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ENHANCING CRASH DATA REPORTING TO HIGHWAY SAFETY PARTNERS IN WYOMING BY UTILIZING BIG DATA ANALYSIS AND SURVEY TECHNIQUES

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16. Abstract

Road safety is a crucial topic of transportation engineering. The Wyoming Department of Transportation (WYDOT) collects such data from police crash reports and roadway inventories. WYDOT also provides those data to its partner groups in the form of data records or summary statistics documented in periodical reports. The groups include the Wyoming Seat Belt Coalition, the Wyoming Highway Patrol, the Wyoming Association of Sheriffs and Chiefs of Police, the Wyoming Transportation Safety Coalition, the Governor's Council on Impaired Driving, Wyoming's counties, the Wyoming Bicycle and Pedestrian System Task Force, and motorcycle groups. In this research, surveys were prepared, distributed to, and collected from those groups asking about the quality of the data they receive from WYDOT, particularly when it comes to data provision frequencies and unreported data that would be beneficial to those groups. In addition, big data analyses were conducted to evaluate human factors influencing crash occurrences and data provision frequencies. This research's efforts culminated in lists of recommendations to WYDOT regarding the provision of higher quality data at appropriate frequencies to its partners.

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Enhancing Crash Data Reporting to Highway Safety Partners in Wyoming by Utilizing Big Data Analysis and Survey Techniques

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ABSTRACT

Road safety is a crucial topic of transportation engineering. The Wyoming Department of Transportation (WYDOT) collects such data from police crash reports and roadway inventories. WYDOT also provides those data to its partner groups in the form of data records or summary statistics documented in periodical reports. The groups include the Wyoming Seat Belt Coalition, the Wyoming Highway Patrol, the Wyoming Association of Sheriffs and Chiefs of Police, the Wyoming Transportation Safety Coalition, the Governor's Council on Impaired Driving, Wyoming's counties, the Wyoming Bicycle and Pedestrian System Task Force, and motorcycle groups. In this research, surveys were prepared, distributed to, and collected from those groups asking about the quality of the data they receive from WYDOT, particularly when it comes to data provision frequencies and unreported data that would be beneficial to those groups. In addition, big data analyses were conducted to evaluate human factors influencing crash occurrences and data provision frequencies. This research's efforts culminated in lists of recommendations to WYDOT regarding the provision of higher quality data at appropriate frequencies to its partners.

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EXECUTIVE SUMMARY

Evaluating road safety is essential to reducing crash counts, particularly those of severe crashes, by recommending appropriate safety countermeasures. This may involve redesigning roadway facilities, enhancing enforcement practices, or promoting drivers' education campaigns. The fundamental component of road safety assessments is the data collection. The data, which are primarily those of police crash reports, should be accurate and collected in a timely fashion. The data are then processed to pinpoint the precursors that give rise to crashes, identify crash trends, establish definitive objectives such as reducing the number of road fatalities per 100 million vehicle-miles traveled to one, and reassess road safety conditions to ascertain whether or not the objectives were achieved.

The Wyoming Department of Transportation (WYDOT) is the main agency that collects and maintains Wyoming's road safety data. WYDOT provides such data to its partner groups on a regular basis such that they have a clear understanding of the safety of the state's roads, can set their objectives, and can implement road safety countermeasures to achieve those objectives. The data are provided either as database files or in the form of summary statistics documented in reports available in the WYDOT Highway Safety Office (HSO). The groups are the following:

- Wyoming Seat Belt Coalition (WSBC)
- Wyoming Highway Patrol (WHP)
- Wyoming Association of Sheriffs and Chiefs of Police (WASCOP)
- Wyoming Transportation Safety Coalition (WTSC)
- Governor's Council on Impaired Driving (GCID)
- Wyoming's counties
- Wyoming Bicycle and Pedestrian System Task Force (WBPSTF)
- Motorcycle groups

Providing the appropriate data to each group is an efficient means of addressing road safety. Yet, it should be noted that gaps in road safety data reporting exist. The appropriateness of the frequency at which road safety data are provided to the partner groups should be evaluated as well. For this project, evaluating the data needs of the partner groups and the appropriateness of the data provision frequency was achieved by disseminating a tailored survey to each group. In addition, more profound insights on the human factors that lead to crashes in the state were obtained to better address road safety. This was achieved by using big data analytical techniques conducted on WYDOT's crash data. This project culminated in a series of recommendations for WYDOT regarding specific road safety data reporting requirements to the partner groups. In particular, the recommendations pertained to specific data elements to be reported, crash data reporting intervals, and appropriate formats for presenting the data. Once WYDOT would implement the recommendations, its partners would have access to comprehensive data delivered to them in a timely manner and thus be able to achieve their objectives efficiently.

Suggestions made for WYDOT include the provision of the following data for WHP, WASCOP, and Wyoming's counties:

- Crash statistics by crash type
- Crash injury severity level statistics by age/gender
- Seat belt use statistics
- DUI statistics
- Fatigued-driving-related crash statistics
- Distracted-driving-related crash statistics
- Traffic violation statistics
- Truck policy violation statistics

- Crash statistics by weather condition
- Crash statistics by lighting condition
- Crash statistics by day of the week
- Crash statistics by time of day
- Motorcycle crash statistics
- Hot spots by crash severity level and description (seat belt improper use or non-use, CMV-related, etc.)

Other noteworthy suggestions entail the planning for research studies relating to the following topics:

- Effectiveness of speed, seat belt use, and other violation enforcement policies
- Effectiveness of traffic safety educational campaigns
- Response times of emergency services, particularly for fatal, suspected serious injury and suspected minor injury crashes

For the other groups—the Wyoming Seat Belt Coalition, Wyoming Transportation Safety Coalition, Governor's Council on Impaired Driving, Wyoming Bicycle and Pedestrian System Task Force, and the motorcycle groups—the recommendations are similar. Yet, they are tailored to seat belt use, truck safety, impaired driving, non-motorist safety, and motorcycle safety, respectively. Human factors influencing crash severity, including driving under the influence, leaving the crash scene, distracted driving, the involvement of a young driver aged 20 or below, the involvement of an elderly driver aged 61 or above, the involvement of a female driver, improper or non-use of safety restraints, speeding, and reckless driving were investigated using two techniques. They were the logistic regression framework and the random forest data mining method. Most of those parameters were found to be influential except for speeding, reckless driving, and distracted driving. Furthermore, an analysis was conducted to gauge fluctuations in crash trends. With that, road safety data sharing time frames were suggested. Finally, it is anticipated that WYDOT not only implement the aforementioned recommendations but also develop a strategy to conduct follow-up studies on the aforementioned suggested research topics (e.g., effectiveness of traffic safety educational campaigns, etc.).

1. INTRODUCTION

Road safety is a crucial area that should be addressed by transportation agencies. As per the Insurance Institute for Highway Safety (IIHS), in 2019, Wyoming's roadway death toll was estimated as 1.44 fatalities per 100 million vehicle-miles traveled (*1*). Evaluating road safety is essential to reduce crash counts, particularly those of severe crashes, by recommending appropriate safety countermeasures. This may involve redesigning roadway facilities, enhancing enforcement practices, or promoting drivers' education campaigns. The fundamental component of road safety assessments is the data collection. The data, which are primarily those of police crash reports, should be accurate and collected in a timely fashion. The data are then processed to pinpoint the precursors that give rise to crashes, identify crash trends, establish definitive objectives such as reducing the number of road fatalities per 100 million vehicle-miles traveled to one, and reassess road safety conditions to ascertain whether or not the objectives were achieved.

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Providing the appropriate data to each group is an efficient means of addressing road safety. Yet, it should be noted that gaps in road safety data reporting exist. The appropriateness of the frequency at which road safety data are provided to the partner groups should be evaluated as well. For this project, evaluating the data needs of the partner groups and the appropriateness of the data provision frequency was achieved by disseminating a tailored survey to each group. In addition, more profound insights on the human factors that lead to crashes in the state were obtained to better address road safety. This was achieved by using big data analytical techniques conducted on WYDOT's crash data. This project culminated in a series of recommendations for WYDOT regarding specific road safety data reporting requirements to the partner groups.

1.1 Study Objectives

The main objective of this project was to investigate the data needs of WYDOT's partner groups, pinpoint the gaps in road safety data reporting, and suggest appropriate guidelines for WYDOT on the reporting of the data to the groups. This was achieved via the circulation of questionnaires to those groups. The second objective was to examine the human factors that contribute to crashes in Wyoming via big data analyses.

WYDOT's partner groups would then have access to enhanced data in the form of database files or summary statistics in a timely fashion. Thus, they would have a more comprehensive understanding of road safety conditions, especially the human factors that contribute to crashes. This would enable the groups to propose effective measures to address road safety.

1.2 Report Organization

Chapter 2 comprises background information and a review of previous studies related to this project. Chapter 3 entails the summarized results of the responses to the surveys, which were distributed to WYDOT's safety partners. Chapter 4 presents results of discussions of big data analyses that were conducted to evaluate the human factors influencing Wyoming's crashes and ascertain appropriate periods for reporting crashes to WYDOT's partners. Finally, Chapter 5 is composed of the conclusions of this research and recommendations for future work.

2. BACKGROUND AND LITERATURE REVIEW

2.1 Background

WYDOT employs the Wyoming Electronic Crash Reporting System (WECRS), an online system that is used to log crash reports. The data format and quality of the data from the system have not been found to be completely satisfactory to WYDOT's partner groups. This introduces an issue in assessing and addressing road safety efficiently.

Another area of concern is the human factor, which is one of the principal crash precursors. As per the Insurance Institute for Highway Safety (IIHS), the proportion of unbelted vehicle occupants in Wyoming who died in traffic crashes was estimated at 45% in 2019 (*2*). Improper use or non-use of safety restraints is an issue that is addressed by the WSBC. Other human factors include, but are not limited to, inexperienced teenage drivers who recently obtained their drivers' licenses, reckless driving, distracted driving, and driving under the influence (DUI) of drugs/alcohol. WHP and WASCOP both strive to combat the aforementioned factors. This emphasizes the importance of the timely provision of comprehensive high-quality data to WYDOT's partner groups when it comes to the evaluation of road safety and the implementation of safety improvement strategies.

2.1.1 Overview of the Wyoming Department of Transportation's Safety Partners

This subsection comprises an introduction to WYDOT's safety partner groups, which are WSBC, WHP, WASCOP, WTSC, GCID, WBPSTF, Wyoming counties, and the motorcycle groups.

The Wyoming Seat Belt Coalition endeavors to educate the public through the use of the media, seminars, and other outreach programs about the importance of properly buckling up since the seat belt use rate in the state is below that of the nation on average (*3*). Also, the group holds assemblies to discuss research and strategies regarding increasing the rate of proper restraint use in order to reduce traffic injuries, including fatal injuries.

The WHP enforces traffic polices and other laws by patrolling the major highways in the state. It also supports emergency services and engages in other activities. The WHP duties include running dispatch stations, completing crash reports, conducting criminal procedures, conducting vehicle inspections, managing road closures, controlling traffic in special situations, and other activities. WHP officers also contribute to safety outreach programs across the state since one of their motives is to improve road safety. WHP manages multiple road safety-oriented programs, such as the Alive-at-25 and Report Every Drunk Driver Immediately (REDDI) programs, among others (*4*).

The Wyoming Association of Sheriffs and Chiefs of Police is a union of federal and state officials (*5*). On behalf of the WASCOP's members, several entities represent the association, including commissions/boards of the Wyoming State Legislature and charity groups. The association promotes efficient law enforcement practices within the policing community. Its goal is to address issues related to Wyoming's law enforcement agencies. It also provides advice to the legislative body regarding law enforcement and public safety laws. The association is engaged in several road safety projects, including targeting alcohol use and crime. This entails the sponsoring of data collection efforts (*6*).

The Wyoming Transportation Safety Coalition is supported by the Wyoming Trucking Association. Members of the coalition are diverse and represent freight firms transporting various types of merchandise (*7*). Other members include those of power generation firms, WYDOT, WHP, the

Department of Homeland Security (DHS), and other members. The coalition's objective is to improve the safety of truck drivers via educational campaigns.

The Governor's Council on Impaired Driving (2019) is aimed at addressing DUI drivers (*8*). This is performed by means of educational/outreach campaigns. The campaigns are run to educate the public about the disastrous consequences of DUI. Programs include the chemical testing program and the 24/7 sobriety program, to name a few. The council collects its DUI-related data from WYDOT and WASCOP.

Wyoming's counties comprise multiple departments, including the clerks of courts, local sheriffs' offices, planning, public health, and emergency management, among other agencies (*9*). In the context of this project, the local sheriffs' offices enforce the traffic laws while the health departments strive to upkeep the health and well-being of society, especially when it comes to treating victims of traffic crashes. The clerk of courts prosecutes the at-fault drivers involved in traffic crashes and those who received citations for committing traffic violations. Wyoming's counties collaborate with WYDOT and a proportion of its partners, as well as contributing to coordinated efforts addressing road safety.

The Wyoming Bicycle and Pedestrian System Task Force is a coalition of members from WYDOT, the City of Cheyenne, the Wyoming Office of Tourism, the Bicycle Station shop, Wyoming Pathways, Platte River Trails, the Wyoming Business Council, the Wyoming Department of Health, and Wyoming State Parks, among other critical entities. The task force was established to provide advice to Wyoming's legislature/local governments regarding insights gained from assessing the state's bicycle and pedestrian trails. The insights are those of financial gains, feasibilities, safety concerns, and the fostering of travelers' health (*10*).

Other than Wyoming's counties, there are several motorcycle groups and clubs in Wyoming. They include, but are not limited to, the Wyoming Central A Brotherhood against Totalitarian Enactments (ABATE), and the Harley-Davidson motorcycle groups. The Wyoming Central ABATE provides training for their neophyte motorcyclists, raises motorcycle safety awareness, and fosters rider sobriety. The group also hosts fundraising events to uphold motorcycle riders' legal rights. The Harley-Davidson groups are dealerships that sell and service Harley-Davidson motorcycles. They are also involved in motorcycle events.

2.2 Literature Review

Road safety improvement is a result of a confluence of efforts from transportation agencies and groups. Their ultimate objectives are to reduce the counts of crashes and their unfavorable consequences, namely fatalities and severe injuries. They also aim to prevent specific behaviors, such as seat belt non-use and/or DUI. Extensive high-quality data should be available and well maintained in order to assess road safety. It is also essential that the data be processed to gain a better understanding of the various crash contributing factors, including human factors, traffic patterns, geometric conditions, and weather conditions. The influence of enforcement policies and comprehensive crash costs should be incorporated in the data analyses. Comprehensive crash costs quantify damages to property, medical expenses, coroner expenses, and any costs to society incurred because of the crashes (*11, 12*).

Road safety management systems comprise the personnel, tasks, hardware, and software needed to perform multiple essential tasks. They include gathering, analyzing, and maintaining roadway crash data, as per the World Health Organization (WHO) (*13*). An essential component of any road safety management system is its stored crash records. Crash reporting is conducted by police officers manually on hard copy forms; yet, reporting on digital forms and web-based forms is gaining momentum among multiple jurisdictions. Reporting crashes on web-based forms diminishes errors in data coding and

transfer leading to the compilation of accurate data (*14*). In addition, web-based crash reports are accessible instantly after being uploaded online.

2.2.1 Wyoming Electronic Crash Reporting System

The WECRS implements the ReportBeam digital crash reporting tool. The ReportBeam is an online system operable via Microsoft Windows platforms. It is interfaced with the Smart Roads drawing software that enables quick and detailed sketching in the reports.

The ReportBeam entails two components, namely the client system and the server. In the client system, the details are entered into the reports and stored in a manner similar to that of emails. A report manager with an inbox folder, drafts folder, and a folder for new reports is consulted to maintain the reports. The new folder contains the templates for the reports to be filled out. Any reports with missing records are saved in the drafts folder and those that are completed, submitted, or yet rejected are transferred to the inbox folder. The server is an online system that grants access to database management professionals who approve or deny the reports. The server also features tools that are utilized for the analysis and circulation of the reports.

The ReportBeam performs four tasks: entering information into the reports, maintaining the reports, evaluating the data, and disseminating the reports. Police officers complete crash reports promptly and submit them. An advantage of the ReportBeam is that it may be used to complete crash reporting forms offline. It also features a tool that records the driver's license information by scanning the license. Police officers may also create their profiles such that every time they fill out a new report, they need not re-enter their personal information.

Uploaded crash reports approved by the database managers are transferred to another database for inspection. Incomplete reports, or those that are judged to contain faulty information, are returned to the officers who uploaded them with comments. Every activity or person, including the officers who inputted the information in the reporting forms, the database management professionals who inspected the reports, comments provided, and changes made to the reports, are audited in a log. Once the reports are approved, they are assigned referencing codes and their data are logged into a dataset.

The crash data are available once uploaded online. The database management professionals can inspect the locations of the crashes, depicted summary statistics, and locations of police officers via maps. The mapping tool has a special feature that allows the user to visualize all crashes, hot spots (locations that are likely to experience an abnormally large number of crashes), and other crash trends. The hot spots are identified by computations built in the system and facilitate the prioritization of crash sites that are targeted for safety countermeasure implementation. The system also includes a data analysis tool used for generating charts describing specific crash summary statistics. Such statistics may be obtained for both roadway segments and intersections.

2.2.2 Human Factors

The WECRS contains three classifications of road safety data, vehicle characteristics data, environmental characteristics data, and drivers' characteristics data, or simply human factors data. Human factors constitute the main contributing factors that result in crashes. It is estimated that 94% of crash precursors are attributed to the drivers (*15*). Dingus et al. (2016) examined multiple sub classifications of human factors, which are DUI/tiredness, driving blunders (e.g., encroaching on an adjacent lane while turning), judgment errors (e.g., tailgating) and identifiable distractions (e.g., use of electronic device) (*16*). DUI/tiredness was estimated to raise the odds of being involved in a crash by 5.2 times, while driving blunders were estimated to raise such odds by 18.2 times assuming all else was unchanged.

The preponderance of large amounts of data collected from not only crash reports but also social media, mobile phones, hospital records, and others has motivated the proposition of employing big data analysis techniques. They are utilized for processing gigantic datasets that otherwise cannot be processed using conventional data analysis methods to uncover data patterns and relationships among variables. When it comes to road safety data analyses, big data methods, which are data mining/machine learning algorithms, are widely implemented (*17-19*).

Multiple big data methods categorize crash injury severity by detecting trends and implementing models to organize crash data points into severity categories, such as property-damage-only (PDO), injury, or fatality (*20-26*). This type of analysis reveals insights regarding the conditions that lead to both severe and non-severe crashes. Typical crash injury severity models employed include decision trees (*20, 27, 28*), support vector machines (*29-31*), and artificial neural networks (*32, 33*).

Decision tree methods and their variants (*34*) are non-parametric methods that do not specify any relationship between the outcome being modeled, whether it be the counts or severities of the crashes, and the crash precursors, which are the human factors, roadway geometric conditions, and environmental conditions, among others. Decision trees subset the data to facilitate the interpretation of the crash precursors' effects on the outcome and present the results in the form of branches/leaves. For instance, a decision tree model's output diagram may illustrate two branches, one being roadway segments with shoulders that are wider than six feet and the other representing those with shoulders that are six feet or narrower. By visually inspecting the diagram, the user may simply infer that the segments with the wider shoulders are likely to experience fewer lane departure crashes.

The support vector machine technique is another viable machine learning method that is mainly used for modeling outcomes that are not continuous (e.g., crash severity). It has been shown to perform well among the variety of machine learning methods (*35*).

Artificial neural networks are methods used to estimate non-linear relationships between the outcome modeled (e.g., crash count) and the variables influencing it (e.g., crash precursors), unlike traditional statistical methods (*36*). Artificial neural networks function as a trend recognition tool similar to that of the human brain and are shown to exhibit better predictive power than those of multiple statistical methods (*37*).

