U.S. Department of Transportation
Federal Highway Administration

ASSESSMENT OF DATA SOURCES FOR FIRST RESPONDER STRUCK-BY CRASHES

FINAL REPORT

FHWA-HOP-23-069

January 2024

ZERO IS OUR GOAL
A SAFE SYSTEM IS HOW WE GET THERE

FOREWORD

This report documents the effort by the Federal Highway Administration (FHWA) Office of Safety and Operations Research & Development and the FHWA Office of Operations to assess current data sources, to compile existing data, to review gaps, and to propose a data collection strategy that will start to quantify the occurrence of responder struck-by crashes. Often these crashes are not captured in traditional data systems, but they can result in serious or fatal injuries and compromise the safety of the entire roadway system.

This study is part of the National Highway Traffic Safety Administration's efforts to evaluate driver behavior; move over law efficacy; and technologies that protect law enforcement, first responders, roadside crews, and others while on the job. FHWA applied NHTSA funding towards examining these issues and needs from a roadway safety and operations perspective.

This report documents current findings, as well as insights from subject matter experts who provided guidance and input on prospective data collection and identification methodologies. Foundationally, this study developed a data definition for struck-by crashes to establish consistent and replicable data collection. Using the new definition, agencies can develop countermeasures based upon aggregated, consistent, and replicable collected data. This study's results will help create safety strategies and countermeasures to protect workers operating in difficult environments.

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16. Abstract
This report details the approach and findings from research conducted regarding the occurrence of responder struck-by crashes. There is not one national source of responder struck-by crashes from which to draw and analyze data to better understand and mitigate these tragic incidents. This project sought to cast a wide net across many different potential sources of data on responder struck-by crashes, assess these sources, identify gaps and limitations in the data, and develop and analyze a composite dataset of verified struck-by crashes.

The research resulted in a common definition for a responder struck-by crash for consistency in identifying responder struck-by crashes. The findings from an in-depth review and assessment of over 20 sources of data for responder struck-by crashes are presented, including various data elements and attributes within each of the data sources. Verified responder struck-by crashes are compiled into a composite dataset, which includes 505 crashes that occurred between 2011 and 2021 across 42 States. Gaps and limitations of each data source are documented.

To assist with similar future research, a template for collecting data on responder struck-by crashes is provided. This template leverages the common definition of a responder struck-by crash and details five steps that were applied to collect and assess the data sources used for this project.

A virtual stakeholder workshop brought together 47 stakeholders representing local, State, and Federal responder agencies. Potential action items and next steps for improving the ability to identify responder struck-by crashes within the data sources are identified and discussed.

Recommendations for next steps and future research on responder struck-by crashes are provided.

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SI* (MODERN METRIC) CONVERSION FACTORS

APPROXIMATE CONVERSIONS TO SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
in	inches	25.4	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
		AREA		
in^2	square inches	645.2	square millimeters	mm^2
ft^2	square feet	0.093	square meters	m^2
yd^2	square yard	0.836	square meters	m^2
ac	acres	0.405	hectares	ha
mi^2	square miles	2.59	square kilometers	km^2
		VOLUME		
fl oz	fluid ounces	29.57	milliliters	mL
gal	gallons	3.785	liters	L
ft^3	cubic feet	0.028	cubic meters	m^3
yd^3	cubic yards	0.765	cubic meters	m^3
		NOTE: volumes greater than 1,000 L shall be shown in m^3		
		MASS		
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2,000 lb)	0.907	megagrams (or "metric ton")	Mg (or "t")
		TEMPERATURE (exact degrees)		
°F	Fahrenheit	5 (F-32)/9 or (F-32)/1.8	Celsius	°C
		ILLUMINATION		
fc	foot-candles	10.76	lux	lx
fl	foot-Lamberts	3.426	candela/m^2	cd/m^2
		FORCE and PRESSURE or STRESS		
lbf	poundforce	4.45	newtons	N
lbf/in^2	poundforce per square inch	6.89	kilopascals	kPa

APPROXIMATE CONVERSIONS FROM SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
mm	millimeters	0.039	inches	in
m	meters	3.28	feet	ft
m	meters	1.09	yards	yd
km	kilometers	0.621	miles	mi
		AREA		
mm^2	square millimeters	0.0016	square inches	in^2
m^2	square meters	10.764	square feet	ft^2
m^2	square meters	1.195	square yards	yd^2
ha	hectares	2.47	acres	ac
km^2	square kilometers	0.386	square miles	mi^2
		VOLUME		
mL	milliliters	0.034	fluid ounces	fl oz
L	liters	0.264	gallons	gal
m^3	cubic meters	35.314	cubic feet	ft^3
m^3	cubic meters	1.307	cubic yards	yd^3
		MASS		
g	grams	0.035	ounces	oz
kg	kilograms	2.202	pounds	lb
Mg (or "t")	megagrams (or "metric ton")	1.103	short tons (2,000 lb)	T
		TEMPERATURE (exact degrees)		
°C	Celsius	1.8C+32	Fahrenheit	°F
		ILLUMINATION		
lx	lux	0.0929	foot-candles	fc
cd/m^2	candela/m2	0.2919	foot-Lamberts	fl
		FORCE and PRESSURE or STRESS		
N	newtons	2.225	poundforce	lbf
kPa	kilopascals	0.145	poundforce per square inch	lbf/in^2

*SI is the symbol for International System of Units. Appropriate rounding should be made to comply with Section 4 of ASTM E380. (Revised March 2003)

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF ACRONYMS

AAA	American Automobile Association
AADT	annual average daily traffic
ACDA	assured clear distance ahead
API	application programming interface
BLS	U.S. Bureau of Labor Statistics
CD	compact disc
CDOT	Colorado Department of Transportation
CFOI	Census of Fatal Occupational Injuries
CRSS	Crash Report Sampling System
DHS	U.S. Department of Homeland Security
DOL	U.S. Department of Labor
EDT	electronic data transfer
EMS	emergency medical services
ERSI	Emergency Responder Safety Institute
FACE	Fatality Assessment and Control Evaluation
FARS	Fatality Analysis Reporting System
FAT/CAT	Weekly Fatalities and Catastrophes
FBI	Federal Bureau of Investigation
FHE	first harmful event
FHWA	Federal Highway Administration
GAO	Government Accountability Office
IAFC	International Association of Fire Chiefs
IIF	Injuries, Illnesses, and Fatalities
IRB	Institutional Review Board
LEOKA	FBI Law Enforcement Officers Killed and Assaulted
LODD	line of duty death
MMUCC	Model Minimum Uniform Crash Criteria
MSA	metropolitan statistical area
MUTCD	*Manual on Uniform Traffic Control Devices*
NASEMSO	National Association of State EMS Officials
NASS GES	National Automotive Sampling System General Estimates System
NCCI	National Council on Compensation Insurance
NCHRP	National Cooperative Highway Research Program
NEISS-Work	National Electronic Injury Surveillance System—Occupational Supplement
NEMSIS	National Emergency Medical Services Information System
NFDC	National Fire Data Center
NFIRS	National Fire Incident Reporting System
NFPA	National Fire Protection Association
NHTSA	National Highway Traffic Safety Administration
NIOSH	National Institute for Occupational Safety and Health
NLEOMF	National Law Enforcement Officers Memorial Foundation
NOII	Nonfatal Occupational Injuries and Illnesses
NUG	National Unified Goal

ODMP	Officer Down Memorial Page
OIICS	Occupational Injury and Illness Classification System
OSHA	Occupational Safety and Health Administration
PDO	property damage only
PHI	protected health information
PII	personally identifiable information
PSAP	public safety answering point
REACT	Regional Action Coordinating Team
RRSP	Road Ranger Safety Patrol
SAS	Statistical Analysis System
SHRP2	Strategic Highway Research Program 2
SOII	Survey of Occupational Injuries and Illnesses
SSP	safety service patrol
STA	Statewide Towing Association, Inc.
TIM	traffic incident management
TRAA	Towing and Recovery Association of America, Inc.
TRB	Transportation Research Board
TTIRS	Towing Traffic Incident Report System
UCR	Uniform Crime Reporting
URL	Uniform Resource Locator
USDOT	U.S. Department of Transportation
USFA	United States Fire Administration
UTC	Coordinated Universal Time
UUID	universal unique identifier
WORK-RISQS	Work-Related Injury Statistics Query System

EXECUTIVE SUMMARY

This report details the approach and findings from research conducted into the occurrence of responder struck-by crashes. For consistency in identifying responder struck-by crashes during the research, the project team developed a common definition for a responder struck-by crash with input from various responder stakeholders. This definition is as follows:

> *A "responder struck-by" incident is a collision between a motor vehicle in transit and a responder working a roadway incident, which would be recorded on a State traffic crash reporting form in the jurisdiction where it occurred. The responder may be a nonmotorist, an occupant of a stopped response vehicle, or an unoccupied response vehicle.*

There is not one national source of information on responder struck-by crashes from which to draw and analyze data to better understand and mitigate these tragic incidents. As such, this project sought to cast a wide net across many different potential sources of data on responder struck-by crashes, assess these sources, identify gaps and limitations in the data, and develop and analyze a composite dataset of verified struck-by crashes.

DATA ASSESSMENT

The project team reviewed and assessed over 20 sources of data for responder struck-by crashes. These data sources included official State and Federal reporting systems (e.g., State crash reporting systems, National Emergency Medical Services Information System (NEMSIS), National Fire Incident Reporting System (NFIRS)), as well as data from private and nonprofit industry reporting systems (e.g., Emergency Responder Safety Institute (ERSI), Towing Traffic Incident Report System (TTIRS), Officer Down Memorial Page (ODMP)). The team explored various data elements and attributes within each of the data sources; identified, verified, and cross-checked responder struck-by crashes, where possible; and documented gaps and limitations associated with each data source.

Based on this review and assessment, the team compiled 505 verified responder struck-by crashes into a composite dataset. These crashes occurred between 2011 and 2021 across 42 States. About half of the responder struck-by crashes identified occurred in Florida and Tennessee, as the team had access to many years of crash data from these two States. The team identified about one-third of the responder struck-by crashes in ERSI articles associated with crashes in 36 States. The team identified the remaining responder struck-by crashes through various other sources, including NFIRS; TTIRS; National Institute for Occupational Safety and Health (NIOSH) Fatality Assessment and Control Evaluation (FACE) reports; and crash reports from Arizona, Illinois, and Ohio. Most of the crashes (67 percent) in the dataset occurred in Arizona, Colorado, Florida, Illinois, Ohio, and Tennessee, and the remaining 33 percent were scattered across 36 other States.

CHALLENGES AND LIMITATIONS WITH THE DATA

While the team identified a wide range of challenges and limitations associated with the data sources (e.g., data accessibility, data limited to crashes involving only one responder group), there were four primary limitations in identifying responder struck-by crashes from the data sources reviewed.

The first major limitation is the lack of a specific struck-by data element that is consistent and only pertains to responders (i.e., does not include other nonresponder persons):

- Many of the data sources assessed had no data element on which to query for responder struck-by crashes.

- The Model Minimum Uniform Crash Criteria (MMUCC) guideline data elements used to capture responder struck-by crashes, as implemented by States and as captured by law enforcement in the field, fall short of current data needs for efficiently identifying responder struck-by crashes within crash data:

  - MMUCC NM.2 "Non-Motorist Action/Circumstance Prior to Crash" and associated "Working in Trafficway (*Incident Response*)" data attributes are not very effective in identifying responder struck-by crashes, as only about 20 percent of these crashes were determined to be struck-bys in a review of crash data from Florida.
  - While the MMUCC 5th Edition has brought forth an "Incident Responder?" data attribute under the P4. "Person Type" data element, to date, only a few States have adopted it on their crash report forms. Furthermore, upon reviewing 200 crashes from 2020 Illinois data that were flagged with the "Incident Responder?" data attribute, and that also involved a pedestrian, only 3 of the crashes were verified as responder struck-by crashes per the definition. Most of the crashes reviewed (194 out of 200 crashes) did not involve responders (or responder vehicles) struck at traffic incident scenes.

- A few States have included other explicit data elements (not MMUCC-aligned) for responder struck-by crashes; however, two of the three datasets assessed showed issues with miscoding by officers completing the crash forms, which resulted in few of the crashes flagged with these data elements being verified as responder struck-bys.

- Some of the data sources have some type of "struck-by" data element (e.g., ODMP, NFIRS, firefighter fatalities in the United States), but the definitions are inconsistent with the definition developed for the purpose of this project. For example, struck-by incidents in the firefighter fatalities in the United States data include those that involved firefighters being struck-by falling debris or fire apparatuses.

The second and third major limitations of some of the data sources reviewed involved **the self-reporting nature of the data/systems** and **datasets that focus only on fatal crashes**. The self-reporting approach severely limits the number of struck-by crashes contained in the database, as self-reporting is voluntary, easy to dismiss, and intentionally avoided in some cases (e.g., towing industry). A focus on fatal crashes also severely limits the amount of data available on responder struck-by crashes, as there are likely many more injury-related responder struck-by crashes (including both minor and major injuries) as compared to fatal crashes.

Finally, the fourth major limitation in identifying responder struck-by crashes in the various datasets is that, in almost all cases, **summaries or narratives of the crashes must be reviewed to verify if the crashes can be classified as responder struck-bys**. This limitation ties back to the first limitation related to the lack of a specific and consistent responder struck-by data element/attribute in the datasets. Three related challenges are: 1) often, narratives cannot be shared due to sensitive/personal information, 2) crash report narratives are sometimes stored as images as opposed to searchable text strings, and 3) reviewing narratives is a manual process that is labor intensive and time consuming.

To assist with similar future research, the project team developed a template for collecting and assessing data on responder struck-by crashes from a variety of sources. The template leverages the common definition of a responder struck-by crash and details five steps that were followed to collect and assess the data sources used for this project. This same process could be applied to other data sources and in future efforts.

ANALYSIS AND FINDINGS

The project team conducted an analysis of the 505 responder struck-by crashes in the composite dataset. The analysis included summary statistics breaking down the crashes by various crash and responder variables, chi-square tests, a cluster analysis, and a case study of over 600 responder vehicle-only struck-by crashes in Florida.

The responder struck-by crashes in the composite dataset were analyzed by responder-related variables (e.g., discipline, location at scene, response type, injury sustained) and crash-related variables (e.g., hour, day, and month of crash; area type, roadway classification, environmental and lighting conditions). Because the composite dataset is not a random sample of responder struck-by crashes, the data may not be representative of the range of injury types, responder disciplines, response activities, locations, conditions, etc., for these crashes.

Major take-aways from the analysis of responder-related variables include the following:

- The majority of the responders involved (57 percent) were law enforcement.
- Most of the responders were struck as nonmotorists outside their vehicles (82 percent of crashes with this information).
- 70 percent of the responders suffered a fatality or injury (a suspected major or suspected minor injury), and an additional 15 percent of responders suffered possible injuries.
- 40 percent of crashes and 44 percent of responders were struck when responding to a prior crash.
- For 38 responders who were struck, for whom information on the use of retroreflective gear was available, 33 responders (87 percent) were wearing retroreflective gear when struck.
- Tow operators represented the highest percent of fatal injuries (49 percent), followed by fire personnel (31 percent) and law enforcement (14 percent).
- More responders were injured or killed as nonmotorists as compared with those who were occupants of parked responder vehicles (70 percent versus 59 percent), but these results show that being struck in a parked vehicle still represents a risk for responders.

Major take-aways from the analysis of crash-related variables include the following:

- More of the responder struck-by crashes in the dataset occurred:
  - During the fall and winter months, as opposed to spring and summer
  - On weekends (Friday through Sunday) as opposed to weekdays
  - In the evening/late evening hours as opposed to daytime hours
  - During dry weather conditions

- Most struck-by crashes occurred in urban versus rural areas:
  - A plurality of urban crashes occurred on interstate and local roads (27 percent for each roadway classification category) followed by 24 percent that occurred on State routes.
  - A plurality of rural crashes occurred on interstates (33 percent) followed by State roads (26 percent).

- Information on roadway characteristics in the crash reports, including geometric features and annual average daily traffic (AADT), were available for very few crashes, and therefore could not be used to summarize the struck-by crashes.

- Over 40 percent of the crashes had missing information on contributing circumstances, and over 30 percent of the crashes had unknown contributing circumstances. For those that had information on contributing factors, a range of potential factors were identified from either the crash reports or via review of articles:

  - 18 percent of the contributing factors were associated with driver-related factors, such as improper driving actions (e.g., speeding, improper lane change, following too closely), driving under the influence of drugs and/or alcohol, or driver inexperience or familiarity with the area.
  - Just under 10 percent of the contributing factors were associated with roadway obstructions due to work zones, other crashes, and other obstructions.
  - 4 percent of the contributing factors were associated with environmental factors, such as snow and ice conditions and reduced visibility resulting from inclement weather.

Due to the large number of missing variables in the data, the cluster analysis was largely inconclusive, as the clustering generally took place around the unknown values.

NEXT STEPS AND FUTURE RESEARCH

A virtual stakeholder workshop brought together 47 stakeholders representing local and State transportation and law enforcement agencies; local and national fire agencies and organizations; local and national emergency medical services (EMS) agencies and organizations; national law enforcement organizations; local, State, and national towing agencies and organizations; and various Federal agencies. Breakout groups organized during the workshop focused on multiple datasets assessed by the team and provided the opportunity to learn about additional data sources that may be of interest for identifying responder struck-by crashes. Each breakout group discussed the challenges associated with the data sources and identified potential action items and next steps for improving the ability to identify responder struck-by crashes within the data sources. Discussions in a subsequent webinar with a smaller group of the stakeholders drilled down into the next steps and set some actions in motion for making positive change with respect to improving the data for future use.

As a result of the research and stakeholder input, recommendations for next steps and future research include the following:

- Finalize and adopt a national definition for a responder struck-by crash
- Improve and leverage the traffic crash report forms to improve information on responder struck-by crashes
- Explore potential changes to the MMUCC P4 "Person Type" data element and the associated P4.2 "Incident Responder?" data attribute
- Develop local and national training for law enforcement officers to improve the collection of data on responder struck-by crashes
- Collaborate with specific data owners identified in this research to review, modify, and better leverage these data sources for responder struck-by crashes
- Engage and work with the towing industry to collect data on responder struck-by crashes

CHAPTER 1. INTRODUCTION

BACKGROUND

Each day, emergency responders and road workers face hazards while working in or around moving traffic, and throughout each year, there are media accounts of responders and workers struck by vehicles. Industry groups have recognized the importance of using struck-by data to raise awareness of the dangers of working on the roadway; however, for the most part, struck-by crashes are reported in an ad hoc fashion—there are no standards or consistency in reporting within or across disciplines. Where requirements do exist, there are difficulties in obtaining compliance with reporting.

While there is no standardized method, State repository, or national repository for collecting and tracking these incidents, or the associated injuries and deaths, some national sources on worker deaths and injuries do exist. These sources include, but are not limited to, responder organizations (e.g., National Law Enforcement Officers Memorial Fund (NLEOMF), National Fallen Firefighters Foundation, International Towing and Recovery Hall of Fame and Museum, ERSI, NIOSH, the Occupational Safety and Health Administration (OSHA), and the U.S. Bureau of Labor Statistics (BLS)). These and other sources provide insight into the scope of the problem:

- According to the NLEOMF, 134 police officers were killed in struck-by crashes between 2005 and 2014, or about 13 per year (NLEOMF 2023).
- The National Fire Protection Association (NFPA) completed a study of fire personnel who were struck and killed by vehicles in 2014. They found that in the most recent 10 years, a total of 28 personnel were struck and killed by nonfire vehicles, or about 3 each year (Fahy 2014).
- The towing profession loses "about 40 to 50" operators per year, and an estimated three-quarters of these deaths involve struck-by crashes (Rodgers and Millman 2011).
- The number of transportation workers killed on the job is even more difficult to pin down, because, in addition to government employees, there are many private industry contractors involved in struck-by crashes. In work zone settings, more than 100 workers lose their lives annually, with nearly one-quarter of those being struck or run over by nonconstruction vehicles (FHWA n.d.a.).
- There is no published number of deaths involving safety service patrol (SSP) program operators. A safety analysis of service patrols programs through 2016 found that at least 20 SSP operators had been killed in the line of duty since inception of these programs (Carrick et al. 2018).

While these sources do provide some insights, they are generally not well-suited for identifying struck-by crashes with the accuracy and completeness required for a comprehensive analysis**,** leaving national statistics to document and track struck-by incidents elusive. Where demand for the study of responder struck-by crashes is high, national data are in short supply. *A Framework for Collecting Emergency Responder/Roadside Worker Struck-by/Near-Miss Data*, developed under National Cooperative Highway Research Program (NCHRP) 20-07(321) in March 2013, identified the following needs: standard definitions and procedures for collecting information on responder struck-by crashes, a central repository for the associated data, and an institutional effort to change the culture of reporting (Rensel et al. 2013).

At the State level, laws require that collisions involving death or injury be reported to police (AAA 2017). The challenge is that the States' reporting systems are quite different, particularly in terms of data elements that describe nonmotorists or pedestrians. While decidely different, the crash reporting systems used thoughout the States do have some data consistency.

RESEARCH OBJECTIVE

There is a need to collect struck-by crash data and aggregate that data nationally to better understand where, when, and why these crashes occur and to help with the development and/or improvement of training, policies, procedures, technology, and equipment among responder disciplines to mitigate the occurrence of these crashes. This need is consistent with NHTSA's efforts to evaluate driver behavior; move over law efficacy; and technologies that protect law enforcement, first responders, roadside crews, and others while on the job. FHWA applied NHTSA funding towards examining these issues and needs from a roadway safety and operations perspective.

The objective of this research was to develop a proof of concept for reliably identifying struck-by injuries and fatalities by compiling, assessing, and analyzing available data sources, assessing gaps in the data, and conducting a stakeholder workshop to provide critical feedback into the approach and associated findings.

APPROACH

The project team laid out an approach to meet the objectives of the research. This approach involved the following tasks:

- Develop a common definition for a responder struck-by crash
- Compile and assess sources of responder struck-by crashes
- Identify gaps and limitations in the data
- Assemble a composite database of responder struck-by crashes
- Analyze the data in the composite database
- Conduct a stakeholder workshop

The remainder of this report elucidates these tasks and the associated outcomes.

RESPONDER STRUCK-BY DEFINITION

An important first step in understanding responder struck-by crashes is to have a clear definition of what a responder-struck by entails. The project team worked with a multidisciplinary group of stakeholders made up of responders, data analysts, and crash experts to discuss and characterize responder struck-by crashes for the purposes of this project. After several conversations and iterations of the definition based on the stakeholder group's feedback, the project team recommended the following definition:

A "responder struck-by" incident is a collision between a motor vehicle in transit and a responder working a roadway incident, which would be recorded on a State traffic crash reporting form in the jurisdiction where it occurred. The responder may be a nonmotorist, an occupant of a stopped response vehicle, or an unoccupied response vehicle.

Further guidance on the definition includes:

- A nonmotorist is every crash-involved person who was NOT the driver or occupant of a motor vehicle (National Highway Traffic Safety Administration (NHTSA) 2012). The types of nonmotorists include bicyclists, other cyclists, pedestrians, other pedestrians (wheelchair, person in a building, skater, personal conveyance, etc.), occupants of nonmotor vehicle transportation devices, or other unknown types of nonmotorists (NHTSA n.d.a).

- Responders are governmental and nongovernmental emergency public safety, fire, law enforcement, emergency response, emergency medical and related personnel, agencies, and authorities (Homeland Security Act 2002), including public works and other skilled support personnel, like towing (Bush 2003).

Responders include individuals who are "off-duty," but who are in the process of performing similar duties in their jurisdiction when responding to an exigent circumstance; their personal vehicles, however, would not be included as vehicles struck.

ORGANIZATION OF REPORT

The remainder of this report is organized as follows:

- Chapter 2. Potential Sources of Responder Struck-By Crashes—This chapter describes the review and assessment of over 20 different sources of data for responder struck-by crashes. The chapter also explores data elements and attributes of the data sources. The chapter also summarizes gaps and limitations of each data source for providing information on responder struck-by crashes.

- Chapter 3. Composite Responder Struck-By Database—This chapter details the composite responder stuck-by database resulting from the data source review. The chapter breaks down the number of responder struck-by crashes that came from various sources, along with the percentage of those reviewed that were found to be struck-bys. Additionally, this chapter provides a data collection template to repeat or expand the effort of gathering and compiling responder struck-by crashes from different sources.

- Chapter 4. Findings From Analysis of Responder Struck-By Crashes—This chapter provides the findings from an analysis of the responder struck-by crashes in the composite database. Analyses include summary statistics breaking the crashes down by various crash and responder variables, chi-square tests, a cluster analysis, and a vehicle-only struck-by case study from crashes in Florida.

- Chapter 5. Stakeholder Engagement and Input—This chapter describes a virtual workshop with nearly 50 stakeholders representing local and State transportation and law enforcement agencies; local and national fire agencies and organizations; local and national EMS agencies and organizations; national law enforcement organizations; local, State, and national towing agencies and organizations; and various Federal agencies. Outcomes of the workshop are summarized.

- Chapter 6. Summary and Recommended Next Steps—This chapter summarizes the research effort and details potential next steps for closing gaps and overcoming limitations of existing data sources to improve the collection and analysis of responder struck-by crashes in the future.

CHAPTER 2. POTENTIAL SOURCES OF RESPONDER STRUCK-BY CRASHES

REVIEW OF EXTANT DATA SOURCES

A 2020 Government Accountability Office (GAO) review of emergency responder roadside safety included an evaluation of databases related to emergency responder fatalities and injuries and a brief overview of several sources (GAO 2020). While there are many potential sources of information on responder struck-by crashes, few of these sources are complete in terms of the numbers of struck-by crashes, their locations, and their severities.

As such, the project team sought to gather, explore, and assess national and State data sources that could provide information on responder struck-by crashes. This project went beyond the assessment in the GAO report to include more data sources, as well as new data resulting from reporting changes (e.g., 5th Edition of the MMUCC). The review included data sources maintained by State and Federal agencies (official reporting systems), various industry organizations, and private and non-profit organizations, as follows:

- Official reporting systems:
    - State traffic crash reports
    - Fatality Analysis Reporting System (FARS)
    - Crash Report Sampling System (CRSS)
    - NEMSIS
    - NFIRS
    - Firefighter Fatalities in the United States
    - OSHA
    - BLS
    - Worker compensation programs/systems
    - NIOSH
    - FBI Law Enforcement Officers Killed and Assaulted (LEOKA)

- Private and nonprofit industry reporting systems:
    - NFPA
    - Towing and Recovery Association of America, Inc. (TRAA)
    - TTIRS
    - ERSI
    - NLEOMF
    - Office Down Memorial Page (ODMP)

To gather information on these reporting systems, the project team conducted interviews with representatives from the organizations responsible for the data. After the project team made contacts and arranged interviews (the project team was not able to arrange an interview in all cases), the project team focused on gathering information to answer the following questions with respect to each of the data sources:

- Are data on responder struck-by incidents collected in any fashion?
- If so, for what years are the data available? What is the geographic coverage of the data?
- Are the data accessible? If so, in what format (e.g., online, formal request)?

- How are the data collected (e.g., who collects the data, how often is it collected, who maintains the data)?
- Does the database include all crashes for the coverage area (i.e., the population) or just a portion of the crashes (i.e., a sample)?
- How are crash severity levels defined?
- Are coordinates/location references to directly or indirectly geo-locate crashes available?
- What are the gaps/limitations in the data with respect to identifying, describing, or locating responder struck-by crashes?

In cases where interviews were not able to be arranged, the project team conducted research (e.g., online searches) into the dataset to answer these questions. The following sections present the findings from the research into these data sources in support of identifying responder struck-by crashes.

Official Reporting Systems

State Traffic Crash Reports

Law enforcement agencies typically collect and maintain State crash records. A public agency like a department of transportation, State law enforcement, or motor vehicle agency, administers statewide repositories. Data are often archived for many years, though access can be restricted, particularly that which contains personally identifiable information (PII) (e.g., crash report narratives). State crash data contain coordinates, a crucial piece of information for mapping, examining, and analyzing crashes. Injury severity classification often varies by State. The Federal Highway Administration's (FHWA) Safety Performance Management Measures Final Rule (23 CFR 490) and the NHTSA's Uniform Procedures for State Highway Safety Grants Program Interim Final Rule (23 CFR 1300) establish a single, national definition for States to report serious injuries per the MMUCC 4th Edition "Suspected Serious Injury (A)" attribute found in the "Injury Status" element. The requirement under 23 CFR 490.207 went into effect on April 15, 2019 (FHWA n.d.b.). States are strongly encouraged to adopt the full "Injury Status" data element for clarity (K for fatal injury, B for suspected minor injury, C for possible injury, and O for no apparent injury); however, they may report the injury severity using other categories.

State traffic crash reporting systems hold promise for capturing responder deaths and injuries from struck-by vehicle crashes. In every jurisdiction, it is required that a motor vehicle collision resulting in injury or death be reported. The reporting of property damage only (PDO) crashes varies depending on the cost of the damages sustained. Different States have different cost thresholds for reporting PDO crashes, typically ranging anywhere between $500 to $3,000 (AAA 2017), whereas if the cost of the damages is above the threshold value, it is required that the crash be reported. Due to these requirements, State crash databases include a significant percentage of the entire population of crashes in the coverage area. Consequently, crash reporting could become a good systematic collection mechanism for struck-by crashes, particularly those involving injuries or fatalities. In addition, when combined with scores of data elements describing crash events, the State crash report could be a tool for understanding the responder struck-by crash.

The main challenge, however, is that most States do not have a data element on the crash report to specifically identify a crash involving a responder or a responder vehicle. For those States that do include a potential data element/attribute on their crash report, there is a range of ways that they do so, including those that align with the MMUCC guidance and other similar data elements that do not.

The first attempt at including a data element/attribute in the MMUCC to identify a responder struck-by crash may have been in the 3rd Edition (NHTSA 2008). Introduced in 2008, this version included an attribute called "Working in trafficway (incident response)," which was classified under the P22 "Non-motorist actions/circumstances at time of crash" data element.

The 5th Edition of the MMUCC (NHTSA 2017), which was introduced in 2017, includes the P4. "Person type" data element and Subfield 2 "Incident responder?" data attribute. Additional data attributes include the type of incident responder involved in the crash (e.g., EMS, fire, police, tow operator, transportation, and others). This data element/attribute was added to more easily and accurately identify responders involved in crashes, as well as to identify the discipline of the responders involved.

Several States include nonmotorist data elements/attributes that are similar to the MMUCC 5th Edition responder struck-by data attribute but are not MMUCC aligned. Examples include Arizona, Missouri, Ohio, and Tennessee, which have similar explicit data elements that identify responder involvement and some type of categorization of the responder's discipline. The data elements/attributes used by each of these States in their crash reporting are summarized in table 1.

Table 1. State-specific (Non-Model Minimum Uniform Crash Criteria) data elements/attributes that can be used to identify potential responder struck-by crashes.

State	Target Data Elements/Attributes
Arizona	**"Is this a Secondary Collision?"** "If yes, were any of the following first responders hit?" (law enforcement, fire, EMS, tow operator, department of transportation (DOT) worker, other)
Missouri	**"Pedestrian"** (law enforcement, other emergency services personnel, Missouri DOT worker, other trafficway worker)
Ohio	**"Non-motorist Location at Impact"** 12 First responder at incident scene
Tennessee	**"Pedestrian Action Code"** 10 Emergency services personnel 11 Law enforcement officer 13 Other working in roadway

The involvement of responder vehicles in a crash is another aspect of struck-by reporting (according to the definition). A responder may be sitting in the vehicle when struck, or the vehicle may be unoccupied. Some States capture police, fire, and ambulance vehicle involvement, some States have vehicle attributes that identify the most common responder vehicle types (police, fire, ambulance, and tow truck), and a few States also capture the involvement of service patrol or incident response vehicles. However, identifying response vehicles stopped at incident scenes is challenging, let alone identifying those that are struck. A combination of crash report elements associated with the vehicles and events can narrow the dataset, but ultimately hand searching narratives and diagrams is necessary to define responder vehicle involvement.

Another approach to discovering responders in crash reporting systems involves finding crashes involving violations of the “move over” law. Most States capture violations that are cited in conjunction with collisions, which can point to potential responder struck-by crashes. As there is a “move over” law in all 50 States plus the District of Columbia and Puerto Rico, a potential approach to finding responder struck-by crashes involves associating crashes involving nonmotorists and move-over violations.

The project team gathered crash data from five States: Arizona, Florida, Illinois, Ohio, and Tennessee. Each of these States uses a different data element that the project team queried to identify potential responder struck-by crashes (table 2). There were two main challenges to finding responder struck-by crashes in these data. The first challenge was the misclassification of crashes or misuse/misunderstanding of these data elements. In other words, a review of the crash report narratives showed that most of the crashes flagged with the identified data elements/attributes, in fact, were not responder struck-by crashes (e.g., crashes included other types of nonmotorists, crashes included other types of crashes not involving nonmotorists, crashes involved responders but were not struck-bys). Due to the misuse of these data elements, it is imperative that crash narratives be reviewed before determining if crashes flagged with these data elements are actually responder struck-by crashes.

Table 2. Percentage of crashes determined to by struck-bys based on use of different crash report data elements.

State	Data Element Queried To Identify Potential Struck-By Crashes	Percentage of Crashes Determined To Be Struck-Bys
Arizona	**"Is this a Secondary Collision?"** "If yes, were any of the following first responders hit?" (law enforcement, fire, EMS, tow operator, DOT worker, other)	6.4%
Florida	**Model Minimum Uniform Crash Criteria (MMUCC) NM2. Non-Motorists Action/Circumstance Prior to Crash** Subfield 1 Action/Circumstance 08 Working in trafficway (incident response)	23%
Florida	**MMUCC P15. Violation Codes** "Move-Over Law" (511)	6.1%
Illinois	**MMUCC P4. Person Type** Subfield 2 Incident Responder? 02 EMS 03 Fire 04 Police 05 Tow operator 06 Transportation	1.5%
Ohio	**"Non-motorist Location at Impact"** 12 First responder at incident scene	38.5%
Tennessee	**"Pedestrian Action Code"** 10 Emergency services personnel 11 Law enforcement officer 13 Other working in roadway	44.2%

The second challenge involves the review of the crash report narratives. Crash report narratives often contain PII (e.g., names of responders, crash victims); therefore, most States are reluctant, if not prohibited, to share them. In addition, while most agencies have moved to electronic filing of crash reports, crash narratives and diagrams in some States continue to be stored as images, which limit their electronic searchability. When narratives are stored as text, a variety of tools can be used to search the text for key words, terms, and phrases to help identify potential responder stuck-by crashes. Finally, manual review of crash report narratives, while effective in identifying responder struck-by crashes, is resource intensive.

Fatality Analysis Reporting System (FARS)

NHTSA administers FARS (NHTSA n.d.b), a publicly available national resource for crashes involving motor vehicles on trafficways open to the public where an individual died within 30 days of the crash. FARS relies on State submissions of fatal traffic crash records. Once submitted, FARS staff enriches the crash reports with related data like driver license, motor vehicle, vital statistics, and other records. From these documents, the FARS analysts code more than 140 FARS data elements. As such, it is a highly reliable resource for monitoring traffic fatalities. The data are accessible online back to 1975 and are available in CSV and Statistical Analysis System (SAS) format.

As FARS relies heavily on State traffic crash reports, there are the same opportunities and challenges with using FARS to identify responder struck-by crashes as there are with the associated State traffic crash reporting systems. Presently, nonmotorist responders are likely only to be found in FARS data using MMUCC NM2. Nonmotorist action/circumstance prior to crash and the associated attribute "Working in trafficway (incident response)." However, as previously noted, crashes reported with this attribute include different types of workers, as well as civilians, and therefore require a review of the crash narratives to confirm the circumstances. As the report diagrams and narratives are not part of the FARS data, the ability to identify responder involvement in FARS data is limited. Additionally, the project team inquired about getting access to the crash narratives for potential struck-by crashes found in FARS, but FARS staff were not able to provide the narratives directly.

Crash Report Sampling System (CRSS)

As a part of NHTSA's data collection program, the CRSS (NHTSA n.d.c) is a sample dataset of police-reported crashes involving all types of motor vehicles, pedestrians, and cyclists. The crashes in the CRSS include all crash severity levels ranging from PDO crashes to those that result in a fatality. CRSS provides injury severity on the KABCO scale and includes crash location coordinates. CRSS is used to estimate the overall crash trends; identify highway safety needs and priorities; drive consumer information initiatives; and form the basis for benefit–cost analyses of highway safety policies, programs, and regulations.

CRSS system crash data are available on the NHTSA website for years 2016–2020. In 2016, the CRSS system replaced the National Automotive Sampling System General Estimates System (NASS GES) system, which began operating in 1988 and was discontinued in 2016. The NASS GES contained data from a nationally representative sample of police-reported crashes of all severities, including those that resulted in death, injury, or property damage. While the data sampling procedures for CRSS and NASS GES are similar, the number of data elements between the two systems is different, and the CRSS estimates for 2016 and later are not comparable with the NASS GES estimates from 2015 and earlier (NHTSA 2021).

The data in CRSS are a nationally representative probability sample selected from the estimated 5 to 6 million police-reported crashes that occur annually. Samples are taken for 60 selected areas across the United States, and the sampling procedure is designed so that these areas are reflective of the geography, population, miles driven, and crashes in the United States. Each year, CRSS sampling staff review crash reports from hundreds of law enforcement agencies within the sampling sites and randomly select tens of thousands of crash reports. Subsequently, the staff obtain copies of the reports and send them to a central location for coding. Unlike FARS, CRSS relies solely on the crash reports. Using information from the sample of crash reports, CRSS staff code approximately 120 data elements into a common format. Subsequently, CRSS staff perform quality checks on the data, both electronically and manually, focused on data validity and consistency. Upon completion, the CRSS data files, in CSV and SAS formats, and the coding documentation, in PDF format, become publicly available.

CRSS data, like FARS data, include data elements that could be used to identify crashes where responders or their vehicles may have been involved in a crash. As in the case of FARS data, the main challenge remains getting access to crash diagrams and narratives needed to verify if the crashes identified through the data elements are indeed responder struck-by crashes.

National EMS Information System (NEMSIS)

The NEMSIS (n.d.), incepted in 2001 by NHTSA, is a universal standard for how EMS agencies from States and territories collect patient care information resulting from emergency 911 calls for assistance. NEMSIS provides the framework for collecting, storing, and sharing standardized EMS data from States nationwide. In 2006, the first public release of NEMSIS data was made available for research and included 300,000 EMS activations from three States (NEMSIS n.d.).

NEMSIS data are generated by local EMS providers and then aggregated at the State level. A national NEMSIS dataset is compiled from State submissions. Electronic collection is accomplished with software from multiple national vendors.

There are several data elements that might contribute to identifying responder struck-by crashes, including:

- eDispatch:
  - 01 – Dispatch Reason – Traffic/Transportation Incident
- eSituation:
  - 14 – Work-Related Illness/Injury
  - 15 – Patient's Occupational Industry
  - 16 – Patient's Occupation
- eResponse:
  - 10 – Type of Scene Delay – Vehicle crash involving this unit
- eOther:
  - 05 – Suspected EMS work-related exposure, injury, or death
  - 06 – The type of work-related injury, death, or expected exposure

However, getting accesses to the data is challenging, if not impossible. The project team spoke with representatives at both the national level (NHTSA and the University of Utah) and the State level (Florida Department of Health) and found that sharing of the NEMSIS data is limited. NHTSA and the University of Utah could share the data in the nationally aggregated NEMSIS database, but it does not contain most of the data elements of interest and cannot be shared at a level that is disaggregate enough (without State approval) to determine crash location. Individual States have more disaggregate data; however, accessing these data would likely involve going through an Institutional Review Board (IRB) process for approval. Furthermore, while these data elements could begin to point in the direction of crashes that may have involved a responder or responder vehicle, it would be necessary to review the narratives associated with the crashes to verify them as struck-bys. The Florida Department of Health indicated that, even with IRB approval to share the data, they would not be able to share the associated narratives.

National Fire Incident Reporting System (NFIRS)

The NFIRS is the standard that fire departments use to uniformly report on the full range of their activities from fires to EMS to severe weather and crashes. The United States Fire Administration's (USFA's) National Fire Data Center (NFDC) houses NFIRS, which operates within the U.S. Department of Homeland Security (DHS). USFA focuses on training, prevention, and data and administers grant programs for the fire service and related topics. The USFA has been involved in emergency vehicle safety through its Emergency Vehicle Safety Initiative (USFA n.d.b.).

