends pertaining to private and commercial vehicles in the context of collision manners. This necessitates addressing both audiences differently by updating both manuals and designing different messages. Collisions involving commercial vehicles are found to be more fatal. For private vehicles, following too closely is the main and only top primary factor of collision across all road classes, whereas for commercial vehicles the trend varies. In the context of construction type, lane change and work on shoulders are the most problematic. The factors leading for collisions associated with each construction type are following too closely and unsafe lane movement, respectively.

The campaign survey results indicate that the demographics of the college student sample are more representative of the demographics of Indiana as a state than those of the Indiana resident sample. This implies that the results from the college student sample are more generalizable to the population of Indiana as a state. Also, the results indicate that participants from both Indiana residents and college student samples perceived all the 15 campaign messages to be effective at encouraging safe driving behaviors in Indiana work zones. Specifically, five of the campaign messages (i.e., TFA1, DSC1, SSN3, DFA1, and SSN2) received the highest favorable mean scores from both samples, suggesting that these messages are perceived to be the most effective. The results also indicate that participants from both samples believed that they could perform the safe driving behaviors recommended by each message. The results indicate that participants believed the recommended safe driving behaviors would be effective in preventing crashes in Indiana work zones. The results indicate that participants from both samples would prefer to receive and read work zone safety campaign messages on billboards, portable changeable message signs, Instagram, Facebook, INDOT's website, and at rest areas. The result from the qualitative data indicate that the vast majority of campaign messages received largely positive qualitative feedback from participants of both samples. With a select number of easily remediable tweaks to the design and messaging components where applicable, the team believes that these campaign messages are ready for implementation.

Lastly, the education curriculum survey results indicate that the demographics of participants are generally representative of the demographics of the state of Indiana (with the exception of age), suggesting the survey results are relatively generalizable to the state's population. The results also indicate that participants felt that the content of the curriculum was well organized, very insightful, and useful for new drivers and those who need a refresher. Participants suggested that more images should be incorporated into the curriculum for better content engagement, more content clarity, and easier content recall and understanding. Participants also suggested that short, animated videos that explain some of the safety signs and how to merge in work zones should be incorporated into the curriculum. Additionally, participants suggested that the knowledge questions and answer choices should be varied by adding more difficult questions and some open-ended questions. Participants suggested that shorter sentences should be used for easier information retention and recall. Finally, participants suggested that key points in the curriculum be highlighted for greater emphasis and easier information recall.

7.2 Strength and Limitations of Campaign Formative Study

The strength of the formative study is that both close- and open-ended survey questions were utilized. The close-ended questions helped to measure perceptions about the perceived effectiveness of the 15 campaign messages in encouraging work zone safety driving behaviors among sampled participants. The open-ended questions helped to gather participants' suggestions about ways to improve each message to make them potentially more effective and appropriate. The formative study, however, has some limitations. First, findings are not based on an entirely representative sample of Indiana drivers. For instance, our survey respondents are predominantly women. However, other demographics such as income, race, and age are more representative of the demographics of Indiana as a state. The demographics of the college student sample,

for instance, are more representative of the demographics of Indiana, suggesting that the college student sample can be generalized to the population of Indiana. A second limitation of the formative study is the use of self-reported data. This is a limitation because respondents might not give responses to some survey questions that reflect their actual behaviors while driving. However, our survey allowed us to get at respondents' perceptions of these messages and their intent to behave after viewing these messages. Behavioral intent has been shown to be a predictor of actual behavior. Thus, we are confident that our results are pointing towards what could be actual behavioral change.

7.3 Recommendations

In the short-term, the team recommends that 5 of the 15 messages (i.e., TFA1, DSC1, SSN3, DFA1, and SSN2) should be used for the campaign implementation because they received the highest favorable mean scores, although all 15 campaign messages were perceived to be effective. The findings suggest that these five messages of the 15 created have the potential to be the most effective at encouraging safe driving behaviors in Indiana work zones. The team also recommends that the campaign messages should be disseminated through billboards, portable changeable message signs, Instagram, Facebook, INDOT's website, and at rest areas or welcome centers. The team recommends that two to three employees of INDOT should be selected to serve as "faces" of the campaign. Doing so would add credibility to the campaign as Indiana audiences are likely to more easily relate to employees who are fellow Hoosiers. These INDOT employees can be featured in DSC1 and SSC1 messages. The team recommends that all 15 messages should be revised based on feedback from survey respondents before implementation. Based on the results, the team recommends that INDOT should address the need for high quality, situation-specific photos as a priority. Instead of relying extensively on images from copyright-free public domains, investing in eye-catching photos for future campaign message designs should be considered.

The team recommends that the communication campaign should be implemented in Indiana (see the implementation plan below). The team also recommends that the communication campaign should be evaluated at various points during the campaign. In the short-term, the team recommends that a process evaluation should be conducted during the campaign implementation. A process evaluation refers to an evaluation study that is carried out during the campaign to determine whether the campaign has been implemented and is working according to plan (Delhomme et al., 2009). A process evaluation will help the campaign implementers determine whether campaign activities are being implemented as expected. For instance, if campaign implementers plan to post campaign messages on all their social media outlets twice every week (i.e., Monday and Friday), a systematic process evaluation will help them to track whether the messages are implemented according to this plan.

In the long-term, the team recommends that an outcome evaluation study should be conducted 5 months after the campaign implementation to measure the overall effectiveness of the campaign. An outcome evaluation refers to an evaluation study that is carried out to determine whether the campaign has achieved its specific objectives (Delhomme et al., 2009). This outcome evaluation study could utilize a survey design to examine whether the campaign positively influenced safe driving behaviors among drivers in Indiana work zones. More specifically, some of the survey questions could ask participants if they had seen and read campaign messages about work zone safety, where they saw these messages, what the messages were about, and whether they changed their driving behaviors in work zones after seeing and reading these messages. Data could also be gathered on actual numbers of crashes in the work zones where the communication campaign were implemented to draw correlational findings from those data. In the long-run, a cost effectiveness analysis could be performed to assess the benefits of the campaign in terms the number of crashes that were avoided compared to the campaign costs. The team recommends that the campaign should not be implemented alongside other awareness programs (e.g., Back-of-Queue Crash Program) so that any impacts could be directly attributed to the campaign. Additionally, the team recommends that INDOT should work with driving schools and instructors to incorporate new material related to work zone safety in drivers' educational curricula.

Based on the education curriculum survey results, the team recommends that more images should be used in both driver's manual and education curriculum to explain some safety signs and how to merge in work zones. This would help drivers to better visualize and understand merging in work zones. The team also recommends that the driver's manual and this education curriculum should have short sentences to encourage easier information retention and recall. The team recommends that open-ended questions that require written responses be included in the knowledge questions for this education curriculum. This would encourage learners to read the content of the curriculum. The team recommends that key points in both driver's manual and education curriculum should be highlighted or bolded for greater emphasis and easier information recall. The team recommends using examples from "aspirational" state manuals. Finally, the team recommends that short, animated videos on merging in work zones should be incorporated in the online version of the education curriculum to enhance information recall and understanding.

7.4 Communication Campaign Implementation Plan

There are many factors to consider when implementing a communication campaign. We have found the

best results when we work closely with our client organization to implement the campaign. The following are the questions we would ask and factors we would consider in implementing the data-driven communication campaign we have designed.

1. *Location:* What construction projects are planned for August 2022 to July 2023?
2. *Likelihood of work zone crashes:* What roadways in Indiana are historically prone to work zone crashes?

The answers to these first two questions will help us determine what parts of the state to implement the communication campaign in.

3. *Audience:* What do we know about the media consumption habits of drivers in the parts of Indiana we want to target?
4. *Cost and budget:* How much does it cost to place a campaign message on a billboard on I-65, for example? What is the budget that INDOT has to work with?
5. *Coordination with other organizations and agencies:* If we want to put messages in rest areas, for example, who would we coordinate with?
6. *Message production:* Who would produce the messages? What is the amount of time they need?

We suggest implementing the campaign in two phases. Phase 1 of the implementation would be a pilot. In Phase 1, we would target one location where construction will take place, and which is historically prone to work zone crashes. We would run the pilot for however long INDOT and the researchers deem appropriate and then survey drivers who frequent that roadway. The survey would ask drivers if they had seen and read campaign messages about work zone safety, where in the work zone they saw these messages, what the messages were about, and whether they changed their driving behaviors in the work zones after seeing and reading these messages. The survey results would inform us of how to implement Phase 2.

Phase 2 would be a broader message dissemination to additional sites where construction will take place, and which are also historically prone to work zone crashes. At these sites, we would implement campaign messages using a combination of billboards, portable changeable message signs, and other road signs. Additionally, we would coordinate with identified organizations and agencies to implement campaign messages at rest areas. Finally, we would work with INDOT's public relations department to implement campaign messages on INDOT's websites, Instagram, and Facebook. We would conduct a process evaluation during Phase 2 implementation to track all campaign activities to determine whether the implementation is going according to plan. After 3 months of Phase 2 implementation, we would conduct an outcome evaluation study using a survey to examine the overall effectiveness of the campaign on safe driving behaviors in Indiana work zones.

REFERENCES

Adamos, G., & Nathanail, E. (2016). Predicting the effectiveness of road safety campaigns through alternative research designs. *Journal of Safety Research*, *59*, 83–95. https://doi.org/10.1016/j.jsr.2016.10.003

Adamos, G., Nathanail, E. G., & Kapetanopoulou, P. (2013). Do road safety communication campaigns work?: How to assess the impact of a national fatigue campaign on driving behavior. *Transportation Research Record: Journal of the Transportation Research Board*, *2364*(1), 62–70. https://doi.org/10.3141/2364-08

Adsit, S. E., Konstantinou, T., Gkritza, K., & Fricker, J. D. (2021). *Public acceptance of INDOT's traffic engineering treatments and services* (Joint Transportation Research Program Publication No. FHWA/IN/JTRP-2021/01). West Lafayette, IN: Purdue University. https://doi.org/10.5703/1288284317280

Ajzen, I. (1988). *Attitudes, personality and behavior*. Open University Press.

Ajzen, I., & Fishbein, M. (1980). *Understanding attitudes and predicting social behavior*. Prentice-Hall.