2.2.3 Assessment of Crash Reporting Systems

As per the United States Government Accountability Office (2004), crash data quality is evaluated based on six criteria: timeliness, consistency, completeness, accuracy, accessibility, and data integration (*38*). Timeliness is the prompt provision of crash data for evaluation purposes, preferably within 90 days of crash occurrences. Consistency refers to the concept that crash data ought to be reported in a format that closely resembles those of the other jurisdictions in the state and is satisfactory according to national standards. Completeness refers to the premise that detailed data be collated for each reported crash and should not omit any critical information. Accuracy is the absence of data errors. Accessibility is the ease of obtaining the crash data by the primary analysts. Data integration refers to the ability to merge the crash dataset with other relevant data (*38*).

Timeliness is a fundamental criterion for transportation safety professionals since obtaining outdated crash data may result in the misidentification of crash sites targeted as priorities for the deployment of safety countermeasures (*39*). Logan and McShane (2006) noted that using data of five crash years disguises the significances of traffic safety problems, motivating the prompt collection of crash data (*40*). Instead, the immediate diagnosis of hazardous crash sites is desired. Mitchell et al. (2009) categorized the

timeliness of collecting and storing crash data by time frame (*41*). The authors ranked data made available within a month, those made available between one, and two years and those made available after two years as “very high,” “high,” and “low,” respectively.

The United States Government Accountability Office assessed data management programs in nine states and, as per the results, crash data were not disseminated for a month to a year and a half in the majority of the states. In addition, in a proportion of states, the data were circulated after the suggested 90-day period (*38*).

Delucia and Scopatz (2005) evaluated the performances of 26 state roadway agencies (*42*). The authors interpreted that 22 states reported all crashes that incurred damages exceeding the reporting thresholds. The reporting threshold is the minimum quantified damage to property sustained to warrant the reporting of a crash. It was also inferred that the minority of the states (20%) inputted the crash data into their statewide database between 91 and 364 days from the crash occurrences. Furthermore, data quality should be assessed promptly so as not to compromise the timeliness of submitting the crash reports to database managers who approve them for entry into the statewide database after corresponding with the officers who completed those reports (*39*).

3. DISSEMINATING SURVEYS TO THE WYOMING DEPARTMENT OF TRANSPORTATION'S SAFETY PARTNERS

The initial task of this research project involved evaluating the data needs of WYDOT's partner groups. This was conducted by drafting and disseminating a tailored survey questionnaire to each group. The survey questions asked about data timeliness, metrics interpreted from analyses of crash data (e.g., seat belt use statistics, DUI statistics, etc.), statistics describing crash consequences (i.e., severities), reports documenting road safety statistics, citation statistics, and relevant topics that might be of interest to those partner groups. Once the surveys were distributed and responses were returned, the responses were evaluated in order to interpret the groups' data needs. From the survey, WYDOT received suggestions regarding not only the data needs of its partners but also the data formats, crash reporting time periods, data quality, and topics for future research. This might include upgrading WECRS.

3.1 Summary of the Wyoming Seat Belt Coalition Survey Response Results

A survey was disseminated to members of the Wyoming Seat Belt Coalition and 13 responses were received. The common question asked in all surveys was how often did the respondents receive/secure road safety data/reports from the WYDOT Highway Safety Office? Less than half (40%) of the respondents claimed that they often obtained crash data from WYDOT once a month, while a third checked the option, "other," and specified the following:

- "Never."
- "I do not receive any."
- "Upon request."
- "Sporadically."
- "Have not received."

When it comes to data transfer protocols, 80% stated that they received the data via email. Also, the respondents were asked whether the current safety data provided to them from the WYDOT HSO fulfilled their needs on a scale of one (not at all) to five (absolutely). Almost half of the respondents declared that the current crash data being provided to them were either of no benefit or were absolutely not beneficial (provided a rating of three), while over a quarter claimed that the data were beneficial (provided ratings of four and five). More importantly, the respondents were asked about the ideal period during which they preferred to receive the crash data from the dates the crashes occurred. Roughly a third stated that they preferred the crash data be delivered to them within a week of crash occurrences, and another similar proportion stated that the desired time frames was a week to two weeks from the dates the crashes occurred.

Regarding the data format preferred, over 90% of the respondents favored summary statistics tables, over 50% preferred figures, and about 20% preferred pie charts. Note that each respondent was provided the option of specifying multiple data formats from a list (i.e., checkboxes).

The respondents were further asked about the preferred method of portraying locations of crashes involving improper use or non-use of safety restraints. They included the following:

- Narrative descriptions of the locations
- Photos
- Color-coded maps
- Road and milepost information
- Geographic information system (GIS) coordinates

- A combination of the above
- Other (please specify)

Remarkably, more than half of the respondents claimed their interest in a combination of methods of depicting the crash locations. The answer choices were provided in the form of checkboxes such that each respondent might have selected multiple options. The respondents also selected the options, “narrative descriptions of the locations,” “color-coded maps,” and “road and milepost information.”

In the following section of the survey, respondents were asked about road safety reports pertaining to the use of restraints. The reports, most of which are available in the WYDOT HSO website, are the following:

- Wyoming Occupant Seat Belt Usage by Year
- Wyoming Drivers Survey, 2016
- 2019 Seat Belt Survey Analysis
- Wyoming Statewide Crashes by Year
- 2019 Highway Safety Crash Data Survey Final Report
- Wyoming Highway Safety Behavioral Program FY2020 Highway Safety Plan
- Wyoming Report on Traffic Crashes 2019

On a scale of one (not at all) to five (absolutely) describing whether the respondents were familiar with these reports and whether they frequently utilized them, roughly 35% provided a rating of three while another roughly 35% provided a rating of five. In the following question, members of the Wyoming Seat Belt Coalition were asked about the importance of the dissemination of road safety data, presented in those reports, in real-time. More than half of the respondents stated that the prompt circulation of such data was critical. Also, 80% of the coalition’s members maintained that they were satisfied with the frequency at which the reports were released. Furthermore, more than half of the respondents preferred addressing the issue of records showing seat belt use habits designated as “unknown” and receiving reports describing the influence that fine amounts for non-seat belt use has on seat belt use habits. In addition, almost half of the respondents favored receiving data on the socio-demographics and aggression levels of drivers who fail to properly buckle up. A proportion of the members of WSBC also stated their concern about distracted improperly belted or unbelted drivers. Such data might be collected from reports of crashes involving improper use or non-use of restraints. Other respondents declared interest in sharing the aforementioned reports among policy makers, the media, and other concerned parties. Such reports are already available to the public via the WYDOT HSO website and may be disseminated as needed.

In the subsequent section of the survey, members of the coalition were asked specific questions about crash data. At least 50% of them indicated interest in the following data collected from crash records:

- Whether the driver was properly wearing the seat belt
- Whether the passenger in the front seat was properly wearing the seat belt
- Whether the passengers in the rear seats were properly secured
- Whether children were properly secured in their appropriate car seats
- Whether children with special needs were properly secured
- Whether the pregnant women were properly wearing their seat belts
- Whether persons with physical disabilities were properly secured
- Whether the driver was injured and the injury severity level
- Whether the passenger in the front seat was injured and the injury severity level
- Whether the passengers in the rear seats were injured and the injury severity level of each passenger
- Whether children requiring car seats were injured and the injury severity level

- Whether children with special needs were injured and the injury severity level
- Whether persons with physical disabilities were injured and the injury severity level
- Whether the driver was licensed
- Driver license level (restricted learner's permit, regular learner's permit, intermediate permit, or regular driving license)
- Whether the young driver was accompanied by a passenger 18 years or older if the license required
- Driver's age
- Driver's gender
- Driver's state
- Driver's race
- Driver's income category
- Driver's seat belt policy violations history
- Driver's other policy violations history
- Makes, models, and years of each vehicle involved in the crashes
- Travel speeds of the vehicles involved in the crashes
- Crash types (rear-end, sideswipe, etc.)
- Impact point information (struck from the side, struck from the front, etc.)
- Airbag deployment information at the times of the crashes
- Seat belt condition (good, poor) at the times of the crashes
- Whether any vehicle occupant was ejected from the vehicle
- Whether any vehicle occupant was trapped in the vehicle
- Length of the trip planned

In addition, the coalition's members were asked whether they were interested in summary statistics in the form of charts, tables, or color-coded maps depicting certain trends. At least half of the respondents indicated their interest in summary statistics depicting the following:

- The association between seat belt use policy violations and counts of injuries/fatalities that were sustained due to crashes
- The difference in fatality and injury counts of belted versus unbelted occupants
- Locations characterized by risks of encountering high severity (fatal, suspected serious injury, and suspected minor injury) crashes involving improper use or non-use of safety restraints
- Locations characterized by risks of encountering high severity crashes involving proper use of safety restraints
- Locations characterized by risks of encountering PDO crashes involving improper use or non-use of safety restraints
- Locations characterized by risks of encountering PDO crashes involving proper use of safety restraints

The respondents were then directed to another section asking whether they were interested in specific data of restraint use habits and other related data. Note that, throughout the survey, some questions were about citation statistics and that the WYDOT HSO does not maintain such data. Instead, independent studies would have to be conducted to collect and evaluate citation data. At least half of the respondents maintained that they preferred the following data:

- Whether the seat belt fitted appropriately
- Whether occupants cited for previous seat belt use violations attended driver's education sessions
- The influence of the driver's seat belt use habits on the passengers
- Seat belt use habits by day of week (weekday versus weekend)

- Counts of occupants (properly belted versus improperly belted or unbelted) by state (Wyoming residents versus out-of-state residents)
- The influence of weather conditions on seat belt use habits
- Seat belt use habits by driver type (passenger car driver, bus driver, or truck driver)
- Whether parents ensured that their children were properly secured
- Whether drivers previously cited for impaired driving were likely or not to buckle up
- Seat belt use citation statistics excluding those of which data were collected from crash records.
- Whether occupants previously cited for improper use or non-use of safety restraints were likely to buckle up
- How changes in seat belt use policies in other states influenced the number of injuries and fatalities incurred as a result of crashes
- Data collected from a survey disseminated to young drivers, who have recently obtained their driver's licenses, asking about their seat belt use habits
- Statistics depicting the association between the number of outreach campaigns and seat belt use habits by county or district
- Seat belt use habits of occupants riding in vehicles with advanced driver assistance systems (ADAS), such as forward collision warning systems
- Seat belt use habits of occupants riding in vehicles with side airbags in addition to the ones in the front

Furthermore, the respondents were asked to provide any additional information of interest. Following are notable responses:

- "If the finalized data can include roadway fatalities that include reservation areas, private roads, etc. Possibly an annual report that includes information from the Wyoming Coroners offices to be sure every fatality that is unbuckled, impaired, or distracted is within the annual information."
- "An interactive map would be a great idea."
- "Separation of Wyoming resident behaviors and out-of-state is imperative."
- "Much of the data in this section would help support or disprove many of the assumptions used in outreach concerning occupant protection."

The respondent who requested fatality count data by area type and the one who suggested the provision of an interactive map were not definitive. Hence, it was inferred that the former was concerned about fatality statistics pertaining to crashes involving improper use or non-use of safety restraints by area type while the latter was interested in an interactive map depicting the locations that were characterized by risks of encountering such crashes by severity level (fatality, suspected serious injury, suspected minor injury, possible injury, and PDO).

3.2 Recommendations for the Wyoming Department of Transportation Regarding the Wyoming Seat Belt Coalition

Based on the interpretations of the Wyoming Seat Belt Coalition's survey results, recommendations were made to WYDOT with regards to the data that would be provided to WSBC. First, it is suggested that the data belonging to crashes involving improper use or non-use of restraints be provided to WSBC at the earliest convenience. It is also recommended that WYDOT provide quarterly summary statistics of restraint use habits, similar to the ones illustrated in Figures 3.1 through 3.20, and Tables 3.1 through 3.5. Such statistics were extracted from the WYDOT HSO 2019 crash data. In addition, heat maps, which are maps of high-risk crash locations or simply hot spots, are presented in Figures 3.21 and 3.22. They were developed using 2017 crash data since this was the latest year when precise coordinates of the crash records were provided by the WYDOT HSO. The maps were generated using the GIS software, ArcMap 10.4 (*43*). In particular, the optimized hot spot and inverse distance weighted (IDW) interpolation features of the software were implemented. Also, the Z's, presented in the heat maps, are the standard normal distribution values that correspond to the crash risks. For the other safety groups—WHP, WASCOP, GCID, WTSC, Wyoming's counties, WBPST, and motorcycle groups—heat maps were generated via the same procedure as that implemented to generate the maps for WSBC.

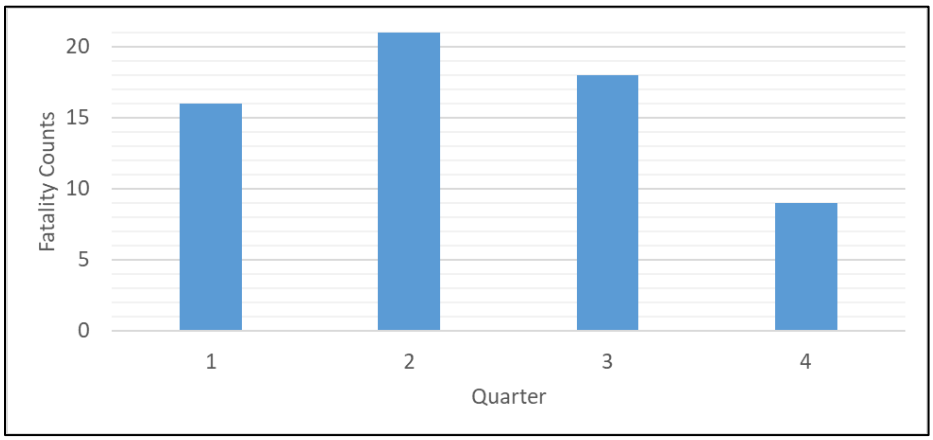

Figure 3.1 2019 fatality counts of improperly belted or unbelted occupants

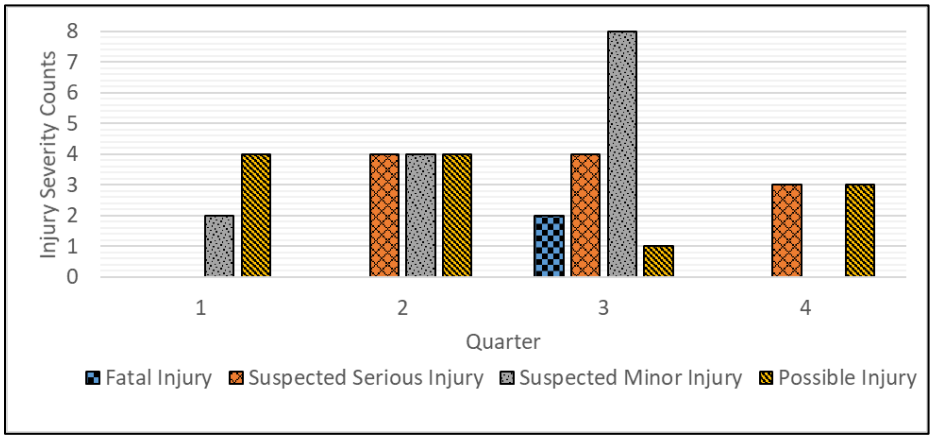

Figure 3.2 2019 counts of killed and injured improperly belted or unbelted distracted drivers

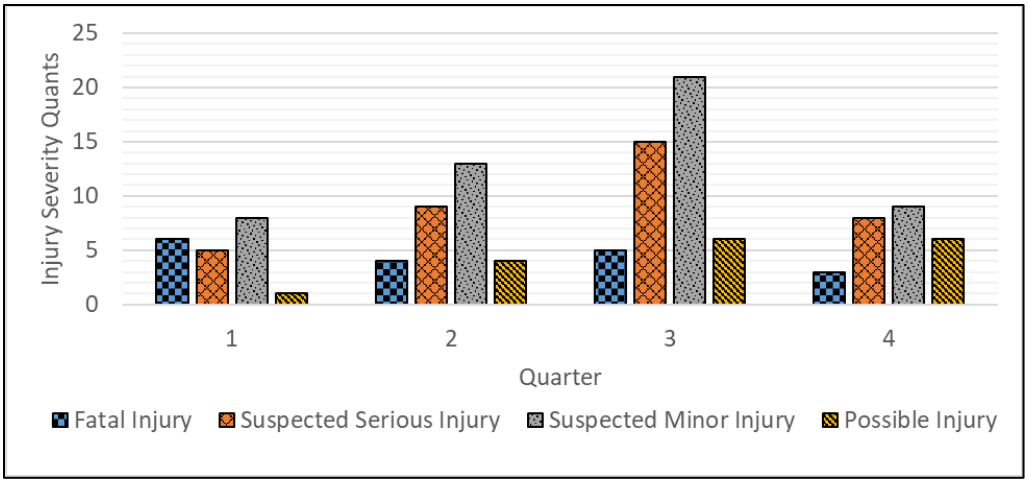

Figure 3.3 2019 counts of killed and injured improperly belted or unbelted impaired drivers

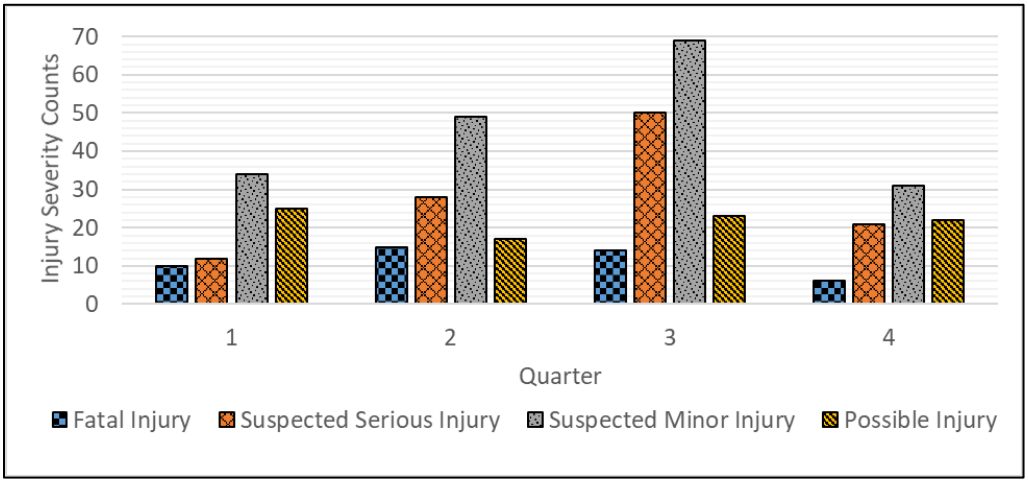

Figure 3.4 2019 counts of killed and injured improperly belted or unbelted drivers

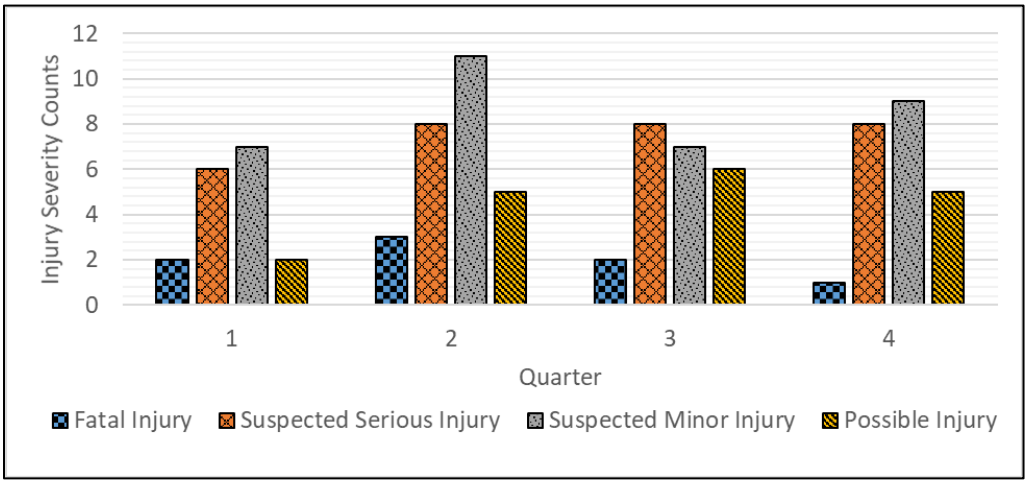

Figure 3.5 2019 counts of killed and injured improperly belted or unbelted front-seat passengers