NFIRS contains data related to struck-by crashes. The NFIRS reference guide provides step-by-step instructions for submitting fire incident information to NFIRS V5.0 (USFA 2015). This version includes a basic module that captures general information on incidents or emergency calls to which a fire department responds, plus 11 other specific modules. The system also includes a supplemental module for fire departments to report information on additional persons involved in an incident. After an incident response, fire department personnel complete one or more of the modules in the system, either manually or electronically. Local agencies forward the completed modules to the State agency responsible for NFIRS data. The State agency combines the information with data from other fire departments into a statewide database and then transmits the data to the NFDC.

The NFIRS reference guide emphasizes that NFIRS is a voluntary system; therefore, not all States or fire departments participate. The guide also notes that States have the flexibility to adapt their reporting systems to their specific needs; thus, data collection system design varies between States. However, the system converts data from various State systems to a single format that is used at the national level to aggregate and store NFIRS data.

Users can access the data on USFA's website or request a compact disc (CD) for any year. The data cover the United States, tribal, and territory departments that choose to submit data. The NFIRS database schema and data elements are generally updated every year. It is possible to submit new data elements or to request changes to existing data elements to enhance the value of the data. While updates and added elements are possible, users of the data should be aware that the reporting is voluntary, and the purpose is fire-centric data reporting. Not all departments complete all data elements, and there are no requirements on completeness of the reports. The process captures about 60 percent of firefighter fatalities.

To further examine the data and their potential, the project team obtained the data from the NFIRS website from 2010 through 2021 for incidents classified as "struck-by," which in the NFIRS data include firefighters struck-by anything, even another person (i.e., assault). The result was 86 "struck-by" crashes. The project team then reviewed the short summary/narrative of each of these incidents and determined whether they were responder struck-by crashes according to the definition. The findings included 28 (30.2 percent of the NFIRS incidents classified as "struck-bys") firefighter struck-by crashes.

Firefighter Fatalities in the United States

USFA also collects and tracks information regarding on-duty firefighter fatalities that occur in the United States. USFA conducts an annual analysis to identify specific problems so that direct efforts can be made toward finding solutions that will reduce future firefighter fatalities. USFA provides these data in CSV format for download from its website (USFA n.d.a.).

The project team downloaded the Firefighter Fatalities in the United States data, and there were 2,457 firefighter fatalities that occurred between February 1978 and December 2020 in the dataset. Information available about each of the fatal incidents includes name, rank, incident date, cause of death, nature of death, activity at the time of the incident, duty (e.g., on-scene, responding, training), and a brief description of the incident. One of the categories for cause of death is "struck-by," and 250 of the 2,457 incidents (10 percent) were classified as such by USFA.

The project team reviewed the descriptions for these 250 incidents and determined that 63 of these incidents (25 percent) aligned with the definition of responder struck-by developed for the project. The descriptions are very detailed, making it relatively straightforward to determine if a fatality was a result of a struck-by crash. The challenge, however, is that there is no location information in the dataset to crosscheck these crashes with crashes from other data sources. As such, USFA would need to be contacted to determine if they have, and if they would be able to provide, this information so that these incidents could be cross-referenced with those from other data sources.

Terms within the descriptions that were useful in identifying firefighter struck-by crashes in the dataset included "on-duty," "reflective," "crash," and "traffic." Many of the identified firefighter struck-by crashes occurred while directing traffic. Inclement weather and lack of lighting/reflective gear were often at play.

Occupational Safety and Health Administration (OSHA)

With the Occupational Safety and Health Act of 1970, Congress created the OSHA to ensure safe and healthful working conditions for workers by setting and enforcing standards and by providing training, outreach, education, and assistance. OSHA is under the umbrella of the U.S. Department of Labor (DOL n.d.).

One of the datasets maintained by OSHA is the Weekly Fatalities and Catastrophes (FAT/CAT) Reports. FAT/CAT Reports include worker-related fatalities that occur under Federal OSHA and State plan jurisdictions. OSHA requires these cases to be reported within 8 hours of occurrence, and the agency has up to 6 months to complete an investigation and determine whether to issue a citation. The reports included in the dataset span from 2017 to 2021.

The project team performed a query of the fire and law enforcement disciplines and identified at least two reports that constituted a fatal responder struck-by crash. The challenges and limitations of using these data as a source for responder struck-by crashes include:

- The data available online include only fatal injuries and only span from 2017 to 2021.
- Some of the reports include only the term "worker" without clarifying the worker's discipline, thus making it difficult to identify all the responder-related fatalities.
- As with other fatal injury datasets, it is highly likely that these fatal crashes would be identified through other data sources. However, because these reports do not include very many details on location, date, and time, it is challenging to deduplicate these fatal responder crashes with those collected from other data sources.

U.S. Bureau of Labor Statistics (BLS)

The BLS provides statistical guidance to the DOL and its agencies and works in partnership with those agencies to support their data needs. BLS manages the Injuries, Illnesses, and Fatalities

(IIF) program, which collects and reports information about workplace injuries and illnesses. The collection of such data is facilitated through the Survey of Occupational Injuries and Illnesses (SOII), which collects information on Nonfatal Occupational Injuries and Illnesses (NOII) and through the Census of Fatal Occupational Injuries (CFOI).

Survey of Occupational Injuries and Illnesses (SOII)

Each year, BLS administers the SOII, which collects information on NOII through the sampling of approximately 200,000 employers in the private industry and the public sector (State and local government). The sampled cases include work-related injuries or illnesses to workers who required medical care beyond first aid. The NOII data are released to the public through the SOII News Release, SOII charts and tables, and through the IIF public database, generally in early November (BLS 2021). In addition to the dataset only providing a sample of the annual injuries that occur throughout the nation, the main challenge in using these data is accessibility. Additionally, the occupation codes used to collect the data may not align with the responder disciplines typically used in the transportation/traffic incident management (TIM) industry.

Census of Fatal Occupational Injuries

The BLS also administers the CFOI annually to collect information on fatal work injuries occurring in the 50 States and the District of Columbia. To be included in the dataset, deceased workers must have been employed for pay, profit, or compensation and engaged in legal work activity or present at the site of the incident as a requirement of their job (U.S. Department of HHS n.d.). CFOI data include all fatalities that occurred in the reference year that were the result of a workplace injury, regardless of when the injury occurred. The data are comprehensive, and to achieve completeness and accuracy, the census uses multiple data sources to gather and verify data on worker fatal injuries.

Since the BLS started collecting data on fatal occupational injuries in 1992 (BLS 2020), the classification systems and definitions of many data elements have changed, and new data elements have been added to increase the depth of the information collected. CFOI collects information on State, location, industry, occupation, ownership, worker status, worker activity, worker age, gender, race, and lastly, occupational injury and illness classification variables such as event or exposure, primary source, secondary source, nature, or part of body.

Although CFOI is considered to be a nationally representative dataset and includes data on all first responders, a major limitation in using these data is the lack of accessibility. As indicated on the BLS webpage, the data can be queried/accessed via:

- Online queries—as in the case of NOII data, summary tables for CFOI data can also be queried online
- Contacting a BLS staff member via email or phone to obtain more complex data queries, which would also result in summary tabulations of the data but not in the data behind the queries

Additionally, there is a lack of alignment between the responder disciplines typically used in the transportation/TIM industry versus the responder discipline codes represented in the web query for CFOI data.

Workers' Compensation Data

Workers' compensation programs were established in 1911 by State statutes to provide funding for medical care, rehabilitation, and benefits to workers who are injured on the job or who experience work-related injuries and illnesses (Murphy et al. 2020). There is no central source for workers' compensation data; however, each State collects some claims information for its private industry, State, and local government employers. The Federal government maintains separate workers' compensation databases for Federal employers. Organizations, such as the National Council on Compensation Insurance (NCCI) and the Workers Compensation Research Institute, also collect claims information in many States (CDC 2020).

Many, but not all, States use standardized data coding systems for workers' compensation claims information. These systems differ in purpose, scope, and data elements. Each State's workers' compensation laws, reporting requirements, and timeframes are also different. The type of workers' compensation data that come from claims information include details such as the nature of illness/injury; how the injury occurred; type and cost of medical care received; cost of wage replacement; number of days off work; and worker characteristics, such as occupation, age, gender, length of employment, etc. (CDC 2020).

The challenge with using data from workers' compensation systems is getting access to the data. In some States, redacted workers' compensation claim data reside on public-facing websites, while others allow public records requests. In many States, data related to law enforcement, fire, and EMS workers are exempt from disclosure. Such is the case in Florida where certain classification codes are removed from datasets in deference to State laws protecting workers in sensitive industries like law enforcement. The NIOSH has established an agreement with the State of Ohio and funds the Cooperative Agreements for Workers' Compensation Surveillance with five other States, including California, Massachusetts, Ohio, Tennessee, and Michigan. The purpose for the agreements is to explore and analyze workers' claim data to promote the prevention of workplace injuries and illnesses (Murphy et al. 2020).

National Institute for Occupational Safety and Health (NIOSH)

NIOSH is the Federal agency responsible for conducting research and making recommendations for the prevention of work-related injury and illness. It is part of the Center for Disease Control and Prevention within the United States Department of Health and Human Services. NIOSH was established to help advance safe and healthful working conditions by providing research, information, education, and training in the field of occupational safety and health.

NIOSH Fatality Assessment and Control Evaluation (FACE) Reports

Through the FACE Program, NIOSH conducts investigations of fatal occupational injuries, including the identification of factors that contribute to these fatal injuries. This program has been in place for nearly 40 years and has worked to prevent occupational fatalities across the nation by identifying and investigating work situations at high risk for injury and then formulating and disseminating prevention strategies to protect workers. Each day, on average, 15 U.S. workers die as a result of a traumatic injury on the job. Investigations conducted through the FACE program allow the identification of factors that contribute to these fatal injuries. The primary intent of this program is to provide interested users with access to the full text of hundreds of fatality investigation reports. This information is also used to develop comprehensive recommendations for preventing similar deaths (CDC 2021a).

There are both NIOSH FACE reports and NIOSH State FACE reports. These reports are available online and are indexed by industry or cause of fatality (CDC n.d., CDC 2021b). Using the "cause" category of "motor vehicles-law enforcement officers," the project team identified five NIOSH FACE reports (out of 626) dating back to 2016. After review, three of the five were determined to be responder struck-by crashes. In addition, the project team identified 8 NIOSH State FACE reports (out of 2,130) on the website dating back to 1994. After review, two of the eight were determined to be responder struck-by crashes.

The challenges identified when exploring the NIOSH FACE reports and NIOSH State FACE reports included lack of comprehensive cause categories for all responder disciplines, as well as a lack of detailed information on location, date, and time of the crash.

Work-Related Injury Statistics Query System (Work-RISQS)

The Work-Related Injury Statistics Query System (Work-RISQS) provides interactive data access to NIOSH's surveillance of nonfatal occupational injuries treated in hospital emergency departments across the United States. NIOSH conducts this surveillance through the National Electronic Injury Surveillance System—Occupational Supplement (NEISS-Work), referred to as NEISS-Work. NEISS-Work data are collected through a probability based stratified cluster sample of hospital emergency departments in the United States. Users can query data through Work-RISQS based on worker demographic characteristics, nature of injury, and incident circumstances for emergency department treated injuries from 1998 through the present to obtain national estimates (CDC 2021c).

Work-RISQS provides users direct access to NEISS-Work data through a structured online query system with user selected query parameters (CDC 2021d). Users can obtain estimates of the number of emergency department treated injuries with confidence intervals. The data elements on which users can query to obtain an estimate on the nonfatal worker injuries include:

- Time period (treatment year and month)
- Demographic information (age, gender, race, and ethnicity)
- Nature of injury (diagnosis, part of the body injured, and disposition)
- Incident characteristics (includes the subcategories for events, primary sources, and secondary sources)

"Incident Characteristics – Events" include several subcategories, two of which may have potential for querying for responder struck-by crashes. These events include:

- "Transportation incidents" (2)
  - "Transportation incident, unspecified" (20)
  - "Pedestrian vehicular incident" (24)
  - "Transportation incident, n.e.c" (29) (U.S. Workers Comp 2023)

- "Contact with objects and equipment" (6)
  - "Struck by object or equipment" (62)
  - "Struck against object or equipment" (63)

"Incident Characteristics – Source" and "Incident Characteristics: Secondary Source" include one subcategory of potential interest in querying for responder struck-by crashes:

- "Vehicles" (8)
  - "Vehicle, unspecified" (80)
  - "Highway vehicles, motorized" (84)
  - "Other vehicles" (89)

There are several challenges and limitations in using NEISS-Work data to identify responder struck-by crashes:

- The query system does not offer any occupation categories from which users can narrow into injuries sustained by various responder disciplines.

- The data do not include any location elements (e.g., State, city, road) that could assist in linking these data to other data sources, such as crash reports.

- A significant challenge in using the data is accessibility. The user can query data through the system; however, the results are displayed in a summary table format that may be downloaded in spreadsheet, text, or portable document format. Data confidentiality requirements prohibit the public distribution of raw data files.

FBI Law Enforcement Officers Killed and Assaulted (LEOKA)

Each year, the Federal Bureau of Investigation (FBI) publishes a report titled *Law Enforcement Officers Killed and Assaulted* (LEOKA) to provide information about officers killed or assaulted while performing their duties. The Uniform Crime Reporting (UCR) Program's LEOKA system is the primary means by which these data are collected. The LEOKA program is an official point of collection for line of duty death (LODD) in law enforcement. State and local law enforcement agencies are familiar with UCR data, as they are used for all types of offense reporting.

When the FBI receives notification of an LODD, LEOKA program staff work with FBI field offices to contact the employing agency of the fallen officer and request additional details about the incident. LEOKA staff also obtain criminal history data from the FBI's Interstate Identification Index about individuals who are identified in connection with felonious LODDs (FBI n.d.a).

The LEOKA website provides several summary tables that describe the data, including the manner of death, location (city/State), officer demographics, and other information. For officers struck as pedestrians by motor vehicles, LEOKA provides data on fatal crashes only. According to the responder stuck-by definition, not all these actions constitute a struck-by (e.g., engaging in foot pursuit, overseeing a work zone, training), but most do represent struck-bys. The project team was unable to obtain the data behind these summary statistics. Table 3 summarizes the frequency of these crashes (as classified by LEOKA) during the years 2015 to 2019. According to the responder stuck-by definition, not all these actions constitute a struck-by (e.g., engaging in foot pursuit, overseeing a work zone, training), but most do represent struck-bys. The project team was unable to obtain the data behind these summary statistics.

Table 3. Law Enforcement Officers Killed and Assaulted: Circumstance: pedestrian officer struck by vehicle (Federal Bureau of Investigation (FBI) n.d.b).

Action	2015	2016	2017	2018	2019	Total
Assisting/investigating vehicle crash	4	2	2	2	1	**11**
Assisting motorist	1	1	1	2	2	**7**
Providing/deploying equipment	0	0	1	0	0	**1**
Engaging in foot pursuit	—	—	—	—	1	**1**
Overseeing work zone	0	0	0	0	1	**1**
Patrolling	0	0	0	0	0	**0**
Performing traffic control	1	3	0	0	2	**6**
Performing traffic stop	1	4	0	2	5	**12**
Training	0	0	0	0	0	**0**
Other	0	2	2	3	4	**11**
Total	7	12	6	9	16	**50**

Private and NonProfit Industry Reporting Systems

National Fire Protection Association (NFPA)

The NFPA is an association devoted to eliminating death, injury, and property and economic loss due to fire and related hazards. NFPA is primarily known for its work in codes and standards, public education, training, and research. NFPA publishes an annual report on firefighter fatalities and injuries in the United States. Additionally, NFPA's research group has conducted projects related to responder struck-by crashes, including:

- **U.S. Firefighters Killed When Struck by Vehicles: 2000–2013 (published 2014) (Fahy 2014)**—A review of this report showed that the struck-by definition used to classify the crashes does not completely align with the struck-by definition developed for this project. The NFPA's struck-by crashes include those where firefighters were struck accidentally while in parking lots, fire stations, and other locations that do not involve the roadway or traffic incidents. The report includes a short description of each of the fatal crashes, and a review revealed that there were 34 fatal crashes involving a firefighter responding to a traffic incident between 2000 to 2013. However, the descriptions of the events lack crucial information, such as location and date of the crash and at times, information regarding the circumstances surrounding the crash.

- **U.S. Firefighter Injuries in 2019 (Campbell and Evarts 2021)**—This report provides statistics of firefighter injuries identified from a sample survey of fire departments throughout the United States. This sample includes only fire departments that protect communities with a population larger than 5,000 and is stratified by the size of the community, which amounts to a sample size of 8,672 fire departments. Additionally, a randomly selected sample of fire departments (15,478) that protect communities with less than 5,000 residents was added for a total sample size of 24,150. For each injury statistic, a sample injury rate is computed for each stratum. The sample injury rate consists of the total for that statistic, from all the departments reporting it, divided by the total population protected by the departments reporting the statistic. The report estimates a total of 60,825 firefighter injuries occurred in 2019. It was estimated that 5 percent of the injuries (about 3,041 injuries) were the result of some type of responder "struck-by" incident (including circumstances that do not align with the responder struck-by definition related to traffic incidents). The report provides no details of these injuries other than by type of duty and cause.

The data sources for these NFPA reports are not centralized. NFPA gets data from fire departments and other general news sources and then conducts interviews and searches for other public news data to learn more about each incident. The collected data are entered into a private in-house database that is used to develop reports. The data date back to 1977 and include all 50 States and the District of Columbia. The website indicates that NFPA will pull data if requested; however, the project team was unable to receive any data.

Towing and Recovery Association of America, Inc. (TRAA)

The TRAA is the largest trade association representing the towing industry but does not include all towing companies. TRAA has worked with other organizations to support their members in traffic safety; however, it does not collect or aggregate any data on tow operator struck-by crashes. TRAA has partnered with OSHA to tease out data related to the towing industry, and this effort identified that as many as 66 percent of deaths and injuries in the towing industry are from struck-by crashes. However, the definition of "struck-by" used was quite broad, including incidents where a tow operator was struck by a vehicle being secured and objects other than motor vehicles, such as equipment.

Towing Traffic Incident Report System (TTIRS)

The Massachusetts Statewide Towing Association, Inc. (STA) advocates for the Massachusetts towing industry and collects towing traffic incidents through its TTIRS (STA 2023). TTIRS is an online, voluntary system for the towing industry to report struck-by and near-miss incidents involving tow operators. TTIRS defines struck-by events as "any incident where a tow operator or their work vehicle is hit by another vehicle or object within a traffic incident management area or work zone resulting in an injury, fatality, or property damage" (STA n.d.). The goal of TTIRS is to collect data and make them available to member associations to support move-over enforcement and to help develop training to make roadside work safer for the towing industry (STA 2023). STA has been collecting the TTIRS data since 2015 and encourages the reporting of past crashes.

The individual or organization reporting the incident must provide a contact name, email address, and phone number. The personal information remains confidential and is only used for verification to ensure the integrity of the data and to avoid duplicate records. Additionally, STA recommends that the persons/organizations reporting the incidents to TTIRS take their time and fill the form completely and accurately, providing optional information as well as photos, if available.

The reporting form includes the following:

a. Name of tow operator stuck (required)
b. Tow operator age, role in the incident, and towing experience (optional)

c. Whether the tow operator was Strategic Highway Research Program 2 (SHRP2)/TIM trained at the time of the incident (required) (Einstein and Luna 2018)
d. Incident date, time, and location, including city, State, and facility type (required)
e. Environmental and other contributing factors (optional)
f. Type of incident (struck-by, near miss, or other) (required)
g. Struck-by injuries and/or damage (optional):

    i. Injury requiring or not requiring medical attention for either tow operator, driver of the tow truck, passengers, or customers
    ii. Physical damage sustained by either the tow truck, customer's vehicle, or vehicle causing struck-by
    iii. Fatality of tow operator, tow truck passengers or customers, or driver of struck-by vehicle

h. Whether there is a police report for the incident (required)
i. Additional comments (optional)
j. Photo(s) of the incident (optional)

Through a conversation with STA, the project team learned the following:

- Towing companies are reluctant to report struck-by and near-miss incidents. STA relies primarily on media scraping (i.e., manually searching and recording media reports specific to responder injuries and fatalities) (about 75 percent of the data) and self-reporting (about 25 percent of the data). STA reaches out to towing companies regarding struck-by crashes involving their employees; however, in most cases, STA does not receive a response. It is the opinion of STA that there is a genuine distrust among towing companies that the information is going to fall into the hands of insurance companies, and negatively impact insurance premiums.

- Once the incident reports or online articles are acquired, duplicates are removed, relevant information is extracted from the articles or reports, and the information is supplemented with general weather information for the city in which the incident occurred.

- About half of the data come from Massachusetts, Wisconsin, California, Michigan, Indiana, Ohio, and Pennsylvania. The remainder of the data come from the remaining States.

- The TTIRS database is considered by the towing industry to have the best information available on struck-by crashes and has been promoted at numerous towing industry shows and in newsletters.

- Initially, the goal was to examine trends associated with time of day, whether tow operators were wearing reflective clothing, and what training the tow operators had taken.

- The data are kept in house and not shared with the public; however, the data are shared with researchers and are used for teaching purposes.

The project team was able to access and assess TTIRS data associated with 71 crashes. The primary steps and findings of this assessment include the following:

- Not all crashes in the dataset included information in the comments field, which made it challenging for the project team to verify if a crash involved a tow operator or vehicle struck. Additionally, the data did not include any links to news articles associated with the crashes. Therefore, the project team performed a search of each crash based on the information provided in the dataset (e.g., responder's name, date of incident, town/State where the incident occurred). As a result, the project team was able to find news articles for the 38 crashes that involved a tow operator fatality. Of these 38 crashes, 2 were not responder struck-by crashes per the definition.

- To verify if the remaining 33 nonfatal crashes were struck-bys, the project team used a combination of the information provided in the comments and in the injury severity field:

    - The project team reviewed the comments, where available, to determine if the crash was a struck-by and if any other relevant information could be extracted.
    - The data also included information associated with fatalities, injuries, and/or property damages to vehicle(s) involved in the crashes. The injury severity outcomes in the data included the following:

        - Fatality to tow operator
        - Personal injury to tow operator requiring medical attention
        - Personal injury to tow operator not requiring medical attention
        - Fatality to driver of vehicle causing struck-by
        - Fatality to passenger or customer
        - Personal injury to passengers or customers requiring medical attention
        - Personal injury to passengers or customers not requiring medical attention
        - Physical damage to tow truck
        - Physical damage to vehicle causing struck-by

    - Of the 33 crashes that did not involve a tow operator fatality, the project team identified 11 as responder struck-by crashes based on comments and/or injury severity fields.
- Where possible, the project team extracted additional relevant crash- and responder-related information for use in analysis (e.g., weather, lighting, contributing factors); however, the dataset lacked much of the relevant information of interest. Therefore, additional information was extracted from associated news articles (where available).

Emergency Responder Safety Institute (ERSI)

ERSI is a Committee of the Cumberland Valley Volunteer Firemen's Association focused on protecting emergency responders on roadways. ERSI hosts a website dedicated to the safety of traffic incident responders by engaging in and promoting a variety of activities/efforts, including the development of educational materials; TIM teams; the National Unified Goal (NUG); and national rules, regulations, and trends. The TIMNUG is (NTIMC n.d.):

- Responder safety
- Safe, quick clearance
- Prompt, reliable, interoperable communications

ERSI also maintains a database of responder struck-by crashes. Historically, the primary sources of information on struck-by crashes for this database included self-reported crashes and media scraping. These data are manually entered into ERSI's database and may contain information as to the date, city/county, State, responder discipline, and a link to any media accounts of the event. This approach for collecting data lends itself to duplicate events and scant details about the events and responders involved. ERSI's companion database for LODD includes information on responder duty status, name, organization, activity, and a link to the report providing additional information.

In early 2022, ERSI launched a new online tool—Report a Struck By Incident (CVVFA 2023a). This enhanced platform and capability will help to solicit and collect more structured and consistent information on struck-by crashes from voluntary reporters as compared to the historical approach of media scans. Information collected via the tool includes incident time and date, type, and location; roadway information; weather; responding agencies and response activities; type of vehicle that struck the responder/vehicle; responders struck, responder injuries, responder fatalities, and responder vehicle damage; TIM information; use of high-visibility apparel; and an open section for additional unstructured information about the incident.

As this new tool was not yet available at the time the research on data sources was conducted, the project team scraped all historical articles from ERSI's "Struck-by Incidents" pages, along with associated news articles linked from those pages. As a result, the project team obtained 6,852 records of incidents. Of these records, 4,119 (60 percent) had no retrievable external source (e.g., the link to original article was broken). For the remaining 2,733 ERSI records (40 percent), the project team retrieved associated articles. Subsequently, the project team parsed the articles and extracted the title, article text, published date, and named entities, including city or street names, latitude and longitude, dates, and times.

Initial reviews of the ERSI articles showed that while some articles described crashes that aligned with the responder struck-by definition, others described crashes that involved responders but not necessarily those on duty or even at traffic incident scenes. In addition, it was not always clear from the article if a crash aligned with the struck-by definition.

Below is an example of the content and level of detail of information available in an ERSI article. More information is available by reviewing associated news articles. Based on the following description, the crash does not align with the definition of a responder struck-by crash:

> **California: San Jose Fire Dept. Truck Struck Responding to an Emergency**
> Wednesday, July 11, 2001
>
> San Jose Police arrested a man on suspicion of driving under the influence early Sunday morning after he drove his car into a fire truck. Two firefighters were in the engine, which was just leaving the scene of a one-alarm fire (CVVFA 2023b).

On the other hand, the following is an example of an ERSI article that does describe a crash that aligns with the definition of a responder struck-by crash (CVVFA 2023c):

> **Memphis, TN Police Officer Hit by Car During Traffic Stop**
> Sunday, October 28, 2012

> A Memphis police officer is hurt after getting hit by a car during a traffic stop. It happened on I–240 just south of Airways on Saturday night.

Due to the sheer number of ERSI articles available, the project team commenced by pulling only those incidents from States from which the project team had corresponding crash data, which included a total of 297 ERSI articles from Arizona (2 articles), Colorado (149 articles), Florida (13 articles), Maine (2 articles), Ohio (43 articles), Tennessee (83 articles), Utah (3 articles), and Wyoming (2 articles).[1] This was done in hopes of being able to link struck-by crashes identified in ERSI to actual State crash reports. The project team imported these ERSI articles into a "labeling" tool developed specifically to review these articles. This tool facilitated the review and extraction of relevant information from the articles (e.g., questions to help determine if the crash was indeed a responder struck-by, relevant crash/responder information). The review resulted in the identification of 93 (31 percent) responder struck-by crashes.

Next, the project team attempted to match the ERSI articles to actual State crash reports to have the full set of data elements associated with the crash. The approach involved examining the dates and locations for the crashes in the two datasets. This process resulted in linking 65 (73 percent) of the responder struck-by crashes identified in ERSI to an actual crash report. It should be noted that, for States that did not include location coordinates in the crash data, the linking process was more challenging and time consuming.

Despite the manual effort needed to identify responder struck-by crashes in the ERSI data, the project team pulled 295 additional ERSI articles from 2017–2020 across the United States and added these to the labeling tool. Because none of these crashes could be associated with a crash report (due to not having access to crash data from additional States), the project team added more review questions to the labeling tool to extract additional information from the articles about the conditions surrounding the crashes (e.g., environmental conditions, driver conditions, weather conditions, road type). This process proved to be much more labor intensive than simply reading the article to determine whether the crash was a struck-by. As a result, of the 295 additional ERSI articles, 108 were reviewed, and of those, 74 (24 percent) across 28 States were confirmed as struck-by crashes.

In the end, the project team identified 167 responder struck-by crashes from ERSI. While the historical ERSI data offer the opportunity to identify many more struck-by crashes, it is a labor-intensive process. In the future, the new Report a Struck By Incident tool should help to provide more structured and consistent information in a format that is easier to work with; however, some quality control will be needed to verify that incidents reported are indeed responder struck-by crashes according to the definition.

National Law Enforcement Officers Memorial Fund (NLEOMF)

The NLEOMF is dedicated to telling the story of American law enforcement and making it safer for those who serve. It maintains the largest, most comprehensive database of law enforcement LODDs, conducts research into officer fatality trends and issues, and serves as an information clearinghouse on information and statistics on LODDs. The NLEOMF collects and reviews information about officer deaths from the agency where the officer served. Ultimately names are

[1] The discrepancy in numbers of articles for the States is due to the difference in the number of years of available crash data for the States; ERSI articles were queried only for the years for which a State's crash data were available.

forwarded to a committee that thoroughly reviews each case and votes to approve or deny inclusion of the name in the database. Names of fallen officers are searchable using the organization website.

The NLEOMF publishes a regular Law Enforcement Officers Fatalities Report (last published in 2021), which examines trends and issues in officer fatalities (NLEOMF 2022a). In addition, the website provides a summary table of causes of law enforcement deaths over the past decade, and "struck-by vehicle" is one of 22 causes of death included in the table. Table 4 shows a breakdown of the law enforcement causes of death due to being struck by a vehicle. The project team was not able to get access to the data behind these summary statistics.

NHTSA has provided funding to the NLEOMF to encourage better tracking of officer-involved traffic fatalities, including struck-by vehicle crashes. NHTSA has also collaborated with the NLEOMF to produce training materials aimed at law enforcement traffic-related safety issues (NLEOMF 2022b).

Table 4. National Law Enforcement Officers Memorial Fund Officer (NLEOMF) cause of death by year (NLEOMF 2021).

Cause	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Total
Struck-By Vehicle	10	14	12	10	11	16	10	15	19	14	131

Officer Down Memorial Page (ODMP)

The ODMP is a nonprofit organization dedicated to honoring America's fallen law enforcement officers. The ODMP collects data associated with all law enforcement LODDs. It was founded in 1996 and has since been the go-to data analysis source for law enforcement LODDs. The ODMP includes data associated with over 25,000 LODDs spanning 200+ years in the United States. ODMP has worked with Federal agencies to perform analysis using this database. One example is assessing move-over laws, where ODMP worked with the Federal Law Enforcement Training Center to analyze data and assess effectiveness. ODMP has also assessed the deployment of stop sticks and the occurrence of struck-by crashes involving officers trying to deploy tire deflation devices.

ODMP reports real-time statistics and has provided application programming interface (API) access in the past to enable real-time data feeds for various applications. The data contain location coordinates for modern-day records. It can be mapped on the ODMP website and mobile application.

The ODMP makes its data available on its website. Data include incident date, location (latitude/longitude, city, State), date and cause of death, and title of officer, along with a relatively detailed narrative. The project team searched the data from January 2016 to January 2021 under the "struck by vehicle" category, which resulted in 52 incidents. As with other sources of data, the narratives of these reports would need to be reviewed to verify if the crashes met the responder struck-by definition, and then these would need to be cross-checked with other data to remove duplicates.

DATA GAPS AND LIMITATIONS

This section summarizes limitations and gaps with respect to identifying, describing, and locating responder struck-by crashes from the data sources previously described. Limitations and gaps were identified from a review of each data source to form a more in-depth assessment of each data source, where possible. This more in-depth assessment involved getting access to the data; working with the data in their native format; looking for and assessing available data elements, attributes, and time and location information; reviewing unstructured summaries/narratives; and formatting the data in preparation for the composite database.

There are three primary limitations in identifying responder struck-by crashes from the data sources that were reviewed. The first major limitation is the **lack of a specific struck-by data element that is consistent and only pertains to responders** (i.e., does not include other nonresponder persons):

- The MMUCC nonmotorist data element and associated "Working in trafficway (incident response)" data attribute is not very effective in identifying responder struck-by crashes, as only about 20 percent of these crashes were determined to be struck-bys in a review of crash data from Florida:
  - While the MMUCC 5th Edition has brought forth an "Incident Responder" data attribute, to date, only a few States have adopted it on their crash report forms.
  - Upon reviewing 200 crashes from Illinois in 2020 that were flagged with the "Incident Responder" data attribute and that also involved a pedestrian, the research project team identified only three responder struck-by crashes per the responder struck-by definition. Three additional crashes involved responders struck but did not fit the responder struck-by definition. The majority of the crashes that were reviewed (194 out of 200 crashes) did not involve responders (or responder vehicles) struck at traffic incident scenes.
- A few States have included other explicit data elements for responder struck-by crashes; however, two of the three datasets assessed showed issues with miscoding by officers completing the crash forms:
  - Only about 50 percent of crashes in Tennessee coded as "Emergency services personnel" or "Law enforcement officer" under the "Pedestrian action code" data element were responder struck-bys.
  - In 2019, 220 crashes in Arizona were marked as secondary crashes that involved a responder being hit. Of these, however, 177 (80 percent) were marked as an "other" type of responder being hit. Further analysis of these 177 crashes proved that in fact they involved civilian motorists being hit rather than responders. Furthermore, 8 crashes were marked as involving a specific responder discipline but in fact did not involve a responder being hit, and 17 involved responders striking other responders or civilian vehicles at or near incident scenes. In the end, the project team verified that only 14 of the 220 crashes involved responders struck at incident scenes, either as a pedestrian or while inside a responder vehicle, and 4 were identified as were responder vehicle-only struck-by crashes.

The second major limitation of some of the data sources reviewed includes **the self-reporting nature of the data/systems** and **datasets that focus only on fatal crashes**. The self-reporting approach severely limits the number of struck-by crashes contained in the database, as self-reporting is voluntary and easy to dismiss and, in some cases, intentionally avoided (e.g., towing industry). A focus on fatal crashes also severely limits the amount of data available on responder struck-by crashes, as there are likely many more injury-related responder struck-by crashes (including both minor and major injuries) as compared with fatal crashes.

Finally, the third major limitation in identifying responder struck-by crashes in the various datasets is that, in almost all cases, **summaries or narratives of the crashes must be reviewed to verify if the crashes can be classified as responder struck-bys**. This limitation ties back to the first limitation related to the lack of a specific and consistent responder struck-by data element/attribute in the datasets. Three related challenges are that 1) often, narratives cannot be shared due to sensitive/personal information, 2) crash report narratives are sometimes stored as images as opposed to searchable text strings, and 3) reviewing narratives is a manual process that is labor intensive.

Table 5 summarizes the specific gaps and limitations identified for each data source.

Table 5. Summary of gaps/limitations in data with respect to identifying, describing, or locating responder struck-by crashes.

Data Sources	Gaps/Limitations in Data

Arizona crash reporting system	• Explicit data element for responder involvement first requires acknowledgement that the incident was a "secondary collision."
	• Secondary crash definition on crash form is inconsistent with national guidance, which could lead to inaccurate identification of responder struck-by crashes.
	• There was an unexpected large number of "other" responder types checked, which requires manual review of the report narratives; 177 crashes (80 percent) were marked as "other" but involved civilian motorists rather than responders.
	• Nonresponder struck-by crashes were identified in those marked as a responder hit:
	  o Crashes included responders striking other responders or civilian vehicles at or near an incident scene.
	  o This required a manual search of report narratives to weed out non-motorist crashes involving nonresponders

Florida crash reporting system	• No explicit responder involvement data element; relies on the nonmotorist action prior to crash data element and the "working in trafficway (incident response)" data attribute, which has proven to be unreliable in identifying responder struck-by crashes (~23%). • This required a manual search of report narratives to weed out nonmotorist crashes involving nonresponders.

Data Sources	Gaps/Limitations in Data
Illinois crash reporting system	• The crashes with the "responder involved" data element must be crossed with other data elements/attributes (e.g., "pedestrian") to narrow in on potential struck-by crashes. This takes multiple queries to identify different types of struck-by crashes (i.e., pedestrian, responder in stopped vehicle, responder vehicle only). • Data element and queries only point to potential struck-by crashes. Narratives still need to be reviewed to weed out nonresponder struck-bys. • The definition of the 43 Incident Responder data element in the Illinois Traffic Crash Report 2019 Instruction Manual for Law Enforcement Agencies is specific to responder struck-by crashes (as opposed to the more general Model Minimum Uniform Crash Criteria (MMUCC) definition of the Incident Responder data element, which can include a responder involved in any type of crash). • The instructions for the Incident Responder data element include a "vehicle" involved, but the example provided in the parenthetical phrase includes both a "driver" or "truck" involved. This could lead to confusion on when to mark the crash as involving an incident responder. • Use of this data element by officers suggests that it is not well understood, as it is being erroneously employed (e.g., most of the crashes identified were those where responders were present on the scene of a crash involving a pedestrian).
Ohio crash reporting system	• Only 13 crashes over 2 years were flagged with the data element "Nonmotorist location at impact" code 12: "First responder at incident scene." The project team determined only 5 of the 13 crashes were responder struck-by crashes. • This required a manual search of report narratives to weed out crashes involving nonresponders.
Tennessee crash reports	• This required a manual search of report narratives to weed out crashes involving nonresponders. • Pedestrian Action Code data element and associated attributes: "Emergency services personnel," and "Law enforcement officer" capture responder struck-by crashes, but 50 percent of the crashes did not involve responders.
Move-Over citations (Florida crash reporting system)	• Citations sometimes include incidents where no struck-by occurred (e.g., violator struck another vehicle or object at an incident scene). • Not all struck by incidents result in a move over citation by virtue of what can be proven by evidence.
Fatality Analysis Reporting System (FARS)	• There is a lack of an explicit struck-by data element for responder involvement. • Nonmotorist action prior to crash code "working in trafficway (incident response)" produces incident responder involvement only about 20 percent of the time. • FARS analysts cannot share crash report narratives for review.
Crash Report Sampling System (CRSS)	• There is a lack of an explicit struck-by data element for responder involvement. • CRSS does not include report narratives. • Nonmotorist action prior to crash code "working in trafficway (incident response)" produces incident responder involvement only about 20 percent of the time.

Data Sources	Gaps/Limitations in Data
National Emergency Medical Services Information System (NEMSIS)	• NEMSIS does not include explicit responder struck-by data elements. • Data available at the national level are too aggregated for detailed analysis and do not include specific data elements that could be used to identify responder struck-by crashes. • State-level data are not readily accessible. Accessing the State-level data would likely require an Institutional Review Board (IRB) review/approval and would not include report narratives, which would be necessary to verify responder struck-bys.
Occupational Safety and Health Administration (OSHA)	• Labor classification codes do not align with responder types. • Responder involvement information is confidential. • OSHA has limited location information. • Report narratives are not available in this data source.
Worker Compensation	• The struck-by vehicle data element must be paired with other elements. • The labor classification codes do not align with responder types. • Responder involvement information is confidential in State data. • Worker Compensation has limited location information. • Report narratives are not available in Worker Compensation.
National Institute for Occupational Safety and Health (NIOSH) FACE reports	• NIOSH FACE does not include specific struck-by data fields; "motor-vehicle-law enforcement officers" is the closest. • There is limited data on crashes involving responder struck-bys; a search on "motor-vehicle-law enforcement officers" cause of death produces only 13 total reports (since 1982) and only 5 of these were responder struck-by crashes. • NIOSH FACE results are in an unstructured data format. • NIOSH FACE has limited location information.
National Electronic Injury Surveillance System—Occupational Supplement (NEISS-Work)—Occupational Supplement	• NEISS-Work does not have specific struck-by data fields. • This source does not allow access to data. There is only a tool for querying the data. • The data includes only a sample of injuries requiring visit to emergency departments.
FBI Law Enforcement Officers Killed and Assaulted (LEOKA)	• LEOKA data is limited to fatal crashes. • LEOKA is limited to law enforcement only. • LEOKA has limited location information. • Raw data are not available in LEOKA.

Data Sources	Gaps/Limitations in Data
National Fire Incident Reporting System (NFIRS)	• The "struck-by" category includes a firefighter being struck-by anything, including another person. • NFIRS requires review of incident summaries/narratives to filter out those not meeting struck-by definition. • NFIRS has limited location information. • A review of a sample of NFIRS "struck-by" incidents resulted in only 32.6 percent being responder struck-by crashes according to the project definition.
National Fire Protection Association (NFPA)	• NFPA does not include a specific crash data element. • NFPA does not include an explicit struck-by data element. • NFPA is limited to fatal crashes. • Data gathering is through fire department self-reporting and news media searches. • The project team was not able to get access to the data.
Towing Traffic Incident Report System (TTIRS)	• TTIRS is a voluntary, self-reporting incident reporting system. • Towing companies are averse to reporting data on tow operator injuries and fatalities, which results in less data collected on these incidents. • Data are not publicly available (one must request the data). • Location information is limited to "location of incident – town/city," and coordinates are not present. • Some of the crashes in the dataset involved property damage to civilian vehicles/motorists only (not involving any responder), and some crashes were near misses (no crash actually occurred). • The data included qualitative information on injury severity, but injury information based on KABCO scale was not available. • Most crashes did not have a narrative or comments describing the incident, thus necessitating a manual search for online news articles corresponding to the crashes. • External online news articles were only found for the fatal crashes, and an extensive review was required to extract additional relevant data fields (e.g., injury severity, weather, response type, responder location, responder type). • For nonfatal crashes without an associated online articles, the determination of whether the crash involved a responder struck had to be made based on comments and/or associated injury information.