Alaska Department of Administration. (2019, September). *State of Alaska driver manual*. https://doa.alaska.gov/dmv/dlmanual/dlman.pdf

AAMVA. (2005). *Commercial driver's license manual*. American Association of Motor Vehicles Administrators. https://www.in.gov/bmv/files/cdl-manual.pdf

Bai, Y., Huang, Y., Schrock, S. D., & Li, Y. (2011). *Determining the effectiveness of graphic-aided dynamic message signs in work zone* (Report No. TPF-5(081)). https://intrans.iastate.edu/app/uploads/2018/08/BaiGraphicAidedDMSFinal-Report.pdf

Banerjee, S., Jeihani, M., & Khadem, N. K. (2019). Influence of work zone signage on driver speeding behavior. *Journal of Modern Transportation*, *27*(1), 52–60. https://doi.org/10.1007/s40534-019-0182-5

Brewer, M. A., Pesti, G., & Schneider, W., IV. (2006). Improving compliance with work zone speed limits: Effectiveness of selected devices. *Transportation Research Record: Journal of the Transportation Research Board*, *1948*(1), 67–76. https://doi.org/10.1177/0361198106194800108

Carcioppolo, N., Jensen, J. D., Wilson, S. R., Collins, W. B., Carrion, M., & Linnemeier, G. (2013). Examining HPV threat-to-efficacy ratios in the extended parallel process model. *Health Communication*, *28*(1), 20–28. https://doi.org/10.1080/10410236.2012.719478

CDC. (2022, April 26). *Distracted driving* [Webpage]. Centers for Disease Control and Prevention. https://www.cdc.gov/transportationsafety/distracted_driving/index.html

Chen, E., & Tarko, A. P. (2012). Analysis of crash frequency in work zones with focus on police enforcement. *Transportation Research Record: Journal of the Transportation Research Board*, *2280*(1), 127–134. https://doi.org/10.3141/2280-14

Cialdini, R. B., & Trost, M. R. (1998). Social influence: Social norms, conformity and compliance. In D. T. Gilbert, S. T. Fiske, & G. Lindzey (Eds.), *The handbook of social psychology* (pp. 151–192). McGraw-Hill.

Cyr, D., Head, M., Lim, E., & Stibe, A. (2018). Using the elaboration likelihood model to examine online persuasion through website design. *Information & Management*, *55*(7), 807–821. https://doi.org/10.1016/j.im.2018.03.099

Daniel, J., Dixon, K., & Jared, D. (2000). Analysis of fatal crashes in Georgia work zones. *Transportation Research*

Record: Journal of the Transportation Research Board, *1715*(1), 18–23. https://doi.org/10.3141/1715-03

Debnath, A. K., Blackman, R., & Haworth, N. (2015). A comparison of self-nominated and actual speeds in work zones. *Transportation Research Part F: Traffic Psychology and Behaviour*, *35*, 213–222. https://doi.org/10.1016/j.trf.2015.10.019

Delaware DMV. (2021, July). *Delaware driver manual*. Delaware Division of Motor Vehicles. https://www.dmv.de.gov/forms/driver_serv_forms/pdfs/dr_frm_manual.pdf

Delhomme, P., Dobbeleer, W. D., Forwad, S., Simões, A., Adamos, G., Areal, A., Chappi, J., Eyssartier, C., Loukopoulos, P., Nathanail, E., Nordbakke, S., Peters, H., Phillips, R. O., Pinto, M., Ranucci, M., Sardi, G. M., Trigoso, J., Vaa, T., Veisten, K., & Walter, E. (2009). *Manual for designing, implementing, and evaluating road safety communication campaigns: Part 1* (pp. 1–162). https://www.researchgate.net/publication/316714195_Manual_for_Designing_Implementing_and_Evaluating_Road_Safety_Communication_Campaigns

Diegelmann, S., Ninaus, K., & Terlutter, R. (2020). Distracted driving prevention: an analysis of recent UK campaigns. *Journal of Social Marketing*, *10*(2), 243–264. https://doi.org/10.1108/JSOCM-07-2019-0105

Domenichini, L., La Torre, F., Branzi, V., & Nocentini, A. (2017). Speed behaviour in work zone crossovers. A driving simulator study. *Accident Analysis & Prevention*, *98*, 10–24. https://doi.org/10.1016/j.aap.2016.09.018

Elder, R. W., Shults, R. A., Sleet, D. A., Nichols, J. L., Thompson, R. S., & Rajab, W. (2004, July 1). Effectiveness of mass media campaigns for reducing drinking and driving and alcohol-involved crashes: A systematic review. *American Journal of Preventive Medicine*, *27*(1), 57–65. https://doi.org/10.1016/j.amepre.2004.03.002

Faus, M., Alonso, F., Fernández, C., & Useche, S. A. (2021). Are traffic announcements really effective? A systematic review of evaluations of crash-prevention communication campaigns. *Safety*, *7*(4). https://doi.org/10.3390/SAFETY7040066

Friemel, T. N., & Bonfadelli, H. (2016). Road safety communication campaigns: Theoretical foundations, validity, and empirical case studies. *Accident Analysis and Prevention*, *97*, 289–291. https://doi.org/10.1016/j.aap.2016.11.011

Ghasemzadeh, A., & Ahmed, M. M. (2019). Exploring factors contributing to injury severity at work zones considering adverse weather conditions. *IATSS Research*, *43*(3), 131–138. https://doi.org/10.1016/j.iatssr.2018.11.002

Guttman, N. (2016). Reprint of "Persuasive appeals in road safety communication campaigns: Theoretical frameworks and practical implications from the analysis of a decade of road safety campaign materials." *Accident Analysis and Prevention*, *97*, 298–308. https://doi.org/10.1016/j.aap.2016.11.004

Harrington, N. G., & Kerr, A. M. (2017). Rethinking risk: Prospect theory application in health message framing research. *Health Communication*, *32*(2), 131–141. https://doi.org/10.1080/10410236.2015.1110004

Hoekstra, T., & Wegman, F. (2011). Improving the effectiveness of road safety campaigns: Current and new practices. *IATSS Research*, *34*(2), 80–86. https://doi.org/10.1016/j.iatssr.2011.01.003

Huang, Y., & Bai, Y. (2012). Determining drivers' acceptance of using graphics on portable changeable message signs in highway work zones. *Sustainable Transportation Systems*, 387–394. https://doi.org/10.1016/9780784412299.0047

Huang, Y., & Bai, Y. (2014). Effectiveness of graphic-aided portable changeable message signs in reducing vehicle speeds in highway work zones. *Transportation Research Part C: Emerging Technologies*, *48*, 311–321. https://doi.org/10.1016/j.trc.2014.09.007

Huang, Y., & Bai, Y. (2019). Driver responses to graphic-aided portable changeable message signs in highway work zones. *Journal of Transportation Safety and Security*, *11*(6), 661–682. https://doi.org/10.1080/19439962.2018.1463336

Indiana Bureau of Motor Vehicles. (2017). *Commercial driver license manual*. https://www.in.gov/bmv/files/cdl-manual.pdf

Indiana Bureau of Motor Vehicles. (2022, January). *Indiana drivers manual*. https://www.in.gov/bmv/licenses-permits-ids/files/drivers-manual.pdf

INDOT. (n.d.a.). *Work zone safety* [Webpage]. Indiana Department of Transportation. https://www.in.gov/indot/safety/work-zone-safety/

INDOT. (n.d.b.). *Zipper merge* [Webpage]. Indiana Department of Transportation. https://www.in.gov/indot/safety/zipper-merge/

Lapinski, M. K., & Rimal, R. N. (2005). An explication of social norms. *Communication Theory*, *15*(2), 127–147. https://doi.org/10.1111/j.1468.2885.2005.tb00329.x

Lewis, I. M., Watson, B., & White, K. M. (2008). An examination of message-relevant affect in road safety messages: Should road safety advertisements aim to make us feel good or bad. *Transportation Research Part F*, *11*, 403–417. https://doi.org/10.1016/j.trf.2008.03.003

Li, C. R., Zhang, E., & Han, J. T. (2021). Adoption of online follow-up service by patients: An empirical study based on the elaboration likelihood model. *Computers in Human Behavior*, *114*, 106581. https://doi.org/10.1016/j.chb.2020.106581

Liu, J., Khattak, A., & Zhang, M. (2016). What role do precrash driver actions play in work zone crashes?: Application of hierarchical models to crash data. *Transportation Research Record: Journal of the Transportation Research Board*, *2555*(1), 1–11. https://doi.org/10.3141/2555-01

Maine BMV. (2022, February). *Maine driver's license manual*. Main Bureau of Motor Vehicles. Retrieved June 25, 2021, from https://www.maine.gov/sos/bmv/licenses/motoristhandbook.pdf

Massachusetts Registry of Motor Vehicles. (2015). *Motorcycle manual*. https://www.mass.gov/doc/motorcycle-manual/download

McMahan, S., Witte, K., & Meyer, J. (1998). The perception of risk messages regarding electromagnetic fields: Extending the extended parallel process model to an unknown risk. *Health Communication*, *10*(3), 247–259. https://doi.org/10.1207/s15327027hc1003_4

Mekker, M. M., Remias, S. M., Bunnell, W. A., Krohn, D. W., Cox, E. D., & Bullock, D. M. (2016). Variable speed limit study upstream of an Indiana work zone with vehicle matching. *Transportation Research Record: Journal of the Transportation Research Board*, *2555*(1), 53–64. https://doi.org/10.3141/2555-07

Merrikhpour, M., & Donmez, B. (2017). Designing feedback to mitigate teen distracted driving: A social norms approach. *Accident Analysis and Prevention*, *104*, 185–194. https://doi.org/10.1016/j.aap.2017.04.016

Mikusova, M. (2015). Role of road safety educational and awareness campaigns. *Archives of Transport System Telematics*, *8*(1), 19–23.

Missouri Department of Revenue. (2022, March). *Driver guide: A guide to understanding Missouri motor vehicle laws and licensing requirements*. https://dor.mo.gov/forms/Driver%20Guide.pdf

Motorcycle Safety Foundation. (2017, January 1). *Indiana motorcycle operator manual* (2nd ed.). https://www.in.gov/bmv/licenses-permits-ids/files/Motorcycle_Operators_Manual.pdf

Nahidi, S. A., & Tighe, S. L. (2019). *Comparative assessment of various random parameter ordered models: A comprehensive evaluation of work zone collision injury-severities* [Paper presentation]. 2019 Canadian Society for Civil Engineering Annual Conference, Laval, Canada.