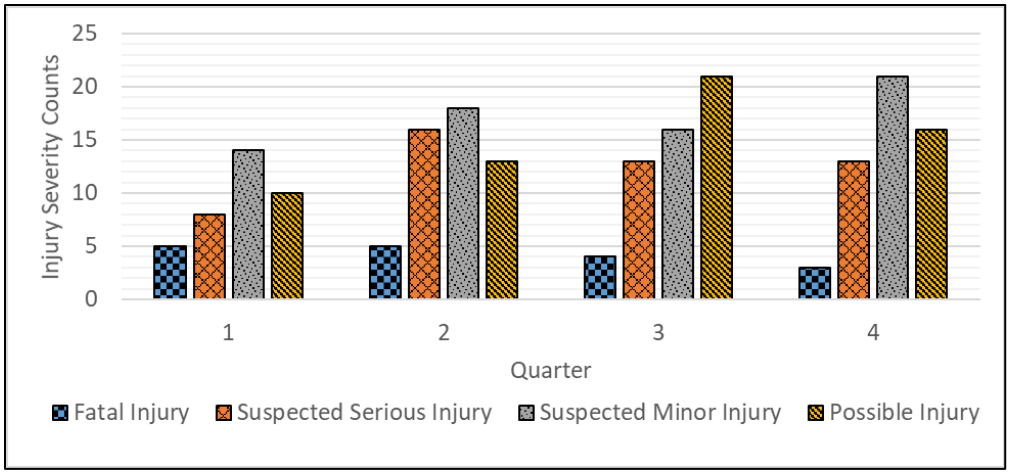

Figure 3.6 2019 counts of killed and injured improperly belted or unbelted rear-seat passengers

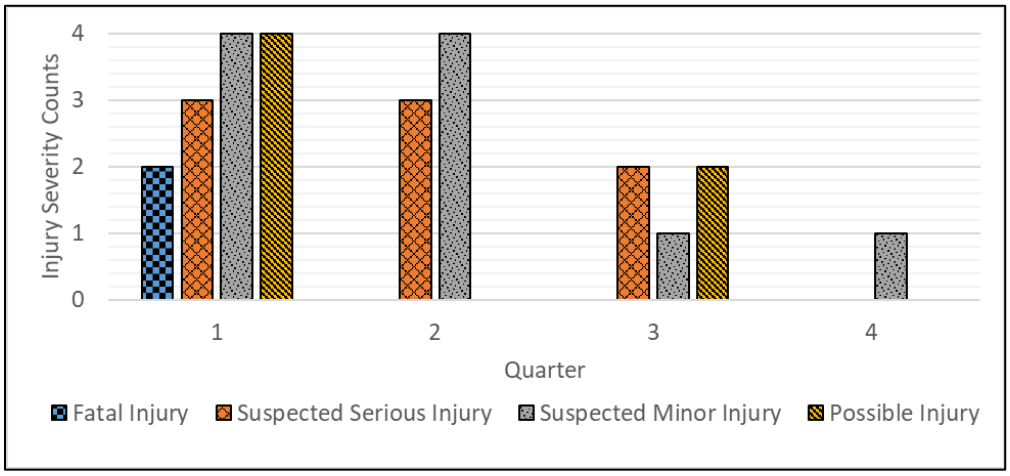

Figure 3.7 2019 counts of killed and injured improperly restrained or unrestrained children 9 years or younger.

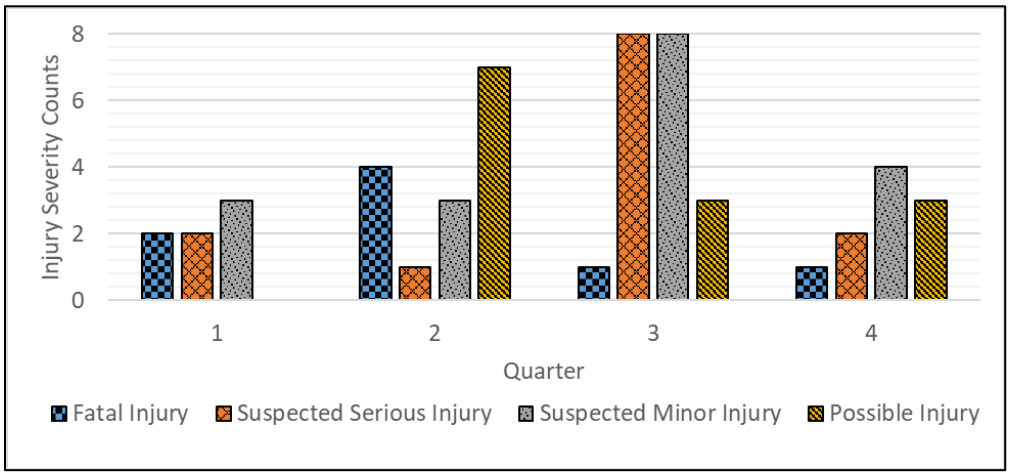

Figure 3.8 2019 counts of killed and injured improperly belted or unbelted unlicensed drivers

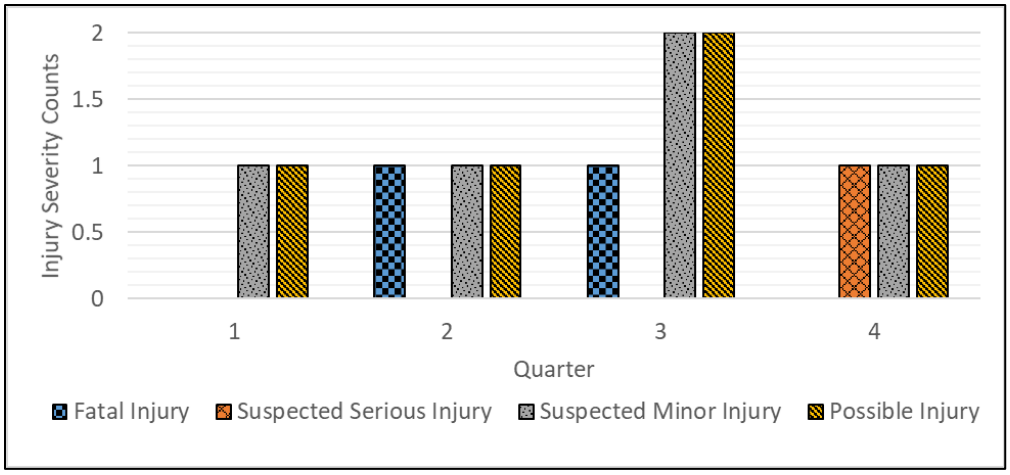

Figure 3.9 2019 counts of killed and injured improperly belted or unbelted drivers with restricted licenses

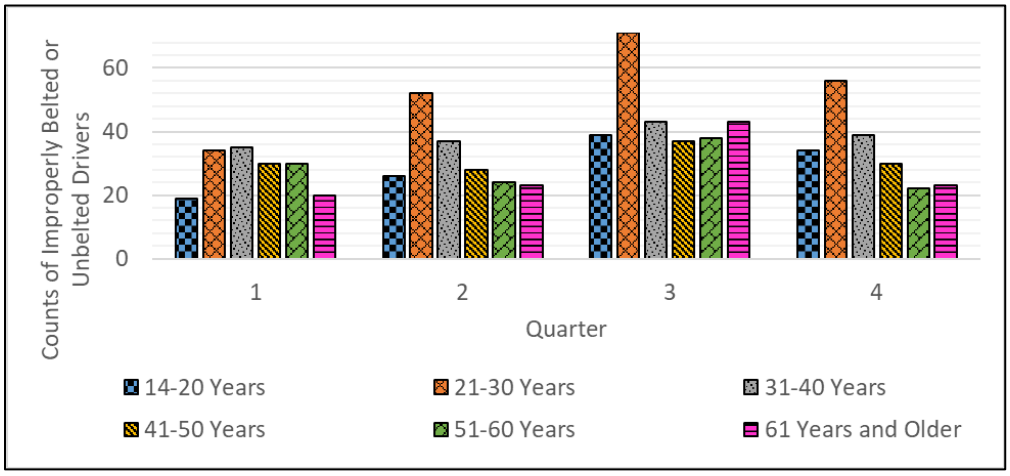

Figure 3.10 2019 counts of killed and injured improperly belted or unbelted drivers by age

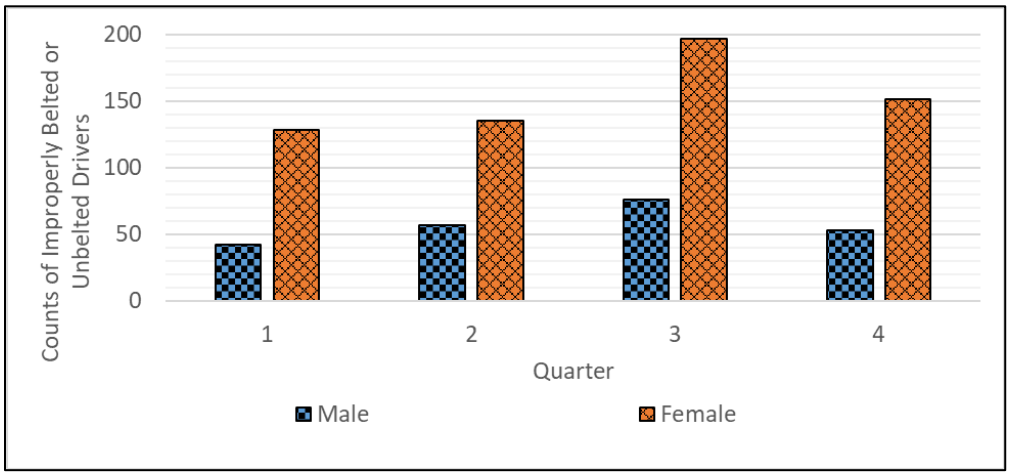

Figure 3.11 2019 counts of killed and injured improperly belted or unbelted drivers by gender

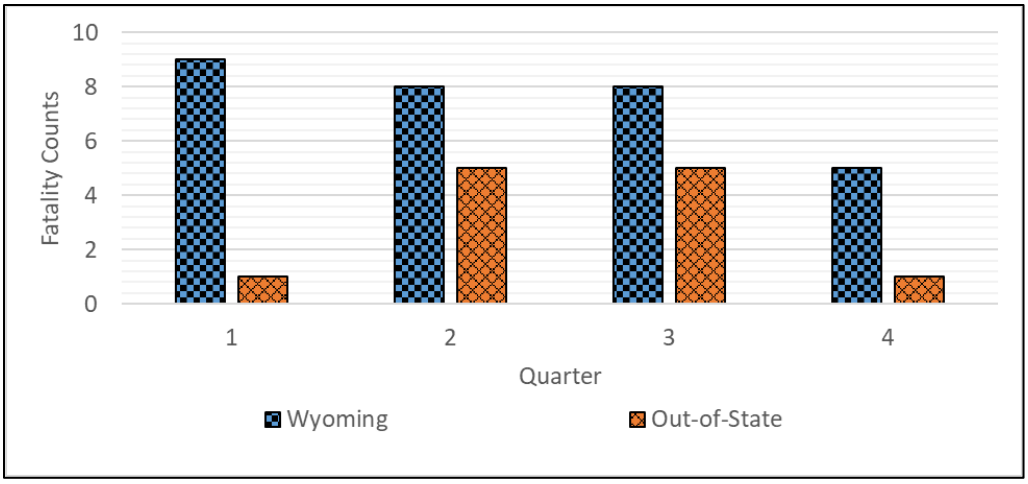

Figure 3.12 2019 fatal counts of improperly belted or unbelted drivers for in/out of state

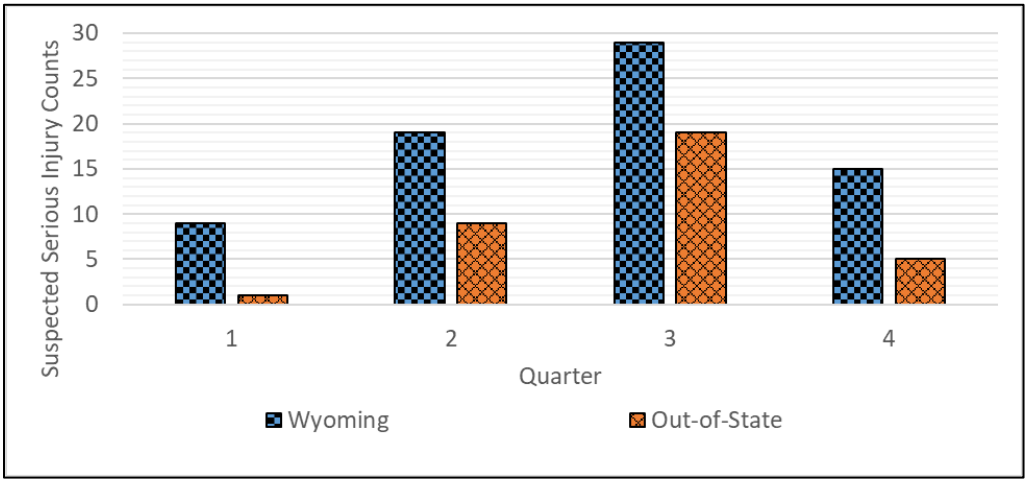

Figure 3.13 2019 serious injury counts of improperly belted or unbelted drivers for in/out of state

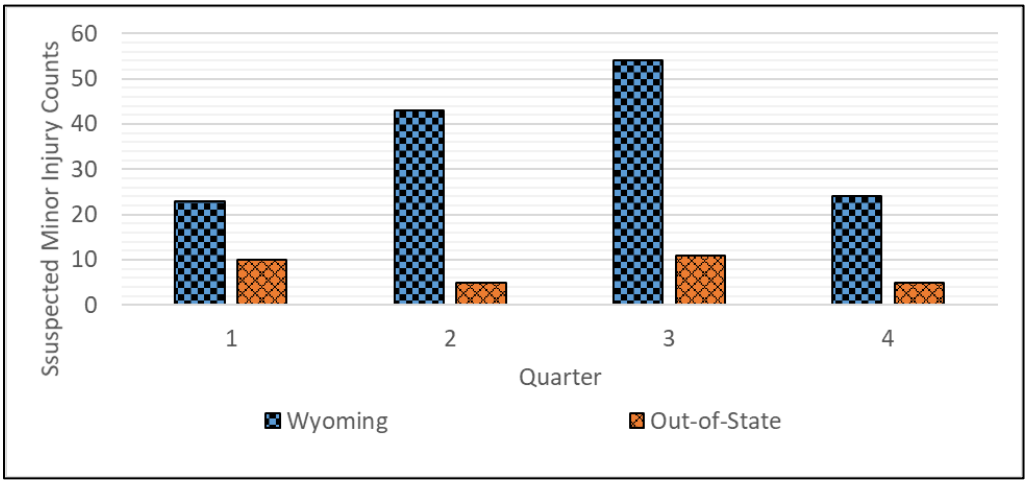

Figure 3.14 2019 minor injury counts of improperly belted or unbelted drivers for in/out of state

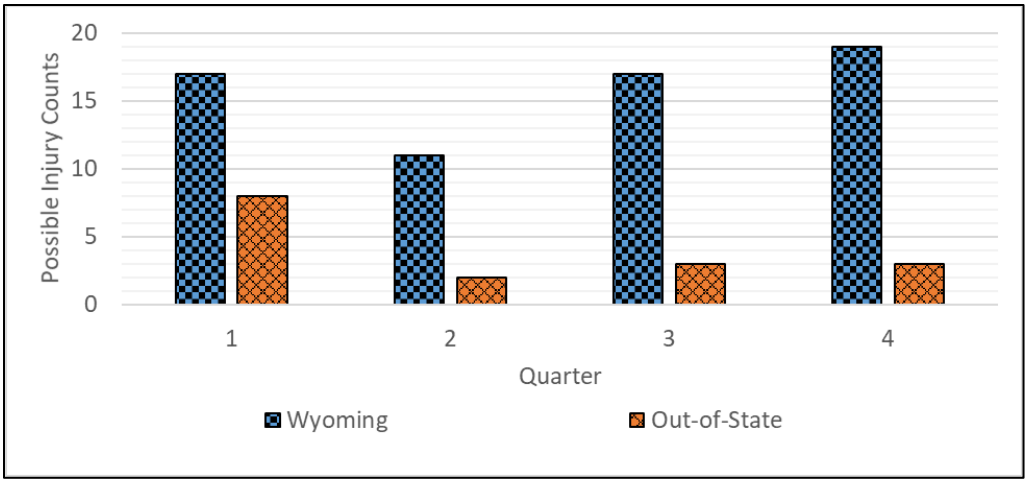

Figure 3.15 2019 possible injury counts of improperly belted or unbelted drivers for in/out of state

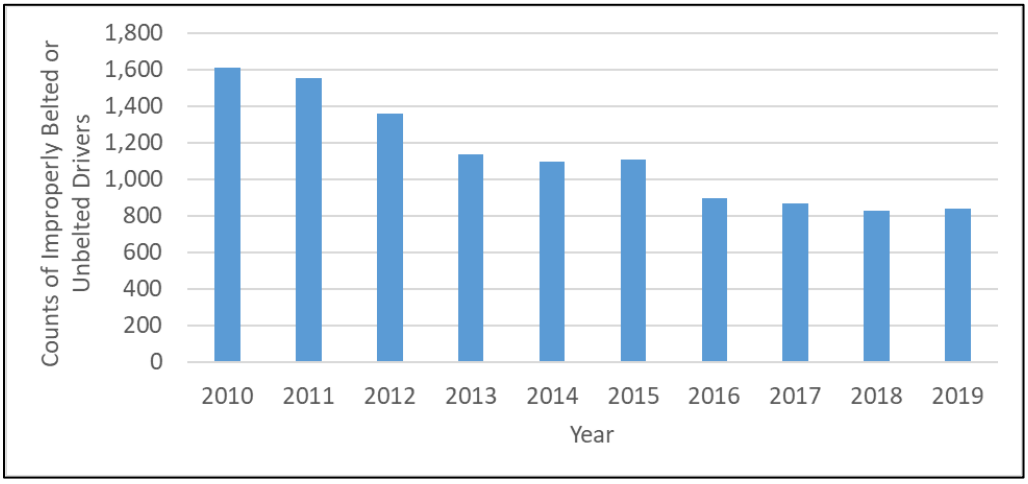

Figure 3.16 Crash Counts of improperly belted or unbelted drivers by year

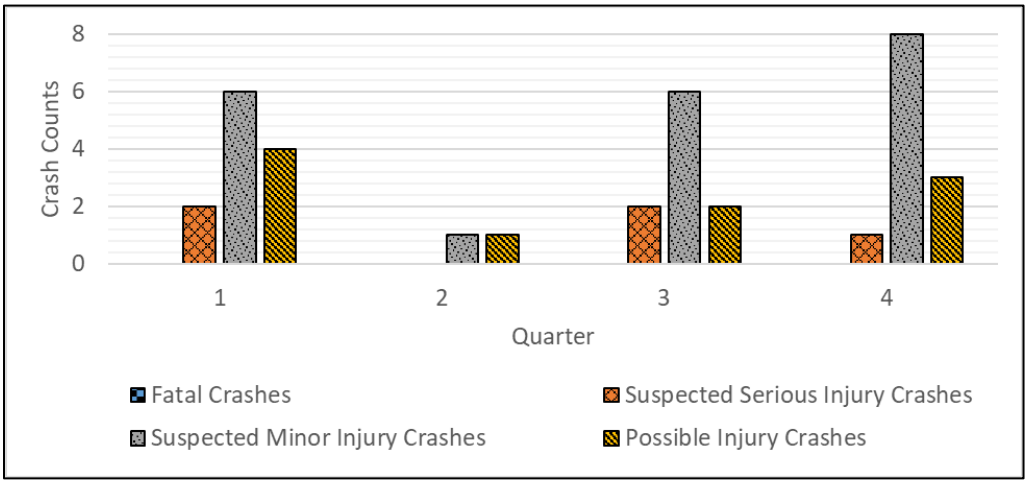

Figure 3.17 2019 counts of speed-related crashes involving improper use or non-use of restraints