Data Sources	Gaps/Limitations in Data
ERSI	• Historical data are unstructured and are based on news articles. • Historical data have limited location information. • For historical data, date and or time of crash information is not always present. • Historical data include many events that do not align with the struck-by definition. • Historical data include duplicate information and records. • Historical data often include only a few details about the crash. • For historical data, articles must be manually reviewed to verify date and location and to extract other relevant information about the crash. • No system for validating if self-reported entries meet the definition of responder struck-by.
National Law Enforcement Officers Memorial Fund (NLEOMF)	• NLEOMF is limited to fatal crashes. • NLEOMF is limited to law enforcement only. • The NLEOMF data are not publicly available.
Officer Down Memorial Page (ODMP)	• ODMP is limited to fatal crashes. • ODMP is limited to law enforcement only. • All pages include an "End of Watch," but many do not include an incident date. • Some of the latitude/longitude data reference the address of the fallen officer's agency. • ODMP must be manually reviewed to verify that the crash aligns with the struck-by definition

KABCO stands for K=fatal injury, A=suspected serious injury, B=suspected minor injury, C=possible injury, and O=no apparent injury.

CHAPTER 3. COMPOSITE RESPONDER STRUCK-BY DATABASE

This section describes the composite database resulting from gathering and reviewing various data sources previous described for responder struck-by crashes, as well as a template for repeating or expanding the effort.

COMPOSITE DATABASE

Table 6 summarizes the data sources in the composite database.

Table 6. Summary of data in draft composite database.

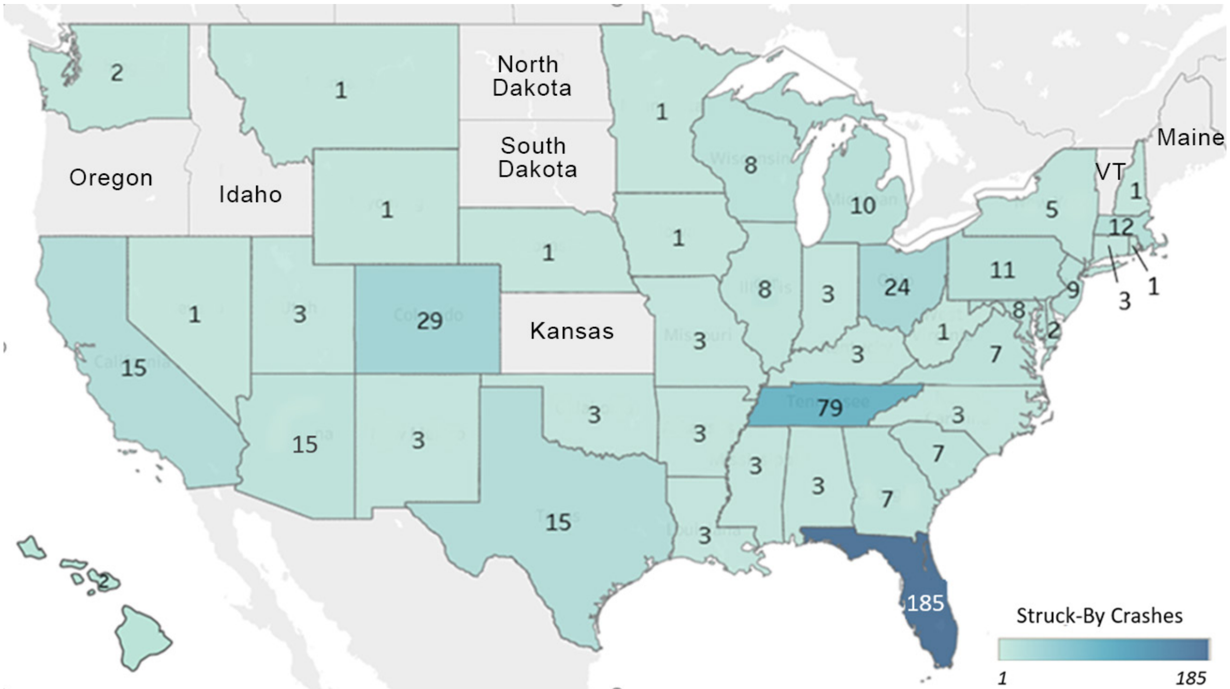
Source/Approach	Total # of Crashes/ Articles	Total # of Potential Struck-Bys (given approach)	Total # (%) Manually Reviewed	Total # in Composite Database (% Reviewed that Were Struck-By)
Arizona crash reporting system – “Secondary collision; Was a responder hit?” (2019)	130,063	220	220 (100%)	14 (6.4%)
Florida crash reporting system: “Working in trafficway (incident response)” (2011–2020)	3,489,855	596	596 (100%)	159 (26.7%)
“Move-Over” citations[1] (2011–2020)		519	519 (100%)	32[2] (6.2%)
Illinois crash reporting system—“Incident responder” + “Pedestrian” (2020)	246,868	398	200 (50.3%)	3 (1.5%)
Ohio crash reporting system—“Nonmotorist location at impact: First responder at incident scene” (2019–2020)	1,679,125	13	13 (100%)	5 (38.5%)
Tennessee crash reporting system—Pedestrian action code: “Emergency services personnel” (10), “Law enforcement officer” (11) (2011–2020)	2,252,013	138	138 (100%)	61 (44.2%)
Emergency Responder Safety Institute (ERSI) articles (across 42 States) (2006–2020)	6,852	6,852	717 (10.5 %)	167 (23.3%)
National Fire Incident Reporting System (NFIRS) (2010–2020)	3,535	457	86 (18.8%)	26[3] (30.2%)
National Institute for Occupational Safety and Health (NIOSH) FACE reports (2013–2015)	2,456	13	13 (100%)	7[4] (53.8%)

Towing Traffic Incident Report System (TTIRS) (2015–2021)	71	71	71 (100%)	47 (66.2%)
Florida Road Ranger Safety Patrol (RRSP) contractor data + Florida crash reporting system data (2014–2021)[5]	476	476	476 (100%)	22[6] (4.6%)
TOTAL CRASHES IN TABLE (INCLUDES OVERLAP)	7,811,314	9,753	3,049 (31.2%)	543[7] (17.8%)
TOTAL CRASHES IN DATABASE (UNIQUE RECORDS)				505

[1] Effort also identified 444 crashes involving responder vehicles
[2] Effort identified 32 struck-by crashes, but 28 were already in the database as a result of reviewing crashes with "working in trafficway (incident response")
[3] Effort identified 26 struck-by crashes, but 4 overlap with those identified through NIOSH FACE reports
[4] Effort identified 7 struck-by crashes, but 4 overlap with those identified through NFIRS
[5] Effort also identified 207 crashes involving responder/patrol vehicles
[6] Effort identified 22 struck-by crashes, but 6 were already in the database as a result of reviewing crashes with "working in trafficway (incident response)"
[7] Total represents all struck-bys that were identified through all approaches but includes overlap between the approaches

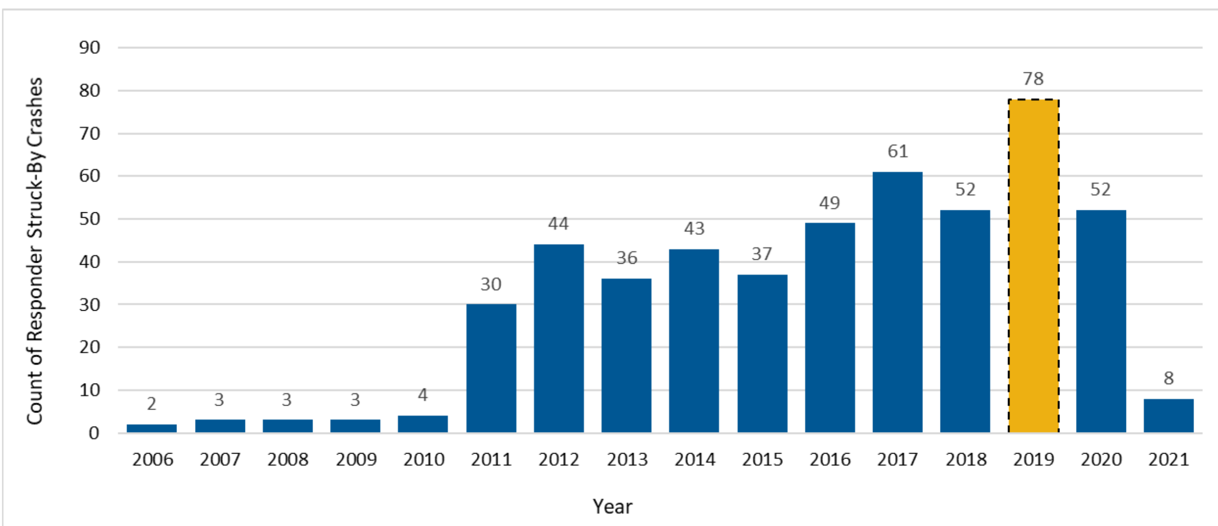
Figure 1 shows a breakdown of the number of struck-by crashes by State in the draft composite database. The States where the project team focused on getting crash reports with some type of responder struck-by data element—Florida, Ohio, and Tennessee—clearly resulted in the identification of the most struck-by crashes. For Colorado, the project team had access to crash reports back to 2006; however, Colorado's crash report does not have a struck-by data element. Therefore, the project team focused on reviewing ERSI articles from Colorado, which also resulted in a larger number of struck-by crashes being identified for that State. For the remaining States, the identification of a smaller number of crashes in each State resulted from the review of ERSI articles and the inclusion of NFIRS and NIOSH FACE reports.

Figure 2 through figure 4 show a breakdown of the responder struck-by crashes by year, day of the week, and hour of the day, respectively.



Source: Federal Highway Administration.

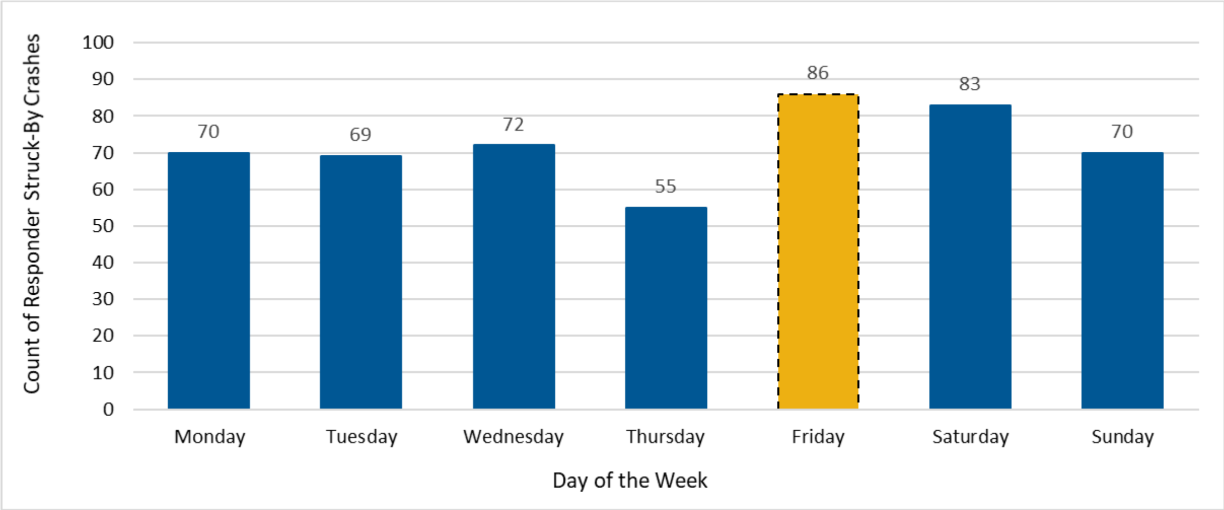
Figure 1. Graphic. Number of responder struck-by crashes per State.[1]



Source: Federal Highway Administration.

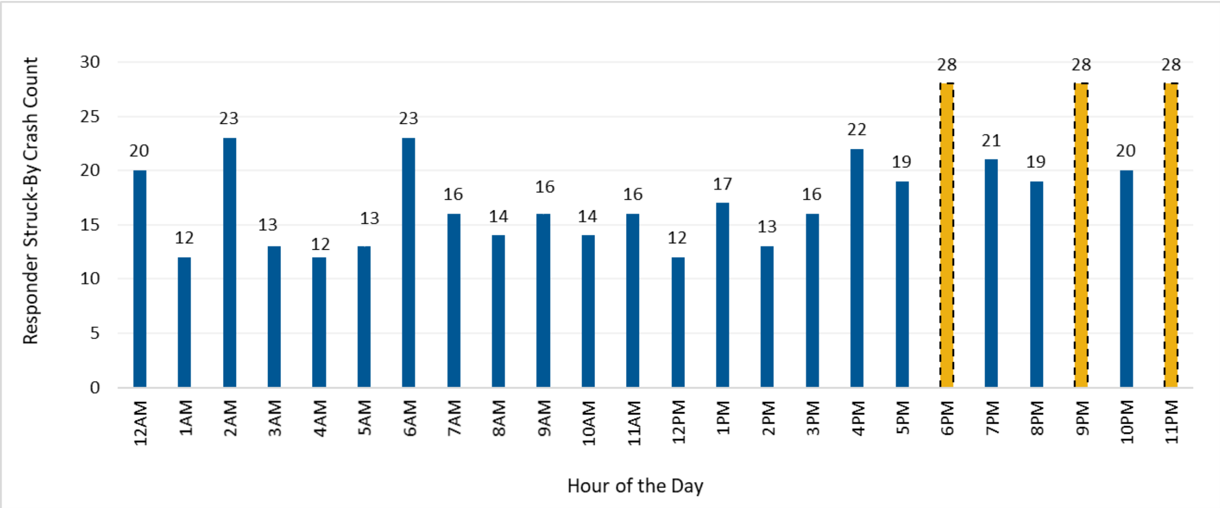
Figure 2. Graphic. Breakdown of struck-by crashes per year in the expanded composite database.

[1]Includes all struck-bys in the expanded composite database.



Source: Federal Highway Administration.

Figure 3. Graphic. Breakdown of struck-by crashes by day of the week in the expanded composite database.



Source: Federal Highway Administration.

Figure 4. Graphic. Breakdown of struck-by crashes by hour of the day in the expanded composite database.

RESPONDER STRUCK-BY CRASH DATA COLLECTION TEMPLATE

This section contains a template, based on this research, for collecting data on responder struck-by crashes. The template includes a common definition for a responder struck-by crash for consistency, as well as details on five steps to be applied for collecting and assessing various data sources for responder struck-by crashes. Applying these steps to various data sources will result in a composite database of verified responder struck-by crashes.

Responder Struck-By Crash Definition

"*A 'responder struck-by' crash is a collision between a motor vehicle in transit and a responder working a roadway incident, which would be recorded on a State traffic crash reporting form in* *the jurisdiction where it occurred. The responder may be a nonmotorist, an occupant of a stopped response vehicle, or an unoccupied response vehicle."*

Further guidance on the definition includes:

- A nonmotorist is every crash-involved person who was NOT the driver or occupant of a motor vehicle (NHTSA 2012). The types of nonmotorists include bicyclists, other cyclists, pedestrians, other pedestrians (e.g., wheelchair, person in a building, skater, personal conveyance), occupants of nonmotor vehicle transportation devices, or other unknown types of nonmotorists (NHTSA n.d.a).

- Responders are governmental and nongovernmental emergency public safety, fire, law enforcement, emergency response, emergency medical and related personnel, agencies, and authorities (Homeland Security Act 2002), including public works and other skilled support personnel, like towing (Bush 2003).

Responders include individuals who are "off-duty," but who are in the process of performing similar duties in their jurisdiction when responding to an exigent circumstance; their personal vehicles, however, would not be included as vehicles struck.

Responder Struck-By Data Collection Steps

The following five steps can be applied to various data sources to review the data, identify responder struck-by crashes, develop a composite database of verified responder struck-by crashes, and extract relevant information for analysis:

- Step 1. Obtain data from sources of interest
- Step 2. Identify data elements and query approach for potential responder struck-by crashes
- Step 3. Review written descriptions/narratives against responder struck-by crash definition
- Step 4. Extract as much information as possible about the responder(s) involved in the crash
- Step 5. Remove duplicate crashes

Step 1. Obtain Data from Sources of Interest

Table 7 summarizes the data sources used for this research to build a composite database of verified responder struck-by crashes, along with a description of, and information on, accessing each source. As previously discussed, these data sources were identified to contain data elements that assisted the research team in identifying stuck-by crashes within the data. These steps could be applied to other data sources with similar data elements.

Table 7. Sources of responder struck-by crashes.

Sources of Responder Struck-By Crashes	Data Source Description	Data Access Information
State crash reporting systems	Due to reporting requirements, State crash reporting systems provide the most comprehensive dataset for the identification of responder struck-by crashes. However, because crash data elements differ between States, there are many approaches to identifying potential responder struck-by crashes.	Request and obtain crash data from State(s) of interest. Request crash narrative information in addition to quantitative data.
Emergency Responder Safety Institute (ERSI)	ERSI maintains a database of responder struck-by crashes. The primary sources of information are self-reported crashes and media scraping. In early 2022, ERSI rolled out an online "Report a Struck By Incident" tool that captures more structured data.	"Report a Struck By Incident" tool: https://www.respondersafety.com/struck-by-near-miss/report-a-struck-by-incident/ Historical crashes can be searched here: https://www.respondersafety.com/news/struck-by-incidents/
Towing Traffic Incident Report System (TTIRS)	TTIRS, maintained by the Statewide Towing Association, Inc. (STA), is an online system for the towing industry to report struck-by and near-miss incidents involving tow operators. TTIRS data are collected through voluntary reporting of towing crashes, as well as media scans.	Make a data request: https://statewidetowing.org/
National Fire Incident Reporting System (NFIRS)	Housed by the United States Fire Administration's (USFA's) National Fire Data Center (NFDC), NFIRS is a voluntary system, which comprises 75 percent of all reported fires that occur annually. States can adapt their reporting systems; however, NFDC converts data from various State systems to a single format that is used at the national level to aggregate and store NFIRS data.	Request data: https://www.usfa.fema.gov/nfirs/
National Institute for Occupational Safety and Health (NIOSH) Fatality Assessment and Control Evaluation (FACE) Reports	NIOSH is the Federal agency responsible for conducting research and making recommendations for the prevention of work-related injury and illness. Through the FACE Program, NIOSH conducts investigations of fatal occupational injuries that allow for the identification of factors that contribute to these fatal injuries.	NIOSH FACE Reports: cdc.gov/niosh/face/ inhouse.html NIOSH State FACE Reports: cdc.gov/niosh/face/inhouse.html

Step 2. Identify Data Elements and Query Approach for Potential Responder Struck-By Crashes

Table 8 provides data elements for the identification of potential responder struck-by crashes for various data sources.

Table 8. Data elements for identification of potential responder struck-by crashes.

Sources of Responder Struck-By Crashes	Data Elements for Identification of Potential Responder Struck-By Crashes
State crash reporting systems	**Model Minimum Uniform Crash Criteria (MMUCC) NM2. Non-Motorists Action/Circumstance Prior to Crash** • Subfield 1 Action/Circumstance: – 08 Working in trafficway (incident response) **MMUCC P4. Person Type** • Subfield 2 Incident Responder? – 02 Emergency Services Personnel (EMS) – 03 Fire – 04 Police – 05 Tow operator – 06 Transportation **MMUCC C2. Crash Classification** • Subfield 3 Secondary Crash? **MMUCC P15. Violation Codes (State specific)** **MMUCC V10. Special Function of Motor Vehicle in Transportation:** – 09 Fire truck – 10 Highway/maintenance – 13 Ambulance – 14 Police – 17 Safety Service Patrols (SSP) – Incident Response – 18 Other Incident Response – 20 Towing – Incident Response Examples of similar non-MMUCC data elements used by specific states: • **"Pedestrian Action Code"** (Tennessee) – 10 Emergency services personnel – 11 Law enforcement officer – 13 Other working in roadway • **"Non-motorist Location at Impact"** (Ohio) – 12 First responder at incident scene • **"Is this a Secondary Collision?"** (Arizona) – "If yes, were any of the following first responders hit?" (law enforcement, fire, EMS, tow operator, DOT worker, other)
Emergency Responder Safety Institute (ERSI)	All crashes are supposed to be responder struck-by crashes but must be reviewed/verified in Step 3.

Towing Traffic Incident Report System (TTIRS)	Type of Incident • **Struck-by**
National Fire Incident Reporting System (NFIRS)	I - Cause of injury • 07—**Struck by or contact with object** (includes assault by persons or animals)
National Institute for Occupational Safety & Health (NIOSH) Fatality Assessment and Control Evaluation (FACE) Report	Cause • **Motor Vehicles-Law Enforcement Officers**

Step 3. Review Written Descriptions/Narratives Against Responder Struck-By Crash Definition

Once potential struck-by crashes have been identified, any associated descriptions/narratives/articles should be reviewed to determine if these crashes are responder struck-bys:

- Did the crash occur at the scene of a traffic incident?
  - A traffic incident is an emergency road user occurrence, a natural disaster, or other unplanned event that affects or impedes the normal flow of traffic— Manual on Uniform Traffic Control Devices (MUTCD) 2009 Edition, Section 6I.01.02, FHWA.
- Does the crash include a) a responder struck as a nonmotorist/pedestrian, b) a responder struck inside a parked responder vehicle, or c) an unoccupied responder vehicle struck?
- Is the responder one of the following: law enforcement, fire, EMS, towing, SSP, public works, or maintenance personnel?
- Responders also include individuals who are “off-duty,” but who are in the process of performing similar duties in their jurisdiction when responding to an exigent circumstance; their personal vehicles, however, would not be included as vehicles struck.

Step 4. Extract as Much Information as Possible about the Responder(s) Involved in the Crash

For each responder struck in the crash, record (at least) the responder-related variables:

- Type of incident at which the responder was struck (prior crash, noncrash incident, traffic stop, directing traffic, debris, fire, weather-related)
- Location of responder when struck (non-motorist/pedestrian, occupant of parked responder vehicle, responder vehicle only)
- Responder injury severity (KABCO)

- Responder discipline (law enforcement, fire, EMS, towing, SSP, maintenance, public works)
- Whether the responder was wearing retroreflective garments
- Any other responder-related variables of interest

For each crash, record (at least) the following crash-related variables:

- Crash location (State, city, road, nearest intersection roadway)
- Crash date and time
- Area type (urban or rural)
- Roadway classification (e.g., interstate highway, US route, State route, county road, tollway/turnpike, local road)
- Environmental and lighting conditions (weather, roadway surface, ambient lighting)
- Contributing factors (driver-related, roadway-related, environmental-related)
- Any other crash-related variables of interest

Step 5. Remove Duplicate Crashes

Remove duplicates by cross-checking the struck-by crashes identified through each source by:

- Crash location (State, city, road, and intersecting road)
- Crash date (year, month, day) and time
- If the crash locations and times do not match any previous crashes, add new crashes to the database.
- If the crash locations and dates are exact matches, check the following variables:
    - Number of responders struck
    - Responder discipline
    - Responder location
    - Responder injury severity
- Check the crash narratives/articles for any other pertinent details that could aid in the identification of duplicate crashes.

CHAPTER 4. FINDINGS FROM ANALYSIS OF RESPONDER STRUCK-BY CRASHES

The objective of the analysis of the responder struck-by crashes was to explore the data to identify any factors that impact responder struck-by crashes. To do so, the project team developed summary statistics, conducted more in-depth analyses, and identified gaps and limitations associated with the analysis of responder struck-by data. More specifically, the project team conducted the following activities:

- Provide a detailed account of the summary statistics of the responder struck-by crashes, both by responder-related and crash-related variables, through a series of tables and graphs that aim to assess any potential trends and patterns in the data. These summaries and visuals serve to identify the data variables of interest on which to base the subsequent data analyses.

- Analyze the correlation among variables of interest in the data and conduct a cluster analysis to establish if there are any variables (or variable values) that are associated with independent groups of responder struck-by crashes.

- Outline a case study of Florida responder vehicle (only) struck-by crashes and provide a detailed account of the summary statistics of these crashes both on a crash level as well as responder vehicle level to assess any trends in the data.

- Provide details about the gaps and limitations related to the two datasets (composite responder struck-by crash dataset and the Florida responder vehicle struck-by crash dataset) and associated analyses.

The outcomes of each of these activities are detailed in this chapter.

SUMMARY STATISTICS OF RESPONDER STRUCK-BY DATA

The objective of the data analysis was to explore the responder struck-by data through the development of summary statistics, tables, and visualization of trends and/or patterns among the variables present in the composite database. These summaries and visuals serve to identify the data variables of interest on which to base the subsequent data analyses. The analysis of the data included the following activities:

- Analyze responder struck-by crashes by responder-related variables.
- Analyze responder struck-by crashes by crash-related variables.
- Develop data summaries and visualizations to explore patterns and trends in the data variables.

The outcomes of each of these activities are detailed in the following subsections of this memorandum.

Overview of Responder Struck-By Crash Data

This section provides a high-level summary of the entire dataset, comprised of 505 responder struck-by crashes. The breakdown of these responder struck-by crashes by data source is as follows:

- 262 crashes identified through a review of crash reports from Arizona, Florida, Illinois, Ohio, and Tennessee
- 243 crashes identified through the following sources:
  - 167 crashes from the ERSI
  - 26 crashes from the NFIRS
  - 7 crashes from the NIOSH FACE reports (note that 4 of these crashes were also found in the NFIRS dataset and are therefore not re-counted towards the 243 total)
  - 47 crashes from the TTIRS

The crashes identified through ERSI, NFIRS, and NIOSH were available in the form of articles/narratives. Upon reviewing these articles/narratives and identifying those that were responder struck-by crashes, the project team extracted the necessary crash- and responder-related information and attempted to link the identified crashes to the State crash reports based on location and time of crash (if this information could be extracted from the articles/narratives). This process resulted in 49 ERSI-identified responder struck-by crashes being linked to an official crash report. With this ERSI-crash report linkage, 311 out of 505 responder struck-by crashes included crash report information; the remaining 194 crashes only included crash-related information that was available in the articles/narratives.

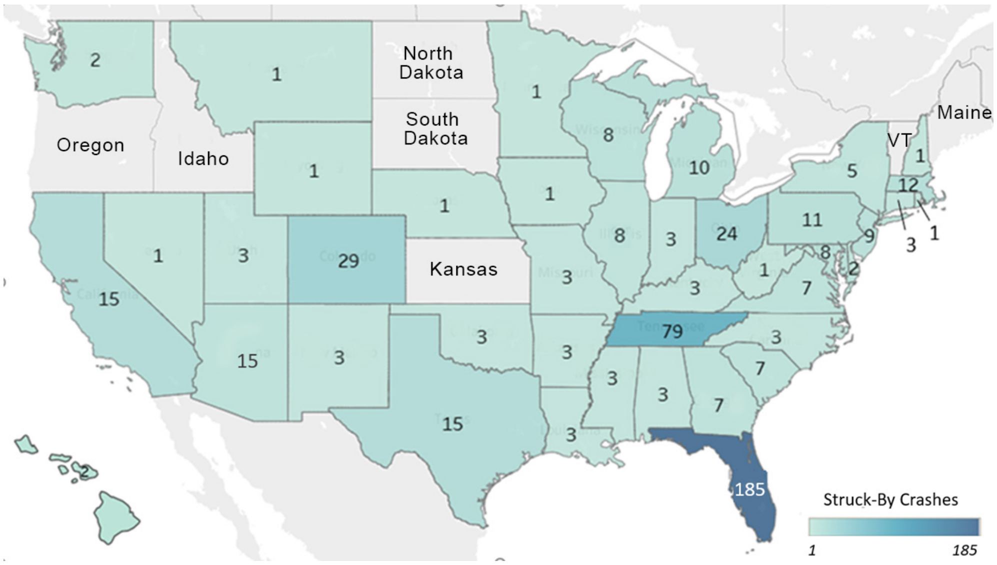
The project team mapped the 505 responder struck-by crashes to illustrate the breakdown of the number of struck-by crashes by State in the composite database. As shown in figure 5, most of the struck-by crashes were identified in the States where the project team had access to crash reports with some type of responder struck-by data element, namely Florida, Ohio, and Tennessee. The project team identified a significant number of struck-by crashes in Colorado through a review of ERSI articles (although the project team had access to Colorado crash reports going back to 2006, the crash reports did not have a struck-by data element to query these specific crashes).

Of the 505 crashes, 277 crashes included geolocation information (latitude/longitude). The project team mapped these crash coordinates to illustrate their distribution across States (see figure 6). As shown, most of these crashes with geolocation information occurred in Florida, followed by Tennessee, Ohio, and Arizona. A few crashes with geolocation information occurred in Illinois, Utah, and Wyoming. The remining 228 crashes (45 percent) did not have location coordinates, including:

- 29 (all) crashes in Colorado, identified through crash reports (15), ERSI (13), and TTIRS (1)
- 14 crashes in Florida, identified through crash reports (12), ERSI (1), and TTIRS (1)
- 7 crashes in Ohio, identified through ERSI (2), NFIRS (2), and TTIRS (3)

- 11 crashes in Tennessee, identified through ERSI and NIOSH articles (6) and crash reports (5)
- The remaining 167 crashes that the project team identified through a review of articles and that were distributed among 36 States

It should be noted that the composite dataset is not a random sample of responder struck-by crashes. Given that responder struck-by crashes are not systematically collected across States or responder groups, the project team had to first identify potential sources of these crashes. This process involved assessing a wide range of data sources, including crash reporting systems from certain States with responder-specific data elements, as well as discipline-specific data sources, some of which are voluntary in nature and/or focus on the collection of crashes resulting in fatalities. As such, the resulting dataset may not be representative of the range of injury types, responder disciplines, response activities, locations, conditions, etc., for these crashes, and this should be considered when interpretating the results and findings of the analyses described in this memorandum.



Source: Federal Highway Administration.

Figure 5. Graphic. Number of responder struck-by crashes per State.[1]

[1]Includes all struck-by crashes in the composite database.

Source: Federal Highway Administration.

Figure 6. Graphic. Map of responder struck-by crashes with coordinates.

Summary Statistics by Responder-Related Variables

This section provides a summary of the findings from an analysis of the responder struck-by crashes by responder-related variables. Information on the responder-related variables was extracted from the person-fields in the crash reports and/or via a manual review of crash narratives and articles/reports (from ERSI, NFIRS, and NIOSH). The responder-related variables of interest included:

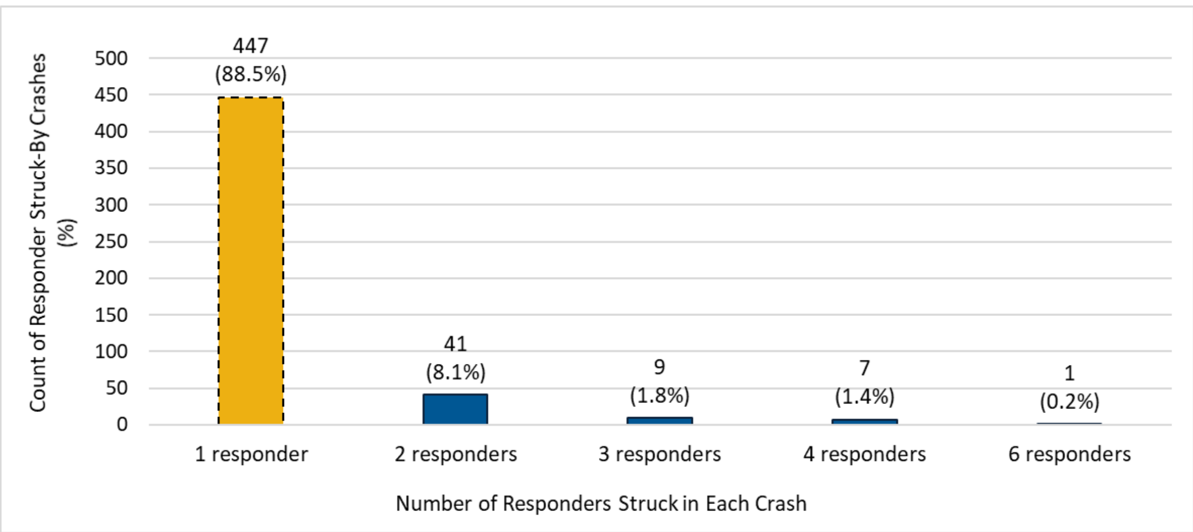
- Responder type—includes whether the responders were law enforcement officers, firefighters, emergency services personnel (EMS), tow operators, and SSP
- Responder location—whether the responder struck was on foot (as a pedestrian) at an incident scene or was an occupant of a stopped responder vehicle at an incident scene
- Response type—the reason for the response (e.g., prior crash, noncollision, such as disabled vehicle or stranded motorist, traffic stop, removing debris, directing traffic)
- Use of retroreflective garments—whether the responder was wearing retroreflective clothing
- Responder injury severity—The level of injury sustained by the responder from the struck-by crash following the KABCO scale, which was developed by the National Safety Council (the acronym KABCO stands for K-fatal injury, A-suspected serious injury, B-suspected minor injury, C-possible injury, and O-no apparent injury) (NHTSA 2017). Across State crash reports, these crash severity levels did not always follow the KABCO scale in terms of phrasing of each severity level; however, the project team converted the severity levels to those of the KABCO scale for consistency.

For the analysis of the responder-related variables, the project team organized the data in the composite database at the person-level, where each responder struck is represented by one row (i.e., responder record) in the data. As such, crashes that involved multiple responders struck have multiple rows/records, where the crash information is repeated, but the responder-specific information is unique to each row/record.

Of the 505 crashes in the composite database, 447 (89 percent) involved only one responder, and 58 (11 percent) involved multiple responders. Of the crashes that involved multiple responders:

- 41 (71 percent) included 2 responders
- 9 (16 percent) included 3 responders
- 7 (12 percent) included 4 responders
- 1 (1 percent) included 6 responders

As such, there were 143 responder records associated with the 58 crashes involving multiple responders. Combined with the 317 rows/records for the crashes involving a single responder, the responder-level dataset included 590 records (rows). Figure 7 provides a breakdown of the 505 responder struck-by crash records. If the number of crashes is multiplied by the number of responders struck-by per each crash, the total number of responders struck in the composite database amounts to 590.

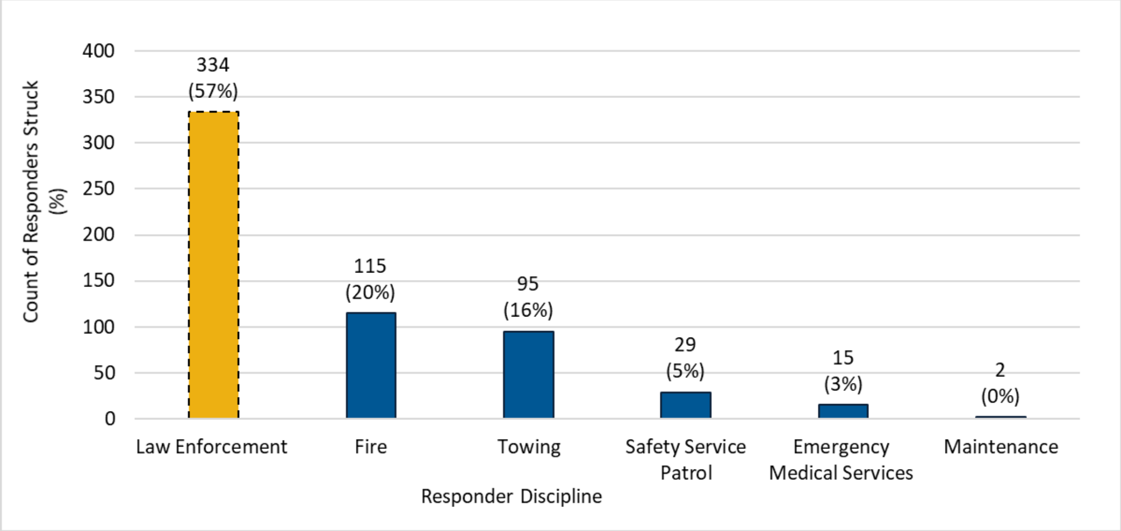


Source: Federal Highway Administration.

Figure 7. Chart. Breakdown of responder struck-by crashes by number of responders struck in each crash.

Responder Type

The breakdown of responders struck by responder discipline is shown in figure 8. The majority of the responders involved in the struck-by crashes in the composite database were law enforcement officers (57 percent). Firefighters comprised 19 percent of the records, followed by tow truck operators at 16 percent, SSP at 5 percent, and EMS personnel at 3 percent. The distribution of the responder disciplines may be impacted by the data collection methodology, which involved the identification of responder struck-by crashes from various sources (some specific to certain disciplines and others more general). While law enforcement makes up over half of the data, this is to be expected due to the nature of law enforcement's response to a wide range of traffic incidents, including not only crashes but traffic stops, debris, and directing traffic.

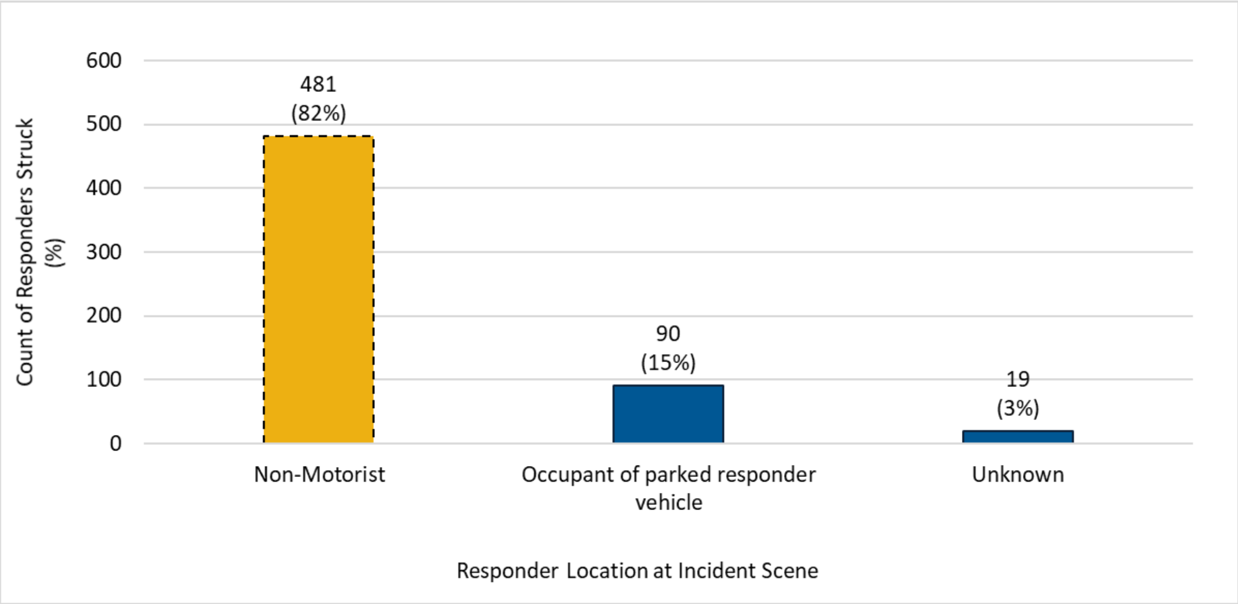


Source: Federal Highway Administration.

Figure 8. Chart. Breakdown of responders struck by responder discipline.

Responder Location

Information related to responder location when struck (as a nonmotorist outside of the responder vehicle or as an occupant of a parked responder vehicle) was available for 571 (97 percent) of the responder records. As shown in figure 9, the majority of these responder records (481 out of 590, or 82 percent) included responders struck as non-motorists. Ninety responders (15 percent) were struck as occupants of parked responder vehicles at incident scenes. These findings are not surprising given that the project team focused on identifying responder struck-by crashes that involved an actual responder (person) being struck (as opposed to a responder vehicle). Additionally, the data elements queried in the crash data generally focused on responders being struck as pedestrians. Responder location was unknown for 3 percent of the responder records in the composite database.