Nathanail, E., & Adamos, G. (2013). Road safety communication campaigns: Research designs and behavioral modeling. *Transportation Research Part F: Traffic Psychology and Behaviour*, *18*, 107–122. https://doi.org/10.1016/j.trf.2012.12.003

Nevada Department of Motor Vehicles. (2021, October). *Nevada driver official handbook*. https://dmvnv.com/pdfforms/dlbook.pdf

New Mexico's Motor Vehicle Division. (2019). *New Mexico driver manual*. https://www.mvd.newmexico.gov/wp-content/uploads/2020/12/English-Drivers-Manualver11.19.19.pdf

NHTSA. (n.d.a.). *Distracted driving* [Webpage]. National Highway Traffic Safety Administration. https://www.nhtsa.gov/risky-driving/distracted-driving

NHTSA. (n.d.b.). *Speeding* [Webpage]. National Highway Traffic Safety Administration. https://www.nhtsa.gov/risky-driving/speeding

Niederdeppe, J., Farrelly, M. C., Nonnemaker, J., Davis, K. C., & Wagner, L. (2011, March). Socioeconomic variation in recall and perceived effectiveness of campaign advertisements to promote smoking cessation. *Social Science & Medicine*, *72*(5), 773–780. https://doi.org/10.1016/j.socscimed.2010.12.025

Phillips, R. O., Ulleberg, P., & Vaa, T. (2011). Meta-analysis of the effect of road safety campaigns on accidents. *Accident Analysis and Prevention*, *43*(3), 1204–1218. https://doi.org/10.1016/j.aap.2011.01.002

Pornpitakpan, C. (2004). The persuasiveness of source credibility: A critical review of five decades' evidence. *Journal of Applied Social Psychology*, *34*(2), 243–281. https://doi.org/10.1111/j.1559-1816.2004.tb0254.x

Ravani, B., & Wang, C. (2018). Speeding in highway work zone: An evaluation of methods of speed control. *Accident Analysis & Prevention*, *113*, 202–212.

Rimal, R. N., & Real, K. (2005). How behaviors are influenced by perceived norms: A test of the theory of normative social behavior. *Communication Research*, *32*(3), 389–414. https://doi.org/10.1177/0093650205275385

Rista, E., Barrette, T., Hamzeie, R., Savolainen, P., & Gates, T. J. (2017). Work zone safety performance: Comparison of alternative traffic control strategies. *Transportation Research Record: Journal of the Transportation Research Board*, *2617*(1), 87–93. https://doi.org/10.3141/2617-11

Rothman, A. J., Bartels, R. D., Wlaschin, J., & Salovey, P. (2006). The strategic use of gain- and loss-framed messages to promote healthy behavior: How theory can inform practice. *Journal of Health Communication*, *56*, S202-S220.

Sampson, J., Witte, K., Morrison, K., Liu, W., Hubbell, A. P., & Murray-Johnson, L. (2001). Addressing cultural orientations in fear appeals: Promoting AIDS-protective behaviors among Mexican immigrant and African American adolescents and American and Taiwanese college students. *Journal of Health Communication*, *6*(4), 335–358. https://doi.org/10.1080/108107301317140823

Shiwakoti, N., Tay, R., & Stasinopoulos, P. (2020). Development, testing, and evaluation of road safety poster to reduce jaywalking behavior at intersections. *Cognition, Technology and Work*, *22*, 389–397. https://doi.org/10.1007/s10111-019-00573-4

Sommers, N. M., & McAvoy, D. S. (2013). *Improving work zone safety through speed management* (Report No. FHWA/OH-2013/5) Ohio Department of Transportation. https://rosap.ntl.bts.gov/view/dot/26793

South Carolina Department of Motor Vehicles. (2022). *South Carolina driver's manual*. https://dc.statelibrary.sc.gov/bitstream/handle/10827/27492/DMV_Drivers_Manual_2011.pdf?sequence=1&isAllowed=y

Tannenbaum, M. B., Hepler, J., Zimmerman, R. S., Saul, L., Jacobs, S., Wilson, K., & Albarracín, D. (2015). Appealing to fear: A meta-analysis of fear appeal effectiveness and theories. *Psychological Bulletin*, *141*(6), 1178–1204.

Tennessee Department of Safety and Homeland Security. (2018). *Tennessee comprehensive driver license manual*. https://www.tn.gov/content/dam/tn/safety/documents/DL_Manual.pdf

Totzkay, D., Silk, K. J., & Thomas, B. D. H. (2022). Evaluating the extended parallel process model's danger control predictions in the context of dense breast notification laws. *Health Communication*, *37*(1), 103–113. https://doi.org/10.1080/10410236.2020.1824663

Tversky, A., & Kahneman, D. (1981). The framing of decisions and all psychology of choice. *Science*, *211*(4481), 453–458. https://doi.org/10.1126/science.7455683

Ukkusuri, S., Gkritza, K., Qian, X., & Sadri, A. M. (2017). *Best practices for maximizing driver attention to work zone warning signs* (Joint Transportation Research Program Publication No. FHWA/IN/JTRP-2016/15). West Lafayette, IN: Purdue University. https://doi.org/10.5703/1288284316338

Wang, Q., Lu, J. J., & Wang, Z. (2008, November). Identification of contributing factors for work zone crashes. *CUTR Faculty Journal Publications*, *139*. https://digitalcommons.usf.edu/cutr_facpub/139/

Weng, J., Meng, Q., & Yan, X. (2014). Analysis of work zone rear-end crash risk for different vehicle-following patterns. *Accident Analysis & Prevention*, *72*, 449–457. https://doi.org/10.1016/j.aap.2014.08.003

Weng, J., Xue, S., Yang, Y., Yan, X., & Qu, X. (2015). In-depth analysis of drivers' merging behavior and rear-end crash risks in work zone merging areas. *Accident Analysis & Prevention*, *77*, 51–61. https://doi.org/10.1016/j.aap.2015.02.002

Witte, K. (1992). Putting the fear back into fear appeals: The extended parallel process model. *Communication Monographs*, *59*(4), 329–349. https://doi.org/10.1080/03637759209376276

Witte, K. (1993). Message and conceptual confounds in fear appeals: The role of threat, fear, and efficacy. *Southern Communication Journal*, *58*(2), 147–155. https://doi.org/10.1080/10417949309372896

Witte, K. (1994). Fear control and danger control: A test of the extended parallel process model (EPPM). *Communication Monographs*, *61*(2), 113–134. https://doi.org/10.1080/03637759409376328

Witte, K. (1996). Predicting risk behavior: Development and validation of a diagnostic scale. *Journal of Health Communication*, *1*(4), 317–342. https://doi.org/10.1080/10810 7396127988

Witte, K. (1998). Fear as motivator, fear as inhibitor: Using the extended parallel process model to explain fear appeal successes and failures. In P. A. Andersen & L. K. Guerrero (Eds.), *Handbook of communication and emotion: Research, theory, applications, and contexts* (pp. 423–450). Academic Press.

Witte, K., & Morrison, K. (1995). Using scare tactics to promote safer sex among juvenile detention and high school youth. *Journal of Applied Communication Research*, *23*(2), 128–142. https://doi.org/10.1080/00909889509365419

Yun, D., & Silk, K. J. (2011). Social norms, self-identity, and attention to social comparison information in the context of exercise and healthy diet behavior. *Health Communication*, *26*(3), 275–285. https://doi.org/10.1080/104110236.2010. 549814

Zatoński, M., & Herbeć, A. (2016). Are mass media campaigns effective in reducing drinking and driving? Systematic review – an update. *Journal of Health Inequalities*, *2*(1), 52–60. https://doi.org/10.5114/jhi.2016.61421

APPENDICES

Appendix A. Examples of Full Guidance Manuals

Appendix B. Education Curriculum Survey

Appendix C. Crash Data Analysis

Appendix D. Campaign Survey Questions

Appendix E. Campaign Messages

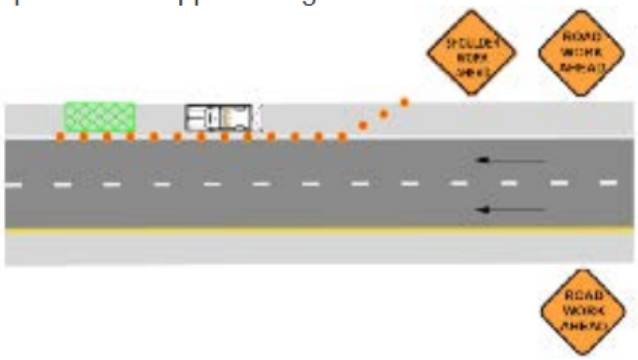
APPENDIX A. EXAMPLES OF FULL GUIDANCE MANUALS

The following appendix includes excerpts from a set of full guidance manuals. Below are some examples from Missouri's driver's manual (Missouri Department of Revenue, 2022). The manual offers a visualization (top view) of scenarios consisting of several work zone types and provides instructions to drivers concurrently.

Shoulder Work Zone

This is work that takes place on the shoulder or beyond the shoulder. You should use caution and perform or be alert of the following:

- Reduce speed when approaching the work zone



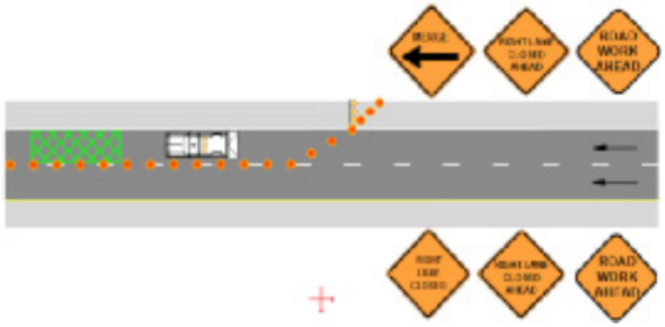
Typical Shoulder Work Setup

(a)

Lane Closure

This is work that takes place in the travel lane of a roadway. You should use caution and perform or be alert of the following:

- Merge to the designated lane or a lane that work is not being performed
- Reduce speed to the designated work zone speed limit



Typical Lane Closure Setup

(b)

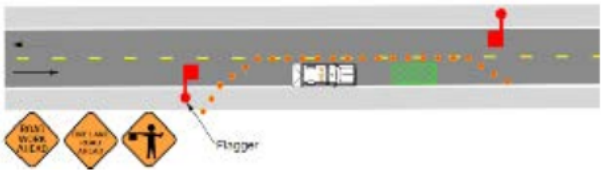
Figure A.1 Excerpts from Missouri's driver's manuals about (a) shoulder work zone setup (b) typical lane closure setup.

Furthermore, the manual offers more details and pictures pertaining to other work zone specifics such as flagging operations and work zone setup.