Table 3.1 2019 Counts of Killed and Injured Improperly Restrained or Unrestrained Occupants by Manner of Collision in the First Quarter

Manner of Collision	Fatal Injury	Suspected Serious Injury	Suspected Minor Injury	Possible Injury	Total
Angle (Front to Side), Opposing Direction	7	0	55	49	111
Angle, Direction Not Specified	0	0	0	0	0
Angle, Right (Front to Side, Includes Broadside)	5	22	70	94	191
Angle, Same Direction (Front to Side)	2	5	43	32	82
Head-On (Front to Front)	16	13	21	38	88
Not a Collision with Two Vehicles in Transport	14	44	366	219	643
Other	0	0	3	0	3
Rear-End (Front to Rear)	2	19	92	136	249
Rear to Front (Normally Backing)	0	0	0	5	5
Rear to Rear (Normally Backing)	0	0	0	0	0
Rear to Side (Normally Backing)	0	0	3	1	4
Sideswipe, Opposite-Direction (Meeting)	1	2	8	9	20
Sideswipe, Same-Direction (Passing)	0	1	11	13	25
Unknown	0	0	0	0	0
Total	47	106	672	596	1,421

Table 3.2 2019 Counts of Killed and Injured Improperly Restrained or Unrestrained Occupants by Manner of Collision in the Second Quarter

Manner of Collision	Fatal Injury	Suspected Serious Injury	Suspected Minor Injury	Possible Injury	Total
Angle (Front to Side), Opposing Direction	3	20	34	47	104
Angle, Direction Not Specified	0	0	0	0	0
Angle, Right (Front to Side, Includes Broadside)	5	15	68	82	170
Angle, Same Direction (Front to Side)	0	2	28	17	47
Head-On (Front to Front)	16	19	78	11	124
Not a Collision with Two Vehicles in Transport	69	143	536	229	977
Other	4	1	4	2	11
Rear-End (Front to Rear)	1	23	77	112	213
Rear to Front (Normally Backing)	0	0	0	0	0
Rear to Rear (Normally Backing)	0	0	0	0	0
Rear to Side (Normally Backing)	0	0	1	2	3
Sideswipe, Opposite-Direction (Meeting)	0	0	54	7	61
Sideswipe, Same-Direction (Passing)	1	3	13	5	22
Unknown	0	0	0	0	0
Total	99	226	893	514	1,732

Table 3.3 2019 Counts of Killed and Injured Improperly Restrained or Unrestrained Occupants by Manner of Collision in the Third Quarter

Manner of Collision	Fatal Injury	Suspected Serious Injury	Suspected Minor Injury	Possible Injury	Total
Angle (Front to Side), Opposing Direction	0	13	56	38	107
Angle, Direction Not Specified	0	2	0	0	2
Angle, Right (Front to Side, Includes Broadside)	3	25	101	98	227
Angle, Same Direction (Front to Side)	0	2	22	17	41
Head-On (Front to Front)	21	29	51	14	115
Not a Collision with Two Vehicles in Transport	104	287	571	150	1,112
Other	0	1	7	2	10
Rear-End (Front to Rear)	8	14	99	135	256
Rear to Front (Normally Backing)	0	0	1	2	3
Rear to Rear (Normally Backing)	0	0	0	0	0
Rear to Side (Normally Backing)	0	0	0	1	1
Sideswipe, Opposite-Direction (Meeting)	1	1	1	2	5
Sideswipe, Same-Direction (Passing)	1	2	13	5	21
Unknown	0	0	0	1	1
Total	138	376	922	465	1,901

Table 3.4 2019 Counts of Killed and Injured Improperly Restrained or Unrestrained Occupants by Manner of Collision in the Fourth Quarter

Manner of Collision	Fatal Injury	Suspected Serious Injury	Suspected Minor Injury	Possible Injury	Total
Angle (Front to Side), Opposing Direction	5	28	30	52	115
Angle, Direction Not Specified	0	0	0	0	0
Angle, Right (Front to Side, Includes Broadside)	6	13	56	118	193
Angle, Same Direction (Front to Side)	0	4	30	22	56
Head-On (Front to Front)	11	7	22	19	59
Not a Collision with Two Vehicles in Transport	18	190	379	273	860
Other	0	0	1	3	4
Rear-End (Front to Rear)	2	13	108	154	277
Rear to Front (Normally Backing)	0	0	0	2	2
Rear to Rear (Normally Backing)	0	0	0	0	0
Rear to Side (Normally Backing)	0	0	2	1	3
Sideswipe, Opposite-Direction (Meeting)	0	0	3	5	8
Sideswipe, Same-Direction (Passing)	4	0	9	11	24
Unknown	0	0	0	0	0
Total	46	255	640	660	1,601

Table 3.5 2019 Counts of Killed and Injured Improperly Belted or Unbelted Occupants by Manner of Collision

Manner of Collision	Fatal Injury	Suspected Serious Injury	Suspected Minor Injury	Possible Injury	Total
Angle (Front to Side), Opposing Direction	15	61	175	186	437
Angle, Direction Not Specified	0	2	0	0	2
Angle, Right (Front to Side, Includes Broadside)	19	75	295	392	781
Angle, Same Direction (Front to Side)	2	13	123	88	226
Head-On (Front to Front)	64	68	172	82	386
Not a Collision with Two Vehicles in Transport	205	664	1852	871	3,592
Other	4	2	15	7	28
Rear-End (Front to Rear)	13	69	376	537	995
Rear to Front (Normally Backing)	0	0	1	9	10
Rear to Rear (Normally Backing)	0	0	0	0	0
Rear to Side (Normally Backing)	0	0	6	5	11
Sideswipe, Opposite-Direction (Meeting)	2	3	66	23	94
Sideswipe, Same-Direction (Passing)	6	6	46	34	92
Unknown	0	0	0	1	1
Total	330	963	3,127	2,235	6,655

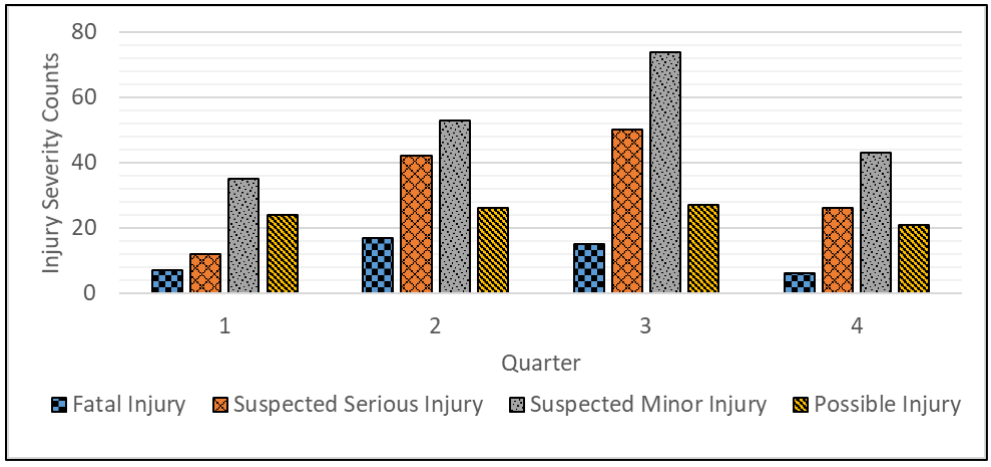

Figure 3.18 2019 counts of killed and injured improperly belted or unbelted occupants in crashes where air bags were not deployed

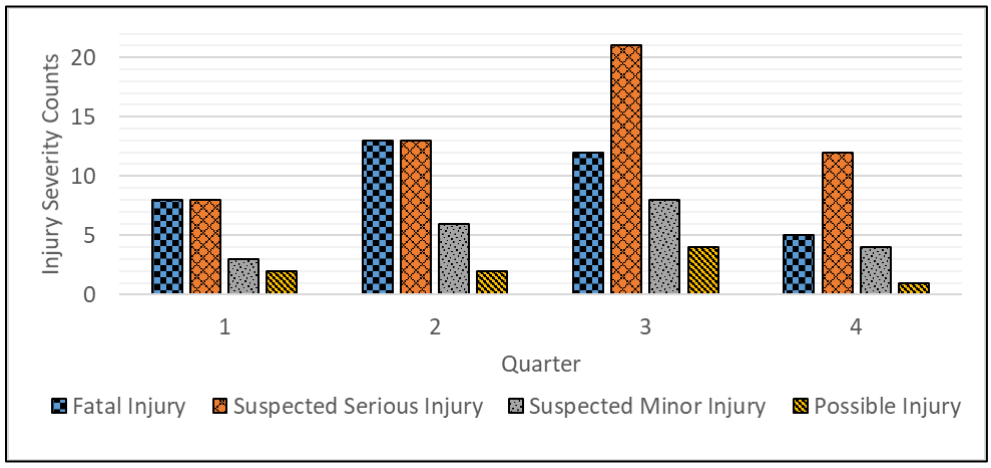

Figure 3.19 2019 counts of killed and injured improperly belted or unbelted ejected/partially ejected occupants

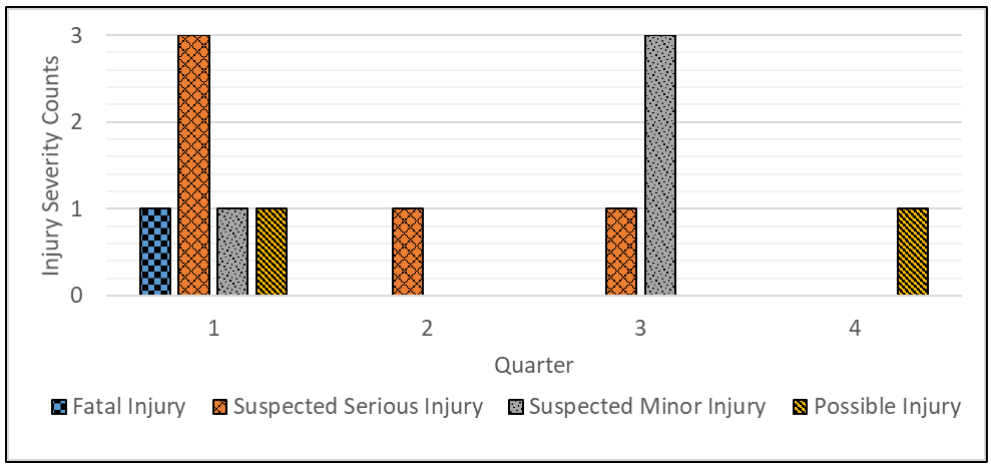

Figure 3.20 2019 counts of killed and injured improperly belted or unbelted trapped occupants

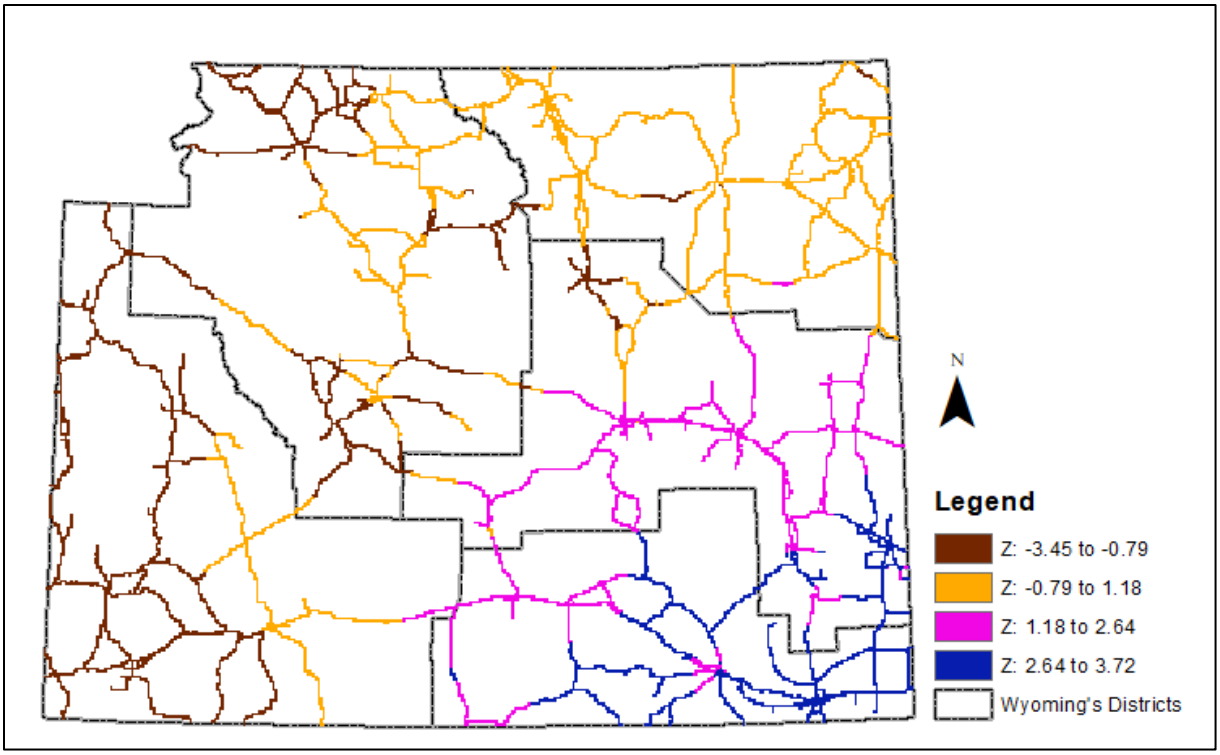

Figure 3.21 2017 heat map of crashes involving improper use or non-use of restraints

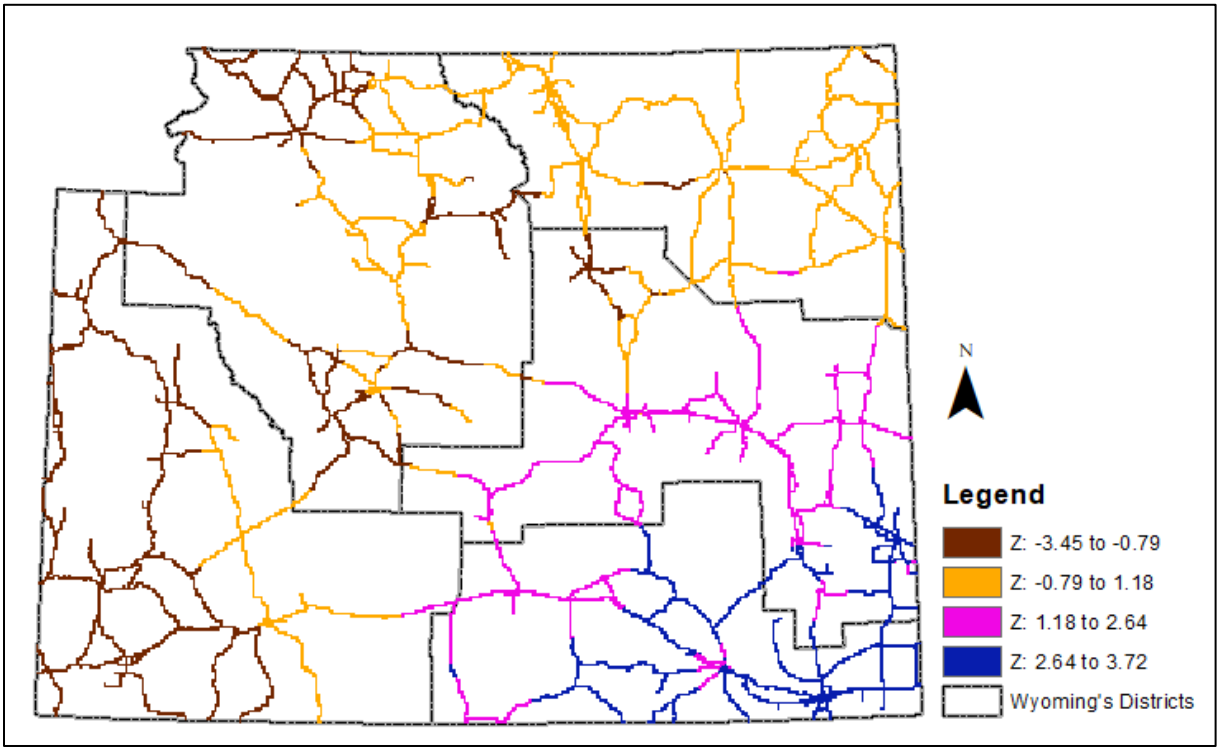

Figure 3.22 2017 heat map of fatal, suspected serious injury and suspected minor injury crashes involving improper use or non-use of restraints

In addition to statistics obtained from crash data, it is suggested to provide other summary statistics data collected from periodical state seat belt surveys (*44*) similar to the ones presented in Figures 3.23 through 3.25. They are descriptive of seat belt use habits by vehicle type, day of week, and weather condition.