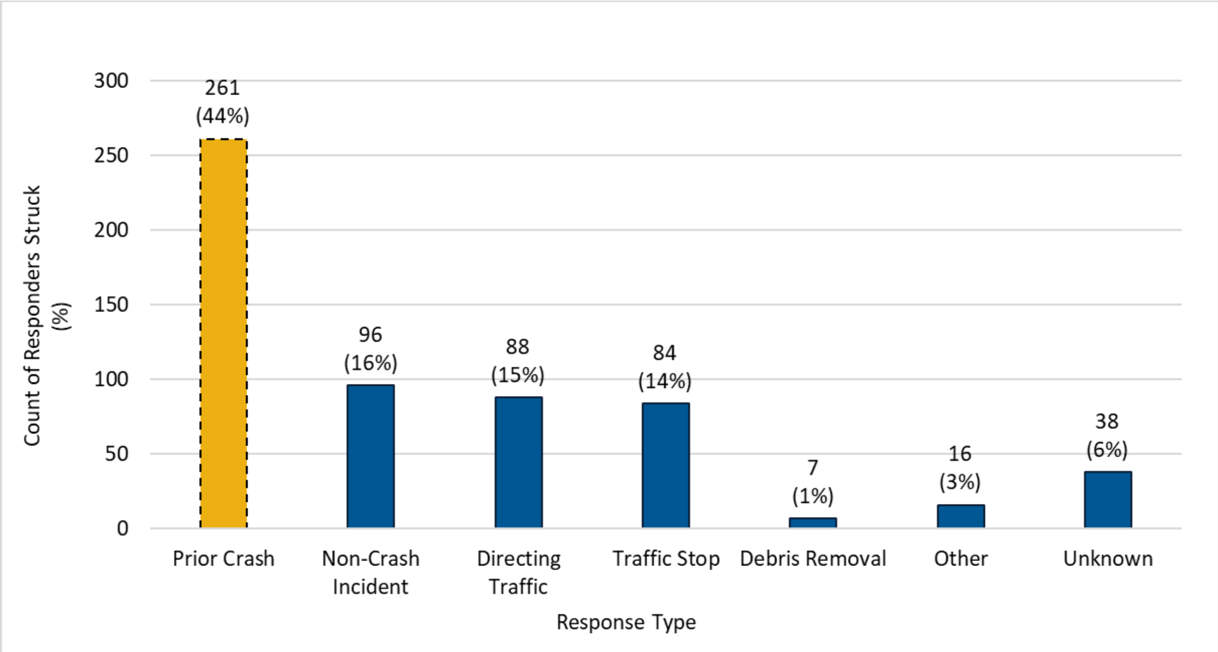
Source: Federal Highway Administration.

Figure 9. Chart. Breakdown of responders struck by responder location at traffic incident scene.

Response Type

Through a manual review of the crashes, the project team extracted information on the type of traffic incidents at which the responders were struck. The response-type categories included prior crashes, noncrash incidents (e.g., a stranded motorist, disabled vehicle), traffic stops, directing traffic, removing debris from the roadway, other, and unknown. The category "other" included any other type of incident not categorized within one of these categories (e.g., fire-related events, weather-related events).

The breakdown of struck-by crashes by response types is summarized in figure 10. The highest number (and percentage) of responder struck-by crashes and responders were associated with prior crashes. This is to be expected, as crashes typically involve more responders than other types of incidents.

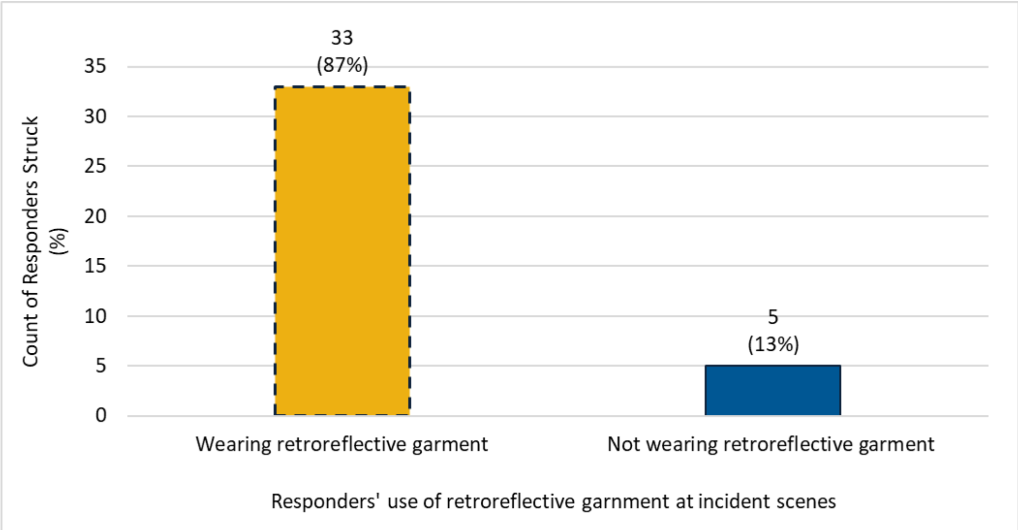


Source: Federal Highway Administration.

Figure 10. Chart. Breakdown of responders struck by type of incident response.

Use of Retroreflective Gear

The project team extracted information (if provided) regarding whether the responders were wearing retroreflective garments at the time they were struck from the crash narratives and articles. Information on the use of retroreflective garments by responders, summarized in figure 11, was available only for 31 crashes (and 38 responders). The majority of these responders (87 percent) were wearing retroreflective garments when they were struck.



Source: Federal Highway Administration.

Figure 11. Chart. Responder use of retroreflective gear while responding to traffic incidents.

Responder Injury Severity

As noted at the beginning of this section, the project team used the KABCO scale to assess responder injury severity for the responder struck-by crashes. Table 9 shows a breakdown of the injuries overall across all responders, as well as by responder discipline, responder location, and response type.

The overall breakdown of injury severity across the responders involved shows that the vast majority of responders that were struck suffered either a fatality (15 percent) or some type of injury (77 percent). This highlights the vulnerability of responders and the risks they face while responding to traffic incidents. The individual percentages shown in table 9 are calculated by dividing the number of responders within each severity-discipline, severity-location, and severity-response type category by the total number of responders struck in the corresponding discipline, location, and response type category. For example, there were 43 tow operator fatalities and 95 total tow operator responders struck; therefore, the percentage shown in table 9 for tow operator fatalities is 43/95 = 45 percent (percentages add to 100 percent across each discipline/location/response type category/row. As such, the percentage of responders in each severity-discipline/location/response category can be compared to the overall percentage for that injury category to see if they are overrepresented or underrepresented with respect to the total injuries in that injury category for the composite database.

The percentage of responder fatalities for fire (23 percent), towing (45 percent), and noncrash incidents (36 percent) are all higher than the overall percentage of fatal injuries in the composite database (15 percent). The percentages of responder fatalities for EMS (7 percent), law enforcement (4 percent), occupants of parked responder vehicles (2 percent), directing traffic (2 percent), and traffic stops (6 percent) are all lower than the overall percentage of fatal injuries.

The percentage of responders with suspected serious injuries for EMS (47 percent), SSP (34 percent), debris (43 percent), and "other" response types (56 percent) are all higher than the overall percentage of responders with suspected serious injuries in the composite database (26 percent). While maintenance is higher at 50 percent, there are only two maintenance worker responders struck in the composite database. The percentages of responders with suspected serious injuries for towing (14 percent), directing traffic (23 percent), and noncrash incidents (22 percent) are all lower than the overall percentage of responders with suspected serious injuries. The percentage of responders with suspected serious injuries across responder locations (including unknown responder locations) were all about the same as the overall average for the database (26 percent).

The percentage of responders with suspected minor injuries for EMS (40 percent), law enforcement (34 percent), debris (43 percent), directing traffic (35 percent), and traffic stops (37 percent) are all higher than the overall percentage of responders with suspected minor injuries in the composite database (29 percent). The percentages of responders with suspected minor injuries for fire (24 percent), towing (17 percent) and non-crash incidents (14 percent) are lower than the overall percentage of responders with suspected minor injuries.

The percentage of responders with possible injuries for directing traffic (28 percent) was nearly twice as high as the overall percentage of responders with possible injuries in the composite database (15 percent). The percentages for EMS (7 percent), fire (5 percent), occupant of stopped vehicle (6 percent), and debris (0 percent) are all lower than the overall percentage of responders with possible injuries.

Finally, 21 percent of occupants of parked responder vehicles had no apparent injuries, which is twice as high as the percentage of responders with no apparent injuries in the composite database (9 percent). All the remaining percentages are mostly in line with the overall percentage of responders with no apparent injuries in the composite database (9 percent).

Overall, from the responder-level analysis of injuries in the composite database:

- Fire was overrepresented in fatalities but underrepresented in possible injuries.
- Towing was overrepresented in fatalities but underrepresented in suspected serious injuries and suspected minor injuries.
- Responders at noncrash incidents were overrepresented in fatalities but underrepresented in suspected serious injuries and suspected minor injuries.
- EMS was underrepresented in fatalities but overrepresented in suspected serious injuries and suspected minor injuries.
- Law enforcement was underrepresented in fatalities but overrepresented in suspected minor injuries.
- Occupants of stopped responder vehicles were underrepresented in fatalities and possible injuries but overrepresented in no apparent injuries.
- Responders directing traffic and making traffic stops were underrepresented in fatalities but were overrepresented in suspected minor and possible injuries. Responders at noncrash incidents were overrepresented in fatalities but underrepresented in suspected serious injuries and suspected minor injuries.
- Responders making traffic stops were underrepresented in fatalities and overrepresented in suspected minor injuries.
- Responders directing traffic were overrepresented in possible injuries.
- Responders removing debris were overrepresented in suspected serious injuries and suspected minor injuries but underrepresented in possible injuries and no apparent injuries.
- The involvement of SSP, nonmotorist responders, and those at prior crashes followed expected trends based on the distribution of injury severity in the overall dataset.

Table 9. Comparison of the overall percentage of responders in each injury category to those by discipline, responder location, and response type category.

	Fatality (K)	Suspected Serious Injury (A)	Suspected Minor Injury(B)	Possible Injury (C)	No Apparent Injury (O)	Unknown Injury Severity (U)
Overall Discipline	15%	26%	29%	15%	9%	7%
Emergency Medical Services (EMS)	7%	47%	40%	7%	0%	0%
Fire	23%	27%	24%	5%	10%	10%
Law enforcement	4%	27%	34%	19%	10%	7%
Maintenance	0%	50%	0%	0%	50%	0%
Safety Service Patrol (SSP)	14%	34%	28%	14%	10%	0%
Towing	45%	14%	17%	15%	6%	3%
Location						
Nonmotorist	17%	25%	28%	17%	7%	5%
Occupant	2%	28%	32%	6%	21%	11%
Unknown	11%	26%	42%	0%	0%	21%
Response time						
Debris	14%	43%	43%	0%	0%	0%
Directing traffic	2%	23%	35%	28%	10%	1%
Noncrash incident	36%	22%	14%	15%	6%	7%
Other	6%	56%	31%	0%	6%	0%
Prior crash	14%	27%	28%	11%	11%	9%
Traffic stop	6%	24%	37%	19%	8%	6%
Unknown	18%	21%	39%	11%	5%	5%

Summary Statistics by Crash-Related Variables

In this step, the project team analyzed the following crash-related (i.e., crash-level) variables from the crash reports:

- Time of occurrence (e.g., year, month, day of week, time of day)
- Area type (urban versus rural)
- Roadway classification (e.g., interstate highway, U.S. highway, State highway, county road)
- Roadway characteristics (e.g., number of lanes, roadway width, median width, AADT, shoulder type)
- Environmental and lighting conditions (e.g., weather, roadway surface, lighting)
- Contributing circumstances

For some of the analyses, these variables were available for all 505 crashes (e.g., year of crash, month of crash, day of crash). For other analyses, these variables were only available for a subset of the crashes. This is due to a couple of factors. First, there were a number of crashes identified through ERSI articles (65), NIOSH reports (3), and TTIRS (47) that were not matched with crash reports. However, while reviewing these data sources, the project team extracted as much crash information as possible, including time of day, area type, roadway classification, weather, lighting, roadway surface information, and contributing factors. Additionally, some of the crash-related variables were missing for many of the crashes with an associated crash report. Therefore, these analyses were conducted on subsets of crash data of different sample sizes. Furthermore, most of the crashes did not have information on roadway characteristics (e.g., number of lanes, roadway width, AADT); as such, the sample sizes for these analyses were very small.

A summary of the findings for each of the crash-related variables is presented in the following subsections.

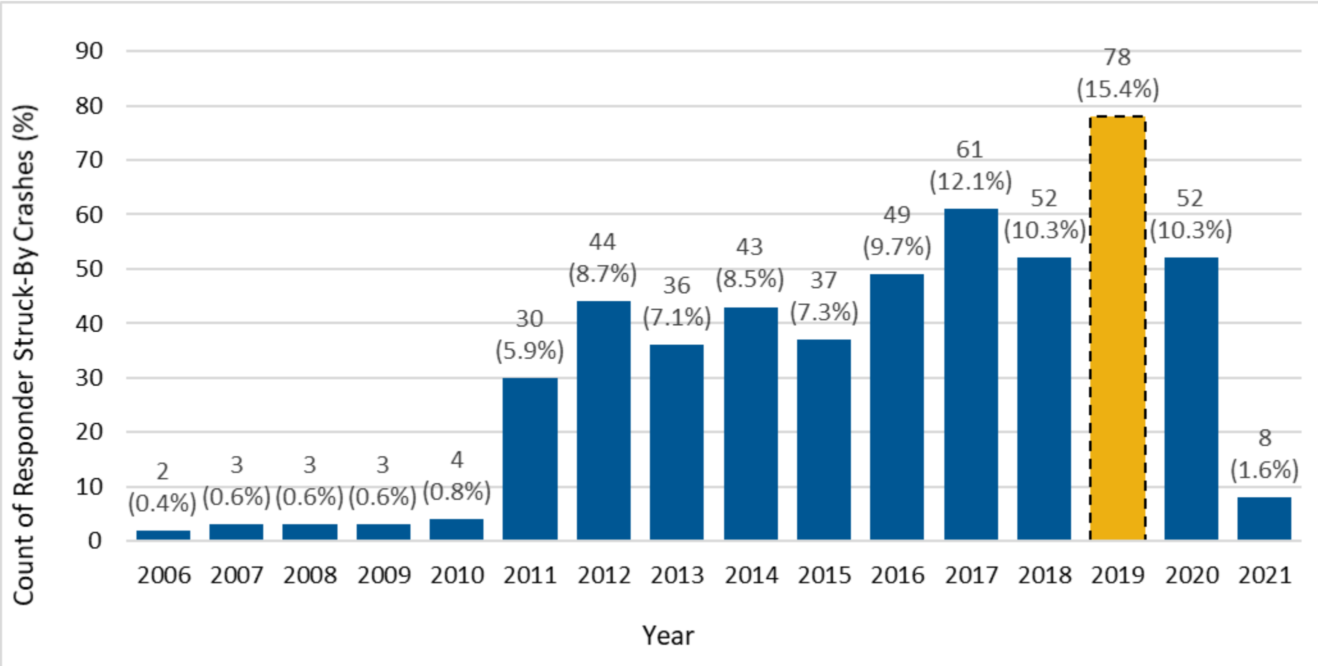
Time of Occurrence

Information on the crash year, month, and day of the week[1] was available for all 505 responder struck-by crashes, whereas information about the time of the crash was available only for the 437 crashes for which the project team had a crash report or for which crash time was available through the review of the articles and narratives.

The frequency of crashes was first examined by year (results shown in figure 12). It should be noted that the crash data obtained from the States were not necessarily for the same years. For

[1]The project team determined "day of week" for the crashes that were not matched with a crash report based on the dates of the crashes.

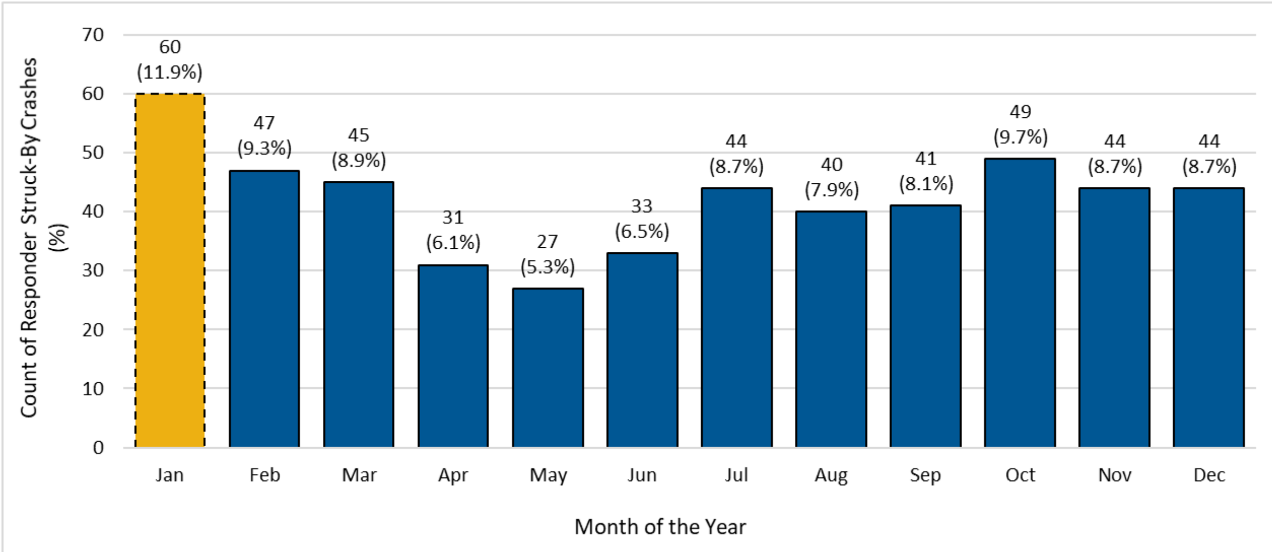
example, the project team had access to crash data from Colorado for 2006–2016, whereas crash data from Ohio was only available for the past 5 years, and crash data from Arizona was only available for 1 year (2019). The year with the most crashes is 2019 with 78 crashes (15.4 percent of the crashes).



Source: Federal Highway Administration.

Figure 12. Chart. Breakdown of responder struck-by crashes by year.

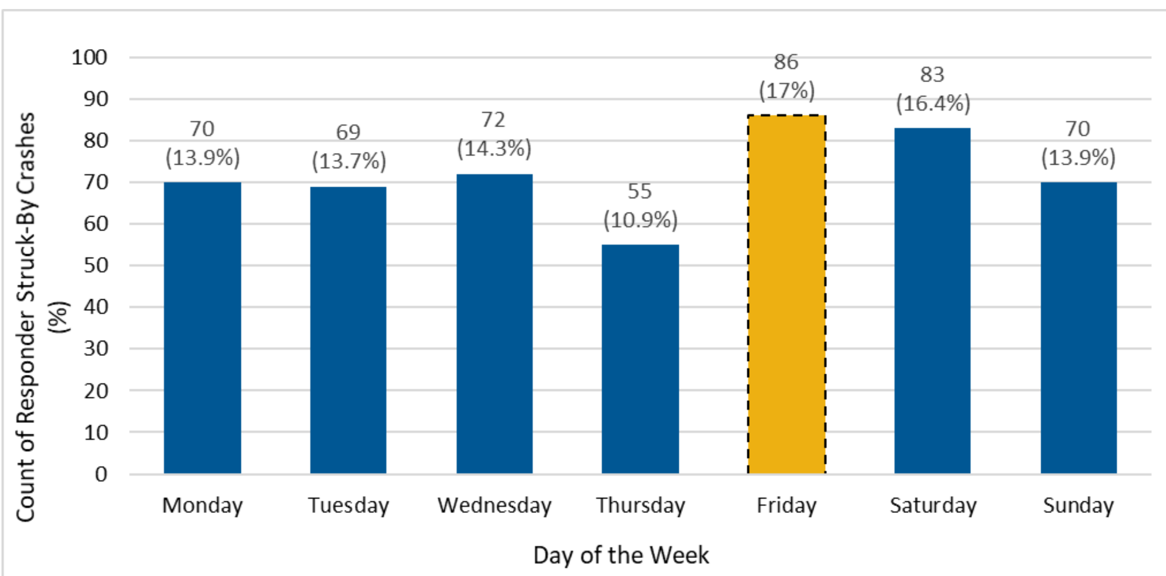
The monthly trend, depicted in figure 13, shows that the highest number of responder struck-by crashes occurred during the month of January; however, there is a less-than-7-percent difference between the month with the most responder struck-by crashes (January, with 60, or 11.9 percent of the crashes) and the month with the fewest responder struck-by crashes (May, with 27, or 5.3 percent of the crashes). Seasonally, more of the responder struck-by crashes in the database occurred during the fall and winter months (over 57 percent), as opposed to spring and summer (less than 43 percent).



Source: Federal Highway Administration.

Figure 13. Chart. Breakdown of responder struck-by crashes by month.

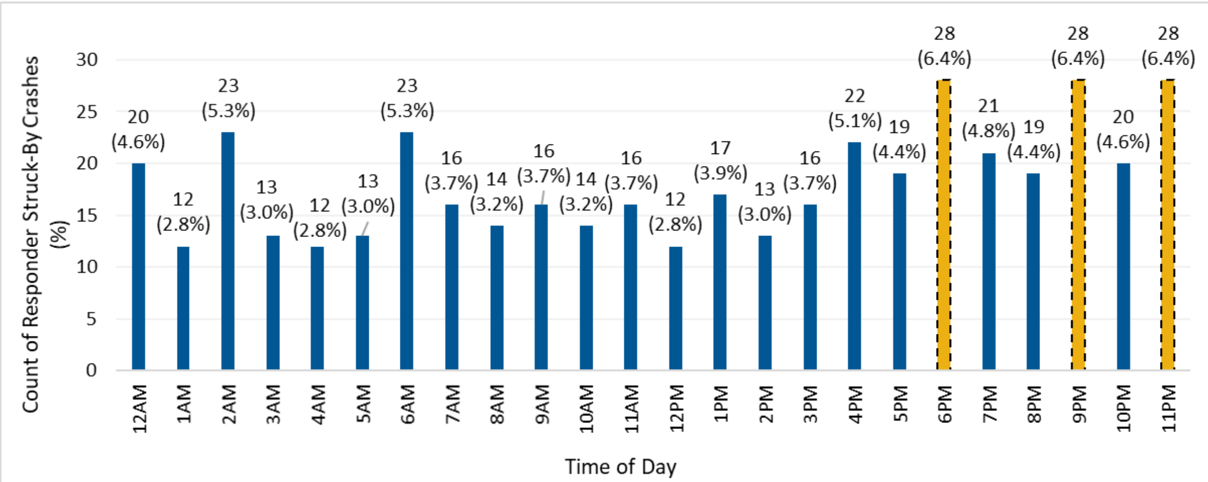
The project team examined the breakdown of responder struck-by crashes by day of the week (shown in figure 14). The day of the week with the most responder struck-by crashes was Friday, with 86 crashes (17 percent). Saturdays saw the second highest number of responder struck-by crashes, with 83 (16.4 percent). In fact, one third of the crashes occurred on Fridays and Saturdays.



Source: Federal Highway Administration.

Figure 14. Chart. Breakdown of responder struck-by crashes by day of the week.

The project team examined the hour of day information, which was available for the 437 crashes (87 percent). The breakdown of responder struck-by crashes by time of day is shown in figure 15. The graph shows that the late afternoon and evening hours (4 p.m.–12 a.m.) are associated with an increase in the number of responder struck-by crashes (along with a few spikes in the early morning hours (2 and 6 a.m.)), as compared with the morning and early afternoon hours.

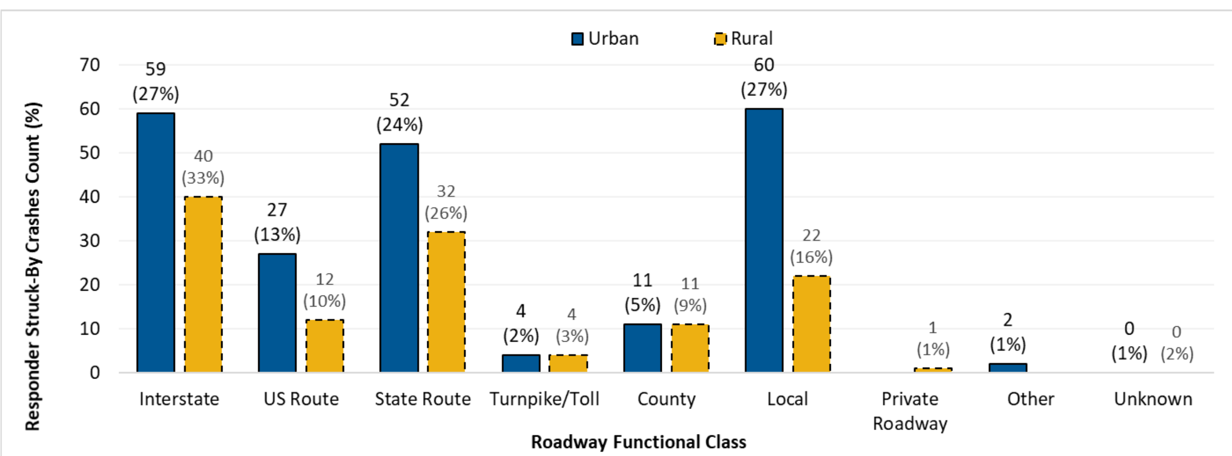


Source: Federal Highway Administration.

Figure 15. Chart. Breakdown of responder struck-by crashes by time of day.

Area Type and Roadway Classification

Information for both area type and roadway classification were available for two-thirds of the crashes (337 crashes or 67 percent). The breakdown of roadway classification by area type (urban/rural) is summarized and illustrated in figure 16. For the urban areas, the highest percentage of responder struck-by crashes occurred on interstate highways (27 percent) and local roads (27 percent), followed by State roads (24 percent). On rural roads, the highest percentage of responder struck-by crashes occurred on interstate highways (33 percent), followed by State roads (26 percent), and local roads (16 percent).



Source: Federal Highway Administration.

Figure 16. Chart. Breakdown of responder struck-by crashes by area type and roadway functional classification.

Roadway Characteristics

The project team examined responder struck-by crashes based on the roadway characteristics from the crash reports, which included:

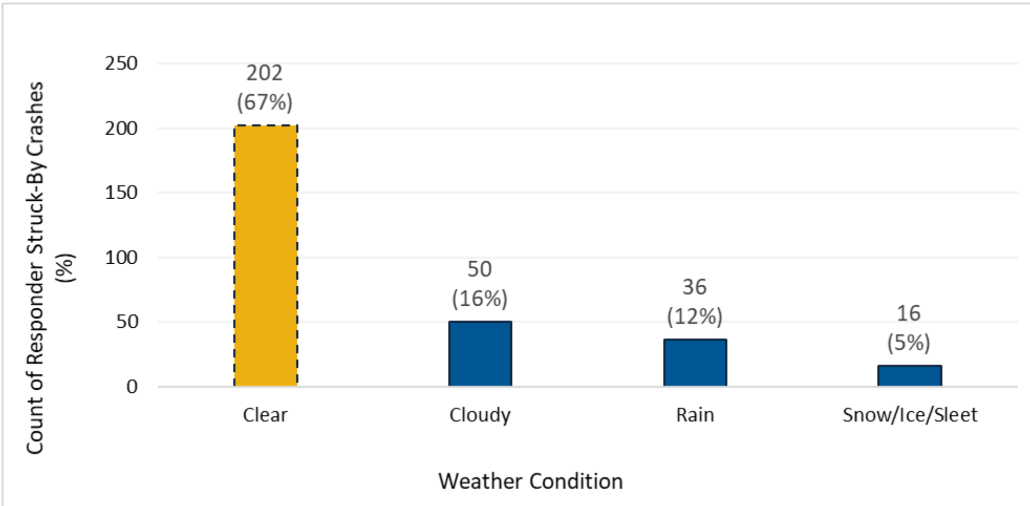
- ***Number of lanes per direction***—Information was only available for 27 of the responder struck-by crashes, which is about 5 percent of the sample size. Values ranged from one to five lanes.
- ***Roadway width***—Information was only available for three responder struck-by crashes, a very small percentage of the sample size (0.6 percent). The range of values included the following:
    - 12 ft. (This location was examined using the crash coordinates and is most likely the lane width. The road was a two-lane highway, with the full roadway width of 55 ft including the shoulders.)
    - 33 ft.
    - 64 ft.
- ***Median width***—Information was only available for 3 responder struck-by crashes, a very small percentage of the sample size (0.6 percent). The range of values included the following:
    - 0 ft.
    - 15 ft.
    - 35 ft.
- ***AADT***—Information was only available for 3 responder struck-by crashes, a very small percentage of the sample size (0.6 percent). The range of values included the following:
    - 18,200 vehicles per day (1 responder struck-by crash)
    - 200,000 vehicles per day (2 responder struck-by crashes)
- ***Shoulder type***—Information was available for 184 responder struck-by crashes:
    - 66 (36 percent) occurred on a road with a curb.
    - 78 (42 percent) occurred on a road with a paved shoulder.
    - 39 (21 percent) occurred on a road with an unpaved shoulder.

Due to the small sample size of responder struck-by crashes for which information is available on number of lanes, roadway width, median width, and AADT, these variables were not included in subsequent analyses, as the small sample size is unlikely to provide any useful information on crash causality.

Environmental and Lighting Conditions

The project team examined weather and lighting information (from the crash reports) associated with the struck-by crashes.

The information on weather conditions was available for 304 (60 percent) of the responder struck-by crashes. A breakdown of the number of responder struck-by crashes for various weather conditions is shown in figure 17. The majority of the responder struck-by crashes (67 percent) occurred during clear weather. Sixteen percent of responder struck-by crashes occurred during cloudy conditions, and 12 percent occurred during rainy conditions. Few of the struck-by crashes occurred in winter weather conditions.

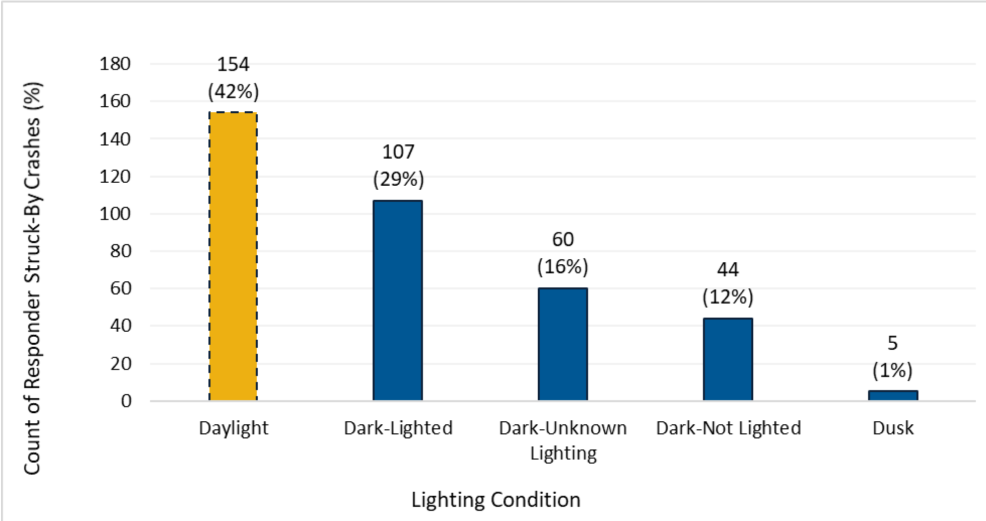


Source: Federal Highway Administration.

Figure 17. Chart. Breakdown of responder struck-by crashes by weather conditions.

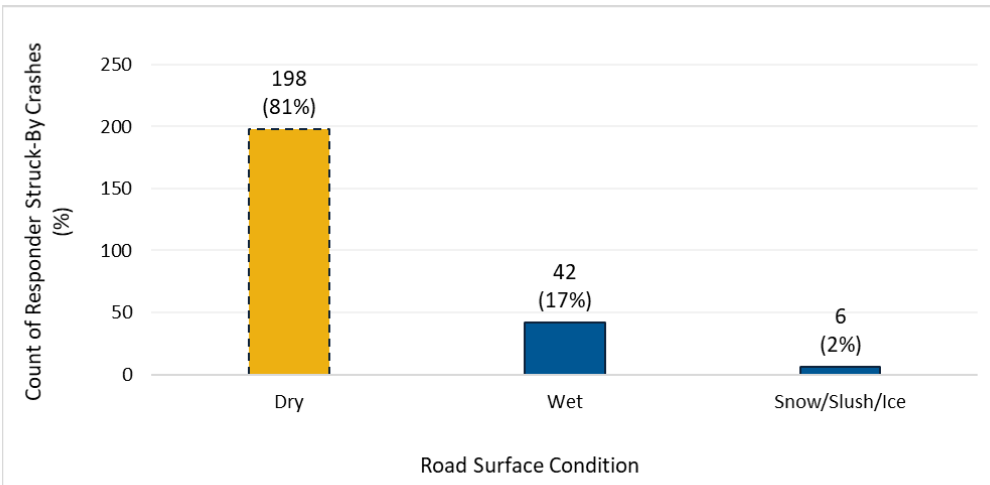
Figure 18 shows a breakdown of the number of responder struck-by crashes, which was available for 370 (73 percent) responder struck-by crashes, for various lighting conditions. The results show that 42 percent of the crashes occurred during daylight, 29 percent occurred at night/dark on lighted roadways, and 12 percent occurred at night/dark in nonlighted roadway conditions.

Information on roadway surface conditions was available for 246 of the responder struck-by crashes. A breakdown of the number of responder struck-by crashes for various roadway surface conditions is shown in figure 19. Most of the responder struck-by crashes (81 percent) occurred during dry conditions. Seventeen percent of the crashes occurred during wet pavement conditions. Only two responder struck-by crashes occurred when there was snow on the road.



Source: Federal Highway Administration.

Figure 18. Chart. Breakdown of responder struck-by crashes by lighting conditions.



Source: Federal Highway Administration.

Figure 19. Chart. Breakdown of responder struck-by crashes by roadway surface conditions.

Contributing Circumstances

The project team examined the contributing factors associated with the 505 responder struck-by crashes to assess if any contributing factors stood out. The project team examined contributing factors separately for responder struck-by crashes identified through crash reports (or from articles that were matched with crash reports) and responder struck-by crashes that were identified though other data sources that were not matched with crash reports. The contributing factors in both cases were categorized as follows:

- Driver—factors associated with driver experience and familiarity, manner of driving, and being under the influence of alcohol or drugs

- Environmental—factors associated with weather, lighting, or roadway surface conditions due to weather

- Roadway—factors associated with any obstructions on the roadway (such as physical objects, presence of work zones, or prior collision) that could impede a driver from seeing responders, and malfunction of roadway traffic control devices

- Other—factors that do not fall under the previous categories; this category includes contributing factors coded as “other”

- No contributing factor—this category includes the crashes coded with “no apparent contributing factor” or crashes with missing contributing factors

First, the project team examined the contributing factors for the 311 responder struck-by crashes identified through crash reports or through ERSI articles matched with crash reports (shown in table 10). It should be noted that 3 of these crashes had 2 contributing factors reported, therefore, the total number of contributing factors listed in table 10 is 314. The percentage of each contributing factor was computed by dividing the count of crashes associated with each contributing factor by 311 (as such, the percentages add up to slightly more than 100 percent). Only 79 of the 311 crashes identified through crash reports or through ERSI articles matched with crash reports had (at least) one contributing factor reported. Of these:

- For 25 out of 311 crashes (8 percent), the contributing factors were associated with driver actions. It should be noted that for only three crashes, the contributing factor was listed as “under the influence of alcohol/drugs.” In further examining the crash report variables for drug and alcohol involvement (crash reports have separate fields where alcohol and drug involvement are reported), there were discrepancies between these variables and the contributing factors/circumstances variable. This discrepancy can cause challenges in determining the contributing factors to crashes. This is not a challenge specific to responder struck-by crashes, but rather all crashes.

- For 13 of the 311 crashes (4.2 percent), the contributing factors were associated with environmental conditions.

- For 30 of the 311 crashes (9.6 percent), the contributing factors were associated with roadway conditions.

- For 11 out of the 311 crashes (3.5 percent), the contributing factor was listed as “other.”

For over 235 crashes (75 percent), there were no contributing factors listed. For 172 crashes (55 percent), the contributing factor was reported as “no apparent contributing factor,” whereas for 63 crashes (20 percent), the contributing factor was not listed (i.e., left blank) by the reporting officer.

Next, the project team examined the contributing factors that were extracted through a manual review of the crashes from other data sources. These 194 crashes were not matched with crash reports; therefore, the project team retrieved crash contributing factors from article narratives, and the description of the contributing factors may not necessarily align with the contributing factors listed in crash reports. However, the project team attempted to match the contributing factor descriptions as closely as possible. Of these 194 crashes, 4 crashes had 2 contributing factors, and 1 crash had 3 contributing factors; therefore, the total number of the contributing factors in table 11 is 200. The percentage of each contributing factor was computed by dividing the count of crashes associated with each contributing factor by 194 (as such, the percentages add up to slightly more than 100 percent).

Table 10. Contributing factors for responder struck-by crashes identified through crash reports.

Contributing Factor	Crash Count	Percent
Driver-Related Contributing Factors	**25**	**8.0**
• Other improper action	7	2.3
• Following too close/assured clear distance ahead (ACDA)	5	1.6
• Under influence of alcohol/drugs	3	1.0
• Failing to yield right of way	3	1.0
• Distracted/other (e.g., food, objects, pet)	2	0.6
• Improper lane change	2	0.6
• Driver inexperience	1	0.3
• Driver unfamiliar with area	1	0.3
• Stopped of parked illegally	1	0.3
Environment-Related Contributing Factors	**13**	**4.2**
• Weather conditions	5	1.6
• Slippery surface	4	1.3
• Road surface condition	3	1.0
• Wet road surface	1	0.3
Roadway-Related Contributing Factors	**30**	**9.6**
• Recent previous accident scene nearby	7	2.3
• Work zone, construction, maintenance, utility	8	2.6
• Nonhighway work	2	0.6
• Obstruction in roadway	5	1.6
• Other obstruction in roadway	3	1.0
• Stalled/disabled vehicle in roadway	2	0.6
• Prior crash	1	0.3
• Traffic control device inoperative, missing or obscured	1	0.3
• Traffic control device not visible, missing, inoperative	1	0.3
Other Contributing Factors	**11**	**3.5**
No Contributing Factors	**235**	**75.6**
• No apparent contributing factor	172	55.3
• Not coded	63	20.3
Total	**314**	**101.0**

For 67 crashes (34.5 percent), the contributing factors were associated with driver actions. For a third of these crashes (24 crashes, or 12 percent), the contributing factor was driving under the influence of drugs and/or alcohol. Speeding was the second largest driver-related contributing factor, which was listed for 15 crashes (almost 8 percent). For 8 crashes (4 percent), the contributing factors were environmental—related to weather conditions or lack of visibility. For 125 crashes (64 percent), the project team was unable to determine a contributing factor based on the review of the article/narrative.

Table 11. Contributing factors for responder struck-by crashes not matched with crash reports.

Contributing Factor	Crash Count	Percent
Driver-Related Contributing Factors	**67**	**34.5**
• Driving under the influence	24	12.4
• Speeding	15	7.7
• Reckless driving	7	3.6
• Distracted driving	6	3.1
• Failure to move over	6	3.1
• Loss of control	6	3.1
• Disregard for road closure	2	1.0
• Swerving	1	0.5
Environment-Related Contributing Factors	**8**	**4.1**
• Lack of visibility (smoke, sunlight)	2	1.0
• Weather (blizzard, ice, snow)	6	3.1
No Contributing Factor	**125**	**64.4**
Total	**200**	**103.1**

IN-DEPTH ANALYSIS OF RESPONDERS INVOLVED IN STRUCK-BY CRASHES

This section provides descriptions of more-in-depth analyses conducted by the project team to determine if any variables of interest (responder-level variables derived from manual review or crash-level variables obtained from the crash reports) have an impact on responder struck-by crashes. Based on the findings from the data summaries, and the limited sample size of some of the variables as previously discussed, the project team considered the following variables for further exploration and analyses:

- **Time of occurrence** (month, day of week, and time of day)
- **Area type** (urban versus rural) and roadway classification (interstate highway, U.S. highway, State highway, county road, local road, and tollway)
- **Environmental and lighting conditions** (weather, roadway surface, and lighting)
- **Contributing factors** (driver, environmental, roadway, other, and none)

- **Responder type** (whether the responders are law enforcement officers, firefighters, EMS, tow operators, or SSP)

- **Responder location** (whether the responder struck was a nonmotorist (on foot, outside their vehicle) or an occupant of their parked response vehicle

- **Response type** (the reason for the response, which included collision, noncollision, traffic stop, debris, and other (such as directing traffic))

- **Responder injury severity** (follows the KABCO scale (as previously defined))

These variables of interest were incorporated into different analyses focused on three general research topics:

1. Whether the observed frequency distribution of responder struck-by crashes for time of occurrence is statistically different from the expected distribution (i.e., uniform distribution). These analyses were performed using the chi-square goodness-of-fit test.
2. Whether there is any correlation among the variables and the associated correlation value (ranging from 0 to 1). These analyses were conducted using the Cramér's V test.
3. Whether any variables are associated with different clusters of responders involved in struck-by crashes.
4. These analyses were conducted using the k-modes clustering method.

The following subsections provide details on each of these analyses and the associated findings.