Flagging Operation

This is work that takes place on a two-lane, two-way roadway with one lane closed. A flagger(s) will be present at the beginning and end points of the work zone providing traffic control to oncoming vehicles. You should use caution and perform or be alert of the following:

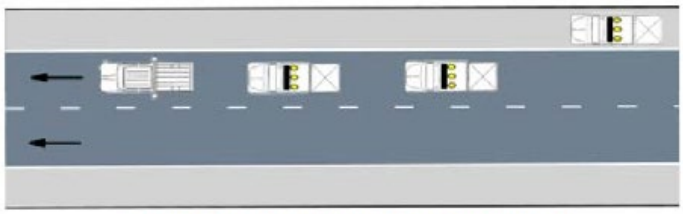
- Be prepared to stop as you approach the work zone
- Follow the flagger's instructions



Typical Flagging Operation Setup

Typical Flagging Station Setup

(a)



Typical Mobile Work Zone Setup

(b)

Figure A.2 Excerpts from Missouri's driver's manual about (a) Flagging station setup (b) typical mobile work zone setup.

Another example is South Carolina's driver's manual (South Carolina Department of Motor Vehicles, 2022). This document touches on work zones twice: once in the context of signage and

once in terms of driving instructions. The excerpts below show how driving instructions are presented in the manual.

Work zones have become increasingly dangerous places for both workers and drivers. Approximately 40,000 people per year are injured as a result of motor vehicle collisions in work zones.

When approaching a work zone, watch for signs, cones, barrels, large vehicles, and workers. Work zone signs have orange backgrounds and black

letters or symbols. Always reduce your speed in a work zone, even if there are no workers. The narrower lanes and rough pavement can create hazardous conditions. If you endanger a highway worker you may be fined and have points assessed against your driving record. *SC Code Section 56-5-1535.*

As a driver in a work zone, you should:

- Reduce your speed, increase your following distance, watch the traffic around you, and be prepared to stop.
- Use extreme caution when driving through a work zone at night **whether workers are present or not**.

- Adjust your lane position to allow space for workers and construction vehicles.
- Observe the posted work zone signs until you see "End Road Work."
- Expect delays, plan for them, and leave earlier to reach your destination.
- When possible, use alternate routes and avoid work zones.

Figure A.3 Excerpts from South Carolina's driver's manual on work zone-related instructions.

Additionally, Tennessee's manual offers detailed information on work zones. The document mentions the words "work zone" 70 times across four difference sections. Below are four excerpts from each section.

Teen Driving in Work Zones

Every three days a teen is killed and seven are injured in a work zone crash in this country according to NETS, The Network of Employers for Traffic Safety. This could be you and your driver, if you drive carelessly through a roadway work zone. They are considered the most hazardous place for workers in the U.S., but they can be even more dangerous for drivers – particularly young, inexperienced ones. Statistics show that drivers comprise four out of five deaths in highway work zones.

Teen drivers have higher rates of fatal crash involvement than any other age group. Studies show young drivers are more likely to become involved in work zone accidents than others, as they are more likely to engage in risk-taking behavior, exercise negative driving habits, are easily distracted while driving, and lack the basic driving skills needed to respond quickly to work zone demands. When it comes to driving, there is no such thing as beginner's luck!

Some work zone safety tips:

- Slow down! Drive within the posted speed limits, which are usually reduced in work zones. If you don't, you'll pay the price. The Tennessee Highway Patrol's program Project CAR (Construction Accident Reduction) places Highway Patrol Troopers in work zones across the state targeting motorists who violate traffic laws while traveling through roadway work zones when workers are present.
- Don't tailgate! Most work zone accidents are caused by rear-end collisions.
- Eliminate distractions! Put down the cell phone; leave the radio dial alone. This is not the time to look for a new CD!
- Keep your ears open! Do not wear earphones or earbuds while driving.
- Merge early! You can be ticketed and be the cause of an accident for being a last chance merger.
- Watch for flaggers! Follow their signals, and don't change lanes within the work zone unless instructed to do so.
- Expect the unexpected! Work zones change constantly.
- Turn your lights on before you enter the zone! Turn on your vehicle's headlights to become more visible to workers and other motorists.

(a)

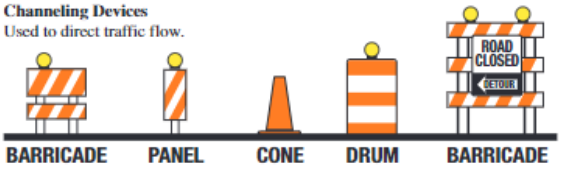
Work Area Signs

These construction, maintenance or emergency operations signs are generally diamond or rectangular shaped, orange with black letters or symbols and warn you that people are working on or near the roadway. These warnings include reduced speed, detours, slow moving construction equipment and lane closures. In work areas, a person with a sign or flag may control traffic. You must obey the directions of these persons.

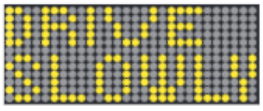
Construction Signs

Construction signs are generally **diamond** or **rectangular** shaped and **orange with black letters symbols**. Their purpose is to warn drivers that people are working on or near the roadway. The warnings include reduced speed, detours, slow moving construction equipment and lane closures.

Channeling Devices
Used to direct traffic flow.



Electronic Message or Arrow Signs: These are mobile devices that are often used on some roads to give advance warning of construction zones, special traffic directions, road closures or in some cases weather hazards. Flashing arrow panels alert approaching drivers of lane closures. You must begin to merge into the remaining open lane(s) well in advance of this sign.



Law Enforcement

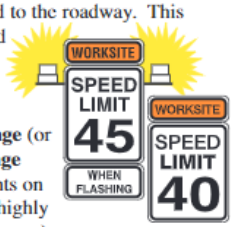
You will see Law Enforcement Officers in the Fluorescent Yellow-Green Vests and rain coats during traffic related emergencies to make sure they can be seen under normal conditions and under low light and poor weather conditions.

Highway Flaggers

Flaggers, at most worksites,

(b)

Speeding in Highway Work Zones: Highway work zones are those portions of a street or highway where construction, maintenance or utility work is being done to the road, its shoulders or any other items related to the roadway. This includes work, such as underground and overhead utility work, tree trimming and survey activities. Highway work zones are easily recognized by the presence of **orange** (or yellow-green) signs and other **orange** traffic control devices, flashing lights on equipment and workers dressed in highly visible clothing (orange or yellow-green).



Highway workers are trained on how to set up safe zones with directional traffic signs and devices. Motorists and pedestrians are responsible for knowing how to read and react to these directions. Paying attention and driving cautiously and courteously are the most important steps to preventing crashes while driving through highway work zones.

TENNESSEE LAW MANDATES A MINIMUM FINE OF $250 DOLLARS AND UP TO A MAXIMUM FINE OF $500 DOLLARS FOR VIOLATIONS OF THE SPEED LIMIT POSTED IN ACTIVE WORK ZONES.

Work zone crashes are preventable. Drivers must obey the reduced speed limit, as well as pay close attention to the ever changing traffic lanes and detours in the construction work zone. Law enforcement provides increased patrols in work zone areas. State figures for 2016 show 14 persons died, 1,243 were injured and there were 3,183 cases of property damage in work

(c)

SHARING THE ROAD WITH HIGHWAY WORK ZONES

Work Zone Safety: It's Everybody's Business
Work zones on U.S. highways have become increasingly dangerous places for both workers and travelers, with the death rate approaching two per day. Approximately 40,000 people per year are injured as a result of crashes in work zones. With more than 70,000 work zones in place across America on a given day, highway agencies are realizing that it is not enough to focus on improving the devices used in the work zone areas, but that they must also reach out to the public in order to change the behavior of drivers so that crashes can be prevented.

What is a Work Zone? A work zone is any type of road work that may impede traffic conditions. Many work zones involve lane closures. They may also be on the shoulder or in the median. Moving work zones such as sweepers, line painting trucks, or mowing equipment and workers are also quite common.

Highway work zones are set up according to the type of road and the work to be done on the road. There are a number of events that make up a work zone. They can be long-term projects of short term actions. A work zone can also exist at anytime of the year. The common theme among work zones is the color orange. Work zone materials such as cones, barrels, signs, large vehicles, or orange vests on workers give you an indication that you are either approaching a work zone or are already in a work zone. In these work zones, workers will normally be wearing bright yellow-green apparel such as shirts, vests or hardhats to ensure they are highly visible.

(d)

Figure A.4 Excerpts from different work-zone-related-sections in Tennessee's driver's manual: (a) teen driving in work zones, (b) work zone signage, (c) speed limits in work zones, and (d) work zone overview (Tennessee Department of Safety and Homeland Security, 2018).

There are other examples of full guidance manuals providing detailed information on work zones and are listed below.

- Pennsylvania
- New Jersey
- Massachusetts
- Kansas
- Colorado
- Arizona
- Delaware

APPENDIX B. EDUCATION CURRICULUM SURVEY

In this survey, you are expected to read an educational curriculum designed to increase drivers' knowledge about work zone safety behaviors, signs, and laws. You will also answer some basic knowledge questions regarding this curriculum. This curriculum has four learning outcomes or objectives. After this training, you are expected to do the following.

1. Know and observe some key safe driving behaviors in and around highway work zones.
2. Know and observe some highway work zone safety signs.
3. Know and observe laws about driving in work zones.
4. Know how and when to merge in highway work zones.

Additionally, this curriculum has three modules. The first module focuses on safe driving behaviors in and around highway work zones. The second module focuses on safety signs and laws about highway work zones. The third module focuses on merging in highway work zones. After each module, you will answer some knowledge questions, and your responses will help to improve this training curriculum for drivers. Some of the contents from Module 1 (particularly the distracted driving and speeding sections) and Module 2 (particularly the safety sign section) of the education curriculum were borrowed (by paraphrasing) from the Oklahoma Work Zone Safety Course for Teens.

B.1 The Safe Driving Behaviors Module

There are five different driving behaviors that likely cause crashes in highway work zones. These behaviors consist of distracted driving, tailgating/following too closely, speeding, unsafe lane movement, and failure to yield right of way in work zones.

B.2 Distracted Driving

Distracted driving is any activity that takes your attention away from driving or your eyes off the road. Distracted driving activities include using a cell phone (i.e., texting or making a call), eating and drinking, chatting with people in your vehicle, changing radio stations, using navigation system, etc., while driving (NHTSA, n.d.a). Using cell phones while driving is the most cause of distraction and sending or reading a text alone takes your eyes off the road for 5 seconds (NHTSA, n.d.a). Nationally, distracted driving caused 3,142 deaths in road crashes in 2019 according to NHSTA data. Every year, distracted driving among private vehicles causes 122 crashes in Indiana work zones alone. Of the 122 crashes in Indiana work zones, 68 are injuries.

The following are the three main types of distractions according to the CDC.