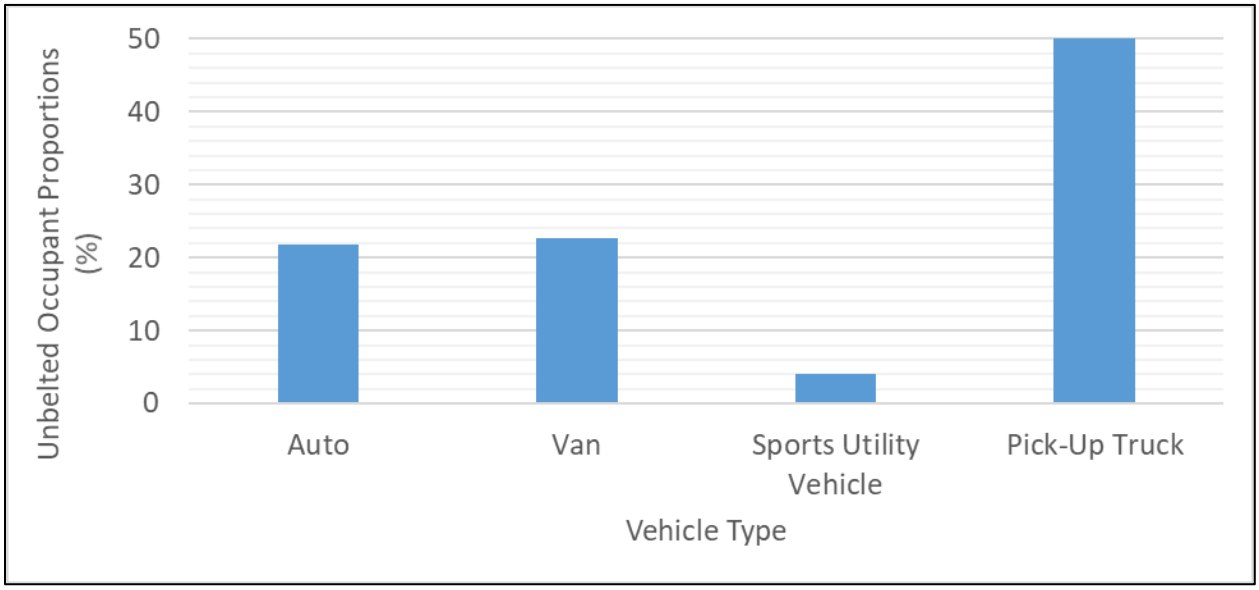

Figure 3.23 2019 distribution of unbelted occupants to vehicles

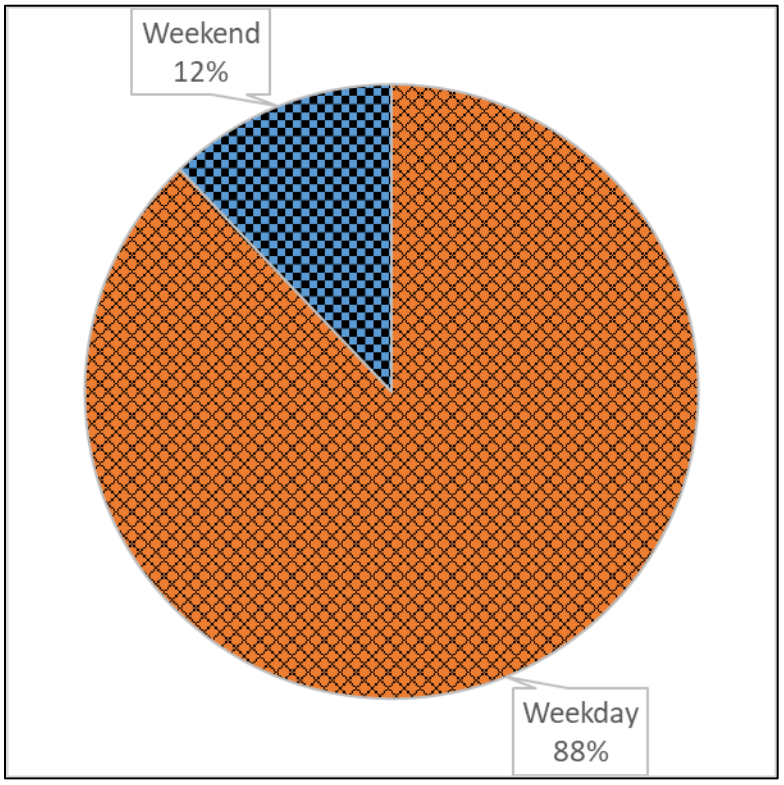

Figure 3.24 2019 restraint non-use proportions by day of the week

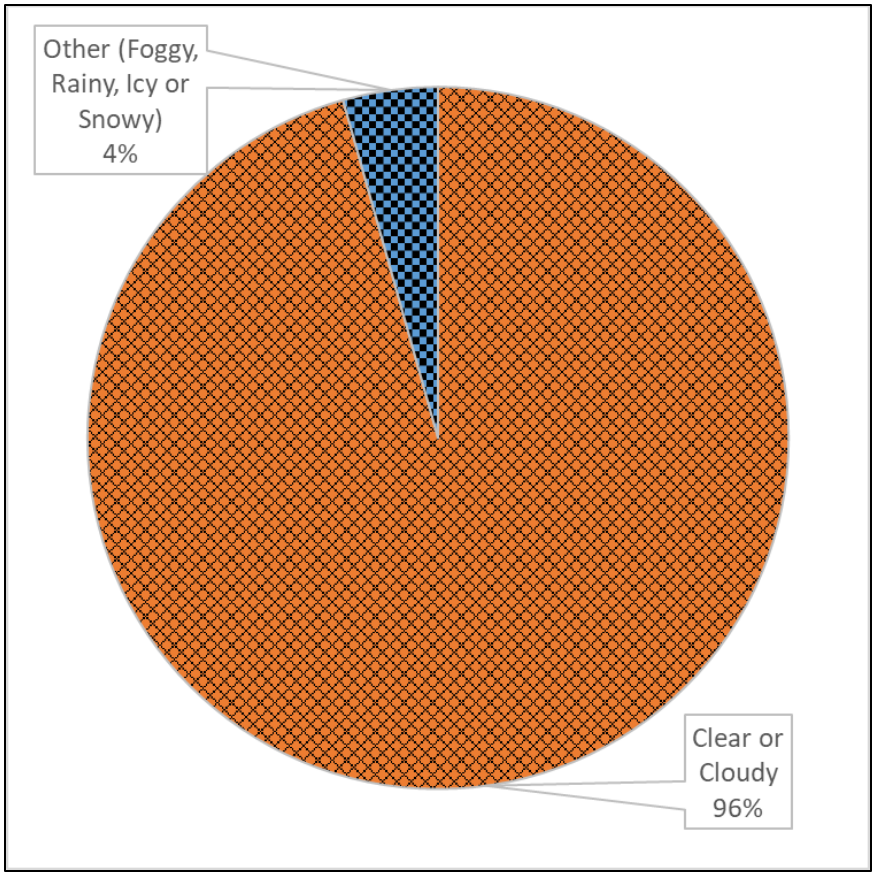

Figure 3.25 2019 restraint non-use proportions by weather condition

It is also recommended that future studies be conducted to assess the following:

- Effectiveness of traffic education sessions in promoting proper safety restraint use
- The influence of drivers' seat belt use habits on those of the passengers and vice versa
- Seat belt use habits of occupants riding in vehicles with ADAS technologies

3.3 Summary of the Wyoming Highway Patrol Survey Response Results

A survey was disseminated to members of the Wyoming Highway Patrol and four responses were received. The common question asked in all surveys was how often did the respondents receive/secure road safety data/reports from the WYDOT HSO? It was found that 50% of the respondents often obtained crash data from the office once a month while some checked the option "other" and specified the following:

- "Unknown"
- "N/A"

When it comes to data transfer protocols, the respondents declared that they received the data mostly via email and online databases. Also, the survey results indicated that this was their preferred method of data acquisition. Other than that, the respondents were asked whether the current safety data provided to them from the WYDOT HSO fulfilled their needs on a scale of one (not at all) to five (absolutely). Of the respondents, 25% declared that the current crash data being provided to them were neither of no benefit nor beneficial (selected three) while 50% claimed that the data were indeed beneficial (selected four and five). More importantly, the respondents were asked about the ideal period during which they preferred to receive the crash data from the dates the crashes occurred. One respondent preferred that the data be delivered within a month of crash occurrences and that this would be the desired period. Another secured the data within a day of the crash occurrences and that this would be the preferred period.

Regarding the preferred data format, half of the respondents favored summary statistics tables, a quarter preferred figures, and half preferred pie charts. One respondent checked the option "other" and stated "as simple as possible." Note that each respondent was provided the option of specifying multiple data formats from a list (i.e., checkboxes).

The respondents were further asked about the preferred method of portraying crash sites. They included the following:

- Narrative descriptions of the locations
- Photos
- Color-coded maps
- Road and milepost information
- GIS coordinates
- A combination of the above

Remarkably, 75% of the respondents claimed they were interested in a combination of methods of depicting crash locations. The answer choices were provided in the form of checkboxes such that the respondents might have selected multiple options. The respondents also selected the options "narrative descriptions of the locations," "color-coded maps," and "road and milepost information." One respondent selected the option "other," and stated "pinpointed on a digital map that you can zoom in and out on."

In the following section of the survey, respondents were asked about road safety reports pertaining to crash data. The reports, most of which are available in the WYDOT HSO website, are the following:

- 2019 Highway Safety Crash Data Survey Final Report
- Wyoming Department of Transportation Highway Safety Behavioral Grants Office 2019 Annual Report
- Wyoming Highway Safety Behavioral Program FY2020 Highway Safety Plan
- Wyoming Report on Traffic Crashes 2019
- Wyoming Drivers Survey 2016
- 2019 Seat Belt Survey Analysis

- Wyoming Statewide Crashes by Year
- Wyoming Statewide Speed-Related Crashes by Year
- Wyoming Statewide Crashes Involving a Wild Animal by Year
- Wyoming Statewide Occupant Seat Belt Usage by Year
- Wyoming Statewide Crashes Involving a Pedestrian by Year
- Wyoming Statewide Crashes Involving Alcohol or Drugs by Year
- Wyoming Statewide Crashes Involving Commercial Motor Vehicles by Year
- Wyoming Statewide Distracted Driving Crashes by Year
- Wyoming Strategic Highway Safety Plan 2017

On a scale of one (not at all) to five (absolutely) describing whether the respondents were familiar with these reports and whether they frequently used them, roughly half provided a rating of four while a quarter provided a rating of five. Also, all declared that they were satisfied with the frequency at which the reports were released. Members of WHP were then asked about the importance of incorporating specific summary statistics safety data in the listed reports. At least half of them indicated their interest in the following:

- Drivers' improper actions/error information preceding the crashes (e.g., driving too fast, improper passing, following too closely, etc.)
- Aggressiveness of drivers who were at fault in the crashes
- Whether the passengers in the rear seats were properly secured
- Socio-demographics of drivers who were at fault in the crashes
- Truck safety and truck policy violations at the times of the crashes (exceeded weight limit, improperly secured hazardous materials, etc.)
- Animal crash hot spots
- Hit-and-run crashes
- The effectiveness of media outreach campaigns in raising traffic safety awareness (traffic safety slogans and/or relevant content disseminated via social media, television, radio, billboards)

In the subsequent section of the survey, WHP officers were asked specific questions about processed crash data. At least half of them said they were interested in the following:

- Crash locations (on the road, on the shoulder, off the road, etc.)
- Crash times (morning, afternoon, etc.)
- Weather conditions at the times of the crashes
- Vehicle travel speeds preceding the crashes (i.e., too slow for the conditions, reasonable or too fast for the conditions)
- Number of vehicles involved in the crashes
- Number of pedestrians and/or bicyclists involved in the crashes
- Types of animals involved in the crashes
- Whether the drivers were properly wearing their seat belts at the times of the crashes
- Whether the passengers were properly wearing their seat belts at the times of the crashes
- Whether children were properly secured in their appropriate car seats at the times of the crashes
- Whether the drivers were driving under the influence of alcohol/drugs at the times of the crashes
- Whether the drivers were tired at the times of the crashes
- Hit-and-run crashes
- Crashes resulting in fires
- Crashes resulting in jackknifed vehicles
- Crashes resulting in ejected occupants
- Crashes in which trucks were overturned by severe winds
- Motorcycle crashes

- Whether the motorcyclists were wearing helmets at the times of the crashes
- Whether the motorcyclists were wearing the appropriate gear (riders' jackets, boots, etc.) at the times of the crashes
- Whether the motorcycle passengers were wearing helmets at the times of the crashes
- Whether the motorcyclists were riding in motorcycle groups at the times of the crashes
- Whether work zone plans were implemented according to the standards when the crashes occurred at or near the work zones
- Whether workers were present when the crashes occurred at or near the work zones
- Shoulder and lane closure information when the crashes occurred at or near the work zones
- Whether drivers violated work zone regulations giving rise to the crashes (i.e., exceeded the work zones' speed limits, failed to obey the traffic guards' signals, etc.)
- Vehicle parts' conditions (tires, brakes, engine, etc.) at the times of the crashes

Furthermore, the officers stated that information regarding the number of injured drivers, passengers, motorcyclists, and pedestrians and their injury severity levels were important. The officers were also asked whether they were interested in summary statistics, in the form of charts and tables depicting certain crash patterns. At least half of the respondents indicated interest in summary statistics depicting the following:

- Crash types (rear-end, sideswipe, etc.)
- Impact point information of vehicles involved in the crashes (struck from the side, struck from the front, etc.)
- Crashes that occurred during special holidays/events (4th of July, Labor Day weekend, Thanksgiving, Christmas, etc.)
- DUI-related crashes by day of the week (i.e., weekdays versus weekends)
- Injury severity levels of DUI-related crashes by blood alcohol concentration (BAC) of the impaired drivers
- Comparison of the injury severity levels among properly buckled and improperly buckled or unbuckled vehicle occupants
- Injury severity levels by drivers' age group and gender
- Crashes on roads with challenging geometric conditions (steep upgrades, steep downgrades, tight horizontal curves, etc.)
- Crashes involving distractions by distraction method (use of electronic device, picking up an object from the vehicle's floor, etc.)
- Crash locations by injury severity level and lighting conditions (daylight, dawn, dark with street lighting, etc.) at the times of the crashes
- Crash locations by injury severity level and road surface conditions (dry, wet, icy, snowy, etc.) at the times of the crashes

The respondents were also asked about the importance of color-coded maps presenting locations characterized by risks of encountering the following types of crashes on a scale of one (not important) to five (crucial). At least half declared scores of four or five for those crashes.

- High severity (fatal, suspected serious injury, and suspected minor injury) crashes
- Possible injury and PDO crashes
- High severity crashes that occurred in the presence of adverse weather conditions (snow, fog, rain, etc.)
- High severity crashes where visual obstructions (vegetation, hill crests, sun glare, headlight glare, other vehicles, animals, fog, snow showers, etc.) posed hazards
- High severity crashes involving improperly buckled or unbuckled occupants
- High severity DUI-related crashes

- High severity speed-related crashes

The respondents were then directed to another section asking about whether they were interested in specific citation information. As was the case of the WSBC survey, the WYDOT HSO would not maintain such data. Hence, a disclaimer was provided stating this fact and that independent studies would have to be conducted to process citation data. At least half of the respondents declared that they preferred the following data:

- Citation counts of unlicensed drivers
- Citation counts of drivers not wearing their prescription glasses/contact lenses if their licenses required so
- Citation counts of young drivers who were not accompanied by passengers 18 years or older if their licenses required so
- Citation counts by violation type and driver's age
- Citation counts by violation type and driver's gender
- Citation counts of seat belt use policy violations by county and year
- Whether vehicle occupants, cited for previous seat belt use violations, attended traffic education sessions
- Citation counts of child restraint policy violations by county and year
- Citation counts of aggressive/reckless drivers by county and year
- Citation counts of tired drivers by county and year
- Speeding citation counts by county and year
- Locations characterized by a considerable number of citations issued

Finally, the officers were asked to select topics they might be interested in for further investigation (i.e., data analyses, interpretation, and documentation of results in reports). At least three-quarters of them declared their interest in the following topics:

- Effectiveness of DUI enforcement policies
- Effectiveness of speed enforcement policies
- Effectiveness of seat belt use policies
- Response times of emergency services, particularly for severe crashes
- Effectiveness of traffic safety educational campaigns
- Effectiveness of other traffic violation enforcement polices (i.e., improper lane change, red light running, etc.)
- Effective methods of capturing motorcyclists committing traffic violations
- Safety benefits of vehicles equipped with ADAS
- Safety benefits of mandatory periodic vehicle inspections in other states
- Fluctuations in traffic fatality rates in Wyoming throughout the years

3.4 Summary of the Wyoming Association of Sheriffs and Chiefs of Police Survey Response Results

A survey was prepared and distributed to members of the Wyoming Association of Sheriffs and Chiefs of Police (WASCOP) asking about road safety data they needed in addition to those already provided in statewide road safety reports and database files they would retrieve from the WYDOT HSO. Three responses were obtained. In the first section of the survey, the respondents indicated that they received road safety data and/or reports once a month via email, which was the preferred means of data acquisition. Note that one of the officers indicated not receiving such data. The respondents also maintained that the data provided fulfilled their needs. Furthermore, one respondent stated that they

received crash data 12 to 15 days from the dates the crashes occurred and that, ideally, this duration ought to be shortened to a week. The other claimed that WASCOP received the crash data a day after the crashes occurred and that this was the ideal time interval. Also, the respondents indicated they preferred crash data be summarized in the form of pie charts/bar charts, summary statistics tables, and figures. Furthermore, two of the three respondents concurred that color-coded maps would be considered efficient means of illustrating crash locations.

In the second section of the survey, members of WASCOP were provided a list of reports available in the WYDOT HSO website, which are the following:

- 2019 Highway Safety Crash Data Survey Final Report
- Wyoming Department of Transportation Highway Safety Behavioral Grants Office 2019 Annual Report
- Wyoming Highway Safety Behavioral Program FY2020 Highway Safety Plan
- Wyoming Report on Traffic Crashes 2019
- Wyoming Drivers Survey 2016
- 2019 Seat Belt Survey Analysis
- Impaired Driver-Involved Crash Statistics
- Wyoming Statewide Crashes by Year
- Wyoming Statewide Speed-Related Crashes by Year
- Wyoming Statewide Occupant Seat Belt Usage by Year
- Wyoming Statewide Crashes Involving a Wild Animal by Year
- Wyoming Statewide Crashes Involving Alcohol or Drugs by Year
- Wyoming Statewide Crashes Involving Commercial Motor Vehicles by Year
- Wyoming Statewide Distracted Driving Crashes by Year
- Wyoming Strategic Highway Safety Plan 2017

When asked about how familiar the respondents were with the reports listed, on a scale of one (not at all) to five (absolutely), one provided a rating of one while another provided a rating of two, and the third provided a rating of three. In particular, one respondent indicated familiarity with three of the aforementioned reports, which are:

- Wyoming Department of Transportation Highway Safety Behavioral Grants Office 2019 Annual Report
- Wyoming Report on Traffic Crashes 2019
- Wyoming Statewide Crashes by Year

Remarkably, one respondent declared that the reports listed in the survey would be considered beneficial to WASCOP, and two respondents indicated satisfaction with the frequency at which those reports were released. Also, none suggested any additional reports to include in the list. Furthermore, two respondents claimed they would like to be presented summary statistics describing drivers' improper actions/error information preceding the crashes in those reports.

After answering questions about the road safety reports, the respondents were asked about particular crash data that would be of interest to them. At least two indicated interest in the following crash data variables presented in the form of summary statistics:

- Crash locations (on the road, on the shoulder, off the road, etc.)
- Crash times (morning, afternoon, etc.)
- Weather conditions at the times of the crashes
- Number of vehicles involved in the crashes

- Vehicle travel speeds at the times of the crashes (too slow, reasonable, or too fast for the conditions)
- Whether the passengers were properly wearing their seat belts at the times of the crashes
- Whether the drivers were driving under the influence of drugs or alcohol
- Motorcycle crashes
- Number of injured drivers/motorcyclists and their injury severity levels
- Crash types (rear-end, sideswipe, etc.)
- Impact point information (struck from the side, etc.)
- Crashes that occurred during special holidays/events (4th of July, Labor Day weekend, Thanksgiving, Christmas, etc.)
- DUI-related crashes by day of the week (weekdays versus weekends)
- Injury severity levels of DUI-related crashes by blood alcohol concentration (BAC) level of impaired drivers
- Comparison of the injury severity levels among properly buckled and improperly buckled or unbuckled vehicle occupants
- Injury severity levels by drivers' age group and gender
- Crashes on roads with challenging geometric conditions (steep upgrades, steep downgrades, tight horizontal curves, etc.)
- Crashes involving distractions by distraction method (use of electronic device, picking up an object from the vehicle's floor, etc.)
- Crash locations by injury severity level and lighting conditions (daylight, dark with street lighting, etc.)
- Crash locations by injury severity level and road surface conditions (dry, wet, icy, snowy, etc.)

Furthermore, two of the three respondents indicated interest in color-coded maps describing specific crash categories, which are the following:

- High severity (fatal, suspected serious injury, and suspected minor injury) crashes
- High severity crashes that occurred in the presence of adverse weather conditions (snow, rain, etc.)
- High severity DUI-related crashes
- High severity speed-related crashes

Other than crash information related questions, members of WASCOP were also asked about citation data. Similar to the WHP survey, a disclaimer was included to inform the respondents that the WYDOT HSO would not maintain citation data and that independent studies would have to be conducted on such data, if needed. From the survey results, only one respondent claimed interest in data of citation counts of aggressive/reckless drivers by county and year. Similarly, one respondent stated a willingness to receive data on citation counts of tired drivers by county and year. Finally, a question was asked about specific research topics that would be of interest to WASCOP. Two respondents suggested that studies be conducted on the following topics:

- Effectiveness of DUI enforcement policies
- Effectiveness of speed enforcement policies

3.5 Recommendations for the Wyoming Department of Transportation Regarding the Wyoming Highway Patrol and the Wyoming Association of Sheriffs and Chiefs of Police

The results of the WHP and WASCOP surveys were similar and, hence, recommendations made regarding the data WYDOT should provide to those groups were combined in one section. The first recommendation was to provide crash records to WHP and WASCOP in the shortest possible time. It is also suggested WYDOT should provide quarterly summary statistics similar to the ones illustrated in Figures 3.26 through 3.65, and Tables 3.6 through 3.10. Similar to the recommendations regarding heat maps to be provided to WSBC, other heat maps are suggested for both WHP and WASCOP. The suggested heat maps would be comparable to the ones presented in Figures 3.66 through 3.73.