Chi-Square Tests of Frequency Distributions of Responder Struck-by Crashes

The project team performed chi-square goodness-of-fit tests on the frequency distribution of responder struck-by crashes for three crash-related variables: month, day of week, and hour of crash. The project team conducted these tests to determine whether the observed distribution of responder struck-by crashes within these variables was statistically different from the expected distribution. If these variables do not impact the occurrence of responder struck-by crashes, then the count of responder struck-by crashes is expected to be uniformly distributed across the months of the year, days of the week, and hours of the day. However, as seen in figure 13 through figure 15, the frequency of responder struck-by crashes within these variables does not appear to be uniformly distributed. Therefore, the chi-square goodness of fit test was used to test the null hypothesis (H_0) that there is no significant difference between the observed and expected frequencies.

The observed and expected frequency of responder struck-by crashes by month are shown in table 12. The observed values are the counts of responder struck-by crashes that occurred in each of the months for the crashes in the composite database. The project team calculated expected frequencies, assumed to be uniformly distributed across the months of the year, by dividing the total number of crashes in the database (all 505 crashes had information on the month of the year) by the number of months per year (505/12 = 42.1).

The chi-squared test resulted in a p-value of 0.04, which is smaller than the p-value of 0.05 (confidence level of 95 percent). Therefore, the null hypothesis is rejected—the two distributions (observed and expected frequencies of responder struck-by crashes across months of the year) are statistically different from each other, which means that month of year may have an impact on the occurrence of responder struck-by crashes. While the chi-square test informs the statistical significance of the difference between the observed and expected frequencies of responder struck-by crashes across the months of the year, it does not specifically inform of which months may impact the occurrence of responder struck-by crashes. However, observation of the distribution of crashes over the months shows that January was the month with the highest number of crashes (60), followed by October (49) and February (47). April, May, and June were the months with the fewest number of crashes (31, 27, and 33, respectively).

Table 12. Observed and expected frequencies of responder struck-by crashes by month.

Month	Observed Frequency	Expected Frequency
January	60	42
February	47	42
March	45	42
April	31	42
May	27	42
June	33	42
July	44	42
August	40	42
September	41	42
October	49	42
November	44	42
December	44	42
Total	505	505

The project team used a similar approach for comparing the distribution of observed and expected of frequencies of responder struck-by crashes across days of week (shown in table 13). The observed values are the counts of responder struck-by crashes in the composite database for each day of the week. Expected frequencies, which were assumed to be uniformly distributed across the days of the week, were calculated by dividing the total number of responder struck-by crashes in the database by the number of days in a week (505/7 = 71.2). The chi-square test for comparing observed and expected frequencies across the days of the week resulted in a p-value of 0.19, which means the null hypothesis is not rejected with a 95-percent confidence level. In other words, day of week may not have an impact on the occurrence of responder struck-by crashes based on hypothesis testing with the sample of data at hand.

Table 13. Observed and expected frequencies of responder struck-by crashes by day of week.

Day of Week	Observed Frequency	Expected Frequency
Monday	70	72
Tuesday	69	72

Wednesday	72	72
Thursday	55	72
Friday	86	72
Saturday	83	72
Sunday	70	72
Total	505	505

The observed and expected values for responder struck-by crashes by time of day are shown in table 14. The observed values are the counts of responder struck-by crashes in the composite database by hour of the day. The project team calculated expected frequencies, which were assumed to be uniformly distributed across the hours of the day, by dividing the total number of responder struck-by crashes in the sample (only 435 crashes in the database had information on the hour of day) by the number of hours per day (435/24 = 18.1). The chi-square test for comparing observed and expected frequencies of responder struck-by crashes by hour of the day resulted in a p-value of 0.06. Therefore, the null hypothesis cannot be rejected with a 95-percent confidence level. In other words, time of day may not have an impact on the occurrence of responder struck-by crashes based on hypothesis testing with the sample of data at hand.

Table 14. Observed and expected frequencies of responder struck-by crashes by time of day.

Time of Day	Observed Frequency	Expected Frequency
1 a.m.	12	18
2 a.m.	23	18
3 a.m.	13	18
4 a.m.	12	18
5 a.m.	13	18
6 a.m.	23	18
7 a.m.	16	18
8 a.m.	14	18
9 a.m.	16	18
10 a.m.	14	18
11 a.m.	16	18
12 p.m.	12	18
1 p.m.	17	18
2 p.m.	13	18
3 p.m.	16	18
4 p.m.	22	18
5 p.m.	19	18
6 p.m.	28	18
7 p.m.	21	18
8 p.m.	19	18
9 p.m.	28	18

10 p.m.	20	18
11 p.m.	28	18
12 a.m.	20	18
Total	435	435

Variables of Interest Correlation Test

The project team performed a correlation test on the variables of interest to determine if any of these variables were correlated. Correlation implies that variables are dependent to some degree. The project team used the Cramér's V test for the analysis, which results in a matrix of the variables of interest (as rows and columns) and a value for the correlation between any pairs of variables. This correlation value ranges from 0 to 1, with values 0 or near 0 indicating little or no correlation and values near 1 indicating high correlation.

The results showed correlations of higher than 0.5 between the following variables:

- Area type (urban versus rural), roadway functional classification, and shoulder type—This can be expected since roadway characteristics, especially pertaining to design, are associated with area type and roadway classification.

- Area type, roadway functional classification, and shoulder type with roadway surface conditions—This may be related to the fact that roadways of higher functional classification may have better surface conditions as compared to lower functional classification roads.

The correlation values are for the most part expected and should not pose difficulties in carrying out further analyses.

Cluster Analysis

Cluster analysis is a statistical method for processing data. It works by organizing items into groups, or clusters, on the basis of how closely associated/similar they are. Cluster analysis is an unsupervised learning algorithm, meaning that the number of clusters is not known before running the model. Unlike many other statistical methods, cluster analysis is typically used when there is no assumption made about the likely relationships within the data. It provides information about where associations and patterns in data exist but not what those associations/patterns might be or what they mean.

Data cleaning is an essential preparatory step for successful cluster analysis. Clustering works at a dataset level where every point is assessed relative to the others, so the data must be as complete as possible (Qualtrics 2023). Since some of the crashes had missing values for several of the variables, for the purposes of clustering, these missing values were replaced with the word "Unknown."

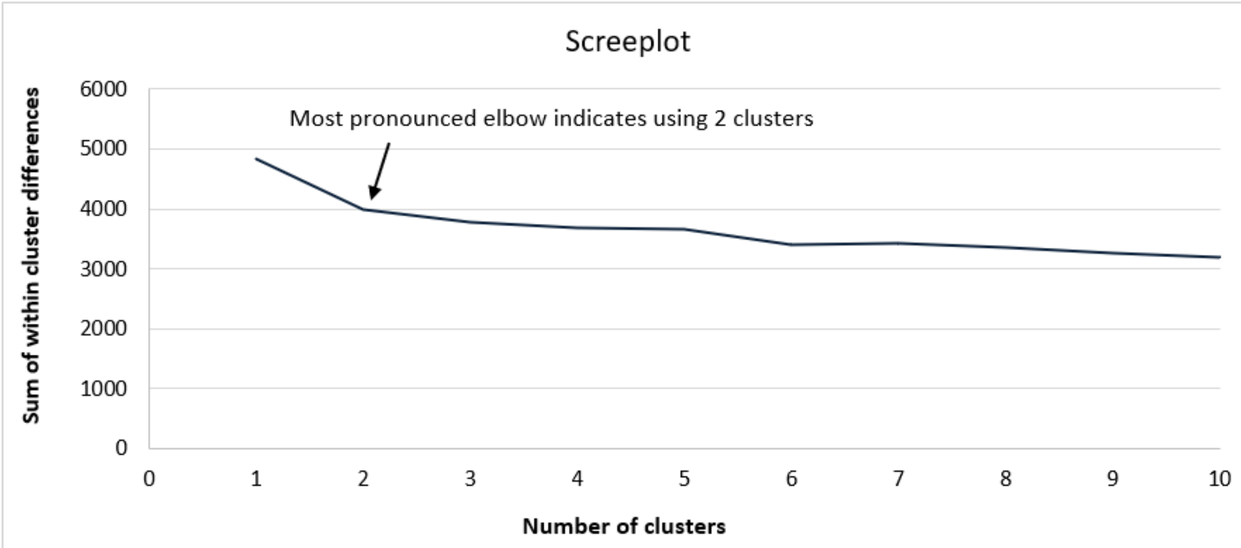
The next step in running a cluster analysis is to find the appropriate algorithm for the data at hand. The responder struck-by data are mostly categorical, as the data variables contain a finite number of categories or distinct groups, and the data might not have a logical order. Because the responder struck-by data are mostly categorical, the project team used the k-modes clustering algorithm, which works well for categorical data. The software package R-Studio, which was used for the analysis, requires the dataset on which the algorithm will be run to be specified (the data have to be a matrix or data frame of categorical data). Observations/records must be in rows and variables in columns.

Additionally, the analyst must also specify the number of modes/clusters. A random set of (distinct) rows in data are chosen as the initial modes. For the purposes of this clustering analysis, two clusters were chosen as the initial number.

Once the algorithm runs, it assigns each record to a cluster. The cluster assignment is provided as a vector of integers indicating the cluster to which each record is allocated.

The k-modes approach modifies the standard k-means process for clustering categorical data by replacing the Euclidean distance function with the simple matching dissimilarity measure, using modes to represent cluster centers, and updating modes with the most frequent categorical values in each of the iterations of the clustering process. These modifications guarantee that the clustering process converges to a local minimal result. The mode vector minimizes the sum of the distances between each object in the cluster and the cluster center (Saini 2021). Since the cluster algorithm does not specify the number of clusters that provides the best solution for a dataset, the algorithm can be run for several numbers of clusters (i.e., start with two clusters and continue from there) and obtain the within differences (a combined statistic that considers the individual distances of each record from the center (mode) of the cluster). Each time the algorithm is run with a different number of clusters, this statistic can be obtained and the results plotted. Typically, there should be an elbow (drop) in the plot of these within differences versus the number of clusters, also called a scree plot. Where the elbow (drop) is most emphasized is typically taken as the most appropriate/feasible solution (number of clusters).

The cluster analysis was performed on the 590 responders struck records to include the responder-related variables in the clustering. The scree plot for the responders involved in struck-by crashes dataset is shown in figure 20. While a drastic drop in the sum of within cluster differences is not present, the most pronounced elbow is seen for two clusters (pointed by an arrow in figure 20).

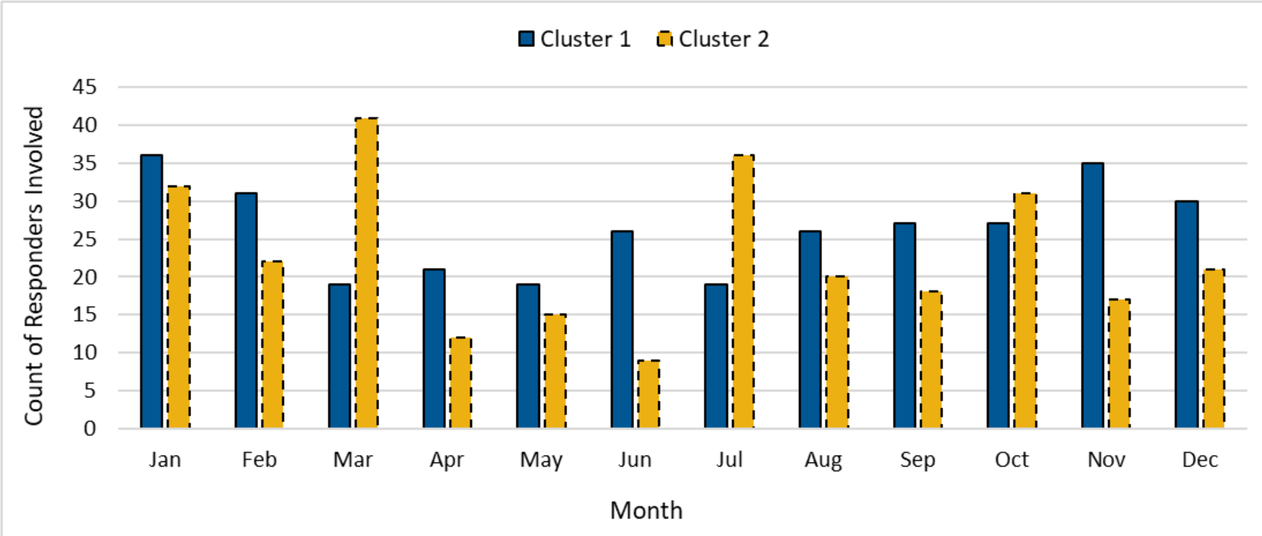


Source: Federal Highway Administration.

Figure 20. Chart. Scree plot for k-modes clustering algorithm on responders involved in struck-by crashes data.

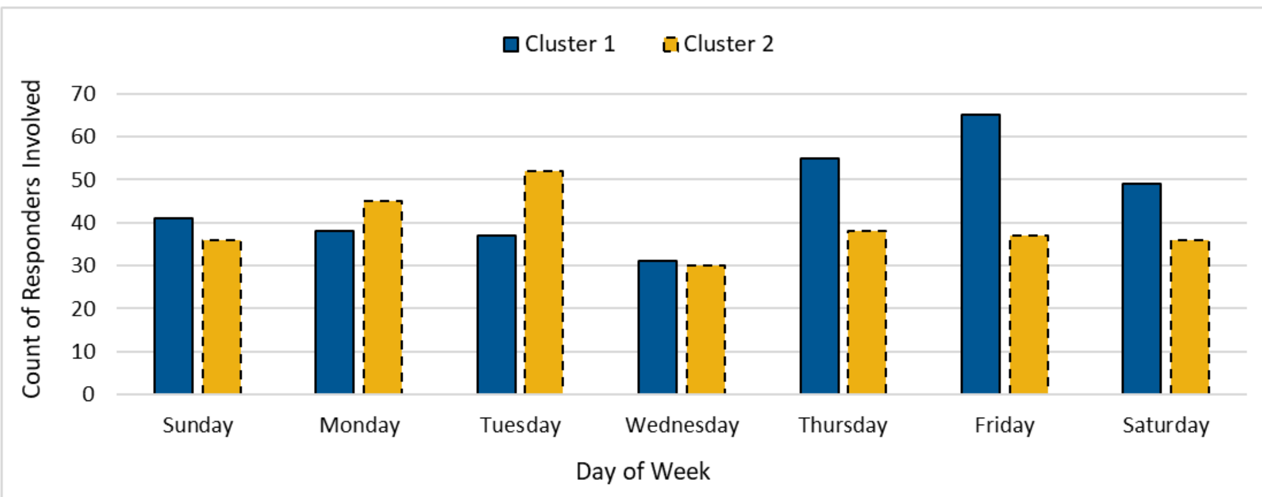
The project team examined the resulting cluster assignment by using bar charts of each of the variables accounted for in the clustering to determine which variables played a role in the clustering and what values of the variables are seen in each of the clusters. Generally speaking, a good clustering will split the data into groups for which the values of certain variables will be different.

First, the project team examined the time of occurrence variables based on the cluster assignment. The bar charts for month of year, day of week, and hour of day are illustrated in figure 21, figure 22, and figure 23, respectively. The charts show that each of the two clusters contains responder records that occur in every month of the year, day of the week, and hour of the day without any striking difference between the two clusters. However, closer inspection does show some minor differences in the distribution of responders struck across the two clusters. For example, figure 22 shows that Cluster 1 has more responders struck on Thursdays, Fridays, and Saturdays and somewhat on Sundays than Cluster 2, which has slightly more responders struck on Mondays and Tuesdays. While it should be noted that the chi-square test results for day of week were inconclusive, the cluster assignment does seem to follow the general pattern seen visually in figure 14, which shows a higher number of responders struck during the weekend, particularly on Fridays and Saturdays.



Source: Federal Highway Administration.

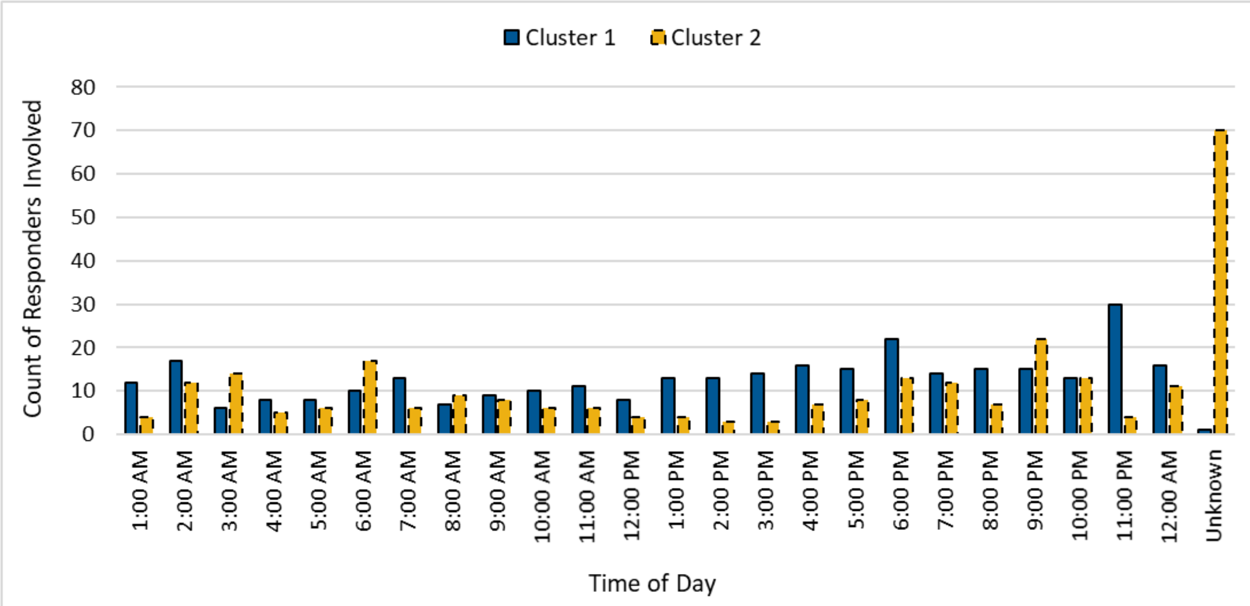
Figure 21. Chart. Responders involved in struck-by crashes by month of year for the two clusters.



Source: Federal Highway Administration.

Figure 22. Chart. Responders involved in struck-by crashes by day of week for the two clusters.

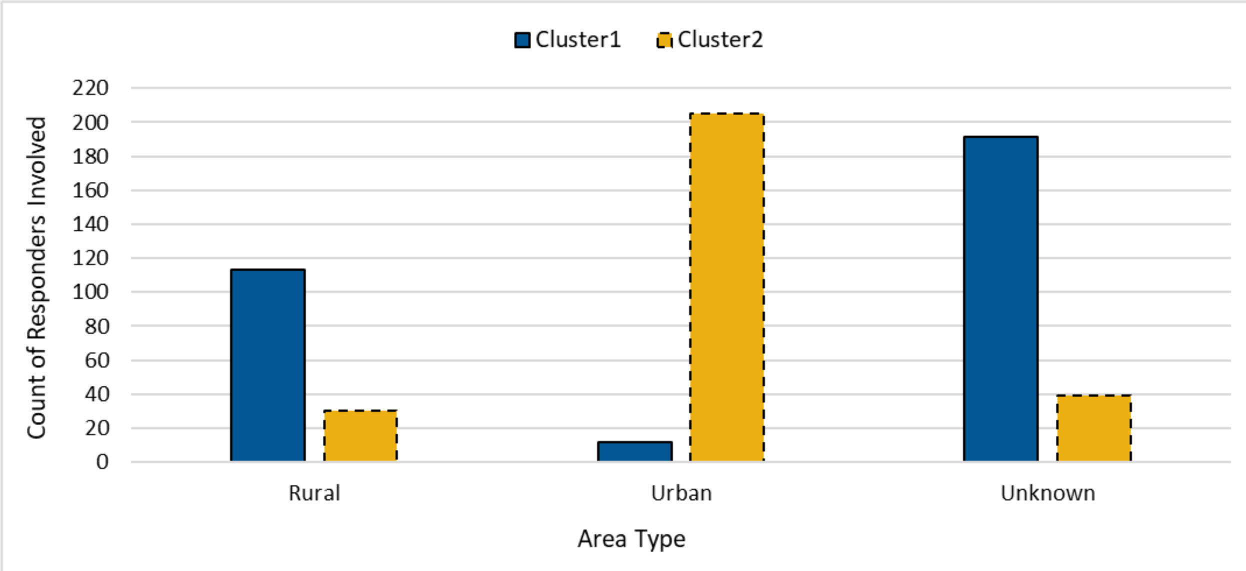
Figure 23 shows how the responder struck-by records with "unknown" values for a variable impact the cluster assignment based on that variable (in this case, cluster assignment based on time of day). As it can be seen, the majority of the records with unknown time are assigned to Cluster 2. The remaining records are split between Cluster 1 and Cluster 2.



Source: Federal Highway Administration.

Figure 23. Chart. Responders involved in struck-by crashes by time of day for the two clusters.

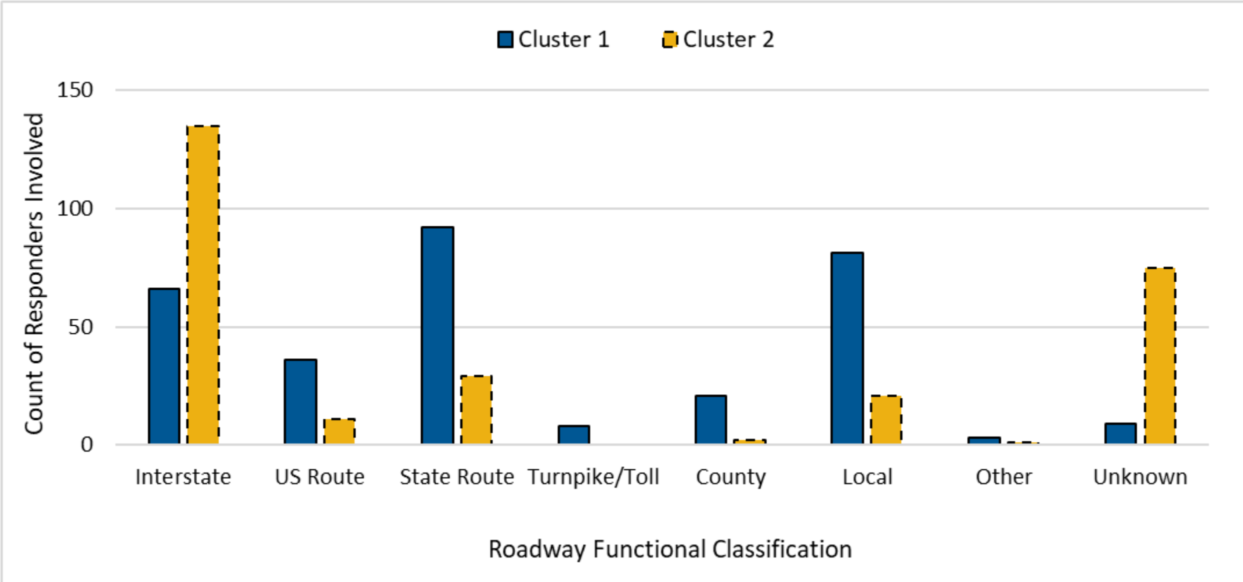
Next, the project team examined the area type, roadway classification, and shoulder type based on cluster assignment, and these are shown in figure 24, figure 25, and figure 26, respectively. For area type, it can be seen that most of the responders struck in rural areas fall in Cluster 1, while most of the responders struck in urban areas fall in Cluster 2; however, Cluster 1 also contains a large number of responders struck where the area type is unknown. Thus, it is clear that the crashes where the area type is unknown (40 percent of the dataset) did have some impact on the cluster assignment.



Source: Federal Highway Administration.

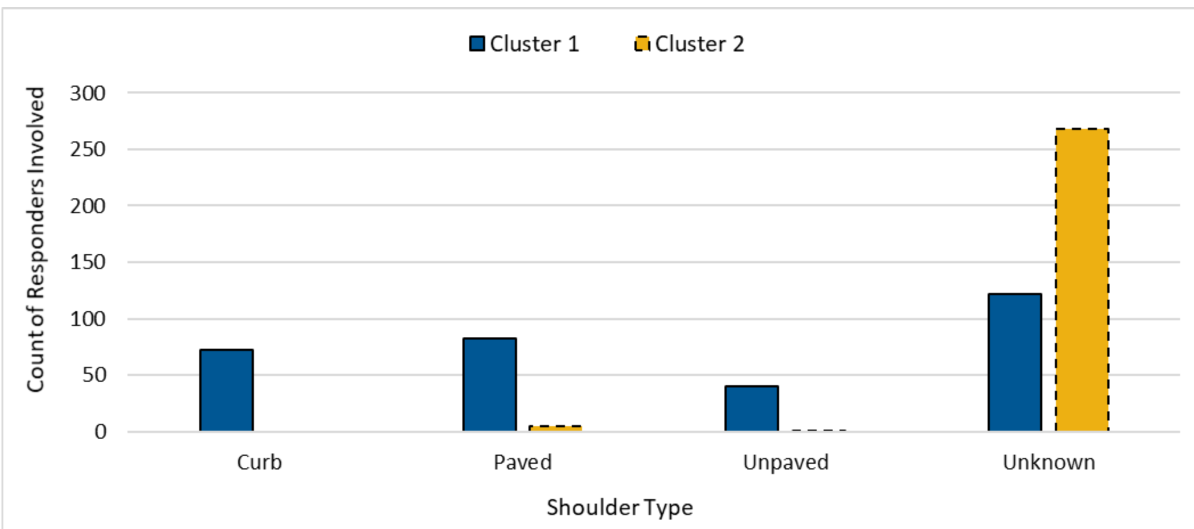
Figure 24. Chart. Responders involved in struck-by crashes by area type for the two clusters.

The cluster assignment for roadway classification shows that each of the two clusters contains records of responders struck that occur in every roadway classification category, except for the few responders struck on turnpike/toll roads, which are entirely contained in Cluster 1. However, Cluster 2 contains over twice as many responders struck on interstates, as well as most of the responders struck on roads of unknown functional class as compared to Cluster 1. Cluster 1, on the other hand, contains many more responders struck on all other types of roads as compared with Cluster 2.



Source: Federal Highway Administration.

Figure 25. Chart. Responders involved in struck-by crashes by roadway classification for the two clusters.

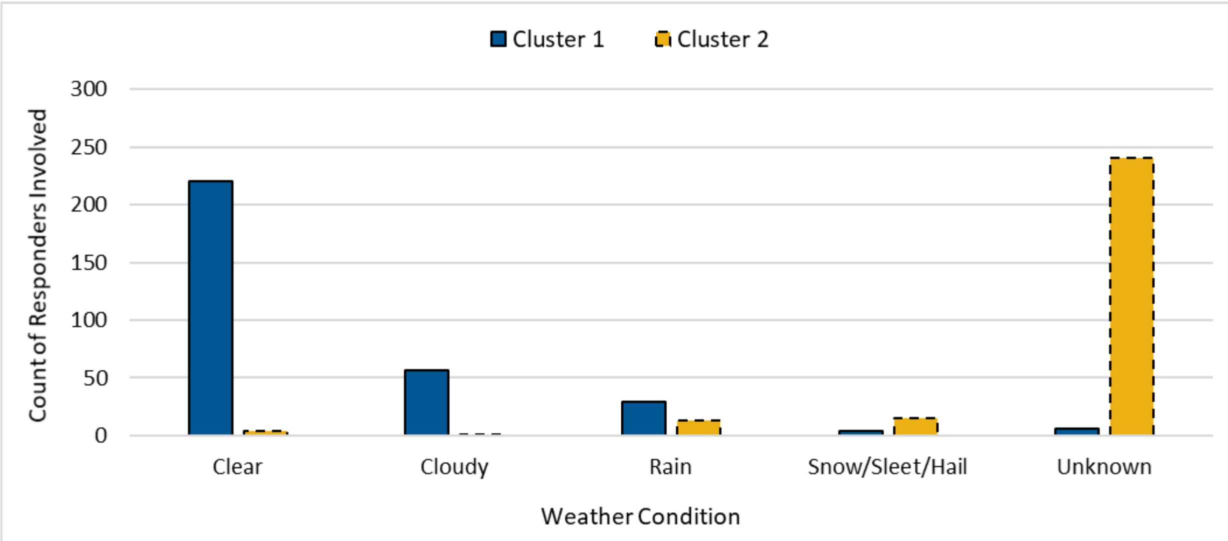


Source: Federal Highway Administration.

Figure 26. Chart. Responders involved in struck-by crashes by shoulder type for the two clusters.

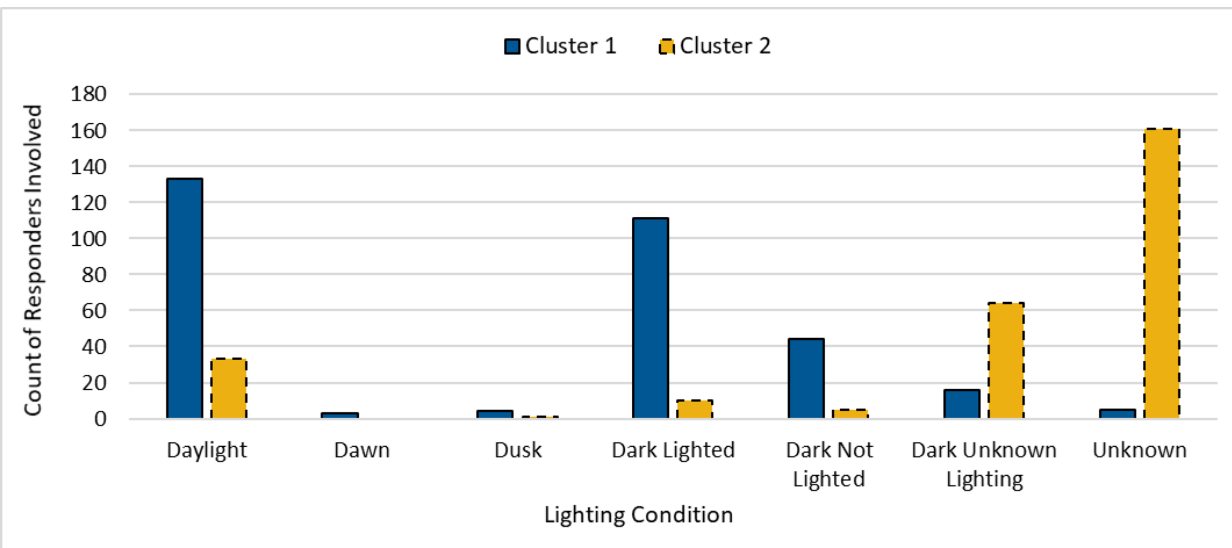
Next, the project team examined the cluster assignment based on environmental conditions. Figure 27, figure 28, and figure 29 illustrate the number of responders involved in struck-by crashes by weather conditions, lighting conditions, and roadway surface conditions, respectively, for each of the two resulting clusters.

The bar charts of the responders involved in struck-by crashes by each of these environmental variables do not show any indication that the clustering occurred on specific values of these variables. Rather the clustering results show that Cluster 2 includes all/most of the unknown values of these variables, as well as some of the known values.



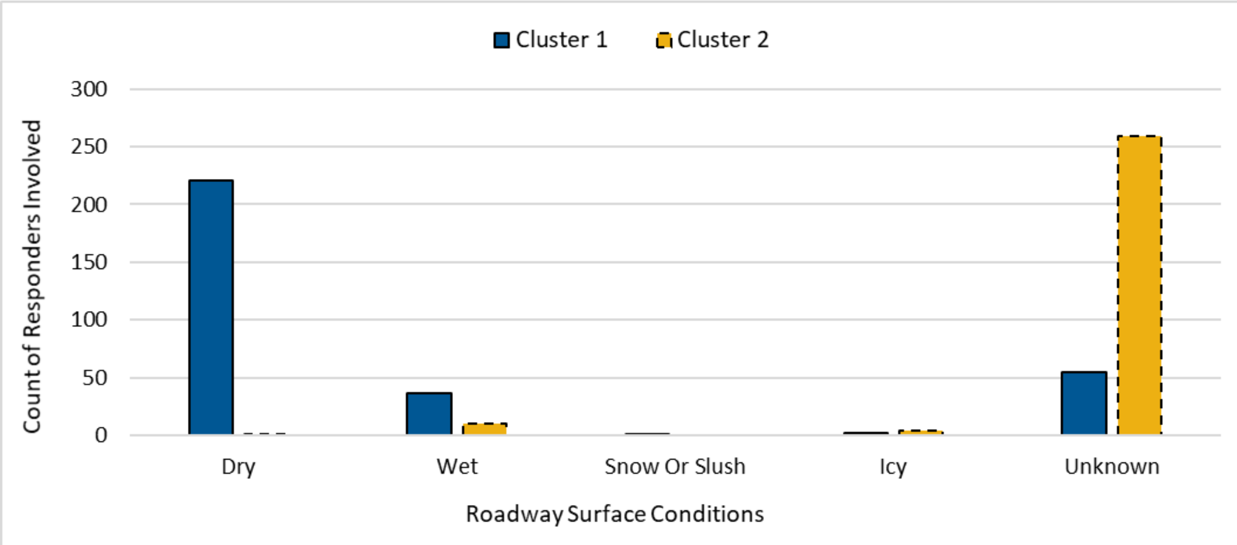
Source: Federal Highway Administration.

Figure 27. Chart. Responders involved in struck-by crashes by weather conditions for the two clusters.



Source: Federal Highway Administration.

Figure 28. Chart. Responders involved in struck-by crashes by lighting conditions for the two clusters.



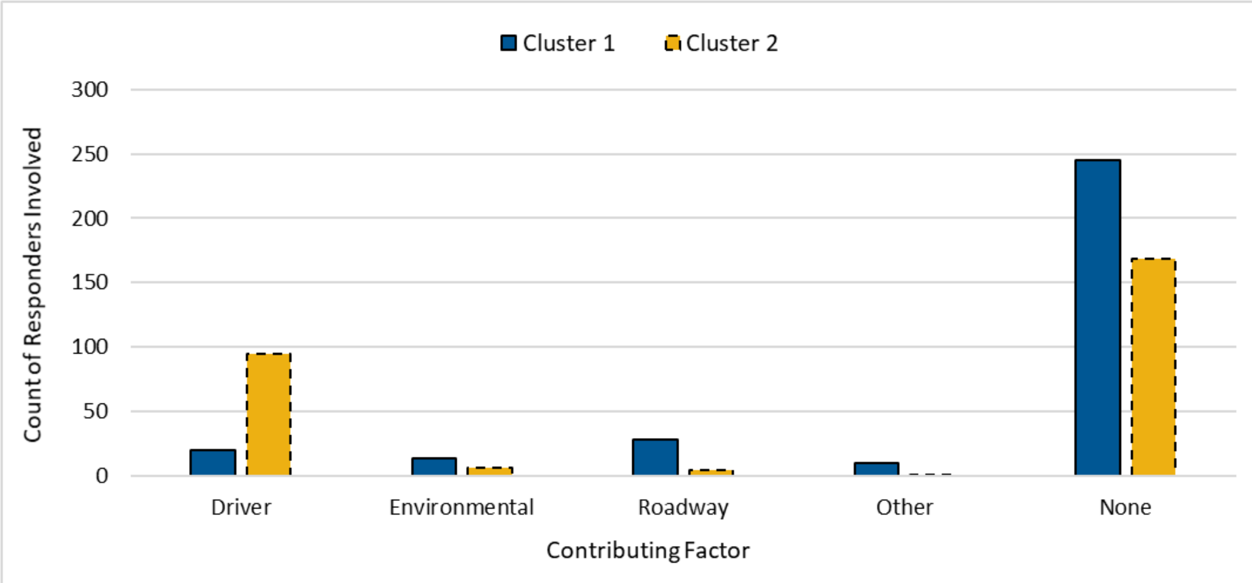
Source: Federal Highway Administration.

Figure 29. Chart. Responders involved in struck-by crashes by roadway surface conditions for the two clusters.

Similarly, the cluster assignment for the responder struck-by crashes based on the contributing factors (illustrated in figure 30) shows that the two clusters take on values for each of the contribution factor categories (driver, environmental, roadway, other, and none).

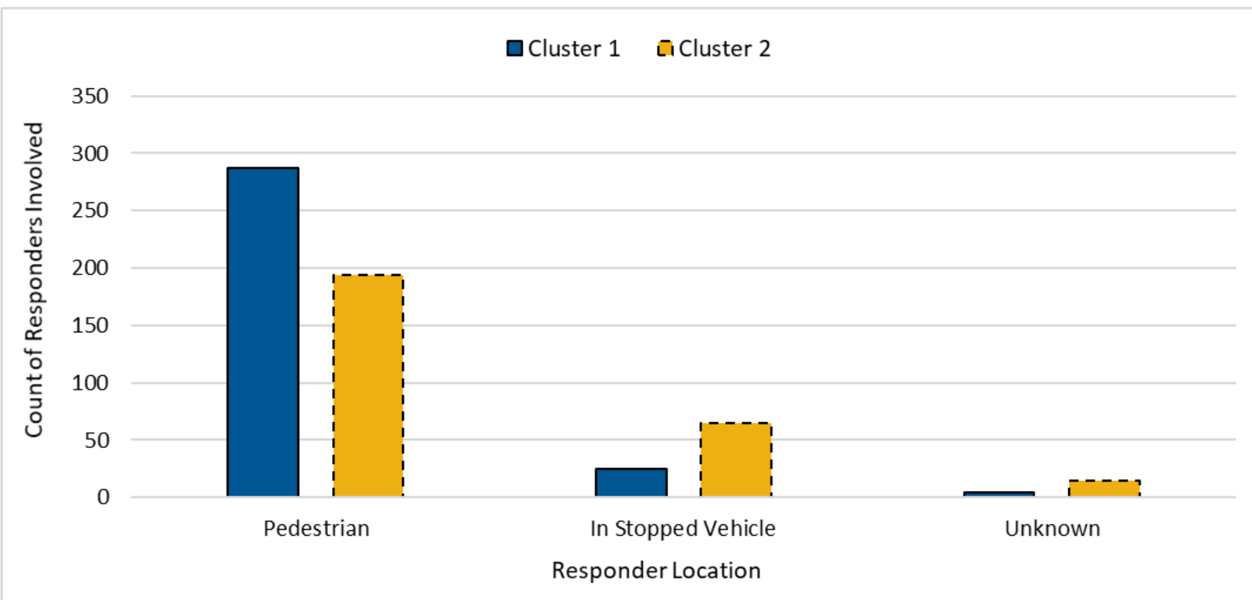
Lastly, the project team examined the responder-specific variables to determine whether they impacted the clustering assignment. Figure 31 (responder location), figure 32 (response type), figure 33 (responder type), and figure 34 (injury severity) depict the number of responders involved in struck-by crashes by responder-specific variables for each of the two resulting clusters.

For responder location at the time of the struck-by, the assigned clusters are split between each of the categories, with more responders struck as pedestrians in Cluster 1 and more responders struck in parked responder vehicles in Cluster 2.



Source: Federal Highway Administration.

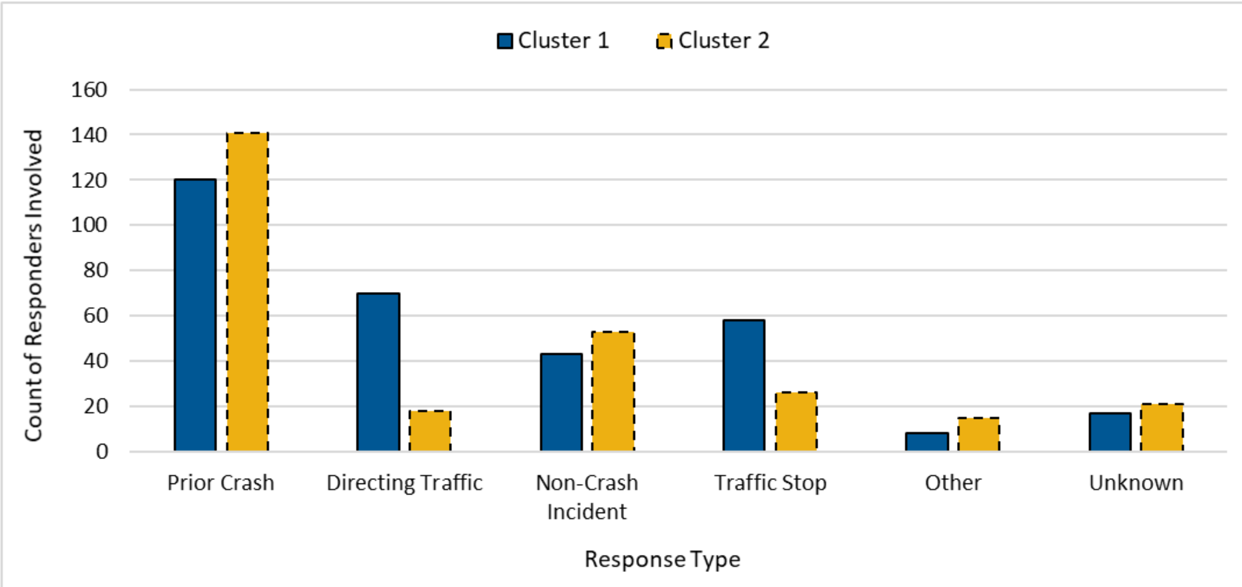
Figure 30. Chart. Responders involved in struck-by crashes by contributing factors for the two clusters.