1. Visual: taking your eyes off the road.
2. Cognitive: taking your mind off driving.
3. Manual: taking your hands off the wheel.

The following are safety tips to prevent distracted driving in work zones:

1. Do not eat while driving through a work zone. You can eat either before driving or after driving.

2. Do not use your cell phone while driving through a work zone, e.g., avoid reading or sending text and making or receiving calls while driving through a work zone.
3. Avoid or minimize chatting with people in your vehicle while driving through a work zone.
4. Avoid changing radio stations while driving through a work zone. Set up your radio station or music playlist before driving.
5. Set up your navigation system before driving.
6. Select alternate routes, if possible, to avoid work zones completely

B.3 Tailgating

Tailgating or following too closely is another behavior that likely causes a highway work zone crash. Rear-end collisions are the most common types of work zone crashes. Every year, tailgating among private vehicles causes 1,301 crashes in Indiana work zones. Of the 1,301 crashes in Indiana work zones, 470 are injuries.

The following are safety tips to prevent tailgating in highway work zones:

1. Stay at least two or three seconds behind the vehicle ahead to avoid work zone crashes.
2. Keep a safe distance on all sides of your vehicles and maintain a safe following distance in Indiana work zones.

B.4 Speeding

The next driving behavior that likely causes highway work zone crashes is speeding. Speeding is when you are driving at a higher rate exceeding the posted speed limit or driving too fast for the road conditions. Traffic congestion; running late for work, school, meeting, appointment, etc.; and disregard for others and the law (i.e., posted speed limits) are major factors contributing to speeding (NHSTA, n.d.b). Nationally, speeding caused 9,478 deaths in road crashes in 2019 according to NHTSA data. Also, according to NHTSA, speeding can potentially do the following.

1. Lead to losing control of vehicle
2. Reduce the effectiveness of occupant protection equipment
3. Increase the stopping distance after perceiving a danger
4. Cause more severe injuries

Speeding is a major cause of crashes in work zones. Every year, speeding among private vehicles causes 100 injuries in Indiana work zones. The following are safety tips to prevent speeding in highway work zones.

1. Obeying the posted speed limits or reducing your speed limit in work zones can ensure the safety of construction workers and motorists.
2. Slow down and use extreme caution when approaching or driving through work zones because lanes are narrower in work zones.
3. Keep in mind that driving at 45 mph instead of 55 mph through a 5-mile work zone will only add 1.2 minutes to your trip.
4. Expects delays and allow extra travel time to travel through work zones to avoid speeding

B.5 Unsafe Lane Moving

Unsafe Lane Movement is another driving behavior that likely causes highway work zone crashes. Every year, unsafe lane movement among private vehicles causes 448 crashes in Indiana work zones. Of the 448 crashes in Indiana work zones, 85 are injuries. The following are tips on safe lane movement in work zones (Indiana Bureau of Motor Vehicles, 2022):

1. Make sure that there is no traffic ahead of you in the lane you would like to enter. Check your mirrors for any vehicle that are preparing to pass you.
2. Briefly turn your head toward the lane that you are entering to make sure that there is no vehicle in your blind spot and that there is sufficient room to move into the adjacent lane.
3. Use your turn signal to alert other drivers of your intention to change lanes.
4. Smoothly move into the new driving lane.
5. You must change only one lane at a time in work zones.
6. When changing lanes to prepare for a turn in a work zone, you should signal your intention to do so at least 200 feet prior to changing lanes or turning.
7. Do not weave in and out of lanes in work zones because doing that will greatly increase your risk of crashing.

The following are tips on passing other vehicles safely in work zones:

1. Make sure the passing lane is clear of traffic, as you must return to the right side of the road no less than 100 feet before any incoming vehicle.
2. Check behind and to the left of your vehicle to make sure that another vehicle is not attempting to pass you.
3. Use your turn signals to alert other drivers of your intention to change lanes.
4. Move into the passing lane, accelerate, and continue to move forward until you can see the vehicle you are passing in your rearview mirror.
5. Before returning to the lane in which you were originally driving, use the appropriate turn signal

B.6 Right of Way

The last driving behavior that likely causes highway work zones is failure to yield right of way. To yield right of way means to let another driver, bicyclist, or pedestrian go first. Every year, failure to yield right of way among private vehicles causes 524 crashes in Indiana work zones. Yielding right of way helps to avoid crashes in highway work zones. The following are safety tips on yielding right of way in highway work zones:

1. Try to anticipate other drivers' actions in work zones and be ready to yield.
2. Yield the right of way whenever needed and required by law in work zones.

B.7 Knowledge Questions for the Safe Driving Behaviors Module

Q1: What driving behaviors likely contribute to work zone crashes?
A. Distracted driving

B. Speeding
C. Tailgating
D. All answers are correct

Q2: What activity will likely take your attention away from driving or your eyes off the road in a highway work zone?
A. Texting or making a call
B. Chatting with people in your vehicle
C. Eating and drinking
D. All answers are correct

Q3: Driving at a higher rate exceeding the posted speed limit in a highway work zone can potentially
A. Increase the stopping distance after perceiving a danger
B. Lead to losing control of vehicle
C. Cause a crash
D. All answers are correct

Q4: To make safe lane movement in work zones, a driver must
A. Check his or her mirrors for any vehicles that are preparing to pass him or her
B. Use his or her turn signal to alert other drivers of his or her intention to change lanes
C. Make sure that there is no traffic ahead of him or her in the lane he or she would like to enter
D. All answers are correct

Q5: Driving at 45 mph instead of 55 mph through a 5-mile work zone will only add 1.2 minutes to your trip.
A. True
B. False

Q6: Sending or reading a text while driving through a work zone takes your eyes off the road for 5 seconds
A. True
B. False

B.8 The Safety Signs and Laws Module

B.8.1 Safety Signs

Work zones pose dangers for both drivers and construction workers. Signs in work zones alert drivers to be careful when approaching and driving through work zones. You must obey all work zone signs, even if workers are not present. Below are some work zone safety signs

Interpretations for below work zone signs:
1 – Stop or flagger ahead;
2 – Uneven road;
3 – Both lanes shift to left;
4 – Diverted traffic first to right;
5 – Flagger

Below are other work zone safety signs

Lane ends ahead. Slow down and be prepared to merge.

Workers are ahead. Slow down and be alert.

Traffic is traveling in two directions. Slow down and be alert for oncoming traffic.

Cones and barricades are used in work zones to direct traffic flow, stop vehicles, and block access to closed areas.

B.8.2 Safety Laws

The law requires drivers or motorists to obey all signs in work zones including posted speed limit signage. First time offenders for speeding (i.e., going beyond the posted speed limits) in a work zone attracts a $300 fine. The fine increases to $500 for a second offense and $1,000 for a third offense within three years. Motorists who drive recklessly or aggressively through a work zone face up to $5,000 fines (INDOT, n.d.a). Drivers who injure or kill a highway worker may end up paying a $10,000 fine and serving up to six years behind bars. Fines generated from the work zone law are used to fund additional work zone patrols in and around work zones.

B.8.3 Knowledge Questions for the Safety Signs and Laws Module

Q7: The Indiana state laws require drivers or motorists to obey all sign in work zone.
A. True
B. False

Q8: Drivers who injure or kill a highway worker may end up
A. Paying a $50,000 fine
B. Paying a $10,000 fine
C. Serving up to 6 years behind bars
D. Answer B and C are correct

Q9: Cones and barricades are used in work zones to
A. Direct traffic flow

B. Stop vehicles
C. Block access to closed areas
D. All answers are correct

Q10: You must obey all work zone signs only when workers are present.
A. True
B. False

Q11: Work zones pose dangers for
A. Drivers only
B. Construction workers only
C. Both drivers and construction workers
D. All answers are correct

B.9 The Merging in Work Zones Module

A zipper merge is used when a lane is closed ahead due to a road construction or maintenance work (INDOT, n.d.b). It keeps traffic moving by allowing drivers to use both lanes until reaching the merge point. It works exactly like a zipper.

1. When you see "lane closed ahead" signs, you should stay in your current lane up to the designated merge point.
2. You should take turns moving into the open lane.
3. When a zipper merge is in place, be respectful of other drivers who wait to merge until just before the lane ends – they're doing it right!

A zipper merge helps to do the following.

1. Reduce speed differences between two lanes.
2. Reduce queue length by up to 40%.
   Reduce congestion and keep traffic moving smoothly.
3. Create a sense of fairness and equity that all lanes are moving at the same rate.
4. Bring order to the merging process.

B.9.1 Early Merge

An early merge is when you start moving into the open lane at the first sight of a "lane closed ahead" sign. Merge early to the open lane when traffic is flowing at highway speeds with no or minimal back-ups.

B.9.2 Knowledge Questions for the Merging in Work Zones Module

Q12: A zipper merge allows drivers to use both lanes until reaching the merge point.
A. True
B. False

Q13: A zipper merge helps to
A. Reduce differences between two lanes
B. Reduce queue length by up to 40%

C. Reduce congestion and keep traffic moving smoothly
D. All answers are correct

Q14: An early merge is
A. When you stay in your current lane up to the designated merge point after seeing a lane closed ahead
B. When you start moving into the open lane at the first sight of a lane closed sign
C. Both A and B
D. All answers are correct

Q15: What recommendation would you provide to improve this training curriculum?

_____

Demographic Questions

Q16: Do you identify as
A. Female
B. Male
C. Non-binary
D. Transgender
F. Prefer to self-describe_____

Q17: What is your current age?
A. 18-24 years
B. 25-34 years
C. 35-44 years
D. 45-59 years
E. 60 and above

Q18: How would you describe yourself?
A. Asian or Asian American
B. Black of African American
C. Latinx
D. Native American, American Indian, or Alaska Native

Q17: Please the answer that indicates your entire household population income in 2020 before tax
A. $49,999 and below
B. $50,000 and above

APPENDIX C. CRASH DATA ANALYSIS

The following appendix includes outputs from the crash data analysis.