Table 3.6 2019 Counts of Drivers' Actions Preceding the Crashes

Drivers' Actions Prior to the Crashes	Quarter				Total
	1	2	3	4	
Avoiding Animal	22	30	49	33	134
Avoiding Motor Vehicle	85	53	70	83	291
Avoiding Non-Motorist	2	0	11	4	17
Avoiding an Object on Road	4	9	14	14	41
Disregarded Other Road Marking	11	33	21	68	133
Disregarded Traffic Signs	135	123	152	170	580
Drove too Fast for Conditions	1,216	322	160	1,401	3,099
Erratic/Reckless/Careless/Aggressive	229	366	363	350	1,308
Evading Law Enforcement	15	35	18	17	85
Failed to Keep Proper Lane	848	657	691	963	3,159
Failed to Yield Right-of-Way	477	444	512	477	1,910
Following Too Closely	378	371	455	424	1,628
Improper Backing	167	189	180	184	720
Improper Parking	16	9	23	10	58
Improper Passing	57	65	75	53	250
Improper Turn or No Signal	136	146	183	153	618
Over Corrected/Over Steered	160	163	195	189	707
Ran Off the Road	950	749	732	1,074	3,505
Ran Red Light	120	91	110	121	442
Speeding	91	162	214	133	600
Swerve Due to Wind/Slippery Surface	246	65	8	205	524
Wrong Side/Wrong Way	49	59	43	33	184
Other Improper Action	230	253	327	329	1,139
No Improper Driving	2,557	2,299	2,663	3,232	10,751
Unknown	253	196	290	286	1,025
Total	8,454	6,889	7,559	10,006	32,908

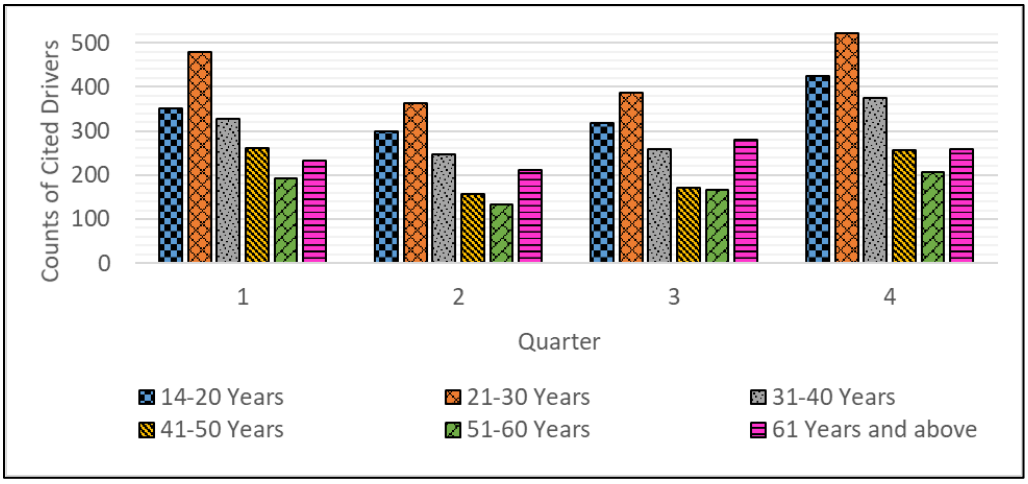

Figure 3.26 2019 counts of cited drivers at the crash scenes by age

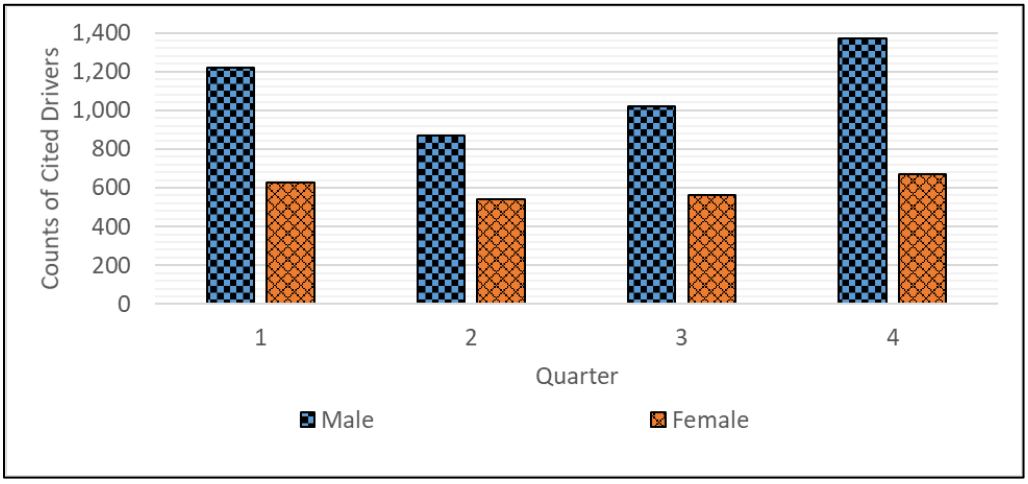

Figure 3.27 2019 counts of cited drivers at the crash scenes by gender

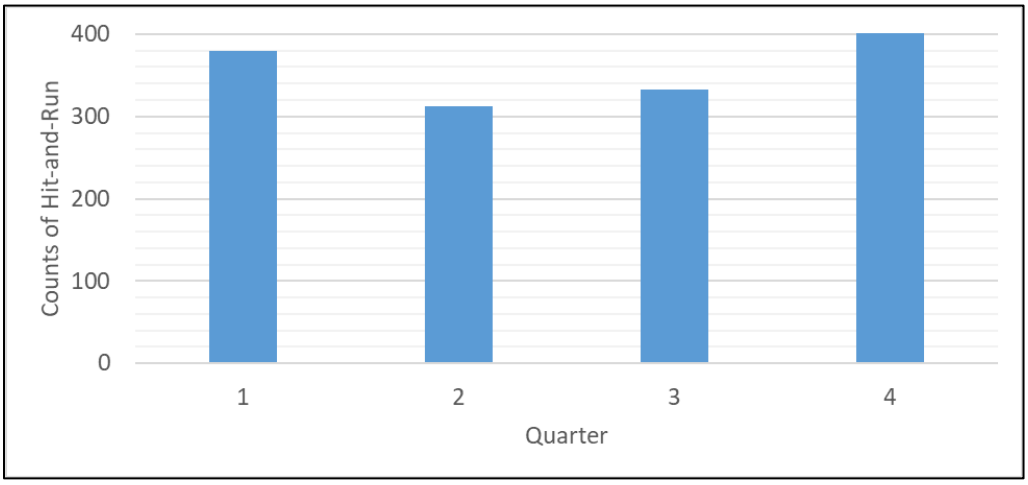

Figure 3.28 2019 counts of hit-and-run crashes

Table 3.7 2019 Counts of Crashes by First Harmful Event Location

First Harmful Event Location	Quarter				Total
	1	2	3	4	
Bridge	2	0	1	1	4
Gore	5	4	5	8	22
In Parking Lane/Zone	223	179	204	269	875
Median	198	131	70	240	639
Off Roadway	858	599	525	1,063	3,045
On Other Roadway	3	0	3	1	7
On Roadway	2,254	2,007	2,475	2,914	9,650
Outside of Right-of-Way	7	5	7	9	28
Port of Entry	1	3	0	0	4
Rest Area	0	0	1	1	2
Separator	3	4	1	3	11
Shoulder	154	107	137	193	591
Tunnel	9	3	0	6	18
Unknown	0	1	2	1	4
Total	3,717	3,043	3,431	4,709	14,900

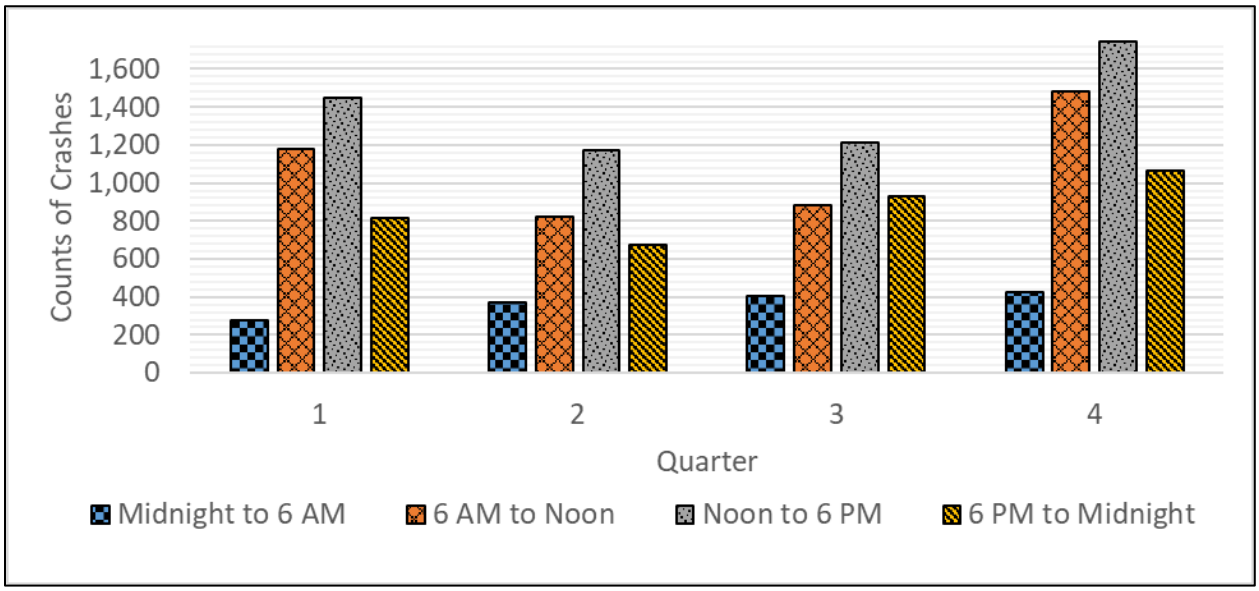

Figure 3.29 2019 counts of crashes by time of day

Table 3.8 2019 Counts of Crashes by Weather Condition

Weather Condition	Quarter				Total
	1	2	3	4	
Blizzard	34	7	0	39	80
Blowing Dust/Sand/Dirt	7	0	0	4	11
Blowing Snow	285	24	0	244	553
Clear	2,394	2,312	3,187	3,168	11,061
Cloudy, Overcast	138	171	61	183	553
Fog	41	26	15	40	122
Raining	18	217	121	42	398
Severe Wind Only	107	9	5	65	186
Sleet/Hail/Freezing Rain	12	28	3	53	96
Smoke	0	2	0	0	2
Snowing	623	199	1	794	1,617
Other	3	0	0	7	10
Unknown	55	48	38	70	211
Total	3,717	3,043	3,431	4,709	14,900

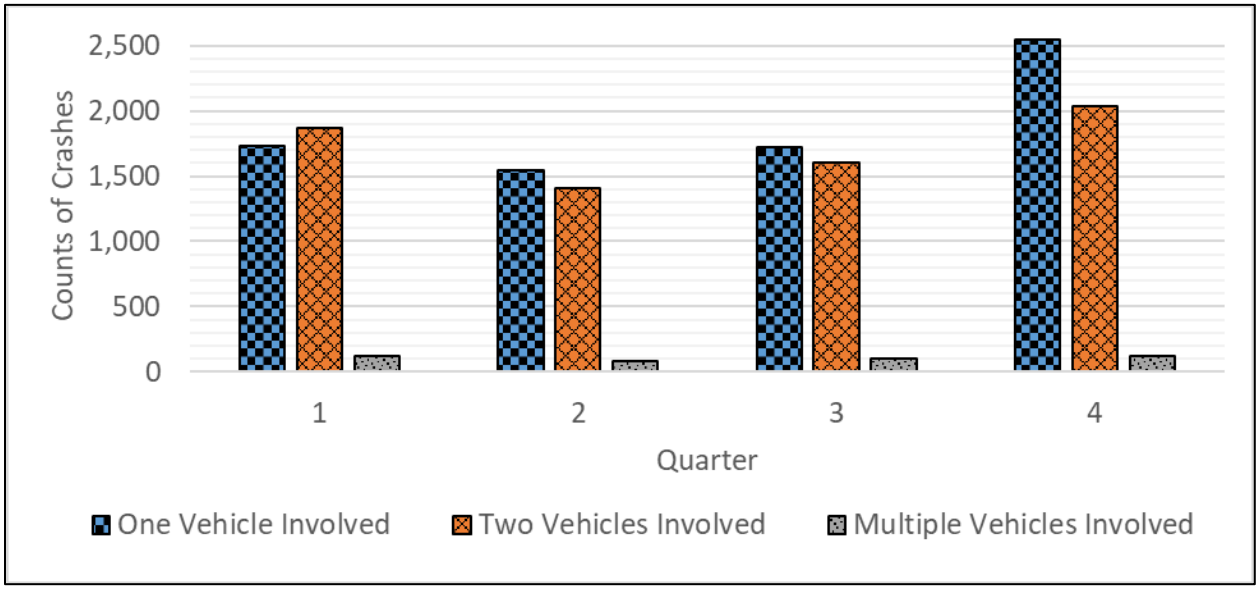

Figure 3.30 2019 counts of crashes by number of vehicles involved

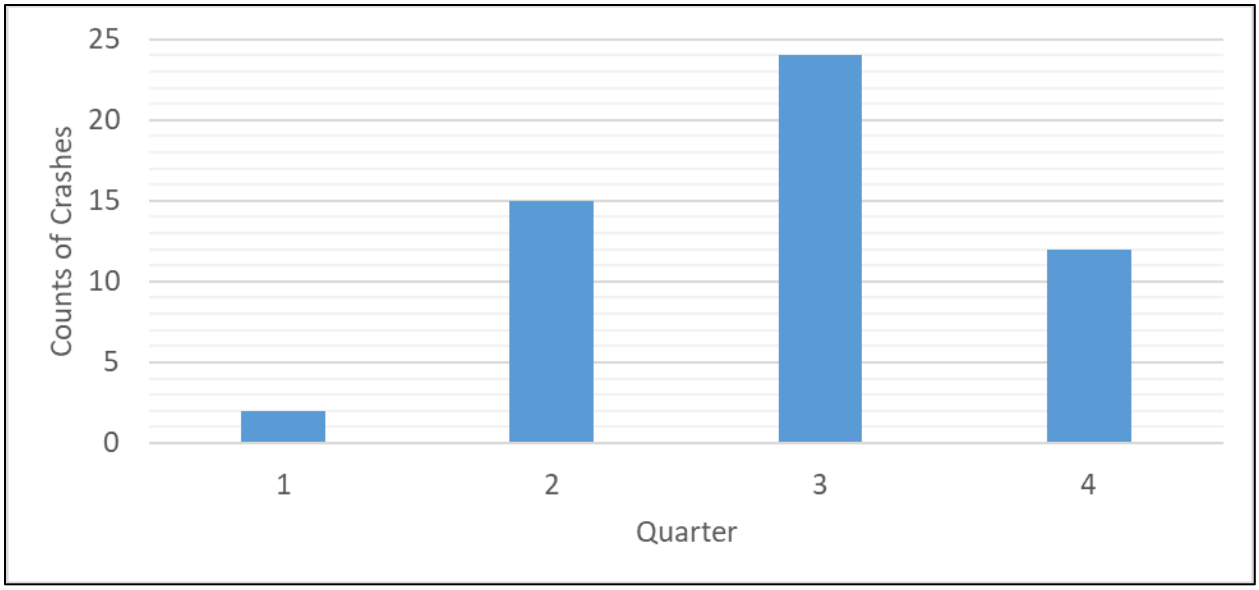

Figure 3.31 2019 counts of bicycle crashes

Table 3.9 2019 Animal Crashes by Type of Animal Struck

Animal	Quarter				Total
	1	2	3	4	
Deer	336	457	613	795	2,201
Antelope	31	65	84	62	242
Elk	17	27	62	36	142
Buffalo	1	1	0	0	2
Moose	7	9	16	9	41
Other Wild	4	8	12	11	35
Cow	13	26	56	46	141
Horse	4	6	4	7	21
Sheep	4	1	3	4	12
Pig	0	1	0	0	1
Other Domestic (Dog, Lama, etc.)	6	7	9	13	35
Total	423	608	859	983	2,873

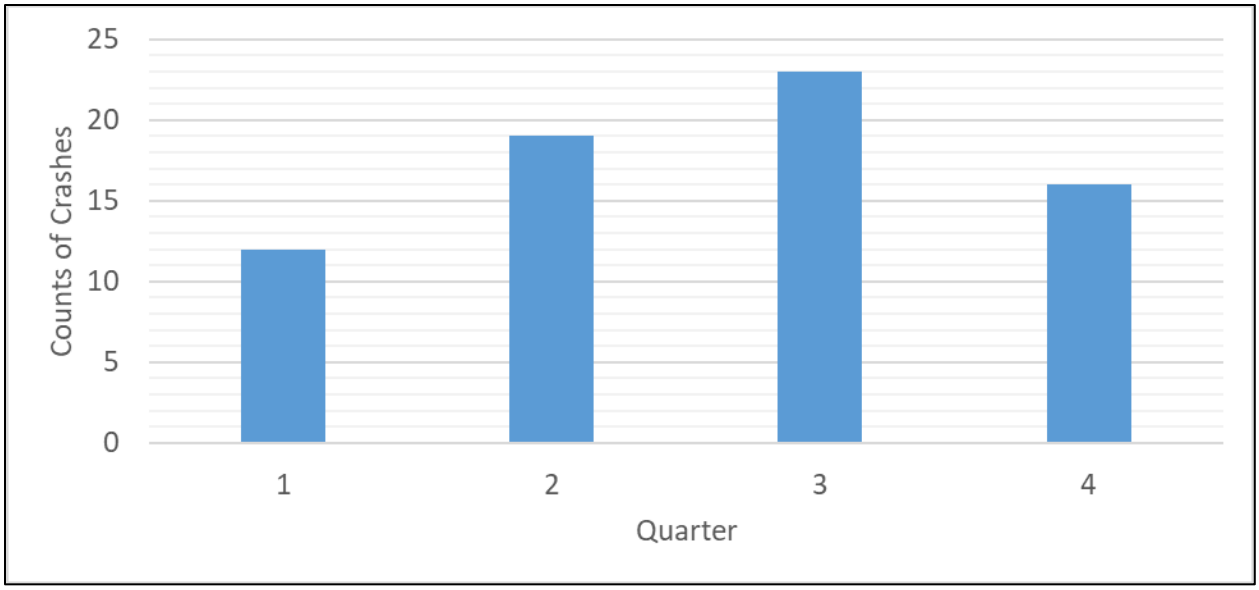

Figure 3.32 2019 counts of crashes resulting in fires

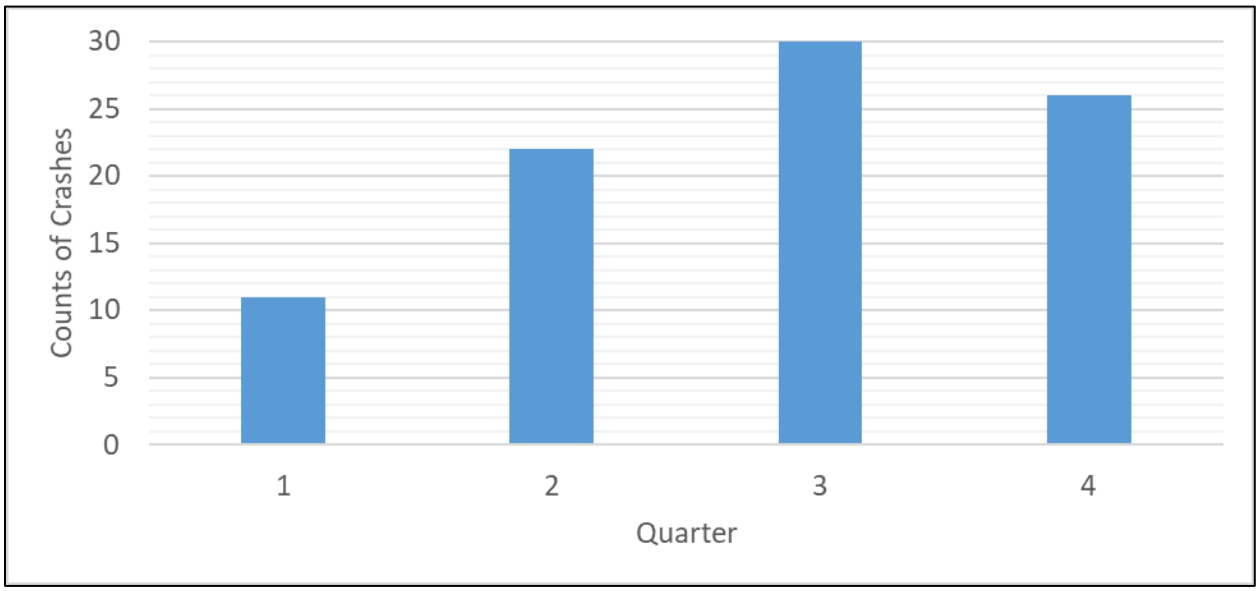

Figure 3.33 2019 counts of crashes involving mechanical failures

Table 3.10 2019 Counts of Crashes by Manner of Collision

Manner of Collision	Quarter				Total
	1	2	3	4	
Head On (Front to Front)	82	52	70	94	298
Angle (Front to Side), Opposing Direction	248	165	176	294	883
Angle Right (Front to Side, Includes Broadside)	424	268	334	405	1,431
Angle Same Direction (Front to Side)	196	138	162	198	694
Angle Direction Not Specified	7	1	3	3	14
Rear End (Front to Rear)	567	450	496	652	2,165
Rear to Front (Normally Backing)	59	50	55	63	227
Rear to Rear (Normally Backing)	12	16	12	20	60
Rear to Side (Normally Backing)	73	79	83	80	315
Sideswipe Opposite Direction (Meeting)	51	32	31	56	170
Sideswipe Same Direction (Passing)	216	184	219	237	856
Other	17	35	30	31	113
Not a Collision with Two Vehicles in Transport	1,321	962	909	1,607	4,799
Unknown or Not Stated	444	611	851	969	2,875
Total	3,717	3,043	3,431	4,709	14,900