Source: Federal Highway Administration.

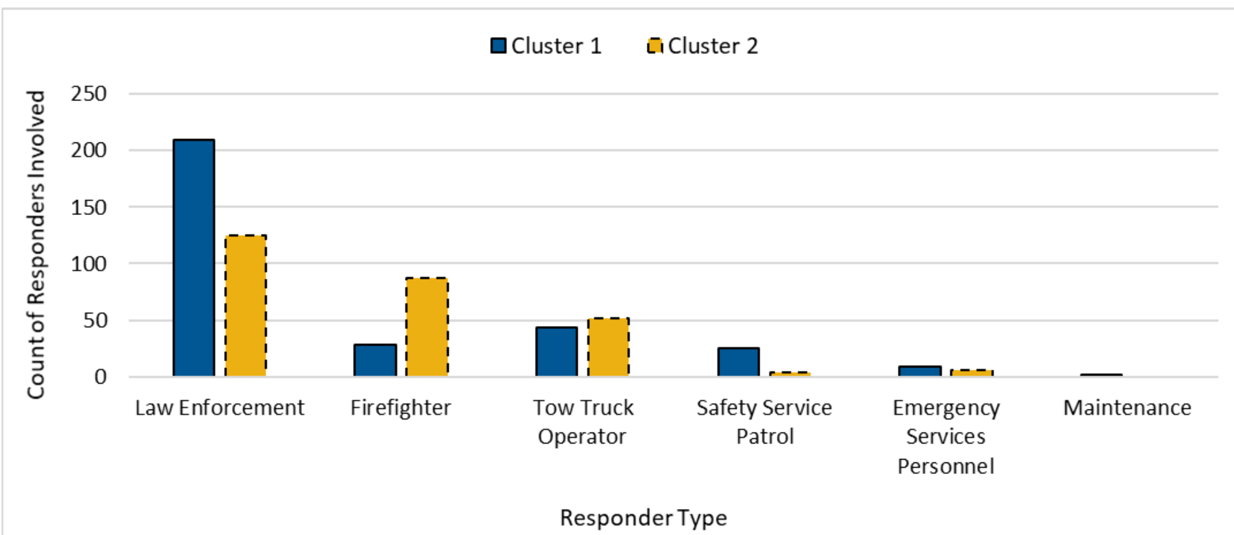
Figure 31. Chart. Responders involved in struck-by crashes by responder location for the two clusters.

Similarly, the bar charts that illustrate the cluster assignments for responders involved in struck-by crashes by response type, responder type, and responder injury severity show that the clusters are split across all the values of the response types (both clusters take on values of all the categories of these variables). However, for responder type, Cluster 1 contains more law enforcement officers struck, and Cluster 2 contains more firefighters struck. Similarly for injury type, Cluster 2 contains more responders who were fatally or seriously injured, whereas Cluster 1 contains a higher number of responders who suffered less severe injuries, specifically, suspected minor injuries, possible injuries, or no apparent injuries.



Source: Federal Highway Administration.

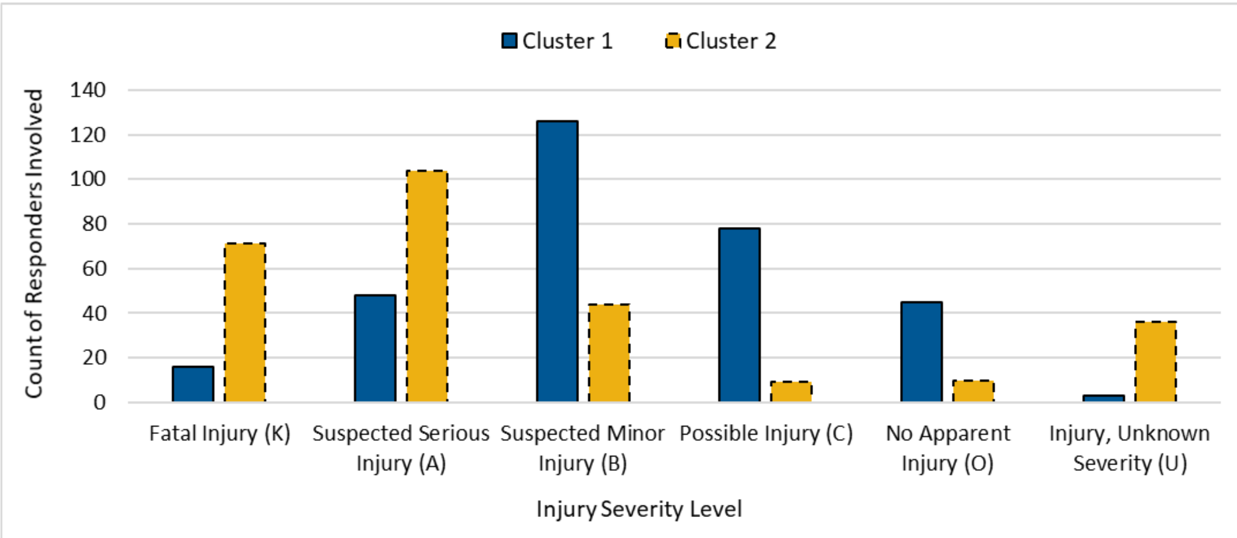
Figure 32. Chart. Responders involved in struck-by crashes by response type for the two clusters.



Source: Federal Highway Administration.

Figure 33. Chart. Responders involved in struck-by crashes by responder type for the two clusters.

The results of the cluster analyses are greatly affected by the large portion of unknown values across the variables for the crashes in the dataset. While theoretically for the cluster algorithm, the two resulting clusters may be correct, practically speaking, the resulting cluster assignments do not provide much additional useful information in terms of determining which variable values impact responder struck-by crashes for each group.



Source: Federal Highway Administration.

Figure 34. Chart. Responders involved in struck-by crashes by injury severity for the two clusters.

FLORIDA CASE STUDY ON RESPONSE VEHICLE ONLY STRUCK-BY CRASHES

The current definition of a responder struck-by crash accounts for responders who are struck as nonmotorists/pedestrians, as well as occupied and unoccupied responder vehicles struck while parked at traffic incidents. While the focus of this research has been mostly on compiling and analyzing responder struck-by crashes resulting in injuries and fatalities, those involving responder vehicles only could represent "near-miss" struck-by crashes with responders. Indeed, if a responder vehicle is struck, a responder is likely not far away. As such, looking at responder vehicle struck-bys in more depth could be insightful.

The challenge is identifying responder vehicle struck-bys in the data. While finding crashes involving police, fire, and EMS vehicles in many State crash data systems is relatively easy due to the use of vehicle functional use codes that differentiate those vehicles from others, it is more challenging to determine which of these vehicles were stopped/parked at traffic incident scenes. Furthermore, finding towing and safety service patrol vehicles involved is a challenge, because codes for these vehicles are not widely used in State crash reporting systems. There have been efforts to build queries using a host of crash reporting data elements to uncover responder vehicles struck at traffic incidents, but most have only been successful at narrowing the potential field of responder vehicle struck-by crashes. Ultimately, a review of each report, narrative, and diagram is needed to verify response vehicle involvement. Such labor-intensive follow-up has not been undertaken for vehicle struck-by crashes given the large number of crashes that would need to be searched.

Additionally, some data sources capture fatal crashes only (e.g., ODMP, International Towing and Recovery Hall of Fame and Museum Wall of the Fallen), and others place a focus on capturing crashes resulting in injuries or fatalities (e.g., ERSI, TTIRS); therefore, very few (if any) responder vehicle struck-bys would be found in these datasets. Thus, this case study leverages past work conducted in Florida to pinpoint crashes involving responder vehicles at traffic incident scenes (Carrick and Srinivasan 2022).

Overview of Responder Vehicle Only Struck-by Crashes Examined in Florida

The responder vehicle only struck-by crashes were identified by two different methods: 1) examining crashes that involved move-over citations (2011–2020), and 2) examining crashes that involved a Road Ranger Safety Patrol (RRSP) vehicle based on records kept by the RRSP contractors (2014–2021). A search of Florida crash report narratives identified a total of 895 known crashes at traffic incidents where responders were present (a criteria necessary to meet the definition of a struck-by crash). Additional filtering was necessary to clean the data for reliable vehicle struck-by crashes. There were 47 duplicate crashes between the two approaches used to search for the potential struck-by crashes (i.e., move-over citations and RRSP vehicles struck). Next, 162 crashes were removed because they did not involve a responder vehicle struck but some other type of vehicle or only a pedestrian responder. The final result was 686 documented response-vehicle-only struck-by crashes.

The following two sections summarize the statistics associated with the crash-related variables and the responder vehicle-related variables for the responder vehicle struck-by crashes.

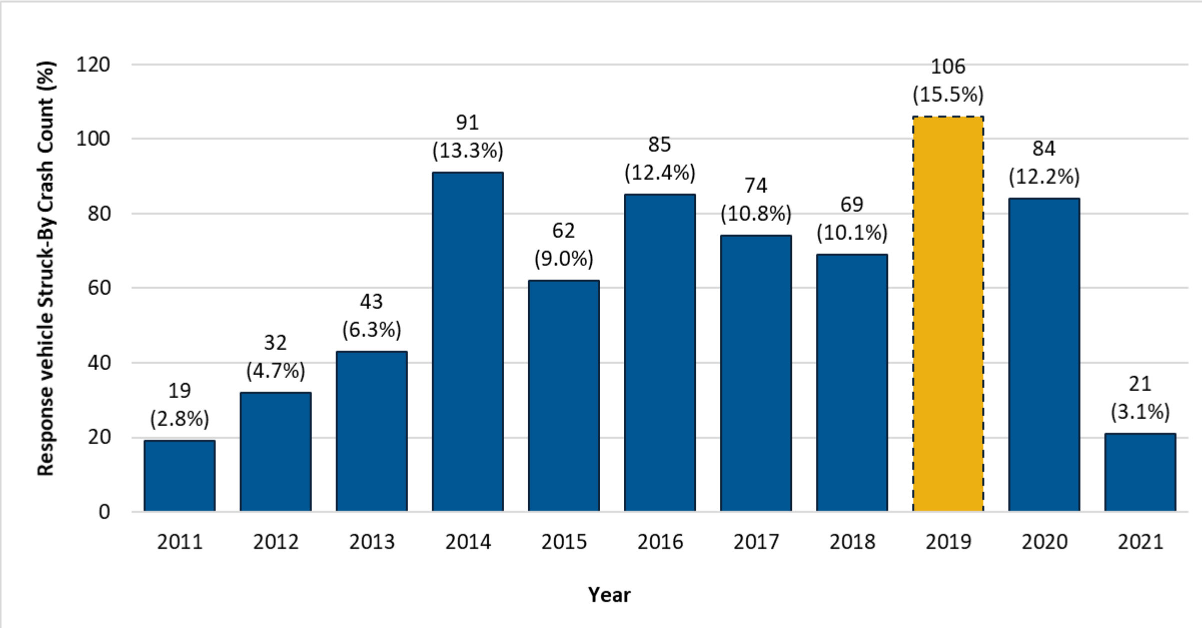
Summary Statistics of Crash-Related Variables

In this step, the following crash-related (i.e., crash-level) variables from the crash reports were analyzed:

- Time of occurrence (e.g., year, month, day of week, and time of day)
- Area type (urban versus rural) and roadway classification (e.g., interstate highway, U.S. highway, State highway, county road)
- Environmental and lighting conditions (e.g., lighting, weather)
- Crash contributing factors (e.g., driver, roadway, environmental)

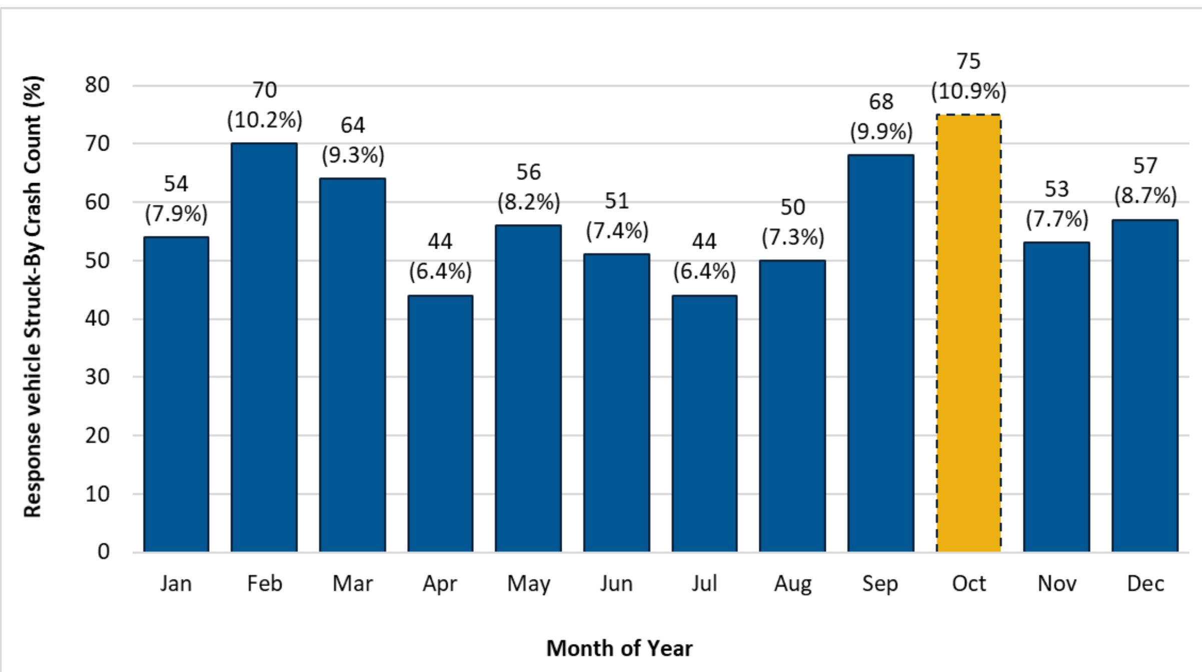
The project team first examined the distribution of the responder vehicle struck-by crashes by year, month, day of the week, and time of the day. A visual examination of the distribution of these crashes by year, illustrated in figure 35, showed that the majority of the crashes identified (over 80 percent) occurred between 2014 and 2020.

Figure 36 depicts the distribution of responder vehicle struck-by crashes by month of the year. The months associated with the most responder vehicle struck-by crashes are those in the fall and late winter/early spring, namely October (10.9 percent), February (10.2 percent), September (9.9 percent), and March (9.3 percent). For the most part, these results appear to follow the monthly distribution of responder struck-by crashes (shown previously in figure 13). For both cases, the month of October saw an uptick in crashes, and the months of February and March also experienced a sizeable portion of crashes (about 20 percent). It should be noted that while the responder dataset was compiled from crashes throughout the United States (although a significant sample of those crashes occurred in Florida), the responder-vehicle-only data were entirely from Florida, where the climate is quite different from that in other areas of the county.



Source: Federal Highway Administration.

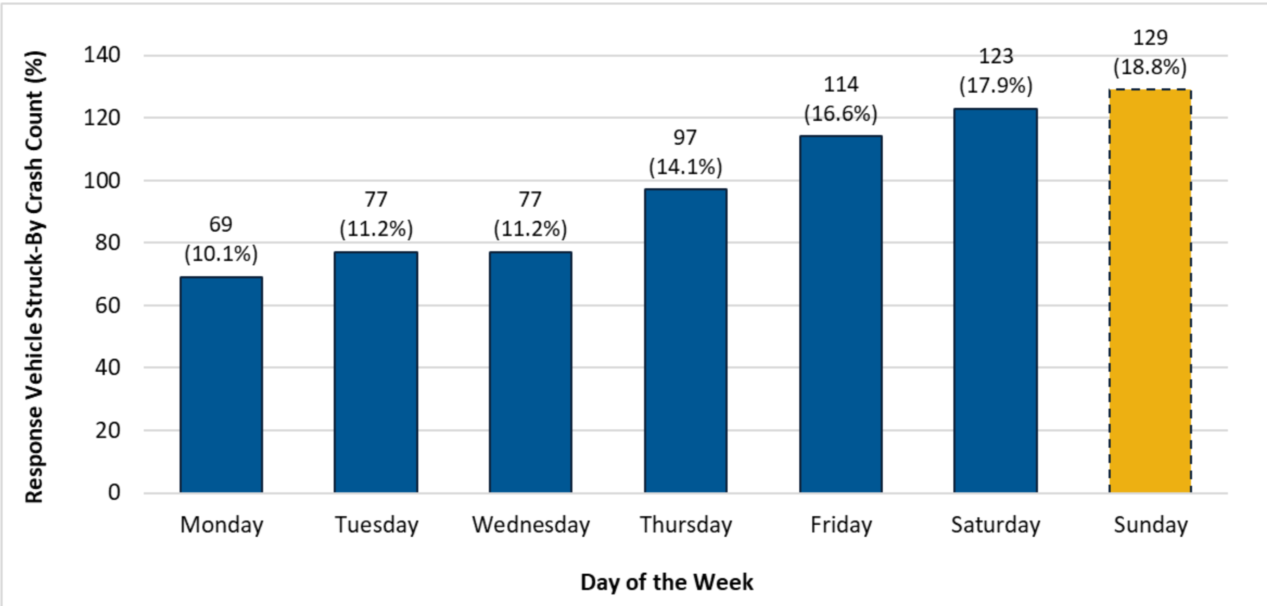
Figure 35. Chart. Yearly count of responder vehicle struck-by crashes.



Source: Federal Highway Administration.

Figure 36. Chart. Monthly frequency of responder vehicle struck-by crashes.

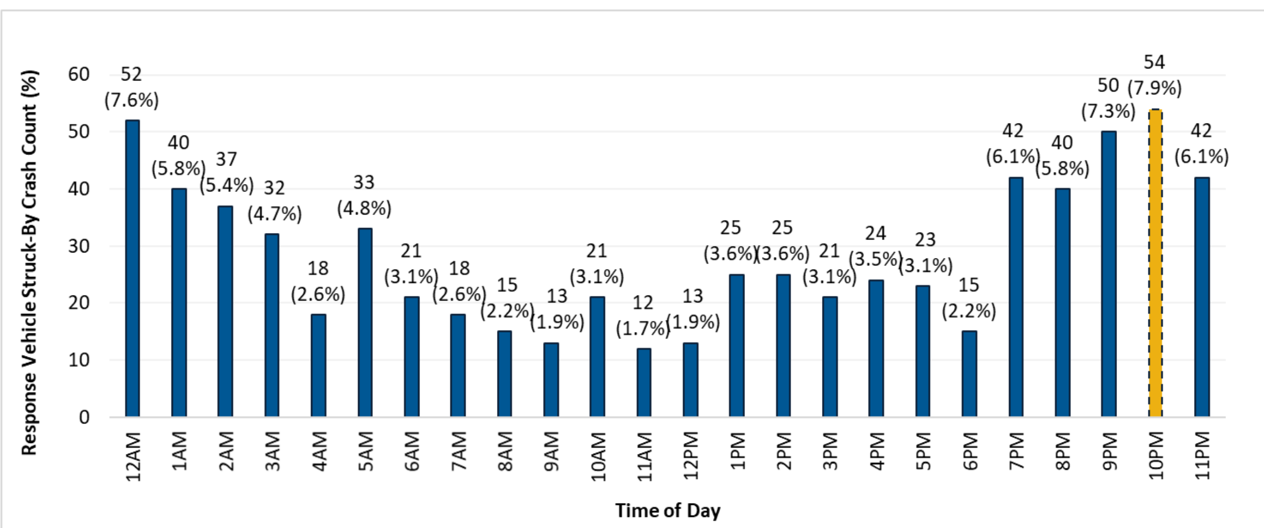
The distribution of crashes by day of week (shown in figure 37) clearly reveals an increase in the occurrence of responder vehicle struck-by crashes over the week, with over half of the crashes (53 percent) occurring on Fridays, Saturdays, and Sundays. The results are similar to the distribution of responder struck-by crashes by day of week, where crashes were highest on weekend days.



Source: Federal Highway Administration.

Figure 37. Chart. Frequency of responder vehicle struck-by crashes by day of the week.

Lastly, a visual examination of the distribution of crashes by time of day (shown in figure 38) reveals that more responder vehicle struck-by crashes (almost 57 percent) occurred in the evening and overnight hours, starting around 7 p.m. and extending to 3 a.m.



Source: Federal Highway Administration.

Figure 38. Chart. Frequency of responder vehicle struck-by crashes by time of day.

Chi-square goodness-of-fit tests were performed to determine if the distributions of observed responder vehicle struck-by crashes by month, day of week, and time of day were statistically different than the expected distributions.

The observed and expected frequency of responder vehicle struck-by crashes by month are shown in table 15. The observed values are the counts of responder vehicle struck-by crashes that occurred in each of the months. The expected frequencies, assumed to be uniformly distributed across the months of the year, were computed by dividing the total number of responder vehicle crashes identified by the number of months per year (686/12 = 57.2). The chi-squared test resulted in a p-value of 0.05, which is equal to the p-value of 0.05 (confidence level of 95 percent). For practical purposes, this means the null hypothesis can be rejected and the month of the year may have an impact on the distribution of responder vehicle crashes. These results are similar to the results obtained from the chi-square test performed on the responder struck-by crash distribution by month. In both cases, month of the year appears to impact the occurrence of responder and responder vehicle crashes. An examination of the distribution of responder crashes and responder vehicle crashes revealed some similarities in that higher numbers of crashes occurred during the months of fall (September, October) and late winter/early spring (February and March), and the lowest crashes occurred during the summer months.

Table 15. Observed and expected frequencies of responder vehicle struck-by crashes by month.

Month	Observed Frequency	Expected Frequency
January	54	57
February	70	57
March	64	57
April	44	57
May	56	57
June	51	57
July	44	57
August	50	57
September	68	57
October	75	57
November	53	57
December	57	57
Total	686	686

The project team followed a similar approach for comparing the distribution of observed and expected frequencies of responder vehicle struck-by crashes across days of week (shown in table 16). The observed values are the counts of responder vehicle struck-by crashes for each day of the week, as shown in figure 37. Expected frequencies, which the project team assumed to be uniformly distributed across the days of the week, were calculated by dividing the total number of responder vehicle struck-by crashes by the number of days in a week (686/7 = 98). The chi-square test resulted in a p-value of 2.32×10^{-6}, which is smaller than the p-value of 0.05 (confidence level of 95 percent). Therefore, the null hypothesis is rejected—the two distributions are statistically different, which means that day of the week may have an impact on the occurrence of responder vehicle struck-by crashes. The results of this test are different than the chi-square test result for the distribution of responder struck-by crashes by day of week, where the null hypothesis could not be rejected for the responder struck-by crash based on hypothesis testing with the sample of data at hand. However, for both datasets, a plurality of crashes occurred in the weekend (Friday–Sunday).

Table 16. Observed and expected frequencies of responder vehicle struck-by crashes by day of week.

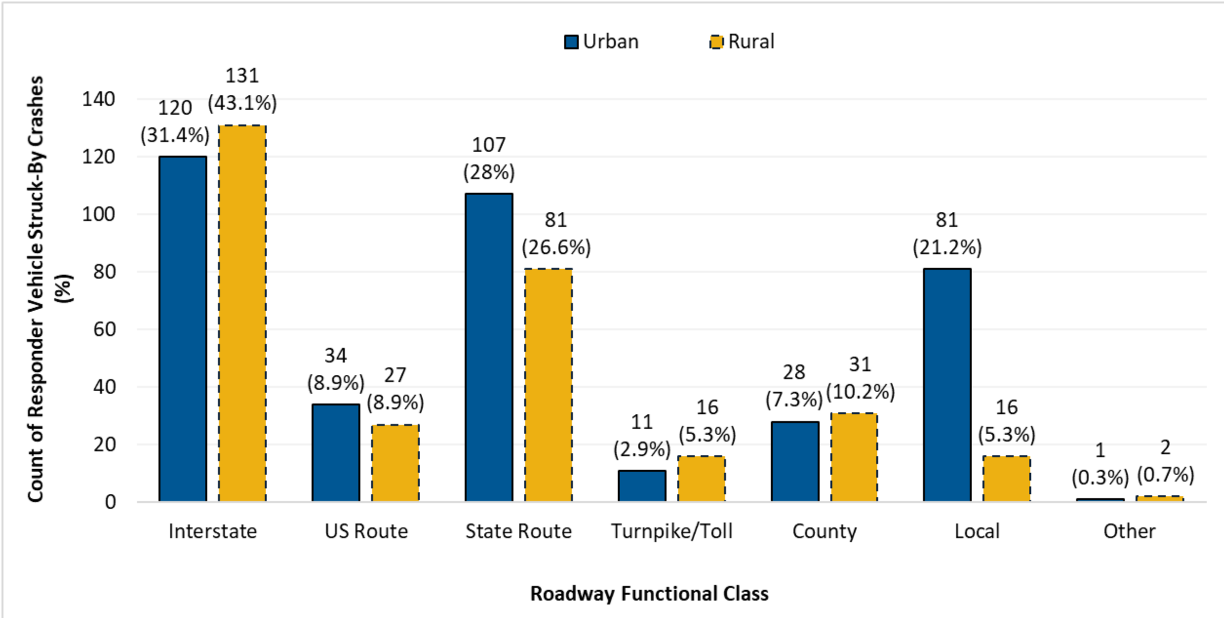
Day of Week	Observed Frequency	Expected Frequency
Monday	69	98
Tuesday	77	98
Wednesday	77	98
Thursday	97	98
Friday	114	98
Saturday	123	98
Sunday	129	98
Total	686	686

The observed and expected values for responder struck-by crashes by time of day are shown in table 17. The observed values are the counts of responder vehicle struck-by crashes by hour of the day, as shown in figure 38. The project team computed the expected frequencies, assumed to be uniformly distributed across the hours of the day, by dividing the total number of responder vehicle struck-by crashes by the number of hours per day (686/24 = 29). The chi-square test resulted in a p-value of 2.32×10^{-18}. Therefore, the null hypothesis is rejected, which means that the two distributions are statistically different and that the hour of the day had an impact on the occurrence of the responder vehicle struck-by crashes. This is different from the chi-square test result on the distribution of responder struck-by crashes by time of day, for which the null hypothesis could not be rejected based on hypothesis testing with the sample of data at hand. However, despite the difference in test results, the distribution of responder vehicle struck-by crashes by time of day is similar to the distribution responder struck-by crashes by time of day, in that for the most part, a plurality of the crashes in each dataset occurs in the evening, night, and early morning hours.

The project team also examined area type and roadway classification for the responder vehicles struck-by crashes. The results, shown in figure 39, revealed that for urban areas, responder vehicle struck-by crashes occurred most often on interstates (31.4 percent), followed by State routes (28 percent), and local roads (21.2 percent). On rural roads, the majority of the crashes occurred on interstates (43.1 percent) and State routes (26.6 percent). There are similarities between the distribution of responder struck-by crashes and responder vehicle struck-by crashes by area type and roadway classification. This can be observed when comparing the two types of crashes for State route and local roads (both in urban and rural areas) and for urban interstates. One difference was noted in the percentage of crashes that occurred in rural areas—responder vehicle struck-by crashes that occurred on interstate highways (43 percent) were considerably higher than responder struck-by crashes that occurred on interstates (33 percent). This could be due to the fact that vehicle dataset was made up of SSP crashes and move-over violations, most of which likely occur on major highways/interstates.

Table 17. Observed and expected frequencies of responder vehicle struck-by crashes by hour of day.

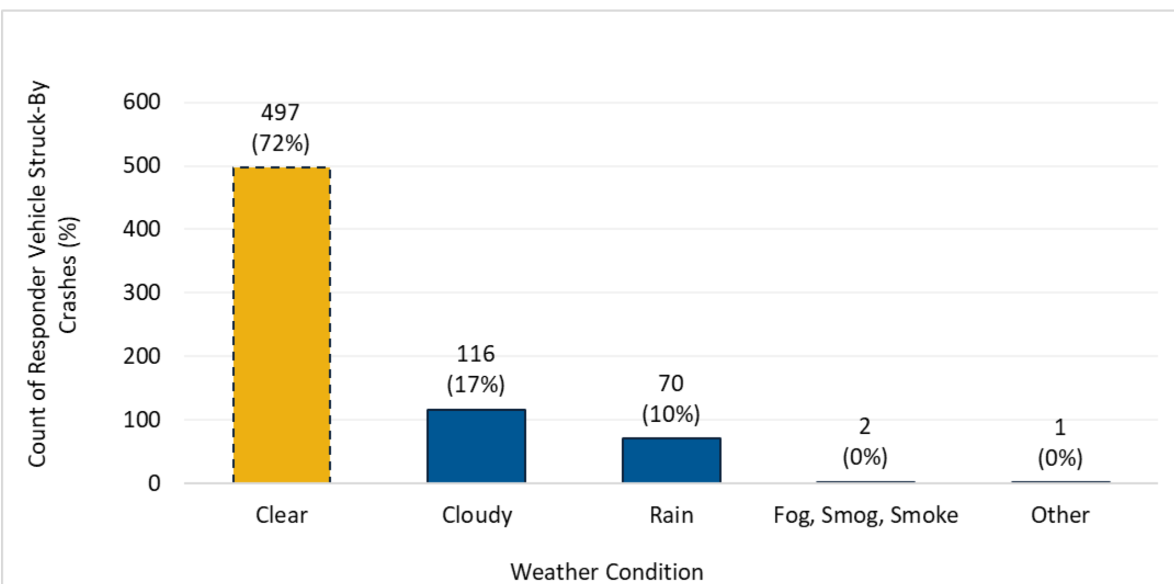
Time of Day	Observed Frequency	Expected Frequency
1 a.m.	52	29
2 a.m.	40	29
3 a.m.	37	29
4 a.m.	32	29
5 a.m.	18	29
6 a.m.	33	29
7 a.m.	21	29
8 a.m.	18	29
9 a.m.	15	29
10 a.m.	13	29
11 a.m.	21	29
12 p.m.	12	29
1 p.m.	13	29
2 p.m.	25	29
3 p.m.	25	29
4 p.m.	21	29
5 p.m.	24	29
6 p.m.	23	29
7 p.m.	15	29
8 p.m.	42	29
9 p.m.	40	29
10 p.m.	50	29
11 p.m.	54	29
12 a.m.	42	29
Total	686	686



Source: Federal Highway Administration.

Figure 39. Chart. Breakdown of responder vehicle struck-by crashes by area type and roadway functional classification.

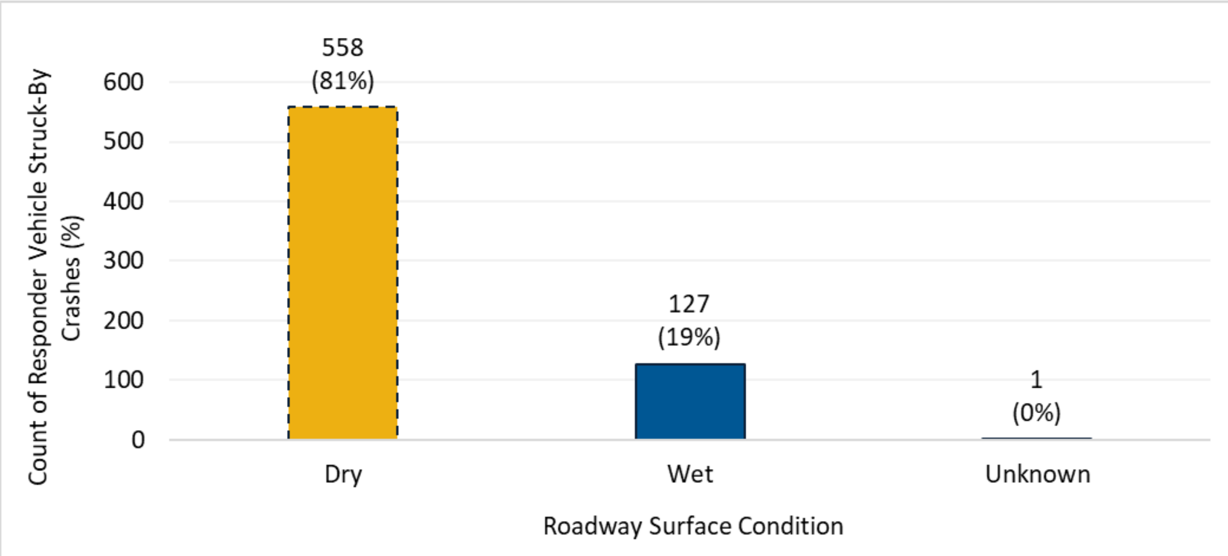
An examination of the weather conditions, illustrated in figure 40, showed that most of the responder vehicle struck-by crashes (89 percent) occurred during clear and cloudy conditions. A small percentage (10 percent) of crashes occurred during rainy conditions, and a few crashes occurred during fog/smoke or other conditions. It is worth noting that because the entire dataset of responder vehicle crashes is from Florida, there are no snow and ice conditions observed as there were for the responder struck-by crashes, which were identified throughout the county.



Source: Federal Highway Administration.

Figure 40. Chart. Breakdown of responder vehicle struck-by crashes by weather conditions.

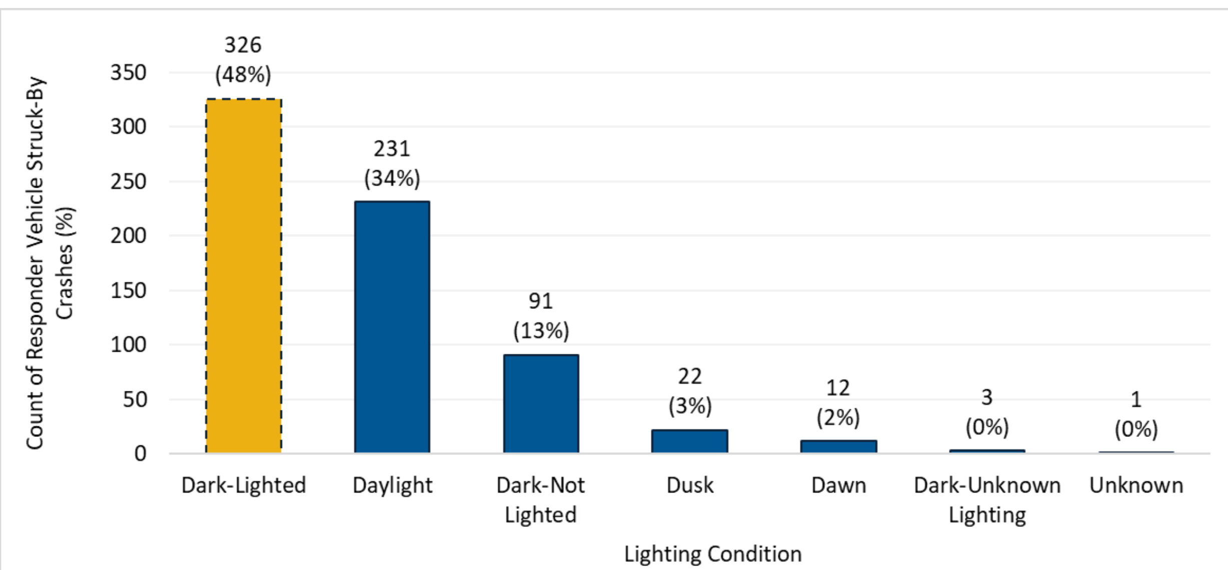
The bar chart in figure 41 summarizes the breakdown of responder vehicle struck-by crashes by roadway surface conditions. Over 81 percent of the crashes occurred on dry roadways, and the remaining crashes occurred during wet conditions.



Source: Federal Highway Administration.

Figure 41. Chart. Breakdown of responder vehicle struck-by crashes by roadway surface conditions.

A breakdown of the lighting conditions, illustrated in figure 42, shows that almost half of the crashes (48 percent) occurred in dark on lighted roadways, and another third of the crashes (34 percent) occurred during daylight. The remaining crashes during dusk/dawn (5 percent) and dark/not-lighted roads (13 percent).



Source: Federal Highway Administration.

Figure 42. Chart. Breakdown of responder vehicle struck-by crashes by lighting conditions.

Lastly, contributing factors/circumstances pertaining to the driver behavior, roadway, and environment were examined. This was done by examining not only the contributing circumstances noted in the crash reports, but also by examining other crash report data elements, such as alcohol and drug involvement, distracted driving, speeding, and work zone presence. The findings included:

- Driver-related factors:
  - Alcohol was involved in 22 percent of the crashes, and drugs were involved in about 4.5 percent of the crashes.
  - Distraction was a factor in 22 percent of the crashes.
  - Speeding was a factor in less than 4 percent of the crashes.

- Roadway-related factors:
  - 5 percent of the crashes involved roadway surface conditions.
  - About 5 percent of the crashes occurred in work zones.
  - Very few crashes involved debris or other obstructions on the roadway.

- Environmental factors:
  - For 4.7 percent of the crashes, the contributing factors were associated with the environment, including weather conditions, glare, or other.

The results obtained by examining the contributing factors noted for the responder vehicle struck-by crashes and responder struck-by crashes showed differences for the following factors:

- The drug and alcohol involvement for responder vehicle struck-by crashes was much higher than in that for the responder struck-by crashes, for which drug and alcohol involvement was noted for only 5 percent of the crashes.

- Similarly, distracted driving was reported as a contributing factor for many more responder vehicle struck-by crashes than for responder struck-by crashes.

- A higher percentage of responder vehicle struck-by crashes were noted to have occurred in work zones (5 percent) as compared with responder struck-by crashes, of which only 2 percent were noted as having occurred in work zones.

These differences were likely due to the presence of additional variables in the responder vehicle crash dataset pertaining to drug involvement, alcohol involvement, speeding, and distracted driving (possibly due to the reporting involved for insurance purposes, in the case of the SSP crashes, and for the issuance of move-over citations).