Table C.1 Descriptive statistics of work zone collisions

Work Zone Collisions	Descriptive Statistics		
Year	Total Work Zone Collisions	Mean County Rate Per 1,000 Collisions	Median County Rate Per 1,000 Collisions
2010	4,683	14.3	NA
2011	4,309	13.2	10.6
2012	3,498	13.2	7.5
2013	2,874	11.9	NA
2014	3,979	13.5	8.1
2016	5,487	113.6	107.8
2017	7,056	19.9	13.1
2018	5,991	21	15
2019	5,459	20	14

Table C.2 Work zone collisions by crash type

Work Zone Collisions	Crash Type			
Year	Fatal	Non-Fatal	Property Damage	Fatal Collisions Per 1000 Work Zone Collisions
2010	12	757	3,914	2.6
2011	17	686	3,606	4
2012	10	637	2,843	2.9
2013	13	481	2,380	4.5
2014	10	622	3,347	2.5
2016	15	804	4,668	2.7
2017	23	925	5,422	3.6
2018	17	790	4,434	3.2
2019	25	805	4,629	4.6

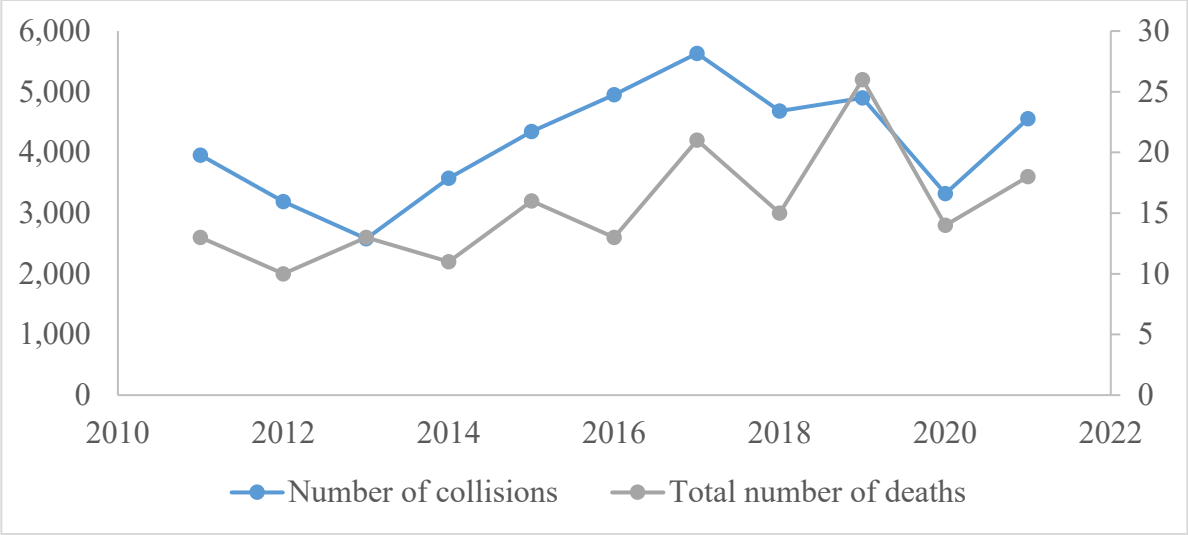
Table C.3 Work zone collisions by Census locale

Work Zone Collisions	Census Locale Per 1,000 Collisions			
Year	Urban	Suburban	Exurban	Rural
2010	28	19	11.7	10.1

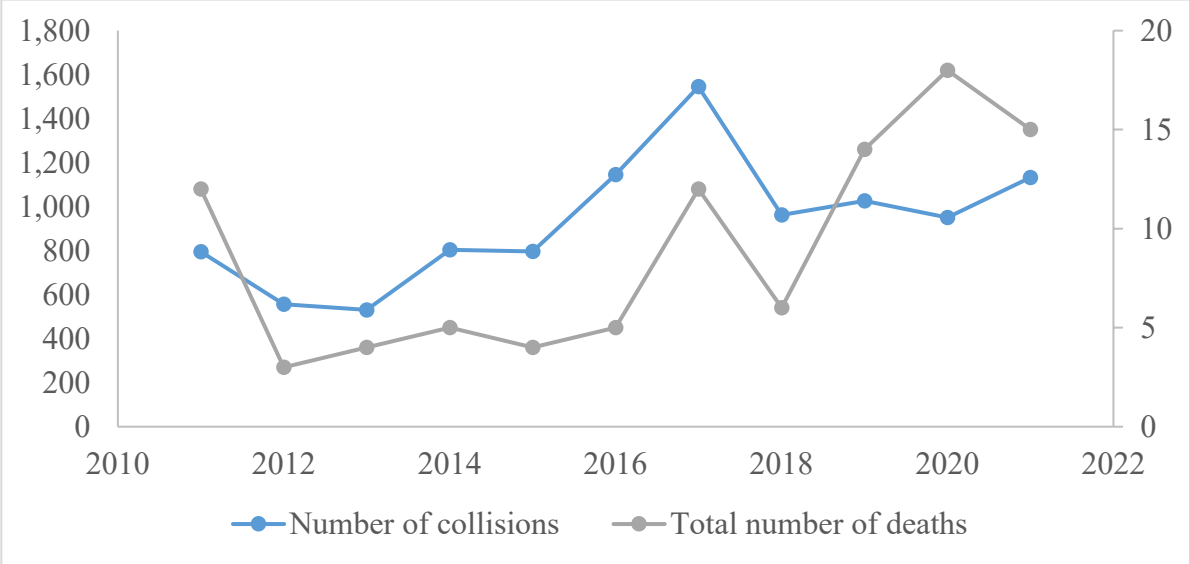
2011	26.6	17.9	11.8	9.5
2012	19.7	18.1	13.4	9.7
2013	14.9	16.7	14.7	8.9
2014	21.1	17.6	17.1	6.7
2016	36.9	21.4	20.6	20.2
2017	26.6	37.5	33	14.4
2018	20.6	34.3	44.7	20.4
2019	24	37.4	27	13.8

Table C.4 Work zone collisions by road class

Work Zone Collisions	**Road Class**				
Year	**Interstate**	**US Route**	**State Road**	**Local/ City Road**	**County Road**
2010	105	27	21	20	7
2011	91.9	20	21.4	21.8	6.3
2012	67.9	23.9	20.1	16.4	5.3
2013	65.6	23.3	15.8	10.3	3.5
2014	82.9	31.1	15.7	13.9	3.3
2016	124	33.3	28.7	13.3	4.8
2017	167.5	28.4	25.4	15.6	5
2018	75.9	44.2	26.1	19.1	6.5
2019	92.1	33.8	30	18.5	4.5



(a)



(b)

Figure C.1 Deaths and number of collisions per year: (a) private vehicles and (b) commercial vehicles.

Table C. 5 Ranking the top primary factors for collisions alongside their corresponding crash type

Rank	Primary Factors for Collisions In/Around Work Zones	Top Resulting Collision Manner (%)
1	Following closely	Rear-end (97%)
2	Unsafe lane movement	Side-swipe (75%)
3	Failure to yield right of way	Right angle (34%) and side-swipe (29%)
4	Distracted driving	Rear-end (74%)
5	Unsafe speeding	Rear-end (68%)

Table C.6 Number of injuries per year and ratio of death/injury for the highest crash types

Rank	Collision Manner	Number of Injuries Per Year	Death/Injury
1	Rear-end	723	0.55%
2	Side-swipe	94	1.42%

Table C.7 Number of injuries per year corresponding to the top crash-causing behavior

Crash-Causing Behavior	Number of Injuries per Year
Following too closely	470
Unsafe speed	100
Unsafe lane movement	85
Distracted driving	68

Table C.8 Ranking the top primary factors for collisions alongside their corresponding collision manner

Rank	Crash Causing Behaviors In/ Around Work Zones	Top Resulting Collision Manner (%)
1	Unsafe lane movement	Side-swipe (84%)
2	Following closely	Rear-end (92%)
3	Unsafe speeding	Rear-end (66%)
4	Distracted driving	Rear-end (55%)

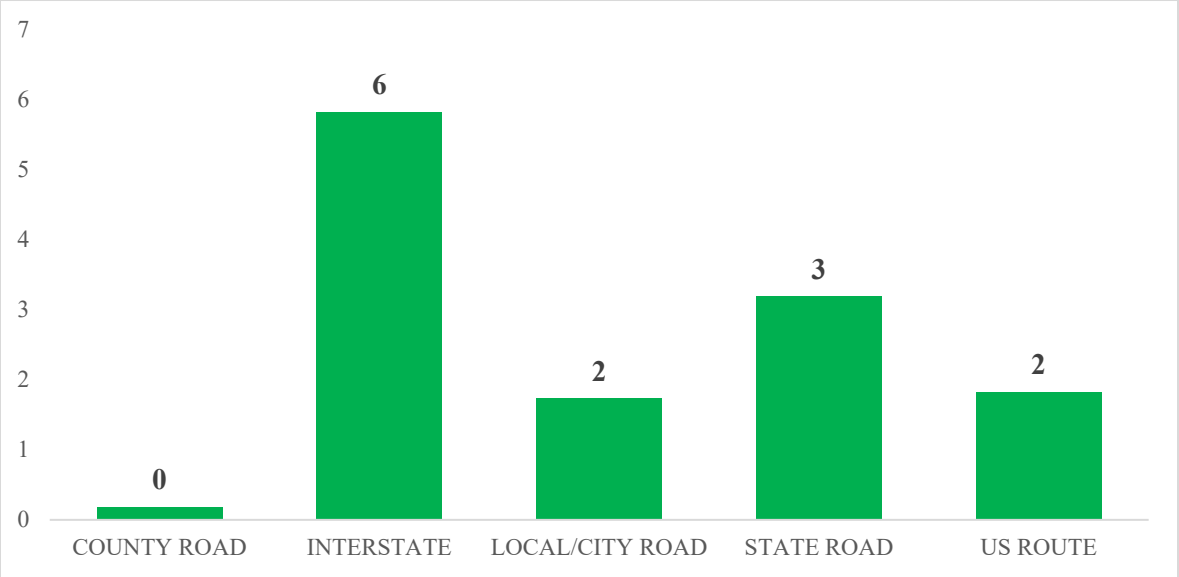
Table C.9 Number of injuries per year and ratio of death/injury for the highest collision manners