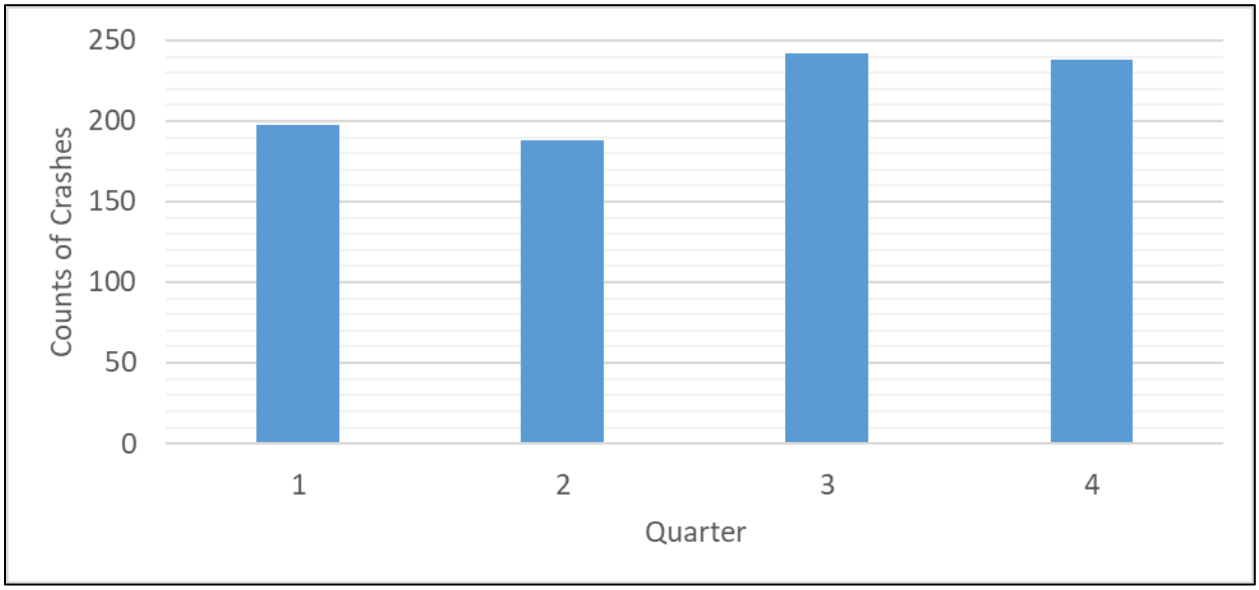

Figure 3.34 2019 counts of weekend driving under the influence crashes

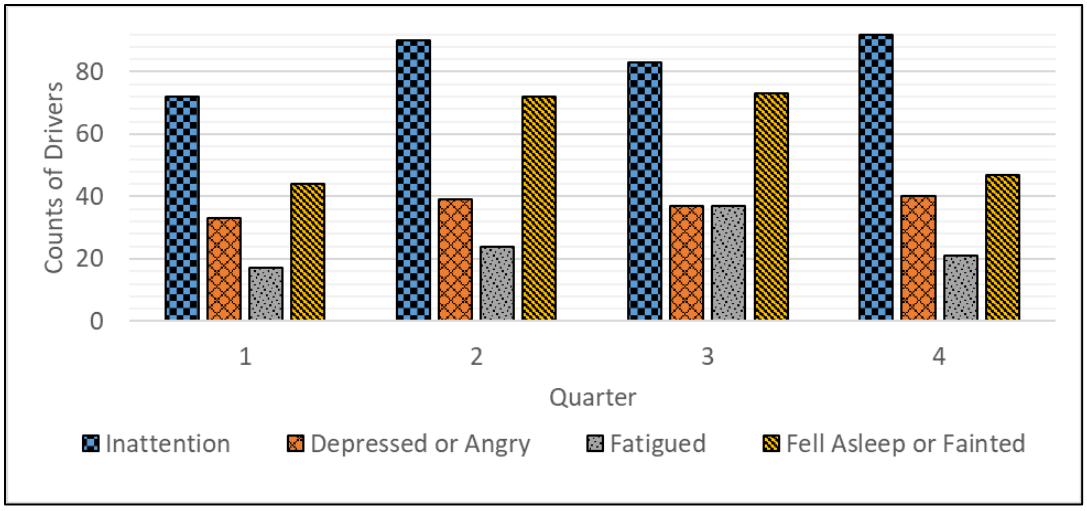

Figure 3.35 2019 counts of drivers by detestable condition

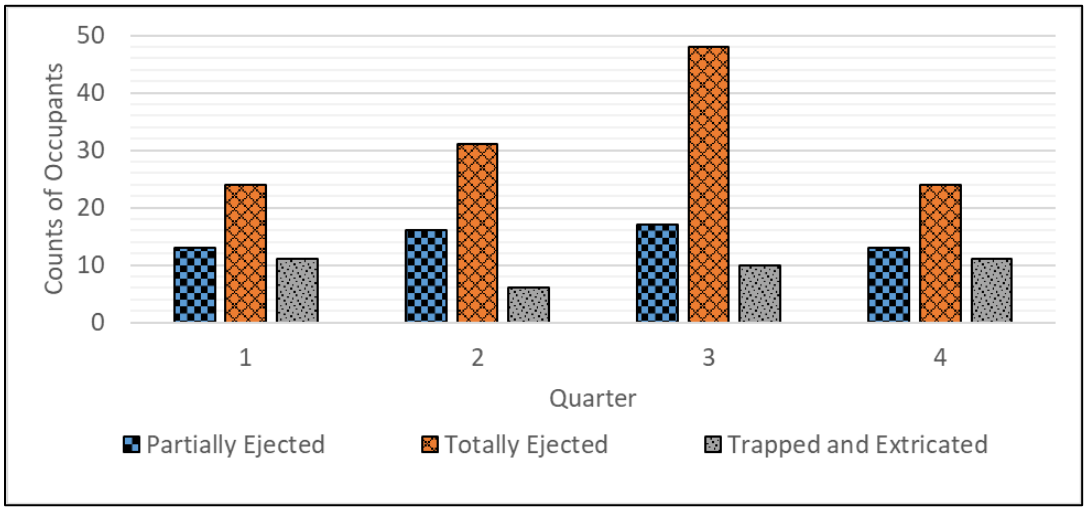

Figure 3.36 2019 counts of ejected, partially ejected, and trapped occupants

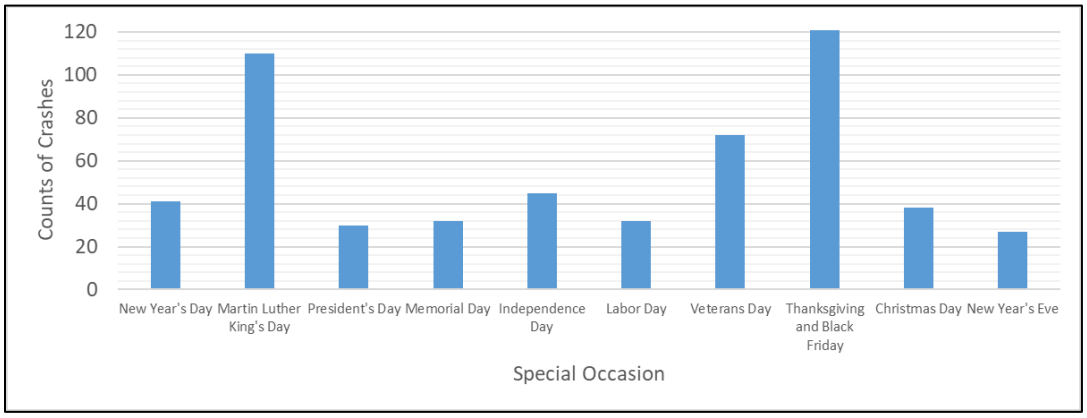

Figure 3.37 2019 special occasion crashes

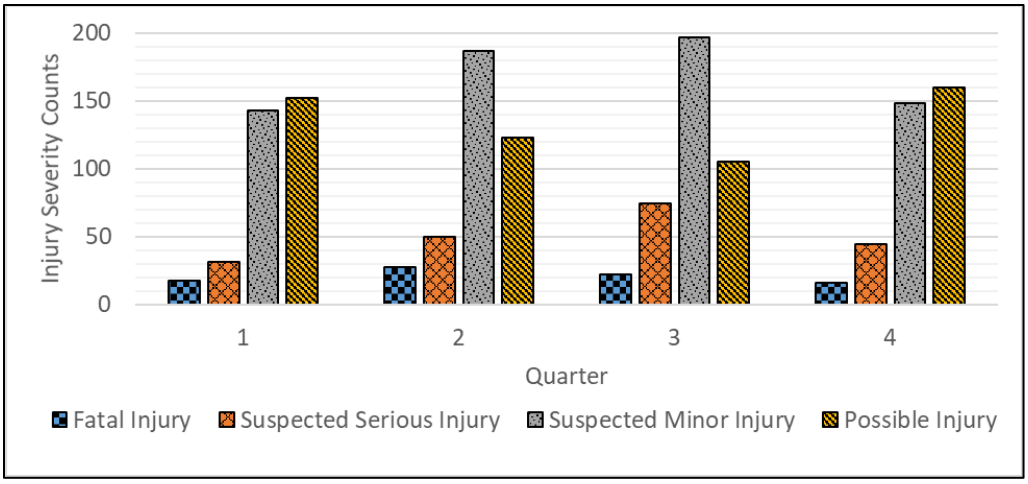

Figure 3.38 2019 counts of killed and injured male drivers

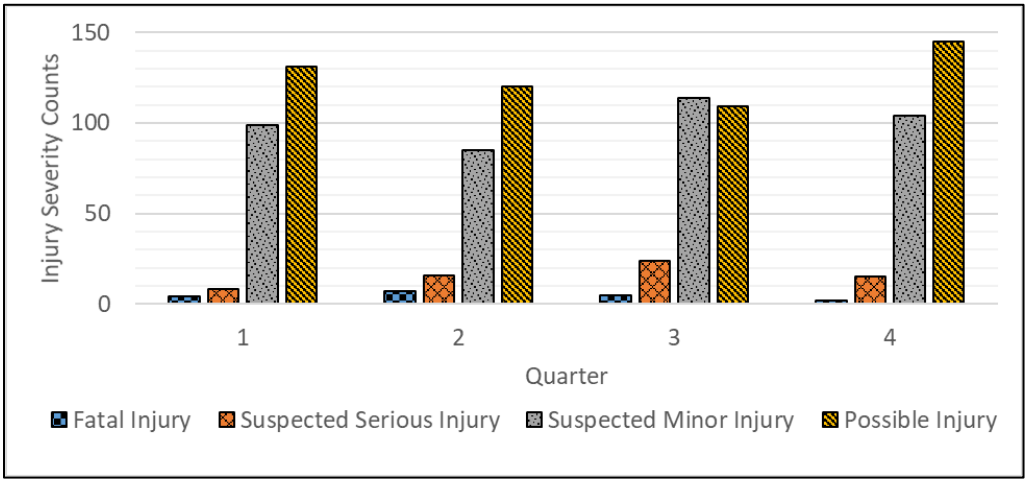

Figure 3.39 2019 counts of killed and injured female drivers

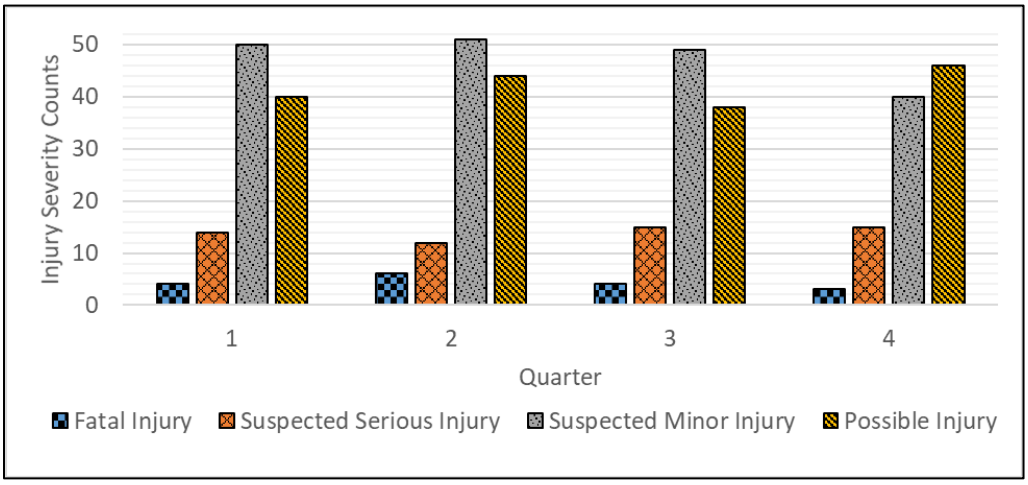

Figure 3.40 2019 counts of killed and injured male passengers

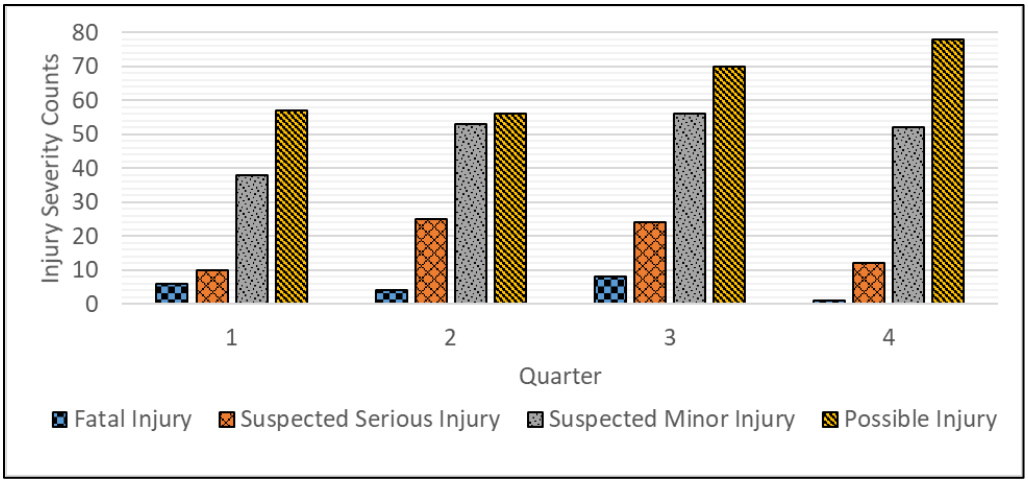

Figure 3.41 2019 counts of killed and injured female passengers

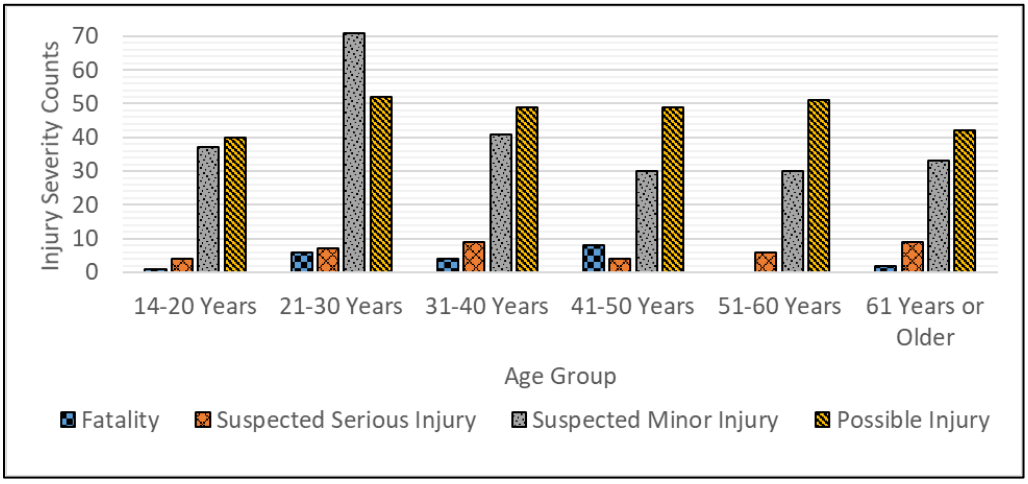

Figure 3.42 2019 counts of killed and injured drivers by age in the first quarter

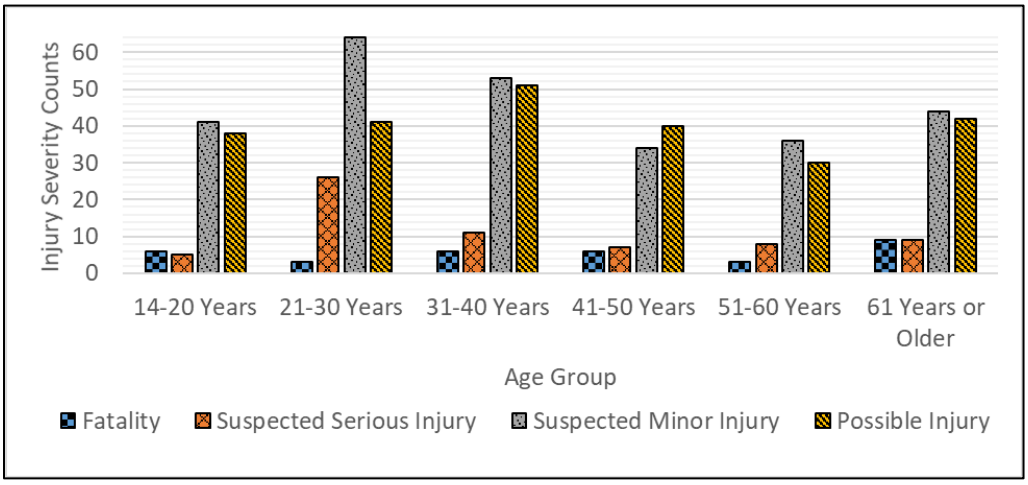

Figure 3.43 2019 counts of killed and injured drivers by age in the second quarter