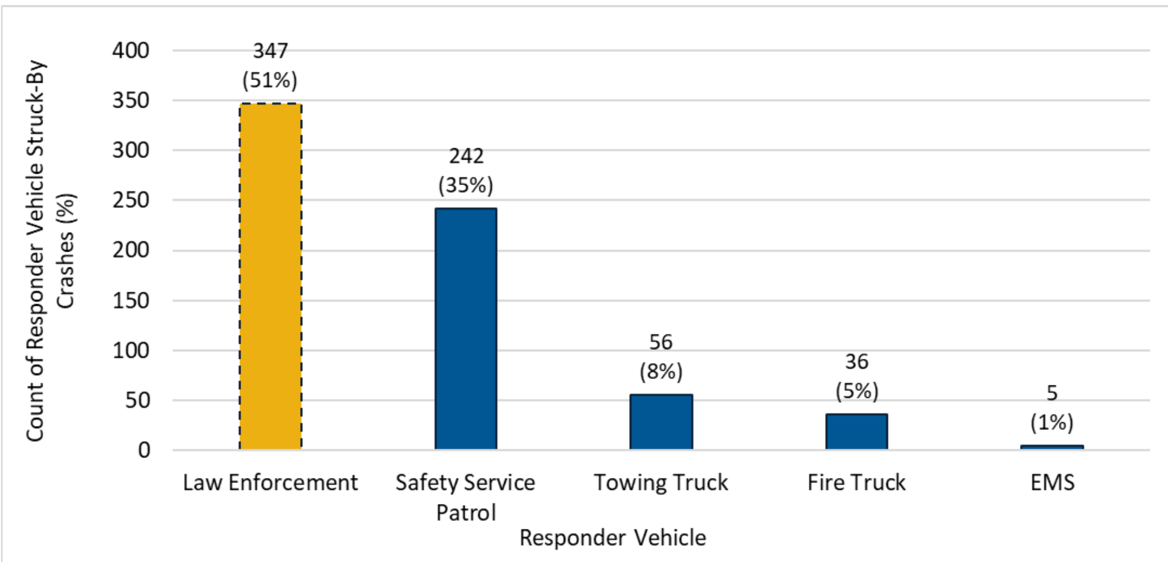
Summary Statistics of Responder Vehicle-Related Variables

This section summarizes the responder vehicle-related variables, including:

- Type of responder vehicle
- Response type
- Position of responder vehicle on the roadway (e.g., on travel lane, on shoulder)

- Manner of collision

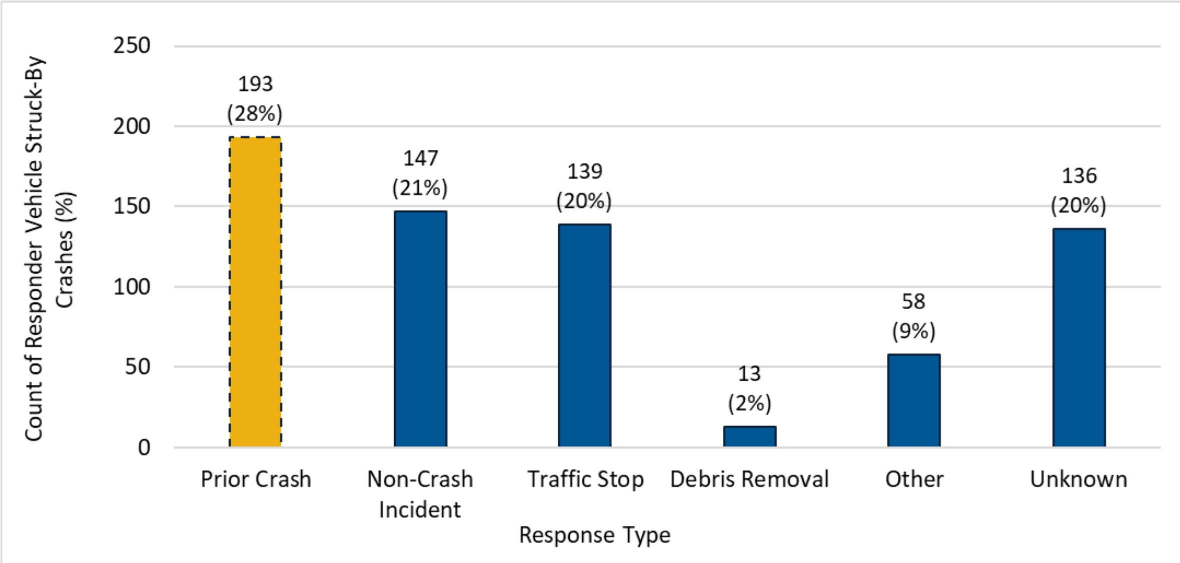
The type of responder vehicle involved in the struck-by crash and the nature of the primary incident are important factors, but because the dataset contains a high number of crashes involving safety service patrol vehicles, not a lot can be read into the relevant exposure by discipline. With that said, the results are shown in figure 43. Consistent with other datasets, the law enforcement discipline was well-represented in the dataset, because law enforcement officers typically engage in more types and numbers of traffic incidents. Overall, 51 percent of responder vehicles struck were law enforcement, followed by SSP (35 percent), towing (8 percent), fire (5 percent), and EMS (1 percent).



Source: Federal Highway Administration.

Figure 43. Chart. Breakdown of responder vehicles struck by responder discipline.

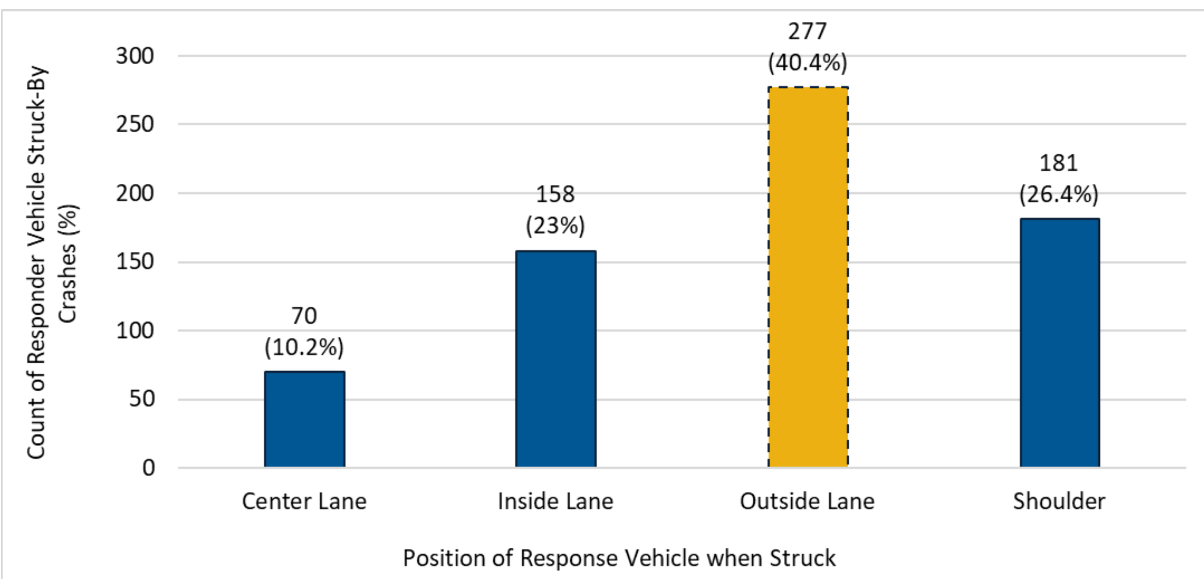
The frequency of responder vehicle struck-by crashes was also examined by type of response, and the results are summarized on figure 44. The crashes occurred relatively equally at prior crashes (28 percent), noncrash incidents (21 percent), and traffic stops (20 percent). Collectively, debris, medical emergencies, fires, and other reasons, included in the "other" category, make up 10 percent of the total crashes.



Source: Federal Highway Administration.

Figure 44. Chart. Breakdown of responder vehicles struck by type of incident response.

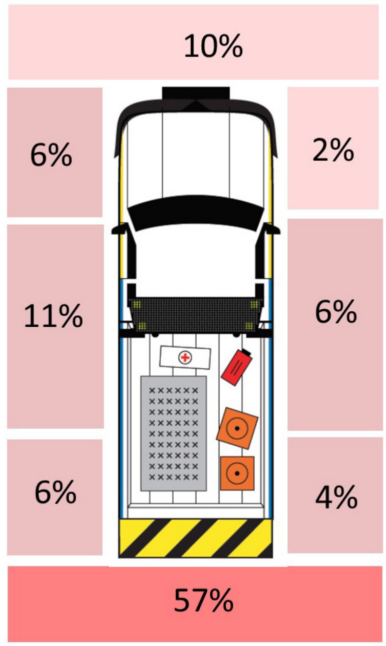
The bar chart in figure 45 illustrates the breakdown of responder vehicle struck-by crashes by lane position when the responder vehicle was struck. Overall, 74 percent of responder vehicles struck at incident scenes were positioned in the travel lanes when they were struck, with the highest percentage being in the outside lane (40.4 percent). The remaining 26 percent were on a roadway shoulder (either inside or outside).



Source: Federal Highway Administration.

Figure 45. Chart. Position of the struck responder vehicle on the roadway by lane.

An examination of the manner of collision associated with responder vehicle struck-by crashes showed that 57 percent of crashes were rear-end in nature, and 35 percent were same-direction sideswipe crashes. Consequently, the point of impact for the responder vehicles heavily reflects rear contact and side damage. Figure 46 is a graphic representation of the point of impact for the responder vehicles struck at incident scenes in the dataset examined. It should be noted that the point of impact represents 736 individual vehicles, as multiple responder vehicles were involved in some of the 686 events.



Source: Federal Highway Administration.

Figure 46. Graphic. Point of impact for the responder vehicles struck at incident scenes in the dataset examined.

GAPS AND LIMITATIONS

This section summarizes the gaps and limitations of the data with respect to data representativeness and quality, which impact data analysis and associated outcomes.

Gaps and Limitations Associated With Responder Struck-By Crashes

First, the responder struck-by dataset is not a random sample, primarily due to the way in which the data were gathered. Data gathering was limited to States that have relevant data elements on their traffic crash reporting forms and from which crash data and narratives could be obtained. The data were also drawn from several sources that are voluntary in nature and thus likely overrepresent tragic responder struck-by crashes that involve fatalities or serious injuries and underrepresent those that involve minor injuries or PDO. Additionally, as some data were drawn from responder-specific datasets (e.g., fire, towing), the data may overrepresent these disciplines, while underrepresenting other disciplines (e.g., EMS, SSP).

Unknown values and missing values are also a gap/limitation of the data, particularly when it comes to data analysis. "Unknown" values are noted as such by the officer who prepared the crash report or were indicated as such by a project team member who reviewed the associated article (ERSI, NIOSH) or crash narrative when there was not enough detailed information. On the other hand, variables with "missing" values are not present on the crash reports, not filled in, or not present in the articles or narratives reviewed. For the purposes of the cluster analyses only, the "missing" variable values were called "unknown." This was done to be able to run the cluster analyses on all the responder records, instead of removing records with missing variable values.

The examination of "unknown" values by data source included the following findings:

- The only crash variables with "unknown" values were weather, lighting, and contributing factors, and the count and percentage of responder struck-by crashes with unknown values for these specific variables were:
  - 10 crashes (2 percent) for which weather information was unknown
  - 60 crashes (12 percent) for which lighting information was unknown
  - 143 crashes (31 percent) responder crashes for which contributing factors were unknown
- The only responder-related variable for which information was unknown was responder injury severity. There were 39 crashes (almost 7 percent) for which the responder injury severity was unknown.

The project team also identified "missing" values across both crash-related and responder-related variables of interest. The count of missing values is given for each variable by data source, as well as for the entire dataset, and the summaries are shown in table 18 and table 19.

Table 18 summarizes the missing values for the crash-related variables. The project team calculated the percentages of missing values by dividing the count of missing values (for each variable) by the entire number of crashes (505). Almost all crash-related variables had missing values except for month and day of week, and the percentage of missing values ranged from 13 percent to almost 64 percent.

Table 18. Count of missing values for crash-related variables of interest by data source.

Data Source	Month	Day of Week	Hour	Area Type	Road System	Shoulder Type	Weather	Lighting	Road Surface	Contributing Factor	Total Count of Unknown Values
Arizona crash data	0	0	0	0	0	14	6	8	6	14	48
Florida crash data	0	0	0	0	5	0	0	0	0	16	21
Illinois crash data	0	0	0	0	0	3	0	0	0	0	3
Ohio crash data	0	0	0	5	5	5	1	1	5	0	22
Tennessee crash data	0	0	0	61	61	61	0	0	30	40	253

ERSI matched articles	0	0	0	39	39	45	1	16	35	9	184
ERSI unmatched articles	0	0	65	107	26	118	112	76	113	83	700
National Fire Incident Reporting System (NFIRS) unmatched articles	0	0	0	25	22	26	26	26	26	10	161
National Institute for Occupational Safety and Health (NIOSH) unmatched articles	0	0	3	3	0	3	3	3	3	0	18
Towing Traffic Incident Report System (TTIRS) crash data	0	0	0	15	0	47	40	3	41	32	178
Total (count)	**0**	**0**	**68**	**255**	**158**	**322**	**189**	**133**	**259**	**204**	1,588
Total (%) of 505 total crashes	**0**	**0**	**13.5**	**50.5**	**31.3**	**63.8**	**37.4**	**26.3**	**51.3**	**40.4**	N/A

N/A = Not applicable.

Table 19 summarizes the missing values for the responder-level data. The project team calculated the percentages of missing values by dividing the count of missing values (for each variable) by the entire number of records for the responder-level dataset (590 records). Compared with the crash-related variables, the percentage of missing values for the responder-related variables was relatively small. The only variables for which information was missing were "response type" (6.4 percent) and "responder location" (3.2 percent).

The crash-related variables for which there are no missing values are month and day of week, and the responder variables with no missing values were responder type responder injury severity. The reason why these variables are generally not missing is because 1) the date of the incident is almost always known (100 percent of the time from the crash reports and almost always from other sources), and 2) the responder variables were extracted through manual reviews of crash report narratives and articles, which generally provide these details. For the remaining variables, however, there are a significant number of missing values, where these values are either not provided by the officer in the crash report or not mentioned in the articles that were manually reviewed. The variables with more than half of the values missing were area type, shoulder type, and roadway surface conditions.

Table 19. Count of missing values for responder-related variables of interest by data source.

Data Source	Responder Location	Response Type	Responder Type	Responder Injury	TOTAL Count of Unknown Values
Arizona crash data	0	1	0	0	1
Florida crash data	0	11	0	0	11
Illinois crash data	0	0	0	0	0
Ohio crash data	1	1	0	0	2
Tennessee crash data	0	2	0	0	1
Emergency Responder Safety Institute (ERSI) matched articles	0	1	0	0	0
ERSI unmatched articles	5	5	0	0	9
National Fire Incident Reporting System (NFIRS) unmatched articles	0	0	0	0	0
National Institute of Occupational Safety and Health (NIOSH) unmatched articles	0	0	0	0	0
Towing Traffic Incident Report System (TTIRS) crash data	13	17	0	0	30
Total (count)	**19**	**38**	**0**	**0**	54
Total (%) of 590 responders	**3.2**	**6.4**	**0.0**	**0.0**	N/A

N/A = not applicable.

As previously mentioned in the Cluster Analysis section, clustering works at the dataset level, where every point is assessed relative to the others, so the data must be as complete as possible. Therefore, because of the high percentage of missing values, the project team was faced with two options: either conduct the cluster analysis only on the data with no missing values for the variables of interest or replace the missing values with "unknown" and run the cluster analysis on the entire dataset. It should be mentioned that cluster analyses are difficult to run when the dataset has missing values (empty cells) due to the inability of the cluster algorithm to run on datasets with missing values. The first option was considered; however, because the missing values across the variables do not always coincide (or happen along the same records/rows), removing all the rows with missing values would reduce the dataset to a sample size of 23 records. Therefore, the second option was selected, and the missing values were replaced with "unknown" in order to run the cluster analysis. The result, however, was a clustering around these unknown values instead of clustering across the known categories/values of the variables of interest.

It should also be mentioned that other variables of interest, other than those previously listed, were dropped from the dataset while conducting the analyses due to the very small sample size of known values for these variables (e.g., alcohol and drug involvement).

Gaps and Limitations Associated With Responder Vehicle Only Struck-By Crashes

There are several challenges associated with identifying responder vehicle struck-by crashes and these affect the data representativeness.

- The first challenge lies in the identification of responder vehicle crashes for various responder disciplines. While it is straightforward to identify responder vehicles for law enforcement, fire, and EMS based on crash report vehicle functional use codes, it is significantly more challenging to do the same for safety service patrol, towing, or maintenance vehicles because vehicle codes for these types of responder vehicles are not widely used in State crash reporting systems.

- Subsequently, once responder vehicles involved are identified, another challenge is determining whether these responder vehicles were stopped at traffic incident scenes at the time of the crash. While some States have data elements for "stopped" and/or "parked" vehicles involved, narratives are still needed to determine if the vehicles were stopped/parked at incident scenes.

- A third challenge with identifying responder vehicle struck-by crashes is that these particular crashes, when not involving any responders or other civilians struck, may be underreported (due to only involving property damage) and thus not show up in various data sources. It bears to say that some of the discipline-specific data sources (e.g., law enforcement, towing) are self-reporting in nature, thus typically including crashes that are more severe in nature (i.e., fatalities, suspected serious injuries).

With respect to the responder vehicle struck-by crash dataset, the project team examined the completeness of information for various crash and responder vehicle-related variables. For the most part, most of the variables examined were complete, with the exception of response type. Twenty percent of the responder vehicle crashes had the response type listed as "unknown."

DATA SUMMARIES FINDINGS

The following is a synopsis of the findings from the analysis of the responder struck-by composite database:

- 505 responder struck-by crashes (either as nonmotorists or occupants of stopped responder vehicles) were available for analysis.

- The majority of the crashes (67 percent) occurred in Arizona, Colorado, Florida, Illinois, Ohio, and Tennessee, and the remaining 33 percent were scattered across 36 other States.

- The crashes were analyzed by:
  - Multiple responder-related variables, including responder type, responder location, response type, use of retroreflective gear, and responder injury
  - Multiple crash-related variables, including time of occurrence, area type, roadway classification, roadway characteristics, environmental and lighting conditions, and contributing circumstances

- Major takeaways from the analysis of responder-related variables for the responder struck-bys in the dataset include the following:
  - The majority of the responders involved (57 percent) were law enforcement.
  - Most of the responders were struck as nonmotorists outside their vehicles (82 percent of crashes with this information).
  - 70 percent of the responders suffered a fatality or injury (suspected major or a suspected minor injury), and an additional 15 percent of responder suffered possible injuries.
  - 40 percent of crashes and 44 percent of responders were struck when responding to a prior crash.
  - For 38 responders who were struck, for whom information on the use of retroreflective gear was available, 33 responders (87 percent) were wearing retroreflective gear when struck.
  - Tow operators represented the highest percent of fatal injuries (49 percent), followed by fire personnel (31 percent) and law enforcement (14 percent).
  - More responders were injured or killed as nonmotorists as compared with those who were occupants of parked responder vehicles (70 percent versus 59 percent), but these results show that being struck in a parked vehicle still represents a risk for responders.

- Major takeaways from the analysis of crash-related variables include the following:
  - More of the responder struck-by crashes in the dataset occurred:
    - During the fall and winter months, as opposed to spring and summer
    - On weekends (Friday–Sunday) as opposed to weekdays
    - In the evening/late evening hours as opposed to daytime hours

  - Most struck-by crashes occurred in urban versus rural areas:
    - A plurality of urban crashes occurred on interstate and local roads (27 percent for each roadway classification category), followed by 24 percent that occurred on State routes.
    - A plurality of rural crashes occurred on interstates (33 percent), followed by State roads (26 percent).

  - Information on roadway characteristics in the crash reports, including geometric features and AADT, were available for very few crashes, and therefore could not be used to summarize the struck-by crashes.

    - 42 percent of the crashes occurred during daylight hours, and 81 percent occurred during dry weather conditions.
    - Over 40 percent of the crashes had missing information on contributing circumstances, and over 30 percent of the crashes had unknown contributing circumstances (most of these crashes with unknown contributing circumstances, or in other words reported as "No Apparent Contributing Factor" in the crash reports were from the Florida crash reports). For those that had information on contributing factors, a range of potential factors were identified from either the crash reports or via review of articles:
        - 18 percent of the contributing factors were associated with driver-related factors, such as improper driving actions (e.g., speeding, improper lane change, following too close), driving under the influence of drugs and/or alcohol, and driver inexperience or familiarity with the area.
        - Just under 10 percent of the contributing factors were associated with roadway obstructions due to work zones, other crashes, and other obstructions.
        - 4 percent of the contributing factors were associated with environmental factors, such as snow and ice conditions and reduced visibility as a consequence of inclement weather.

The following is a synopsis of the findings from the analysis of the unoccupied responder vehicle struck-by dataset:

- 686 unoccupied responder vehicle struck-by crashes were identified from the State of Florida and analyzed by:
    - Crash-related variables, including time of occurrence, area type, roadway classification, environmental and lighting conditions, and crash contributing circumstances
    - Responder vehicle-related variables, including type of responder vehicle, response type, position of responder vehicle on the roadway (e.g., travel lane, shoulder), and manner of crash

- Major takeaways from the analysis of responder vehicle crash-related variables included the following:
    - More of the responder vehicle struck-by crashes occurred during:
        - Early fall (September–October) and early spring (February–March)
        - During the weekend (Friday–Sunday)
        - During the evening and up to the early morning hours (7 p.m.–3 a.m.)
    - The majority of urban crashes occurred on interstates (31 percent), State routes (28 percent), and local roads (21 percent), whereas the majority of rural crashes occurred on interstates (43 percent) and State routes (27 percent).
    - Almost 90 percent of the crashes occurred during clear or cloudy conditions, and over 81 percent of the crashes occurred during dry roadway surface conditions. Almost 48 percent of the crashes occurred during dark but lighted conditions, and a third of the crashes occurred during daylight.

    - Alcohol and distraction were identified as contributing factors in 22 percent of the crashes, a much higher occurrence than was found by analyzing responder struck-by crashes from the composite responder struck-by crash database (although, as previously noted, the majority of the responder struck-by crashes were lacking a contributing factor or had "no apparent contributing factor" listed).

- Major takeaways from the analysis of responder vehicle-related variables included the following:
    - The majority of the responder vehicles struck were law enforcement vehicles (51 percent), followed by safety service patrol vehicles (35 percent).
    - 28 percent of the responder vehicles were struck while on the scene of a prior crash. Another 41 percent of responder vehicles were struck while on the scene of a noncrash incident (21 percent) or while on the scene of a traffic stop (20 percent).
    - Most responder vehicles were struck while positioned in the outside lane (40 percent) and shoulder (26 percent).
    - The majority of responder vehicle struck-by crashes were rear end (57 percent) or sideswipe (35 percent) crashes.

In-Depth Analyses Findings

The following is a summary of findings from the more in-depth analysis of the struck-by data:

- Chi-square goodness-of-fit tests comparing the observed and expected frequencies/distributions of 505 responder struck-by crashes, resulted in the following:
    - Month of year resulted in a p-value smaller 0.05. Month of year may impact the occurrence of responder struck-by crashes.
    - Day of week and hour of the day resulted in p-values that were higher than 0.05. Day of week and hours of day do not appear to impact the occurrence of responder struck-by crashes based on hypothesis testing with this sample of data.

- Chi-square goodness-of-fit tests comparing the observed and expected frequencies/distributions of 686 responder vehicle struck-by crashes in Florida resulted in the following:
    - Month of the year resulted in a p-value equal to 0.05 (for practical reasons, the null hypothesis can be rejected). This means that the month of the year may impact the occurrence of responder vehicle struck-by crashes.
    - Weekday and time of day tests resulted in p-values much smaller than 0.05, which indicates that these variables (day of week and time of day) impact the occurrence of responder vehicle struck-by crashes.

- The project team observed high correlation between area type, roadway functional classification, and shoulder type. This can be expected, as roadway characteristics, especially pertaining to design, are associated with area type and roadway classification. There is also some correlation between area type, roadway classification, and shoulder type with roadway surface, which may be due to the relationship between roadway classification system and maintenance activities.

- From the k-modes clustering algorithm scree plot, it was determined that the two-cluster solution was optimal for the responder struck-by dataset. The cluster assignment examination, however, revealed that instead of clustering around certain values of the variables of interest, the clustering was mainly separating the variables with "unknown" values from those with known values.

Gaps and Limitations Findings

The following is a summary of data gaps and limitations with respect to data analysis:

- The responder struck-by dataset is not a random sample and may not be representative of the population of responder struck-by crashes that occur across the United States.

- A small percentage of the responder struck-by crash data had unknown values across some of the variables, including weather condition, lighting condition, contributing factors, and responder injury severity.

- The only variables for which there are no missing values were month of year, day of week, responder type, and responder injury severity. The remaining variables included a significant percentage of missing values. The variables with the most missing values (over 50 percent) were area type, shoulder type, and roadway surface conditions. The missing values were replaced with the term "unknown" only for the purpose of running the cluster algorithm, the results of which were greatly impacted by the presence of missing information across many of the crash-related variables. The results of the cluster analysis showed that for a number of the variables used in the clustering, the split across the clusters was such that one cluster encompassed all (or nearly all) of the unknown values, whereas the other cluster included the known values of those variables.

Other variables of potential interest were dropped from the analyses due to the very small sample size of known values for these variables (alcohol and drug involvement).

CHAPTER 5. STAKEHOLDER ENGAGEMENT AND INPUT

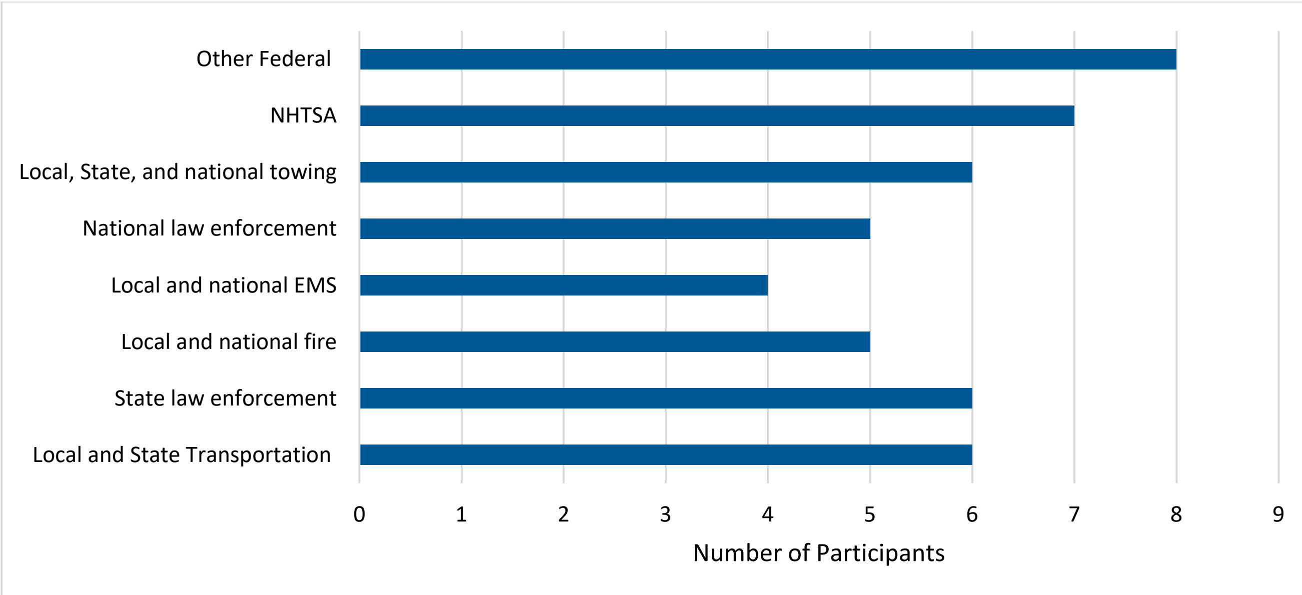
The project team organized and facilitated two virtual stakeholder workshops. The initial workshop involved a broad group of stakeholders and occurred on February 16, 2022 from 12:30 to 4:30 p.m. (the workshop agenda is shown in appendix B). The follow-up workshop involved a smaller group of stakeholders identified from the initial workshop as individuals/groups that might help advance the state of the data on responder struck-by crashes (the workshop agenda is shown in appendix C). The approach and outcomes from each of these workshops are described in this chapter of the report.

INITIAL VIRTUAL STAKEHOLDER WORKSHOP—BROAD RESPONDER GROUP PARTICIPATION

The goal of this stakeholder workshop was to engage data owners and custodians across responder disciplines in a discussion about the available data on responder struck-by crashes and to gather critical feedback into how these data might be improved for future uses. Specific objectives of the workshop included:

- Present and discuss the challenges and gaps in the existing data and discuss the need for and importance of more and better data
- Present and discuss the findings from an analysis of a limited amount of data collected
- Discuss approaches to improving the quantity and quality of data on responder struck-by crashes
- Identify next steps and action items among responder groups and organizations to advance the state of the data available on responder struck-by crashes.

In all, 68 people attended the workshop; 47 of those participants were stakeholders, and 17 were representatives of the FHWA and contractor project team. The 47 stakeholders represented a wide range of local, State, and Federal/national agencies/organizations across responder disciplines, as shown in figure 47.



Source: Federal Highway Administration.
EMS = emergency medical services; NHTSA = National Highway Traffic Safety Administration.

Figure 47. Chart. Workshop participants by discipline.

During the workshop, much of the discussion occurred within the breakout groups. The objectives of the breakout groups were to:

- Identify champions for change to support better data on responder struck-by crashes within groupings of data sources
- Identify actionable items for data champions
- Discuss next steps for filling data gaps within specific data sources

To meet these objectives, the project team formed the breakout groups of stakeholders by data sources/focus areas and included those participants in each group with knowledge of those data. The project team also worked to balance the number of datasets and challenges to be discussed by each group, as well as balance the number of participants in each group:

- Group 1—crash data (consisted of two groups—Group 1a and Group 1b)
- Group 2—national responder data by discipline
- Group 3—industry, nonprofit data
- Group 4—national occupational safety and health data

Each of these groups is described in more detail below.

Group 1—Crash Data

Group 1 discussed crash data sources and data elements used to identify potential responder struck-by crashes. The group facilitators provided background information to guide the discussion, including the various MMUCC and non-MMUCC data elements in State crash reports used to identify potential responder struck-by crashes and the challenges associated with identifying responder struck-by crashes using these data elements. Given the number of participants, Group 1 was divided into two groups. Group 1a consisted of the individuals shown in table 20, and Group 1b consisted of the individuals shown in table 21.

Table 20. Participants in Group 1a.

Title	Organization
Regional Action Coordinating Team (REACT) Program Manager	Maricopa County Department of Transportation
Statewide Traffic Incident Management (TIM) Program Coordinator	Colorado Department of Transportation (CDOT)
Project Manager	Parsons Transportation
Crash Specialist	National Highway Traffic Safety Administration (NHTSA) Crash, Investigation Division
Program Analyst	NHTSA
Tennessee's Integrated Traffic Analysis Network (TITAN) Program Manager	Tennessee Department of Safety and Homeland Security
Roadway Safety Data Program Manager	Federal Highway Administration (FHWA) Office of Safety

Table 21. Participants in Group 1b.

Title	Organization
Senior Survival Factors Investigator	National Transportation Safety Board
Director, Transportation Operations	Federal Highway Administration (FHWA)
Safety Specialist	FHWA
Engineering Analyst	Ohio Department of Transportation
Captain	Colorado Department of Public Safety
Director, Office of Safety Programs	National Highway Traffic Safety Administration (NHTSA)
Incident Management Specialist	Parsons Corporation
Division Chief	NHTSA
Program Specialist	NHTSA
Project Manager	National Sheriff's Association
Data Section Manager	Vermont Agency of Transportation
Law Enforcement Liaison	Governor's Highway Safety Association

Summary of Group Discussion

The discussions centered on several topics: the responder struck-by definition, crash report forms, and training for law enforcement:

- Responder struck-by definition:
  - Participants agreed that there is a need for a consistent, nationally recognized definition of a responder struck-by crash.

    - The responder struck-by definition might be modified to include activities at or near traffic incidents. In particular, removing the word “stopped” in the responder struck-by definition so as to include responders who may be slowing down or maneuvering in close proximity to the incident scene (e.g., performing rolling roadblocks). It was also countered that emergency vehicle operation activities at or near incidents may be outliers, and the benefit of inclusion may not be worth complicating the broader data collection effort.
    - A unifying definition for a responder struck-by crash also needs to be included in the MMUCC. This definition would provide consistent terminology regarding who is a “responder” and would help support buy-in at the State level.

- Crash report forms:
    - Tennessee adopted the MMUCC 5th Edition recommendation for the P4.2 “Responder Involved?” data element/subfield but expressed concern about the effectiveness of this approach.
    - Vermont also adopted the MMUCC 5th Edition P4.2 data element/subfield and found some potential issues with the collection of the data.
    - The group discussed that merely including “responder involved” can be a source of confusion, as it might imply the responder helped the person associated with the person record. A better option might be to change the wording to “Is This Person a Responder?” Another suggestion was to move the “Responder Involved” question from a subfield to a numbered data element.
    - Ohio included on its crash report a data attribute, “First Responder at Scene,” under the “Nonmotorist Location at Impact,” and that they, too, have experienced challenges with the data being collected correctly.
    - Ideas for improving crash reports were to include a checkbox for a crash that involves a responder struck and/or phrases/key words that could be queried/searched by analysts.
    - The crash narrative is the common thread between States’ crash reports, and these narrative fields could be leveraged to identify struck-by crashes. Better information in narratives and the ability to search and analyze narratives was seen by the group as a significant opportunity.
    - Important needs related to crash narratives including building in quality control and time for supervisors to review the narratives and helping reporting officers to use consistent definitions and terms.
    - NHTSA may be able to leverage the FARS electronic data transfer (EDT) from States to make sure they are not missing connections within the crash reports, specifically where the data might be pulled into some of the new attributes developed in FARS to identify responders.
    - As part of an effort to institute training for TIM teams across the State, Colorado Department of Transportation (CDOT) has used data from the State workers’ compensation system in concert with crash reports to identify responder struck-by crashes. The major challenge is the disparity between the two systems. Making changes to systems so they can be integrated is challenging and costly and will not happen without buy-in from leadership.
    - Incorporating innovations like dashboard/body camera footage into narratives and crash databases is an opportunity for better data.

- Training for law enforcement on crash report forms:
  - Respondents agreed that specific training on how to complete crash forms is needed to have more reliable data.
  - In Tennessee, officers receive only a few hours of training on the crash report in basic training. Also, where crashes are less frequent (e.g., rural areas), officers do not have as many opportunities to fill out crash forms. Tennessee has been looking for creative ways to increase training and engagement during and after the academy (e.g., short YouTube videos).
  - Utah is working to implement an education course for their law enforcement officers based on training conducted in Illinois.
  - In addition to local training, there is a need for a national training program for crash report data collection, and there are plans for a NHTSA effort in concert with MMUCC.

Next Steps/Action Items

The groups agreed that to improve responder struck-by crash identification, a nationally recognized definition is needed, along with improvements to crash report form uniformity and training for law enforcement officers. The group identified several next steps and action items, which ranged from short-term to longer-term actions. Table 22 summarizes these next steps and action items.

Table 22. Next steps/action items identified in Group 1a crash data.

Next Step/Action Item
Leverage Fatality Analysis Reporting System (FARS) electronic data transfer (EDT) mapping schema to find possible connections for identifying responder struck-bys across the 19 States that participate.
Develop ideas for training law enforcement officers on responder struck-by crash data collection, including leveraging crash report narratives as a way to "flag" responder struck-by crashes.
Consider if a revision to the responder struck-by definition is needed to include responders/vehicles that are moving near incident scenes.
Develop a unifying definition and incorporate it into the next version of the Model Minimum Uniform Crash Criteria (MMUCC).
Add "Is this person an incident responder" as (Group + Type) numbered data element instead of a subfield under P4 (2 "Responder Involved").
Add high-visibility reflective clothing as an attribute under the nonmotorist (NM5) data element and specify if the responder was wearing an American National Standards Institute (ANSI) vest.
Implement a national education program focused on training law enforcement on responder struck-by crashes.
Incorporate struck-by information in narratives and the ability to do search and analysis of narratives.

Group 2—National Responder Data by Discipline

Group 2 discussed data elements and access to data on responder struck-by crashes in official datasets within specific responder disciplines. Group 2 consisted of the individuals shown in table 23.

Table 23. Participants in Group 2.

Title	Organization
Director At-Large/ Secretary	National EMS Management Association
Subject Matter Expert	International Association of Fire Chiefs (IAFC)
Program Director, National Emergency Medical Services Information System (NEMSIS)	National Highway Traffic Safety Administration (NHTSA)
Training Specialist	National Fire Academy
Executive Director	National Association of State EMS Officials (NASEMSO)
Professor	University of Utah
Transportation Specialist	Federal Highway Administration (FHWA)
Supervisory Fire Program Specialist	United States Fire Administration (USFA), National Fire Data Center (NFDC)
Traffic Incident Management (TIM) Program Manager	FHWA

EMS = emergency medical services.

Summary of Group Discussion

The discussion primarily focused EMS and fire data, particularly NEMSIS and NFIRS. NEMSIS provides a framework for collecting, storing, and sharing standardized EMS run data. Data are generated by local EMS agencies, aggregated by States, and compiled nationally from State submissions. NFIRS is a database for fire departments to uniformly report on the full range of their activities, from fires, to EMS, to severe weather and crashes.

- EMS data:
  - In its current state, it would be challenging to identify responder struck-by crashes in NEMSIS without also including a review of the narratives; however, narratives are not collected at the national level or even by some States. States that do collect narratives typically will not share them due to the potential presence of protected health information (PHI).
  - NEMSIS collects a subset of data on whether a provider has suffered an injury and the type of work-related injury. Type of work-related injury has a code for "vehicular," but it is not collected nationally—it is collected by 20 States. There has been a movement towards making that data element a national element.
  - EMS personnel who complete the reports are likely only thinking about their project team that is providing the care and may not always capture if another responder is struck. There are variables related to location and time.
  - EMS records are the most promising for accurate information about responder injuries.

- There was a suggestion to include a field, on a patient-centric basis, to indicate whether the patient was a first responder, and there is a mechanism that exists to add that data element, provide a clear definition, and have the EMS programs collect it. It would then be collected uniformly across the United States.
- There is a groundswell to add these types of "gateway" data elements (i.e., those that open the ability to gather/track additional, relevant information).
- Data collected at the State level is key. There are many data elements collected only at the State level that may not be in the national database. There are significant opportunities for data linkage in those States. Most States have allowances for research purposes, assuming appropriate levels of aggregation and deidentification.
- The new version of NEMSIS will have a universal unique identifier (UUID) associated with each EMS run report. A goal for the near future would be to have a placeholder for the UUID in crash reports. This would help with linking NEMSIS run reports with traffic crash reports.
- There are also opportunities with connectivity between law enforcement and ambulance laptops and CAD systems, allowing for UUID exchange. The next version of the MMUCC could help by including this element, but there could be nearer term opportunities to coordinate with specific States to pilot the approach. State EMS would be highly motivated to participate.
- Obtaining information that is currently considered confidential, such as exact incident locations and report narratives, may not be possible for privacy reasons associated with the national dataset. This would be a reason to go directly to the local/State level for disaggregate data.

- Fire data:
    - The USFA Firefighter Fatalities in the United States data includes 100 percent of firefighter fatalities and is considered the "gold standard" of firefighter fatality reporting. Nonfatal struck-bys would need to be identified in the casualty module of NFIRS, but USFA is dependent on the localities to input that information.
    - The International Association of Fire Chiefs (IAFC)—Near Miss Reporting System is voluntary and the struck-by near misses are part of the reports the system receives.
    - The group discussed the possibility of looking at 911 dispatch protocols to determine if any of them indicated responder struck-by crashes. Working with some dispatch associations may be a good future next step.
    - There was discussion about the potential to find information on responder struck-by crashes in local 911/public safety answering point (PSAP) data; however, this information is likely to vary significantly depending on the PSAP. There may be some commonalities related to officer down, but this is not likely to extend to other responder disciplines.

Next Steps/Action Items

The group identified several next steps and action items, shown in table 24, which ranged from short-term to longer term actions.

Table 24. Next steps/action items identified in Group 2.

Next Step/Action Item	Additional Information
Add data element to National Emergency Medical Services Information System (NEMSIS) that indicates whether patient is a first responder, along with the responder's discipline.	While this should not be a huge lift, there would be some steps to navigate. The States would appreciate support with implementation. If successful, this would also provide everything that follows downstream (e.g., trauma database, hospital records).
Explore opportunities to work directly with States that have useful State-level variables (e.g., the 20 States with type of work-related injury = vehicle) that are not aggregated at the national level.	This would involve State-by-State level exploration, as each State may do things differently. This should not be as daunting as it may sound.
Explore the opportunity to pilot a universal unique identifier (UUID) exchange between the emergency medical services (EMS) report and the traffic crash report. This UUID will exist in the version of NEMSIS that is being rolled out.	To further the effort to find a home for the UUID on crash reports, National Highway Traffic Safety Administration (NHTSA) could consider this UUID in the next version of Model Minimum Uniform Crash Criteria (MMUCC).
Explore potential to identify responder struck-by crashes in 911 dispatch call records.	This effort could possibly coordinate with dispatch associations. This may be focused on law enforcement officer-involved events, with no indication of crashes involving responders from other disciplines.

Group 3—Industry, Nonprofit Data

Group 3 focused on data elements and access to data on responder struck-by crashes that are collected by industry and nonprofit responder groups. Group 3 consisted of the individuals shown in table 25.

Table 25. Participants in Group 3.

Title	Organization
Project Manager–Director	Cumberland Valley Volunteer Firemen's Association
Executive Director	Arizona Professional Towing and Recovery Association
Executive Director	Officer Down Memorial Page (ODMP)
Cochair	International Towing and Recovery Hall of Fame and Museum Survivor Fund/Wall of the Fallen
President	Emerald Transportation Corp
Office of Operations	Federal Highway Administration (FHWA)
Research Assistant	ODMP

Executive Director	Towing and Recovery Association of America, Inc. (TRAA)
Operations	Pine Tree Towing
Director of Training	Emergency Responder Safety Institute (ERSI)
President	La Linda Consulting

Summary of Group Discussion

The group discussed several data systems and the potential to better align each with the responder struck-by research:

- ERSI "Struck-by Incidents" database:
  - Historically, ERSI has maintained a database of responder struck-by crashes linked to media scans/articles. This database should overwhelmingly be comprised of responder struck-by crashes. ESRI has also expanded from the fire and EMS community to include law enforcement, towing, road service technicians, safety service patrol operators, and other responders.
  - In early 2022, ERSI established the "Report a Struck By Incident," a more structured online tool for collecting information on responder struck-by crashes.
  - ESRI does not yet have a firm plan on how to curate, organize, and share self-reported information. Any kind of incident analysis is time-intensive and requires manual work (most of which is done by volunteers). The new database is designed to collect as much information as possible, but it has yet to be determined how to best handle that information.