Rank	Collision Manner	Number of Injuries Per Year	Death/Injury

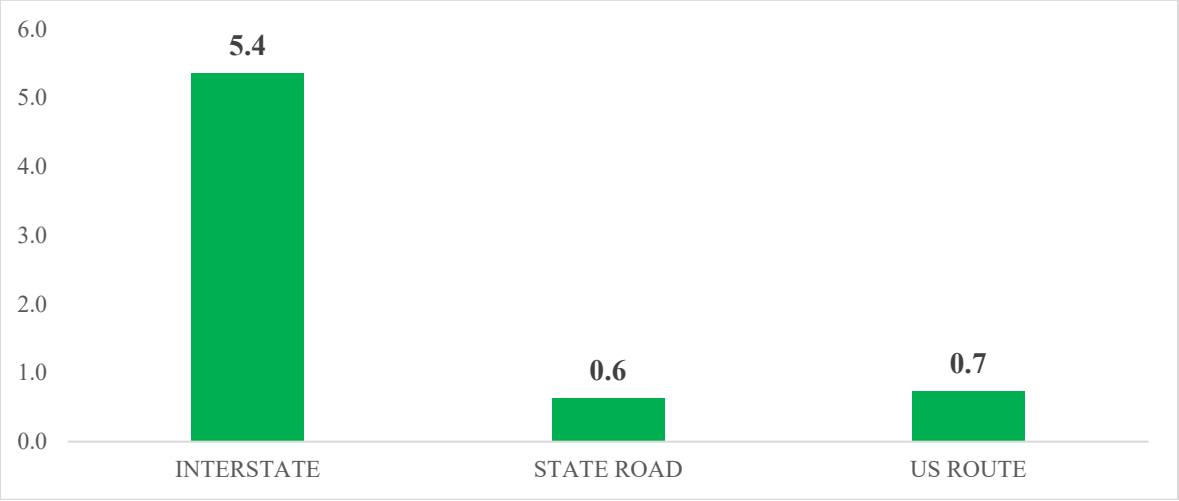
1	Rear-end	65	6%
2	Side-swipe	29	6%

Table C.10 Number of injuries per year corresponding to the top crash-causing behavior

Crash-Causing Behavior	Number of Injuries Per Year
Following too closely	34
Unsafe lane movement	21
Unsafe speed	12
Distracted driving	5

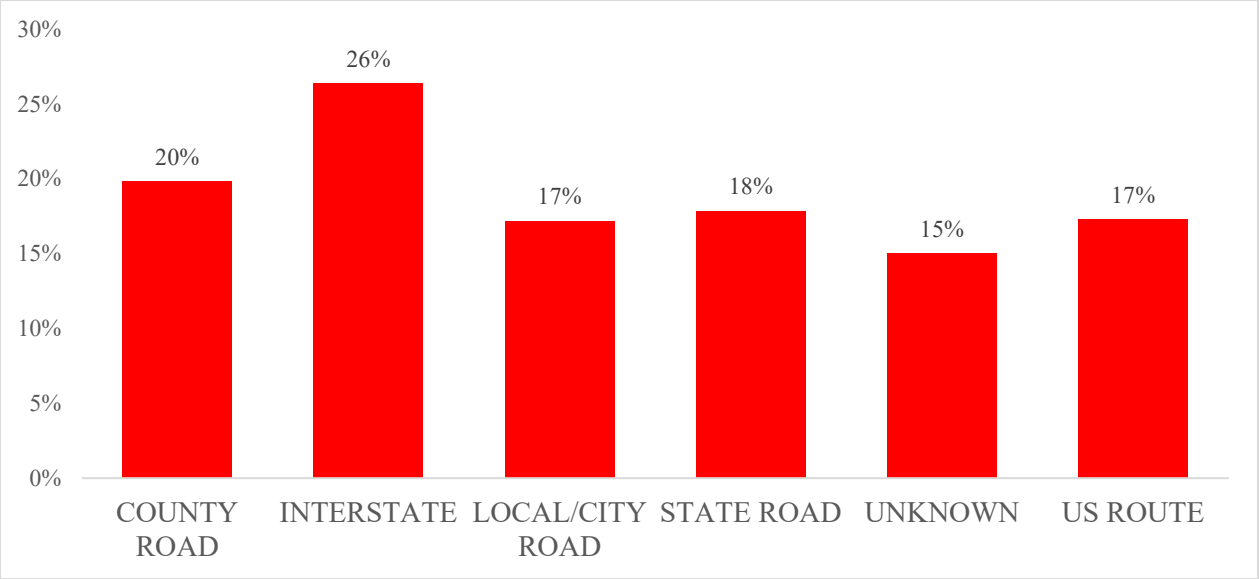


(a)

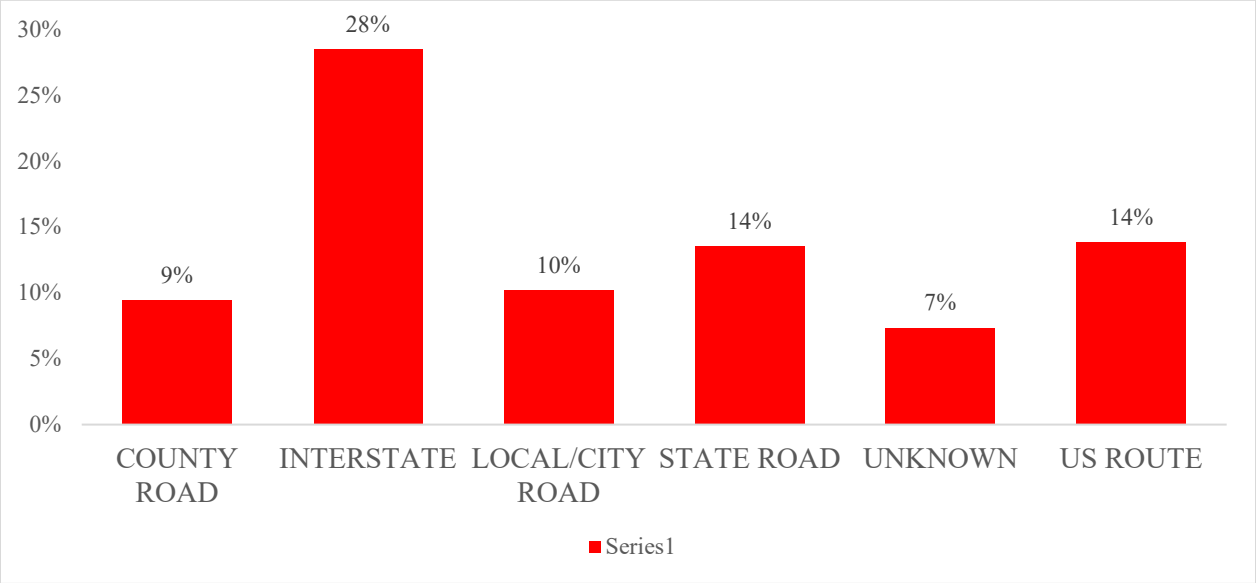


(b)

Figure C.2 Yearly average deaths per road class: (a) private vehicles and (b) commercial vehicles.



(a)



(b)

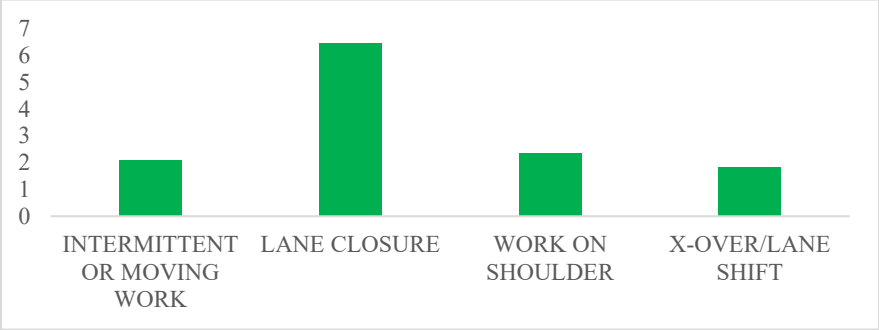
Figure C.3 Collisions in the dark per road class: (a) private vehicles and (b) commercial vehicles.

Table C.11 Top manner of collision per road class

Private Vehicles					
Road Class	**County Road**	**Interstate**	**Local/City Road**	**State Road**	**US Route**
Top manner of collision	Rear end	Rear end	Rear end	Rear end	Rear end
Commercial Vehicles					
Road Class	**County Road**	**Interstate**	**Local/City Road**	**State Road**	**US Route**
Top manner of collision	Sds/ backing crash	Same direction sideswipe	Same direction sideswipe	Rear end	Rear end

Table C.12 Top primary factor of collision per road class for Commercial vehicles

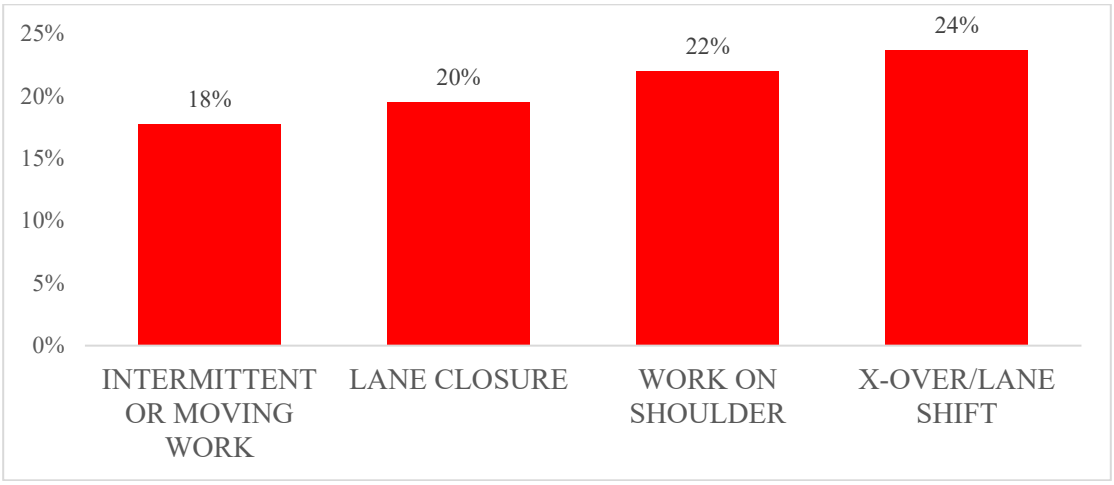
Road Class	**County Road**	**Interstate**	**Local/City Road**	**State Road**	**US Route**
Top primary factor of collision	Unsafe backing	Unsafe lane movement	Failure to yield right of way	Following too closely	Following too closely



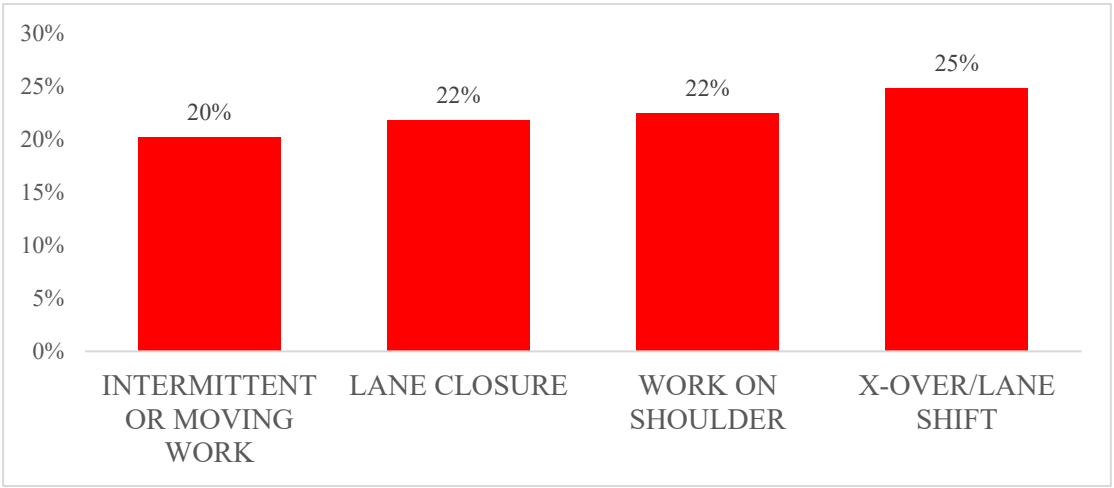
(a)

(b)

Figure C.4 Yearly average deaths per construction type: (a) private vehicles and (b) commercial vehicles



(a)



(b)

Figure C.5 Collisions in the dark per construction type: (a) private vehicles and (b) commercial vehicles.