- STA TTIRS:
  - Data on towing struck-by crashes would be very helpful for legislative and training purposes and can be helpful for towing company owners; however, it has been difficult to get tow operators to self-report data.
  - The group discussed mandating and expanding the reporting of TTIRS data to more relevant data fields; however, there may be issues with aggregating the data as different organizations use different formats. Some suggestions included meeting with owners of towing companies and making them aware of TTIRS; social media could also help connect drivers and company owners.
  - The group agreed that one of the keys to improving the reporting of data is to make it as easy as possible for users to submit.
  - It was suggested that towing dispatch companies, who already have the technological infrastructure to communicate with drivers and owners, be engaged. Engaging towing dispatch companies would allow the use of the same applications that operators already use daily and could provide unprecedented reach to drivers across the country.
  - Engaging insurance companies could also be helpful.
  - Data reporting would likely improve if company owners or safety managers could see the value of the data in better understanding how to improve safety and effectiveness for their companies. Creating the tools to carry this out would not be too difficult. Geocoding the data and having consistency with the MMUCC would be ideal, and the

ultimate goal should be to push data from different sources to a central repository to deepen the available data on each record.
  - It was suggested that this topic be added to the agenda for the next TRB Towing Safety Consortium meeting.

- ODMP:
  - There is some overlap in ODMP's data categories, which is not ideal. ODMP is looking to streamline the database so that the categories are more refined and include metadata tagging to allow for fine-tuning of incident types within the broader categories. Many of these improvements are relevant to this project. For example, one anticipated improvement is to provide more details on the activities being performed by responders when they are struck (e.g., directing traffic, performing a traffic stop, responding to a crash). Any given record could be further refined with any number of potential metadata tags.
  - Many of these enhancements are expected to occur in calendar year 2022; some will occur in 2023 depending on complexity.
  - ODMP plans to eliminate the vehicular assault category and instead categorize an incident as either "auto crash," "struck by vehicle," or "motorcycle crash," and then identify within those three what the responder was doing at the time of the crash.
  - These improvements are a work in progress, and ODMP offered to work with the project team to see what data points would be most helpful. There is crossover between law enforcement and other services (such as towing). If there are data that are not necessarily relevant to law enforcement but would be easy to obtain and helpful to other groups, ODMP would be interested in exploring that.

- NLEOMF:
  - This group is open to sharing the data State-by-State for research and development purposes.

Next Steps/Action Items

Table 26 summarizes next steps and action items identified during the Group 3 Industry, Nonprofit Data discussions.

Table 26. Next steps/action items identified in Group 3.

Next Step/Action Item
Review the new Emergency Responder Safety Institute (ERSI) "Report a Struck-By Incident" tool with respect to how it might be aligned with the responder struck-by definition and desired location information.
Federal Highway Administration (FHWA) to collaborate with the Officer Down Memorial Page (ODMP) owners to review their system and discuss opportunities for better data alignment. ODMP is in the process of updating the metadata associated with the line of duty deaths (LODDs) and is open to sharing their schema for feedback so that struck-by crashes can be more aligned (to more easily find the struck-bys).
Collaborate with tow dispatch agencies and tow app providers to create a simple form to enter key data and make it available/accessible to all who want it (as an application programming interface (API)).

Add topic to agenda for text Transportation Research Board (TRB) Towing Safety Consortium regarding data geocoding, Model Minimum Uniform Crash Criteria (MMUCC) compliance, and goal of pushing data to a central repository.

Group 4 National Occupational Safety and Health Data

Group 4 focused on data elements and access to National Occupational Safety and Health data Group 4 consisted of the individuals shown in table 27.

Table 27. Participants in Group 4.

Title	Organization
Research Epidemiologist	National Institute for Occupational Safety and Health (NIOSH)
Statistician	NIOSH
Senior Economist	Occupational Safety and Health Administration (OSHA)
Branch Chief	U.S. Bureau of Labor Statistics (BLS)
Epidemiologist	BLS
Economist/Occupational Safety and Health Statistics	BLS

Summary of Group Discussion

The group discussion focused on the merits of the different datasets related to occupational safety and health, specifically the CFOI, FAT/CAT Reports, State workers' compensation data, and the nonfatal occupational injury data collected through the NEISS-Work.

- CFOI—Several limitations were identified during the discussion, including:
  - **Lack of crash location information**—Crash coordinates are not retained, and although location information that is limited to metropolitan statistical area (MSA) and county are recorded, this information is not published. Additionally, while the road classification system is recorded, roadway names are not due to privacy reasons. Therefore, this dataset will not allow for linking identified responder struck-by crashes to other data sources, such as crash reports, to ensure that they are not duplicated.
  - **Data access is limited**—Researchers can request detailed queries of the data by contacting BLS staff (via email or phone call) and specifying the characteristics in which they are interested. However, these queries would result in summary tabulations of the data and not in a structured dataset of the responder fatal crash events. Additionally, researchers may request to access the micro (raw) data in person at data centers; however, this requires a research agreement, which takes several months to establish. Furthermore, while the researchers can view, access, and analyze data through a research agreement, they may not be able to access the narratives associated with each fatal crash. Lastly, the user agreements may allow for publication of certain results from the data analysis; however, the micro (raw) data cannot be transferred/shared or added to another/existing dataset.

- **Lack of detailed occupational categories**—The data codes used in CFOI come from the *Occupational Injury and Illness Classification System (OIICS) Manual*, but the occupational codes for responder disciplines may not be aligned completely. Responder disciplines may be difficult to parse from the data. For example, within OIICS, tow operators are grouped with heavy truck drivers. A research paper by Dr. Terry Bunn may be useful for reviewing how different end-users and agencies define occupations (Chandler and Bunn 2019).

    - BLS is in the process of updating the OIICS manual and is considering condensing some variables related to safety equipment (e.g., safety clothing, traffic cones) and environmental control factors (e.g., safety procedures at work zones). OIICS tries to capture these through worker activities, such as responding to an emergency. The improvements to OIICS will impact other datasets, as many datasets rely on CFOI. An idea for improving the OIICS manual and subsequently CFOI data involves including an incident scene as a location, which would allow researchers to cross incident scene with occupation to parse out responders.

- A published paper assessed the data availability, access, and degree of information in CFOI and the Memorial Fund and found that the Memorial Fund was better for accessing fatality data for law enforcement agencies. The paper also discussed near-misses and self-reported data available through the Memorial Fund. Although the data through the Memorial Fund are limited, there is a continued push to educate law enforcement agencies on how to report near-miss crashes.

- Weekly FAT/CAT Reports:
    - The 2021 FAT/CAT reports have not been completely published as of February 2022.
    - The reports are a good source of identifying crash causality factors; however, the data source does not provide a comprehensive inventory of responder struck-by fatal crashes.

- State Workers' Compensation Data:
    - Worker compensation data are maintained by State-run workers' compensation data programs and each program differs regarding what data they capture.
    - There are some limitations with injury coding, which is not always standardized in compensation data.
    - Further investigation of these data would require the establishment of a user agreement with each State to access the workers' compensation data. NIOSH has an agreement with Ohio to access their system and is currently conducting two different studies with the data. The examination of workers' compensation data would require collaboration with a researcher that is an expert in this data source.

- Work-RISQS:
    - NIOSH has an interagency agreement with the NEISS-Work, which collects data on nonfatal injuries sampled through hospital emergency departments throughout the United States.
    - This is a national sample and only includes occupational injuries that are treated in emergency rooms; however, it does provide potential for further investigation.

- The CFOI and the State workers' compensation data presented the most opportunity in terms of further investigation into the data and the possibility of identifying responder struck-by crashes.

Next Steps/Action Items

One of the primary objectives of this group was to understand more about the available data sources and the opportunities for further investigation. This includes exploring research agreements and availability of narratives within CFOI; reviewing and providing feedback on the OIICS manual, which is currently being updated; contacting State-run workers' compensation data systems; and following up regarding non-fatal injury emergency department data through NEISS-Work.

Table 28 summarizes the potential next steps and action items identified during the Group 4 National Occupational Safety and Health Data breakout session.

Table 28. Next steps/action items identified in Group 4 National Occupational Safety and Health Data.

Next Step/Action Item
Establish a research agreement to access microdata and narratives within Census of Fatal and Occupational Injuries (CFOI): • Research agreements may take several months to establish. • It is unknown if narratives are available. • Data may not be shared and/or added to another dataset (researchers can view, analyze, and publish findings, but not transfer the microdata). • User agreements pose requirements for what researchers can publish after analyzing the microdata.
Request draft Occupational Injury and Illness Classification System (OIICS) for review. The review process may present an opportunity to add certain data elements that may support additional queries of the data for responder struck-by crashes.
Request more information on the State-run workers' compensation data systems (such as CA, MA, MI, OH, and TN). Separate agreements would need to be established to access the data. It is unknown how long these agreements would take to establish.
Explore the potential value of the National Electronic Injury Surveillance System—Occupational Supplement (NEISS-WORK) nonfatal injury hospital emergency department data.

FOLLOW-UP VIRTUAL STAKEHOLDER WORKSHOP—FOCUSED STAKEHOLDER/GROUP PARTICIPATION

The objective of the follow-up workshop was to continue the discussions from the initial workshop with a smaller, focused group of stakeholders. The initial workshop generated many ideas for improving the data collection methods that would contribute to a more complete understanding of responder struck-by crashes that occur at traffic incidents. This section provides an overview of the follow-up meeting, which took place on April 7, 2022, from 2 to 4 p.m. ET. Stakeholders invited to the second event represented individuals and agencies with the most potential to make actionable change. Following is a list of organizations that participated in the follow-up workshop:

- FHWA
- NHTSA
- Ohio DOT
- Tennessee Department of Safety and Homeland Security
- ODMP
- University of Utah
- International Towing and Recovery Hall of Fame and Museum Survivor Fund/Wall of the Fallen
- Massachusetts STA
- Parsons Transportation
- Pine Tree Towing

DISCUSSION

The meeting agenda (appendix C) was organized into three main sections: welcome and introductions, review ideas from the first workshop, and discuss next steps for high-priority action items identified after the first workshop. Of those action items, the project team identified nine topics for discussion at the second workshop. The following list details the high priority actions, with the topics noted for further discussion identified with an asterisk:

- **Group 1 Crash Data**
    - *Leverage the FARS EDT mapping schema to identify possible connections for identifying responder struck-by crashes.
    - *Work to leverage crash report narratives to "flag" responder struck-by crashes.
    - Develop ideas for training law enforcement officers on responder struck-by crash data collection (e.g., short YouTube videos, national education program focused).
    - *Develop a unifying definition of responder struck-by crash and incorporate it into the next version of the MMUCC.
    - *Modify MMUCC P4.2 "Incident Responder" attribute (add "Is this person an incident responder" as (Group + Type) Number instead of a subfield under the P4 person type data element, subfield 2 "Responder Involved").
    - Add high-visibility reflective clothing as an attribute under the nonmotorist (NM) NM5 data element.

- **Group 2 National Responder Data by Discipline**
  - *Add data element to NEMSIS that indicates whether patient is a first responder.
  - Explore opportunities to work directly with States that have useful State-level variables but that are not aggregated at the national level (e.g., the 20 States with type of work-related injury = vehicle).
  - *Explore the opportunity to pilot a UUID exchange between the EMS report and the traffic crash report. This UUID will exist in the version of NEMSIS that is now being rolled out.
  - Explore the potential to identify responder struck-by crashes in 911 dispatch call records.

- **Group 3 Industry/Nonprofit Data**
  - Review within the new ERSI tool what might support alignment with desired location information and the responder struck-by definition.
  - *Collaborate with the ODMP to explore opportunities for better data alignment (ODMP is in the process of updating the metadata associated with law enforcement LODDs).
  - *Collaborate with towing dispatch agencies and towing mobile application providers to create a simple form to enter key data and make it available/accessible.
  - *Discuss alignment of data elements within TTIRS to link to crash reports.
  - Add topic to agenda for next Transportation Research Board (TRB) Towing Safety Consortium regarding data geocoding, MMUCC compliance, and goal of pushing data to a central repository.

- **Group 4 National Occupational Safety and Health Data**
  - Establish a research agreement to access microdata and narratives within the BLS CFOI.
  - Request draft OIICS for review. The review process may present an opportunity to add certain data elements that may support additional queries of the data for responder struck-by crashes.
  - Request more information on the State-run workers’ compensation data systems. Separate agreements would need to be established to access the data. It is unknown how long these agreements would take to establish.
  - Explore NEISS-WORK nonfatal injury hospital emergency department data.

Most of the agenda was dedicated to the facilitated discussion focused on the preselected topics. The facilitator asked an identified leader of the topic to provide a brief background and relevant updates. The project team recorded notes using an online whiteboard to identify action steps, leaders, and anticipated timelines. The following provides a summary of the topics and associated discussions.

Topic: Leverage the FARS EDT mapping schema to identify possible connections for identifying responder struck-by crashes.

Discussion/Actions: NHTSA will continue to work with Tennessee to review their EDT mapping schema to where it autopopulates to the person-level form. NHTSA will then identify the opportunities to expand the mapping processes to all States and encourage States to add a checkbox for responder struck-by to their crash reports.

Topic: Work to leverage crash report narratives to "flag" responder struck-by crashes.

Discussion/Actions: One of the things to advocate for is to connect the crash reports with reconstruction reports, which are much more detailed. They are often not circulated back into the State crash reporting system. It would be helpful if a standardized set of key words were developed for reporting officers to use in the report narratives, and this would help NHTSA categorize the FARS attributes. NHTSA would also benefit from clear details as to the responder's role in the crash (e.g., pedestrian, occupant of parked vehicle) to make sure they get a proper designation. Ohio Department of Transportation is evaluating how to connect crash reconstruction reports to the State crash reporting system. Their goal is to create key words to use in crash reports, which would establish the framework for developing an automated process for reviewing crash narratives to identify responder struck-by crashes. The project team has also developed a potential set of key words to consider.

Topic: Develop a unifying definition of responder struck-by crash and incorporate it into the next version of the MMUCC.

Discussion/Actions: NHTSA is currently working on the MMUCC 6th Edition and is accepting suggestions by the end of 2022. One item under exploration is elevating the P4.2 "Incident Responder?" subfield to the data element level. NHTSA is meeting with NEMSIS to add a UUID to MMUCC to align with the UUID being rolled out in the latest version of NEMSIS.

Topic: Add data element to the NEMSIS that indicates whether a patient is a first responder.

Discussion/Actions: NHTSA and the University of Utah are working on a data element at the patient level that identifies the patient as a responder. They are working with NHTSA on the definition and descriptions and alignment between NEMSIS, FARS, and MMUCC. This is the same timeframe as the MMUCC update scheduled for 2024.

Topic: Explore the opportunity to pilot a UUID exchange between the EMS report and the traffic crash report. This UUID will exist in the version of NEMSIS that is now being rolled out.

Discussion/Actions: NHTSA/MMUCC and NEMSIS are jointly championing this ongoing, exploratory effort.

Topic: Discuss alignment of data elements within TTIRS to link to crash reports.

Discussion/Actions: The Massachusetts STA is collaborating with the TRAA to develop a push notification to encourage towers to report a responder struck-by incident. The process requires permissions to send the notification and determining where to send and store the information.

CHAPTER 6. SUMMARY AND RECOMMENDED NEXT STEPS

This report details the approach and findings from research conducted regarding the occurrence of responder struck-by crashes. There is not one national source of responder struck-by crashes from which to draw and analyze data to better understand and mitigate these tragic incidents. This project sought to cast a wide net across many different potential sources of data on responder struck-by crashes, assess these sources, identify gaps and limitations in the data, and develop a composite dataset of verified struck-by crashes.

The research resulted in a common definition for a responder struck-by crash for consistency in identifying responder struck-by crashes:

> *A "responder struck-by" incident is a collision between a motor vehicle in transit and a responder working a roadway incident, which would be recorded on a State traffic crash reporting form in the jurisdiction where it occurred. The responder may be a non-motorist, an occupant of a stopped response vehicle, or an unoccupied response vehicle.*

The project team reviewed and assessed over 20 sources of data for responder struck-by crashes. The project team explored various data elements and attributes within each of the data sources, identified and verified responder struck-by crashes, where possible, and documented gaps and limitations of each data source. The project team compiled the verified responder struck-by crashes into a composite dataset, which included 505 crashes that occurred between 2011 and 2021 across 42 States. About half of the responder struck-by crashes identified occurred in Florida and Tennessee, as the project team had access to many years of crash data from these two States. About one-third of the responder struck-by crashes were identified in ERSI articles associated with crashes in 36 States. The project team identified the remaining responder struck-by crashes through various other sources, including NFIRS, TTIRS, NIOSH FACE reports, and crash reports from Arizona, Illinois, and Ohio.

To assist with similar future research, the project team developed a template for collecting data on responder struck-by crashes from a variety of sources. The template leverages the common definition of a responder struck-by crash and details five steps that were applied to collect and assess the data sources used for this project, which could be applied to other data sources, as well.

The project team conducted an analysis of the 505 responder struck-by crashes in the composite dataset. The analysis included summary statistics breaking down the crashes by various crash and responder variables, chi-square tests, a cluster analysis, and a case study of over 600 responder vehicle-only struck by crashes in Florida.

A virtual stakeholder workshop brought together 47 stakeholders representing local and State transportation and law enforcement agencies; local and national fire agencies and organizations; local and national EMS agencies and organizations; national law enforcement organizations; local, State, and national towing agencies and organizations; and various Federal agencies. Breakout groups focused on multiple datasets assessed by the project team and provided the opportunity to learn about additional data sources that may be of interest for identifying responder struck-by crashes. Each breakout group identified potential action items and next steps for improving the ability to identify responder struck-by crashes within the data sources discussed. Discussions in a subsequent webinar with a smaller group of the stakeholders drilled down into the next steps and set some actions in motion for making positive change with respect to the data.

Recommendations for next steps and future research include the following:

- **Finalize and adopt a national definition for a responder struck-by crash**—A definition for a responder struck-by crash was developed for this project with input from various stakeholders:
    - Make any final adjustments to this definition and adopt and promote it within responder groups to improve awareness, understanding, and consistency in reporting.
    - Incorporate the definition into the next version of the MMUCC.
    - Include the definition in responder training where possible.

- **Improve and leverage the traffic crash report forms to improve information on responder struck-by crashes**—Currently, there is a lot of variability between State traffic crash forms, which makes it challenging to leverage the resulting crash data as a source of responder struck-by crashes. A variety of data elements—MMUCC and State specific—are in use, but most are not accurately capturing responder struck-by crashes. Considerations include:
    - Improving the uniformity of crash reports across States (e.g., MMUCC, training)
    - Leveraging the narrative fields on crash reports to identify struck-by crashes through key words and terms that could be searched to identify potential responder struck-by crashes where there is a lack of data elements/uniformity
    - Improving the ability to do search and analysis of narratives (e.g., store narratives as text as opposed to images)
    - Adding high-visibility reflective clothing as an attribute under the NM.5 "Nonmotorist Safety Equipment" data element, as this was found to be useful information in identifying responder struck-by crashes

- **Explore potential changes to the MMUCC P4 "Person Type" data element and the associated P4.2 "Incident Responder?" data attribute**—There is confusion regarding the definition and use of this data element/attribute. As the MMUCC is actively being revised and updated, the opportunity exists to include this data element/attribute as part of the updates. Considerations include:
    - Clarifying the definition of a responder struck-by crash (using the national definition)
    - Modifying the P4.2 "Incident Responder?" attribute/subfield to "Is this person an incident responder?"
    - Elevating the P4.2 "Incident Responder?" data attribute/subfield to the data element level

- **Develop local and national training for law enforcement officers to improve the collection of data on responder struck-by crashes**—Data on responder struck-by crashes could be improved at the point of collection by increasing the understanding and use of the various data elements and narrative fields for capturing responder struck-by crashes:

- Develop ideas for training law enforcement officers on responder struck-by crash data collection (short videos, roll call).
- Implement a national education program focused on training law enforcement on collecting data on responder struck-by crashes.
- Train officers to use the narrative fields on crash reports to identify struck-by crashes.

- **Collaborate with specific data owners identified in this research to review, modify, and better leverage these data sources for responder struck-by crashes**—ERSI, FARS, NEMSIS, ODMP, and BLS are sources that offer potential to identify responder struck-by crashes in the future:
  - ERSI:
    - Review the new ERSI "Report a Struck By Incident" tool with respect to how it might be aligned with the responder struck-by definition and how desired location information might be collected.
    - Explore the data being generated via the tool. The new database is designed to collect as much information as possible, but it has yet to be determined how to best handle that information.
  - FARS:
    - Leverage FARS EDT mapping schema to find possible connections for identifying responder struck-bys across the 19+ States that participate.
  - NEMSIS:
    - Include a field in NEMSIS, on a patient-centric basis, to indicate whether the patient is a first responder, along with the responder's discipline. There is a mechanism that exists to add that data element, provide a clear definition, and have the EMS programs collect it. It would then be collected uniformly across the United States.
    - Explore opportunities to work directly with States that have useful State-level NEMSIS variables (e.g., work-related injury = vehicle) that are not aggregated at the national level.
    - Explore the opportunity to pilot a UUID exchange between EMS run reports and traffic crash reports. This UUID will exist in NEMSIS.
  - ODMP:
    - Coordinate with ODMP on making improvements to data elements and metadata as part of the ongoing 2022–2023 improvements. ODMP plans to eliminate the vehicular assault category and instead categorize an incident as either "auto crash," "struck by vehicle," or "motorcycle crash," and then identify within those three what the responder was doing at the time of the crash.
  - BLS:
    - Coordinate with BLS to improve the OIICS manual and subsequently the CFOI data to include an incident scene as a location for an occupational injury, which

would allow researchers to cross incident scene with occupation to parse out responders involved.

- **Engage and work with the towing industry to collect data on responder struck-by crashes**—Currently, few companies collect/share data on responder struck-by crashes. The TTIRS dataset is a grass-roots effort to collect these data nationally, but it has been slow to be used or adopted. Considerations include:
  - Discussing this topic at TRB Towing Safety Consortium meetings
  - Encouraging the use of the TTIRS system, including meeting with owners of towing companies; social media could help connect drivers and company owners
  - Expanding the reporting of TTIRS data to include more relevant/aligned data fields
  - Collaborating with tow dispatch agencies and tow app providers to create a simple form to enter key data and make it available/accessible as an API
  - Collaborating with tow company owners and/or safety managers regarding the value of the data to better understand how to improve safety for their companies; creating the tools to collect the data would not be too difficult; geocoding the data and having consistency with the MMUCC would be ideal, and the goal should be to push data from different sources to a central repository to deepen the available data on each record

APPENDIX A. DATA DEFINITIONS

This appendix provides tables that define each column in the draft struck-by database:

- Table 29 defines the "top-level" columns. Top-level columns include metadata about the source from which the data come and provide common, high-level identifying data elements extracted from the source and/or the crash report.
- Table 30 defines the "unified crash report" columns. Unified crash report columns are data from crash records, unified from various DOT-specific formats into one common format. Data for these columns are only available when a crash report is the source or when a crash report was able to be linked to an ERSI article.
- Table 31 defines the "manually labeled" columns. Manually labeled columns consist of data provided during the process of manually parsing and labeling articles and narratives.

Table 29. Top-level columns.

Column	Definition
Source ID	This is number (ranging from 1–638) that was assigned by the project team as the crash dataset was compiled and is simply provided for uniqueness and reference.
Multiple Responders	This is a field assigned by the project team to indicate whether a responder struck-by crash involved multiple responders struck at a single incident scene. In the responder-level dataset, these crash records were included for each responder that was struck. The data element takes values of "Y" for multiple responders and "N" for a single responder.
Responder Count	This is a field assigned by the project team to indicate the number of responders struck in each responder struck by crash. The data element takes values from 1–6.
CR or NCR	This is a field assigned by the project team to indicate whether or not a responder struck-by record was associated with a crash report. This data element takes values of "CR," indicating a record came from a crash report or was linked to a crash report, and "NCR," indicating that a record did not come from a crash report or was not matched to a crash report.
Global Crash Universal Unique Identifier (UUID)	The unique identifier from the project team's unified crash database, typically composed of the DOT's abbreviated name along with the crash report ID. This data element only applies to the responder struck-by crashes that were identified through State crash reports or those that were identified through other data sources but were matched to a State crash report. For the remainder of the responder struck-by records, this field is empty.

Column	Definition
ERSI Uniform Resource Locator (URL)	This is a field added by the project team to include the URL associated with an ERSI responder struck-by crash record. For the records for which a URL was not available, the value for this data field was set as "1."
United States Fire Administration (USFA) URL	This is a field added by the project team to include the URL for the USFA responder struck-by record.
National Institute for Occupational Safety and Health (NIOSH) URL	This is a field added by the project team to include the URL for the NIOSH responder struck-by record.
Towing Traffic Incident Report System (TTIRS) URL	This is a field added by the project team to indicate whether a responder struck-by record was obtained from the TTIRS data. The records for which the URL was available have this information included in this data field. For the records for which a URL was not available, the value for this data field was set as "1."
Crash Timestamp	The date and time representing the crash
Crash Date (Local)	The date of the crash (based on the local time zone where the incident occurred)
Crash Time (Local)	The time of the crash (based on the local time zone where the incident occurred)
Year	The integer year extracted from the date column
Month	The integer month extracted from the date column
Month (text)	The month during which the crash occurred
Day	The integer day extracted from the date column
Day of Week (Local)	The day of the week on which the crash occurred (based on the local time zone when the incident occurred)
Hour (Local)	The integer representing the hour of the day that the crash occurred (ranging from 1–24)
State	The abbreviation of the State in which the crash occurred
Latitude	The latitude at which the crash occurred
Longitude	The longitude at which the crash occurred
Road	The name of the road on which the crash occurred, if available
Intersecting Road	The intersecting road, if the crash occurred at an intersection
Crash Report Confidence	The confidence of the association between a crash report and an ERSI article Valid values are high (obviously a match based on 4 or more shared factors between the article and the crash report, and no obvious discrepancies); medium (may be a match based on 3–4 shared attributes, but there may be questionable discrepancies); low (there are some shared attributes, but some discrepancies indicate it may not be a good match); and source (the crash report is the source, rather than an external article)
Injury Flag	Whether or not there were any injuries documented
Fatality Flag	Whether or not there were any fatalities documented

Table 30. Unified crash report columns.

Column	Definition
Crash Report: Source	The Department of Transportation (DOT) from which the crash report was obtained
Crash Report: Local Crash Identifier (ID)	The ID of the incident as assigned by the DOT
Crash Report: Private Property Flag	Whether or not private property was damaged
Crash Report: Off Road Flag	Whether the crash occurred off the roadway or not
Crash Report: Secondary Crash Flag	Whether or not the incident was classified as a secondary crash
Crash Report: Time Zone	The time zone, in Internet Assigned Numbers Authority (IANA) format, of the coordinates where the incident occurred
Crash Report: Time Zone Abbreviation	The abbreviation of the time zone
Crash Report: Time Zone Offset	The time zone offset
Crash Report: T0 Incident Occurs	The date/time the incident occurred
Crash Report: T1 Incident Reported	The date/time the incident was reported
Crash Report: T3 Response Dispatched	The date/time first responders were dispatched
Crash Report: T4 Response Arrives	The date/time the first responders arrived at the scene of the incident
Crash Report: T5 Roadway Cleared	The date/time the roadway was cleared
Crash Report: T6 Incident Cleared	The date/time the incident was completely cleared
Crash Report: T0 Incident Occurs Coordinated Universal Time (UTC)	The UTC date/time the incident occurred
Crash Report: T1 Incident Reported UTC	The UTC date/time the incident was reported
Crash Report: T3 Response Dispatched UTC	The UTC date/time first responders were dispatched
Crash Report: T4 Response Arrives UTC	The UTC date/time the first responders arrived at the scene of the incident
Crash Report: T5 Roadway Cleared UTC	The UTC date/time the roadway was cleared
Crash Report: T6 Incident Cleared UTC	The UTC date/time the incident was completely cleared
Crash Report: Date (UTC)	The UTC crash date
Crash Report: Day of Week (UTC)	The UTC Day of the week (Monday–Sunday)
Crash Report: Hour (UTC)	The UTC hour of the day (0–23)
Crash Report: Agency	The first responding agency
Crash Report: District	The district where the crash occurred
Crash Report: City	The city where the crash occurred
Crash Report: County	The county where the crash occurred
Crash Report: Urban Rural	Whether the crash occurred in a rural or urban area
Crash Report: Direction of Travel	The cardinal direction of traffic flow where the crash occurred

Column	Definition
Crash Report: Milepoint	The mile post or mile point nearest to where the crash occurred
Crash Report: Distance from Reference Point	The distance between the nearest referenced milepost and the actual location where the crash occurred
Crash Report: Intersection Type	The type of intersection where the crash occurred
Crash Report: Road System	The type of road or road system where the crash occurred
Crash Report: Number of Lanes	The total number of lanes within the road where the crash occurred
Crash Report: Road Width	The width of the roadway where the crash occurred
Crash Report: Road Median Width	The median width on the roadway where the crash occurred
Crash Report: Road Median Width	The median width on the roadway where the crash occurred
Crash Report: Road Category	The category of the road where the crash occurred
Crash Report: Road AADT	The annual average daily traffic (AADT) of the road where the crash occurred
Crash Report: SR Route ID	The State route number of the road where the crash occurred
Crash Report: US Route ID	The US route number of the road where the crash occurred
Crash Report: LRS Road ID	The unique identifier for the road within the Linear Reference System (LRS)
Crash Report: First Harmful Event (FHE)	The first harmful event associated with the crash
Crash Report: Location of FHE	The location of the first harmful event associated with the crash
Crash Report: Location of FHE Relative to Junction	The location of the first harmful event associated with the crash relative to the nearest junction
Crash Report: Location of FHE Relative to Junction	The location of the first harmful event associated with the crash relative to the nearest junction
Crash Report: Manner of Crash	The manner in which the crash occurred
Crash Report: Alcohol Involved	Whether or not alcohol was involved in the crash
Crash Report: Drugs Involved	Whether or not drugs were involved in the crash
Crash Report: Drivers Actions	The driver’s actions immediately before the crash

Column	Definition
Crash Report: Number of Injuries	The number of injuries resulting from the crash
Crash Report: Injury Severity Source	The most severe injury, as specified in the crash report
Crash Report: Injury Severity KABCO	The most severe injury, converted to the KABCO standard
Crash Report: Number of Fatalities	The number of fatalities resulting from the crash
Crash Report: Number of Involved Persons	The number of people involved in the crash
Crash Report: Number of Involved Pedestrians	The number of pedestrians involved in the crash
Crash Report: Number of Involved Pedalcyclists	The number of pedalcyclists (people riding bicycles and other pedaled vehicles) involved in the crash
Crash Report: Number of Involved Drivers	The number of drivers involved in the crash
Crash Report: Number of Involved Vehicles	The number of vehicles involved in the crash
Crash Report: Law Enforcement Agency ID	The unique identifier of the first responding law enforcement agency
Crash Report: Weather Condition 1	The first reported weather condition in effect at the time of the crash
Crash Report: Light Condition	The lighting conditions at the time and location of the crash
Crash Report: Roadway Surface Condition	The road surface condition at the time and location of the crash
Crash Report: Contributing Circumstance 1	The first reported contributing circumstance to the crash
Crash Report: Contributing Circumstance 2	The second reported contributing circumstance to the crash
Crash Report: Relation to Junction Within Interchange Area Flag	Whether or not the crash occurred within an interchange area as defined in *Model Minimum Uniform Crash Criteria* (MMUCC) 5th Edition
Crash Report: Number of Approaches to Intersection	The number of approaches to the intersection where the crash occurred.
Crash Report: Traffic Control Device	The traffic control device nearest to where the crash occurred
Crash Report: School Bus-Related Flag	Whether or not a school bus was involved in or otherwise related to the crash
Crash Report: Crash Cost	The total estimated cost of the crash in U.S. dollars
Crash Report: Response Time	The incident response time in seconds, as reported in the source data
Crash Report: Roadway Clearance Time	The roadway clearance time in seconds, as reported in the source data

Column	Definition
Crash Report: Incident Clearance Time	The incident clearance time in seconds, as reported in the source data
Crash Report: Responder Struck by	Whether or not this is classified as a "Responder Struck-By" incident, where a nonmotorist first responder was struck by a vehicle, based on crash report data as defined by MMUCC-5 or as indicated by the relevant DOT

KABCO stands for K=fatal injury, A=suspected serious injury, B=suspected minor injury, C=possible injury, and O=no apparent injury.

Table 31. Manually labeled columns.

Column	Definition
Label: Description	A short description of the incident
Label: Struck by Moving Vehicle	Whether the first responder was struck by a moving vehicle
Label: Struck by Other	Indicates what struck the first responder, if not a moving vehicle
Label: First Responder Location	(In text) Indicates the position/location of the first responder at the time of incident; takes values of: Pedestrian, Stopped Vehicle, Unknown
Label: First Responder Pedestrian Struck	Whether the first responder was a pedestrian when struck (binary: 1 for Yes, 0 for No)
Label: First Responder in Stopped Vehicle Struck	Whether the first responder was in a stopped vehicle when struck (binary: 1 for Yes, 0 for No)
Label: First Responder in Moving Vehicle Struck	Whether the first responder was in a moving vehicle when struck (binary: 1 for Yes, 0 for No)
Label: First Responder in Unknown Location	If the first responder's location (whether on foot or inside stopped response vehicle) was unknown (binary: 1 for Yes, 0 for No)
Label: Response Type	(In text) indicates the type of response when struck
Label: Action Traffic Stop	Whether the first responder was performing a traffic stop when struck (binary: 1 for Yes, 0 for No)
Label: Action Directing Traffic	Whether the first responder was directing traffic when struck (binary: 1 for Yes, 0 for No)
Label: Action Car Collision Response	Whether the first responder was responding to a car collision when struck (binary: 1 for Yes, 0 for No)
Label: Action Noncrash Incident	Whether the first responder was responding to a noncrash incident such as a medical emergency, a flat tire, a car out of gas, etc. (binary: 1 for Yes, 0 for No)
Label: Action Debris	Whether the first responder was picking up or stopped because of debris when struck (binary: 1 for Yes, 0 for No)
Label: Action Other	Any other reason the first responder was stopped (binary: 1 for Yes, 0 for No)

Column	Definition
Label: Responder Type	(In text) The first responder discipline
Label: Responder Type Law Enforcement Officer	Whether a law enforcement officer was struck (binary: 1 for Yes, 0 for No)
Label: Responder Type Firefighter	Whether a firefighter was struck (binary: 1 for Yes, 0 for No)
Label: Responder Type Emergency Medical Services (EMS)	Whether EMS was struck (binary: 1 for Yes, 0 for No)
Label: Responder Type Tow Truck Operator	Whether a tow operator was struck (binary: 1 for Yes, 0 for No)
Label: Responder Type Safety Service Patrol	Whether a safety service patrol operator was struck (binary: 1 for Yes, 0 for No)
Label: Responder Injury Severity	(In text) Injury severity level for the first responder(s) struck. Takes values of: Fatal Injury, Suspected Serious Injury, Suspected Minor Injury, Possible Injury, No Apparent Injury, and Injury Unknown Severity
Label: Responder Injury Severity KABCO	Injury severity level, based on KABCO scale, for the struck responder(s). Takes values of: K = fatal injury, A = Suspected Serious Injury, B = Suspected Minor Injury, C = Possible Injury, O = No Apparent Injury, and U = Injury Unknown Severity
Label: Damage Fatality	Whether there was a first responder fatality (binary: 1 for Yes, 0 for No)
Label: Damage Injury	Whether a first responder was injured (binary: 1 for Yes, 0 for No)
Label: Damage Property Damage	Whether there was first responder property damage (binary: 1 = Yes, 0 = No)
Label: Damage Unknown	Whether the damage or injury to the first responder is unknown (binary: 1 for Yes, 0 for No)
Label: Contributing Factor	The factor(s) contributing to the first responder being struck, as determined by the project team reviewing the article narrative; these only applied to the crashes identified through data sources other than crash reports and that were not matched with crash reports
Label: Protective Clothing	Indicates whether the responder(s) struck were wearing retroreflective clothing at the time of the crash

APPENDIX B. INITIAL VIRTUAL STAKEHOLDER WORKSHOP—BROAD RESPONDER GROUP AGENDA

RESPONDER STRUCK-BY STAKEHOLDER VIRTUAL WORKSHOP

WEDNESDAY, FEBRUARY 16, 2022

12:30–4:30 P.M. EST

12:30–1 Welcome, Introductions, and Workshop Overview and Objectives

- FHWA welcomes participants to workshop
- FHWA project team and research team introductions
- Workshop agenda and overview of project
- Tasks/effort to date
- Objectives of workshop

1–2 Overview of Data Collection and Analysis

- Present data collection methodology
- Present/discuss challenges and limitations
- Overview of findings from analysis

2–2:15 Break

2:15–3:25 Breakout Group Discussions

- Overview of breakout group process and transfer to groups
- Welcome/roundtable introductions
- Overview of breakout group objectives
- Set stage for discussions
- Group discussion

3:25–3:35 Break

3:35–4:25 Whole Group Discussion

- Report-outs, next steps, and action items from each breakout group

4:25–4:30 Closing remarks

APPENDIX C. FOLLOW-UP VIRTUAL STAKEHOLDER WORKSHOP—FOCUSED STAKEHOLDER/GROUP AGENDA

ASSESSMENT OF DATA SOURCES FOR SERIOUS AND FATAL INJURIES SUSTAINED BY FIRST RESPONDERS

THURSDAY, APRIL 7, 2022

2–4 P.M. ET

2–2:10 Welcome, Introductions, and Workshop Overview and Objectives

- **Welcome**
- **Introductions**
- **Objectives:**
  - Review outputs from the workshop break-out groups.
  - Prioritize ideas.
  - Identify and discuss tangible next steps towards the improvement of data on responder struck-by crashes.

2:10–2:20 Review Ideas from First Workshop Breakout Groups

- **Group 1 Crash Data:**
  - Leverage the Fatality Analysis Reporting System (FARS) electronic data transfer (EDT) mapping schema to identify possible connections for identifying responder struck-by crashes.
  - Work to leverage crash report narratives to "flag" responder struck-by crashes.
  - Develop ideas for training law enforcement officers on responder struck-by crash data collection (e.g., short YouTube videos, national education program focused).
  - Develop a unifying definition of responder struck-by crash and incorporate it into the next version of the *Model Minimum Uniform Crash Criteria* (MMUCC).
  - Modify MMUCC P4.2 "Incident Responder" attribute (add "Is this person an incident responder" as (Group + Type) Number instead of a subfield under the P4 person type data element, subfield 2 "Responder Involved").
  - Add high-visibility reflective clothing as an attribute under the nonmotorist (NM) NM5 data element.

- **Group 2 National Responder Data by Discipline**
  - Add data element to National Emergency Medical Services Information System (NEMSIS) that indicates whether patient is a first responder.
  - Explore opportunities to work directly with States that have useful State-level variables (e.g., the 20 States with type of work-related injury = vehicle) that are not aggregated at the national level.
  - Explore the opportunity to pilot a universally unique identifier (UUID) exchange between the EMS report and the traffic crash report. This UUID will exist in the version of NEMSIS that is now being rolled out.
  - Explore potential to identify responder struck-by crashes in 911 dispatch call records.

- **Group 3 Industry/Nonprofit Data**
  - Review within the new ERSI tool what might support alignment with desired location information and the responder struck-by definition.
  - Collaborate with the ODMP to explore opportunities for better data alignment (ODMP is in the process of updating the metadata associated with law enforcement line of duty deaths (LODDs)).
  - Collaborate with towing dispatch agencies and towing mobile application providers to create a simple form to enter key data and make it available/accessible.
  - Discuss alignment of data elements withing Towing Traffic Towing Incident Reporting System (TTIRS) to link to crash reports.
  - Add topic to agenda for next Transportation Research Board (TRB) Towing Safety Consortium regarding data geocoding, MMUCC compliance, and goal of pushing data to a central repository.

- **Group 4 National Occupational Safety and Health Data**
  - Establish a research agreement to access microdata and narratives within the Bureau of Labor Statistics (BLS) Census of Fatal Occupational Injuries (CFOI).
  - Request draft Occupational Injury and Illness Classification (OIICS) for review. The review process may present an opportunity to add certain data elements that may support additional queries of the data for responder struck-by crashes.
  - Request more information on the State-run workers' compensation data systems. Separate agreements would need to be established to access the data. It is unknown how long these agreements would take to establish.
  - Explore National Electronic Injury Surveillance System—Occupational Supplement (NEISS-WORK) nonfatal injury hospital emergency department data.

2:20–3:55 Discuss Next Steps for High Priority Action Items

3:55–4 Closing Remarks

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ZERO IS OUR GOAL
A SAFE SYSTEM IS HOW WE GET THERE