Table C.13 Top primary factor of collision per construction type: (a) and (b) c

Private Vehicles

Construction Type	**Intermittent or Moving Work**	**Lane Closure**	**Work on Shoulder**	**X-Over/Lane Shift**
Top Primary Factor of Collision	Following too closely	Following too closely	Following too closely	Following too closely

Commercial Vehicles

Construction Type	**Intermittent or Moving Work**	**Lane Closure**	**Work On Shoulder**	**X-Over/Lane Shift**
Top Primary Factor of Collision	Unsafe lane movement	Unsafe lane movement	Unsafe lane movement	Unsafe lane movement

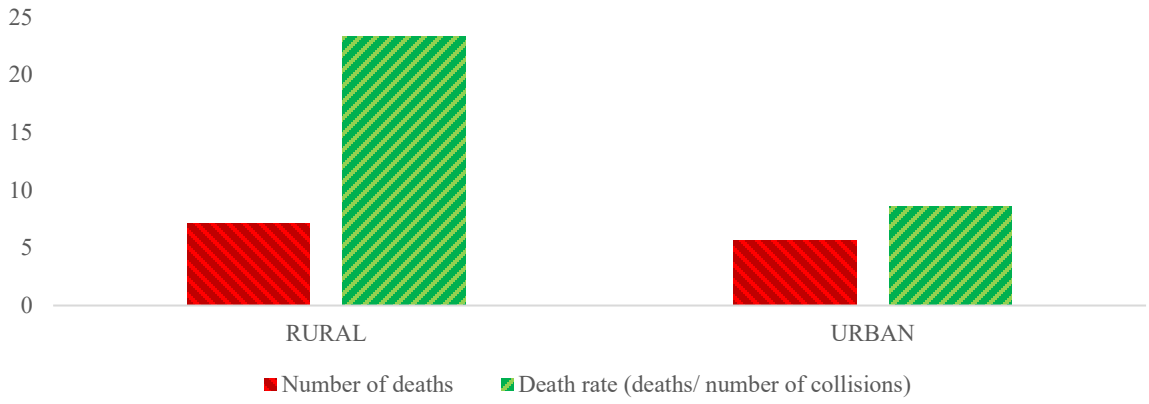
Table C.14 Top manners of collision per construction type. (a) Private vehicles; (b) Commercial vehicles

(a)

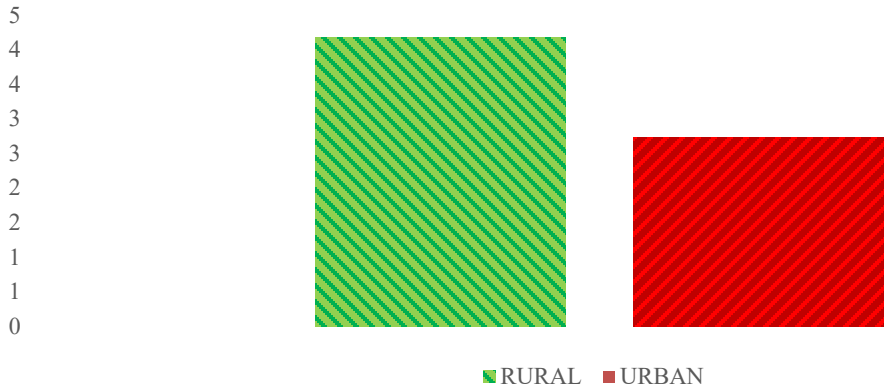
Construction Type	**Intermittent or Moving Work**	**Lane Closure**	**Work on Shoulder**	**X-Over/Lane Shift**
Top Manner of Collision	Rear end	Rear end	Rear end	Rear end

(b)

Construction Type	**Intermittent or moving work**	**Lane closure**	**Work on shoulder**	**X-over/lane shift**
Top Manner of Collision	Sds/ backing crash	Same direction sideswipe	Same direction sideswipe	Rear end



(a)



(b)

Figure C.6 Deaths per locality: (a) private vehicles and (b) commercial vehicles.

APPENDIX D. CAMPAIGN SURVEY QUESTIONS

Section 1: Perceived Message Effectiveness
To what extent do you agree or disagree with following statements about the work zone safety message you have seen and read? Strongly disagree = 1 to Strongly agree = 5
1. This message grabbed my attention.
2. This message made me stop and think.
3. This message was believable.
4. This message made me want to quit…

Section 2: Perceived Self Efficacy
1. I am able to [recommended response] to prevent crashing in a work zone.
2. [Recommended response] is easy to do to prevent crashing in a work zone.
3. [Doing recommended response] to prevent crashing in a work zone is convenient.

Section 3: Perceived Response Efficacy
1. [RR] works in preventing a work zone crash.
2. [Doing the RR] is effective in preventing crashing in a work zone.
3. If I [do the RR], I am less likely to crash in a work zone.

Section 4: Suggestion to improve message (Open-Ended question)
What suggestions, if any, would you provide to improve this message you had seen and read? Please use the below space to write your suggestions.

_____

Section 5: Channel Uses and Preferences
1. From what channels or sources do you read messages about driver safety in Indiana work zones. Please rank which of the following sources or channels you utilize most frequently. You may choose up to 3.
i. Facebook
ii. Twitter
iii. Instagram
iv. INDOT website
v. Portable Message Changeable Signs
vi. Billboards
vii. Others_____

2. In which of the following channels would you most like to receive or read messages about driver safety in Indiana work zones. You may choose up to 3
i. Facebook
ii. Twitter
iii. Instagram
iv. INDOT website
v. Portable Message Changeable Signs
vi. Billboards

vii. Rest areas
viii. Others_____

Section 6: Demographics
1. Gender
Do you identify as
i. Female
ii. Male
iii. Non-binary
iv. Transgender
v. Prefer to self-describe_____

2. Age
What is your current age?
i. 18-24 years
ii. 25-34 years
iii. 35-44 years
iv. 45-59 years
v. 60 years and above

3. Education
What is the highest level of education that you have completed?
i. Some schooling, but no diploma or degree
ii. High school graduate or GED
iii. Some college
iv. College degree
v. Some graduate school
vi. Graduate degree

4. Race
How would you describe yourself?
i. Asian or Asian American
ii. Black of African American
iii. Latinx
iv. Native American, American Indian, or Alaska Native
v. Native Hawaiian or other Pacific Islander
vi. Multi-ethnic/multi-racial
vii. White or Caucasian
viii. Other_____

5. Income
Please indicate the answer that includes your entire income in 2021, before taxes.
i. $49,999 or less
ii. $50, 000 or more

6. Driver's License
Do you have a valid US driver's license?
i. Yes
ii. No

APPENDIX E. CAMPAIGN MESSAGES

The following appendix includes the messages that were designed for the campaign.

Figure E.1 *Distracted driving* fear appeal #1 (DFA1).

Figure E.2 *Distracted driving* positive appeal #1 (DPA1).

Figure E.3 *Distracted driving* source credibility #1 (DSC1).

Figure E.4 *Failure to yield* positive appeal #1 (FYPA1).

Figure E.5 *General* positive appeal #1 (GPA1).

Figure E.6 *Speeding* fear appeal #1 (SFA1).

Figure E.7 *Speeding* fear appeal #2 (SFA2).

Figure E.8 *Speeding* positive appeal #1 (SPA1).

Figure E.9 *Speeding* source credibility #1 (SSC1).

Figure E.10 *Speeding* social norm #1 (SSN1).

Figure E.11 *Speeding* social norm #2 (SSN2).

Figure E.12 *Speeding* social norm #3 (SSN3).

Figure E.13 *Tailgating* positive appeal #1 (TPA1).

Figure E.14 *Tailgating* positive appeal #2 (TPA2).

Figure E.15 *Unsafe lane movement* positive appeal #1 (ULMPA1).

About the Joint Transportation Research Program (JTRP)

On March 11, 1937, the Indiana Legislature passed an act which authorized the Indiana State Highway Commission to cooperate with and assist Purdue University in developing the best methods of improving and maintaining the highways of the state and the respective counties thereof. That collaborative effort was called the Joint Highway Research Project (JHRP). In 1997 the collaborative venture was renamed as the Joint Transportation Research Program (JTRP) to reflect the state and national efforts to integrate the management and operation of various transportation modes.

The first studies of JHRP were concerned with Test Road No. 1—evaluation of the weathering characteristics of stabilized materials. After World War II, the JHRP program grew substantially and was regularly producing technical reports. Over 1,600 technical reports are now available, published as part of the JHRP and subsequently JTRP collaborative venture between Purdue University and what is now the Indiana Department of Transportation.

Free online access to all reports is provided through a unique collaboration between JTRP and Purdue Libraries. These are available at http://docs.lib.purdue.edu/jtrp.

Further information about JTRP and its current research program is available at http://www.purdue.edu/jtrp.

About This Report

An open access version of this publication is available online. See the URL in the citation below.

Chahine, R., Adu Gyamfi, P., Subash, N., Cho, W., Kelley, K. O., Connaughton, S. L., & Gkritza, K. (2022). *Design of educational material and public awareness campaigns for improving work zone driver safety* (Joint Transportation Research Program Publication No. FHWA/IN/JTRP-2022/13). West Lafayette, IN: Purdue University. https://doi.org/10.5703/1288284317375