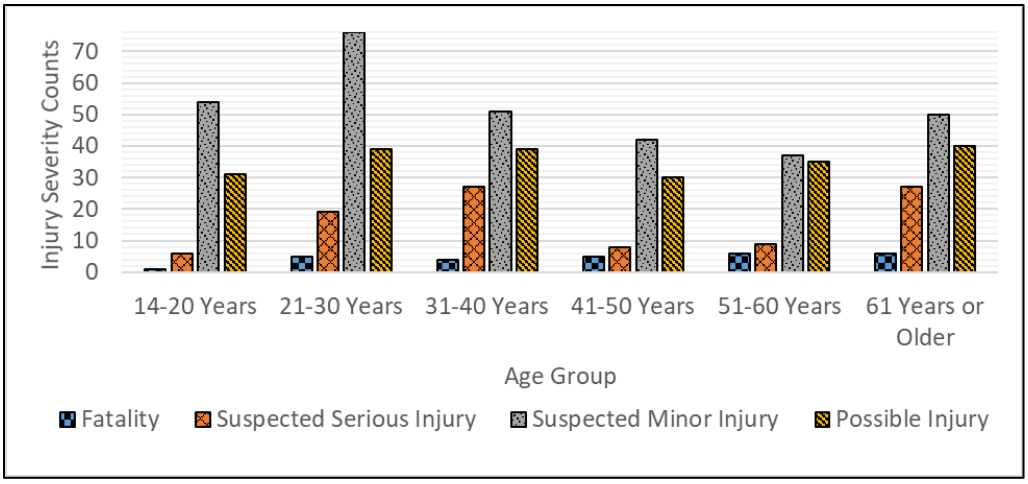

Figure 3.44 2019 counts of killed and injured drivers by age in the third quarter

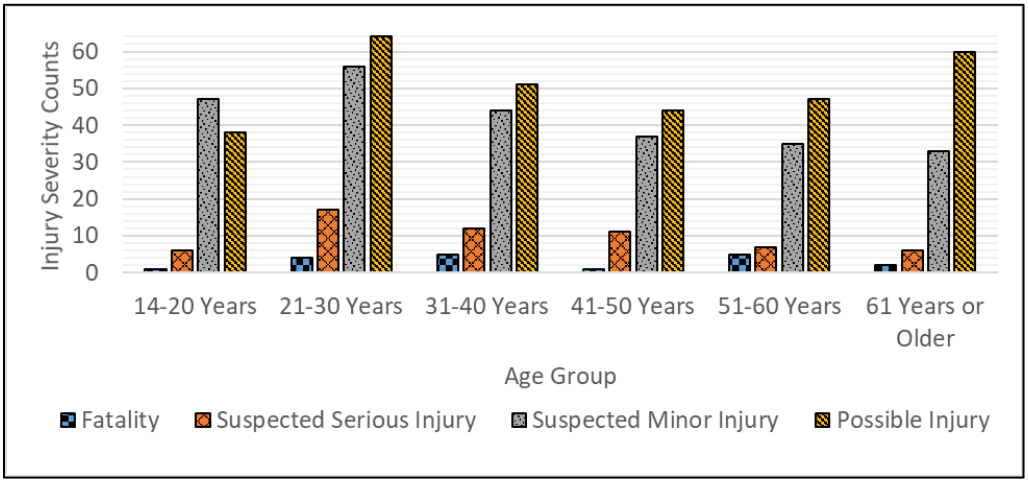

Figure 3.45 2019 counts of killed and injured drivers by age in the fourth quarter

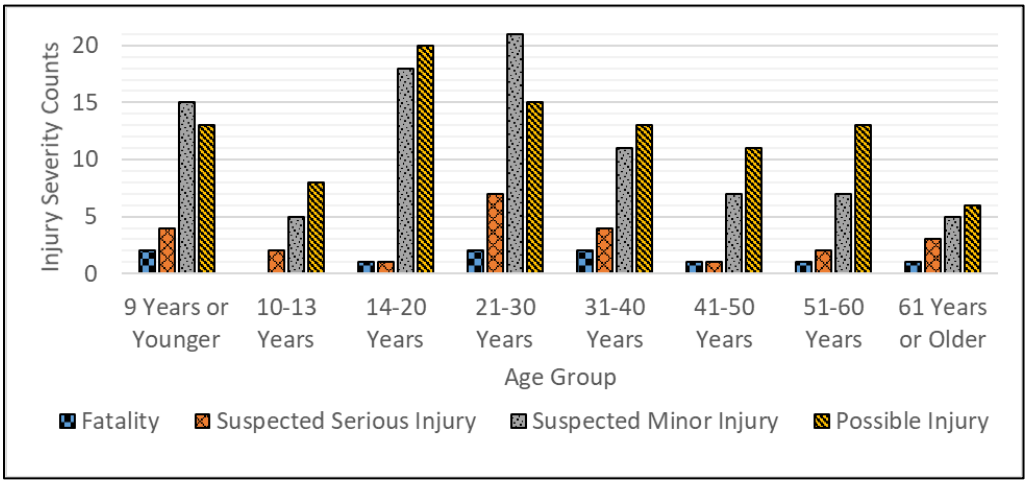

Figure 3.46 2019 counts of killed and injured passengers by age in the first quarter

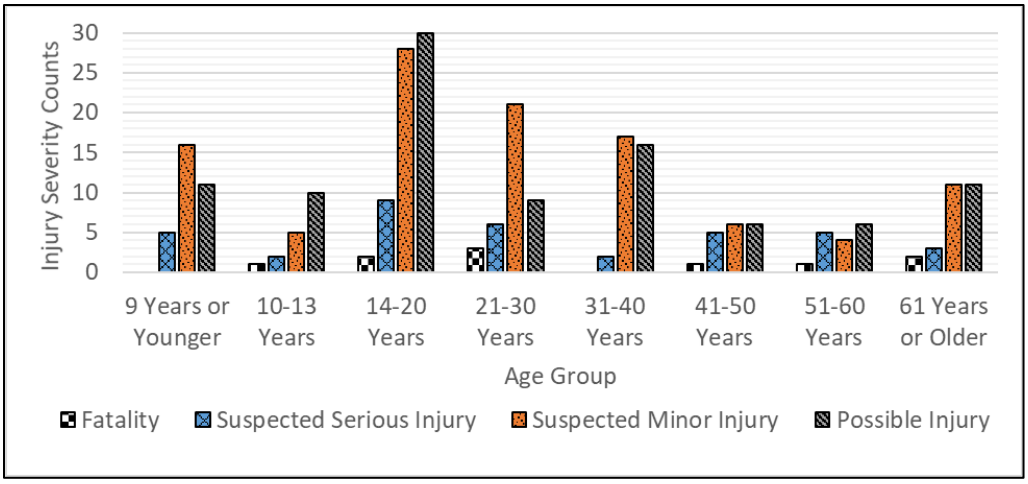

Figure 3.47 2019 counts of killed and injured passengers by age in the second quarter

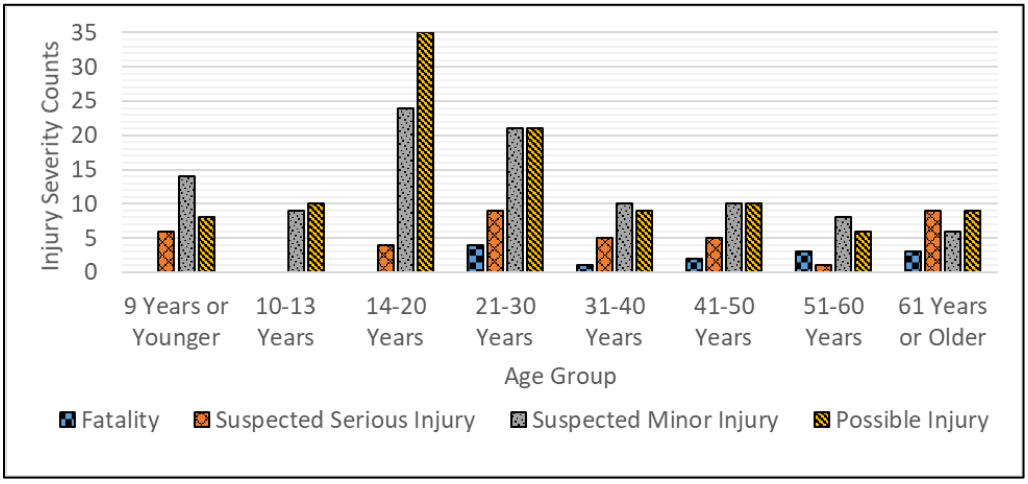

Figure 3.48 2019 counts of killed and injured passengers by age in the third quarter

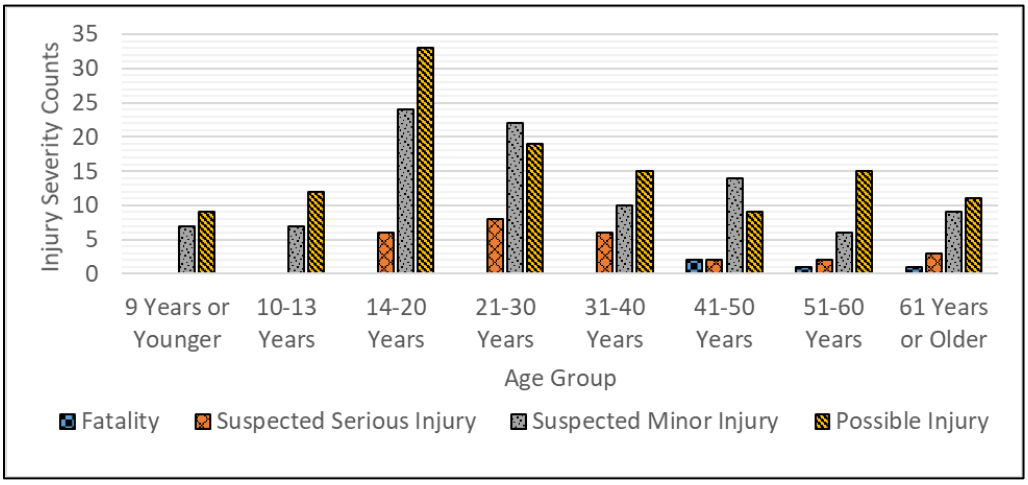

Figure 3.49 2019 counts of killed and injured passengers by age in the fourth quarter

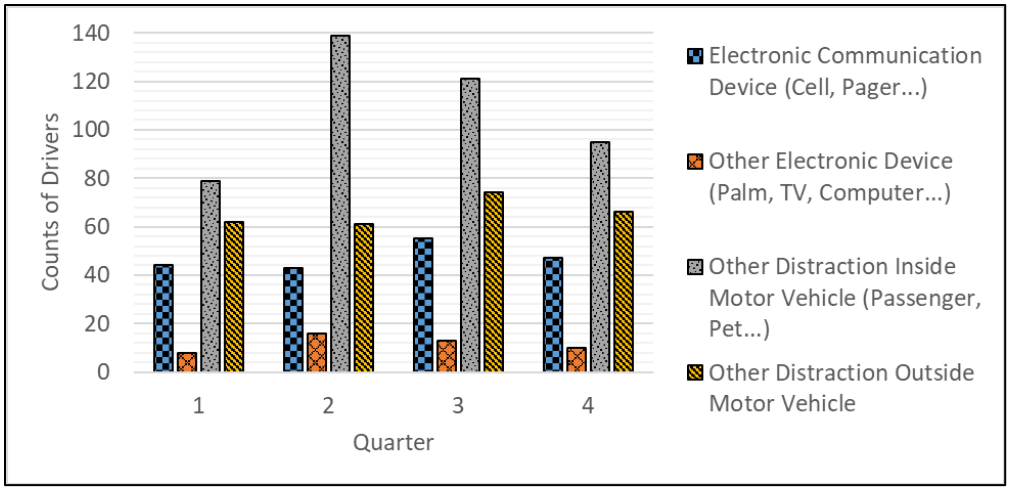

Figure 3.50 2019 counts of distracted drivers by means of distraction

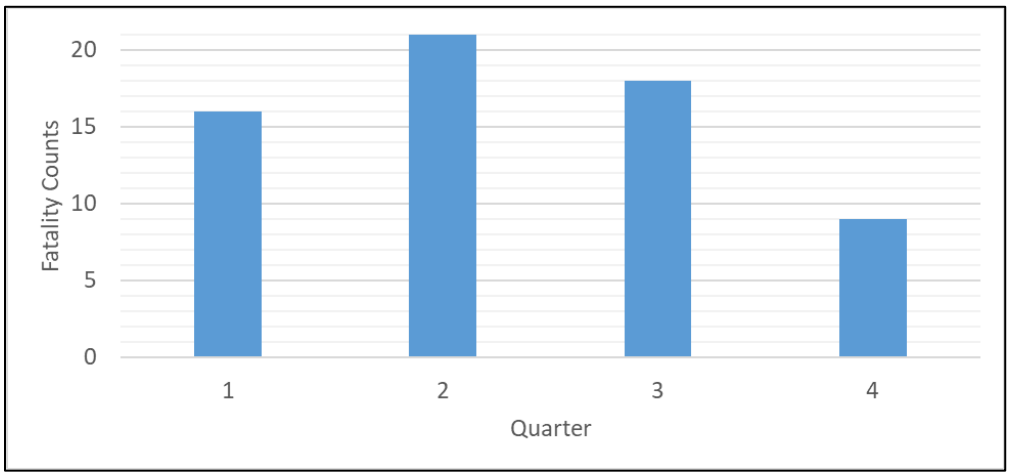

Figure 3.51 2019 fatality counts of improperly belted or unbelted occupants

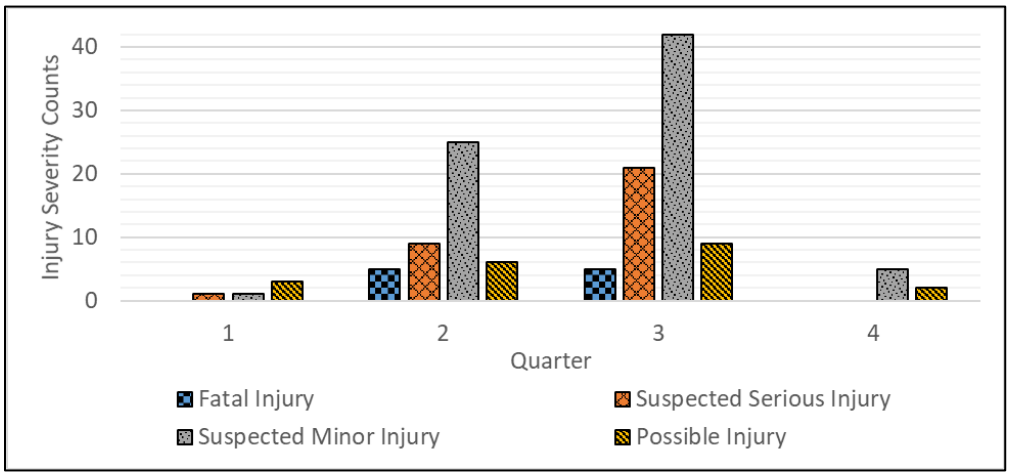

Figure 3.52 2019 counts of killed and injured motorcycle operators

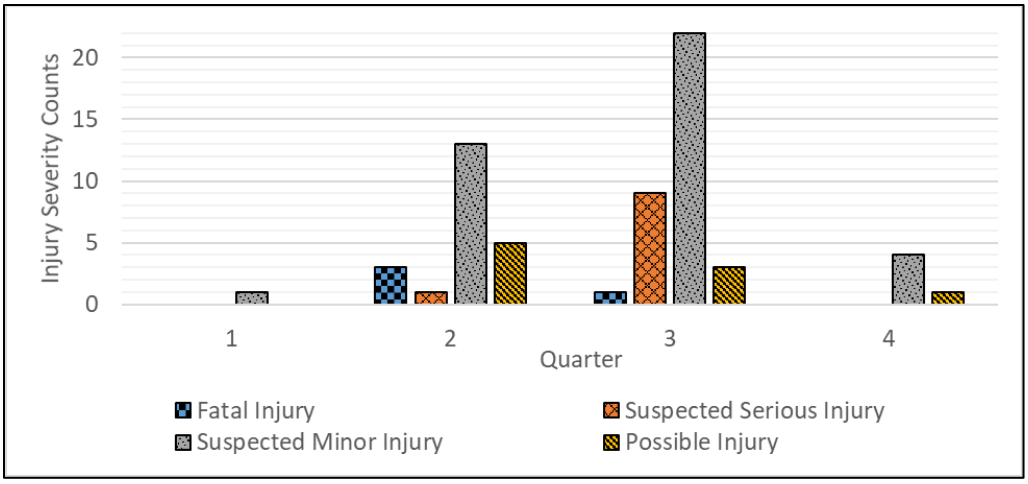

Figure 3.53 2019 counts of killed and injured motorcycle operators wearing helmets

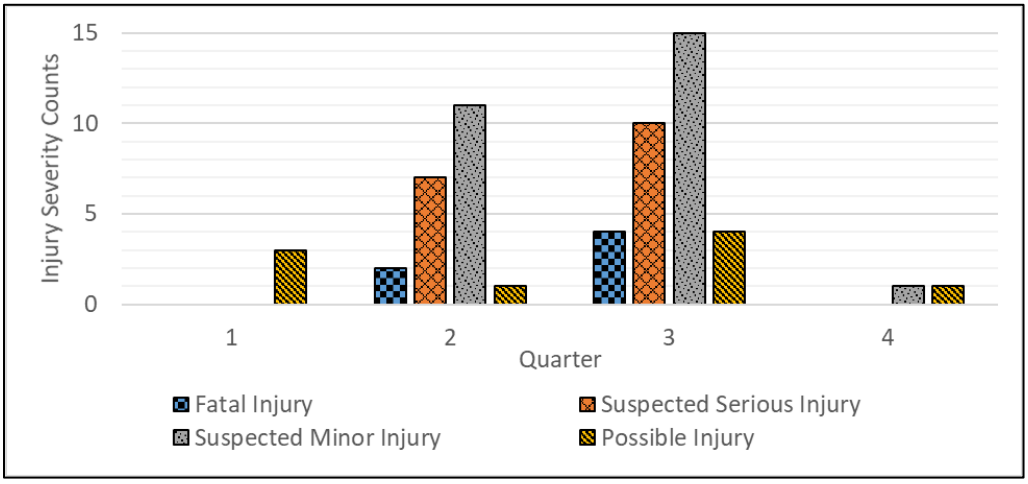

Figure 3.54 2019 counts of killed and injured motorcycle operators not wearing helmets

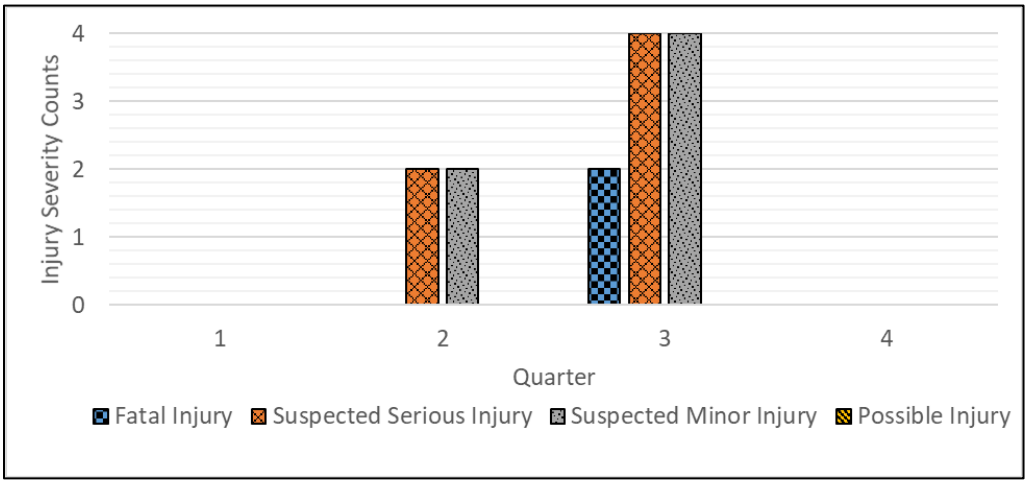

Figure 3.55 2019 counts of killed and injured motorcycle passengers

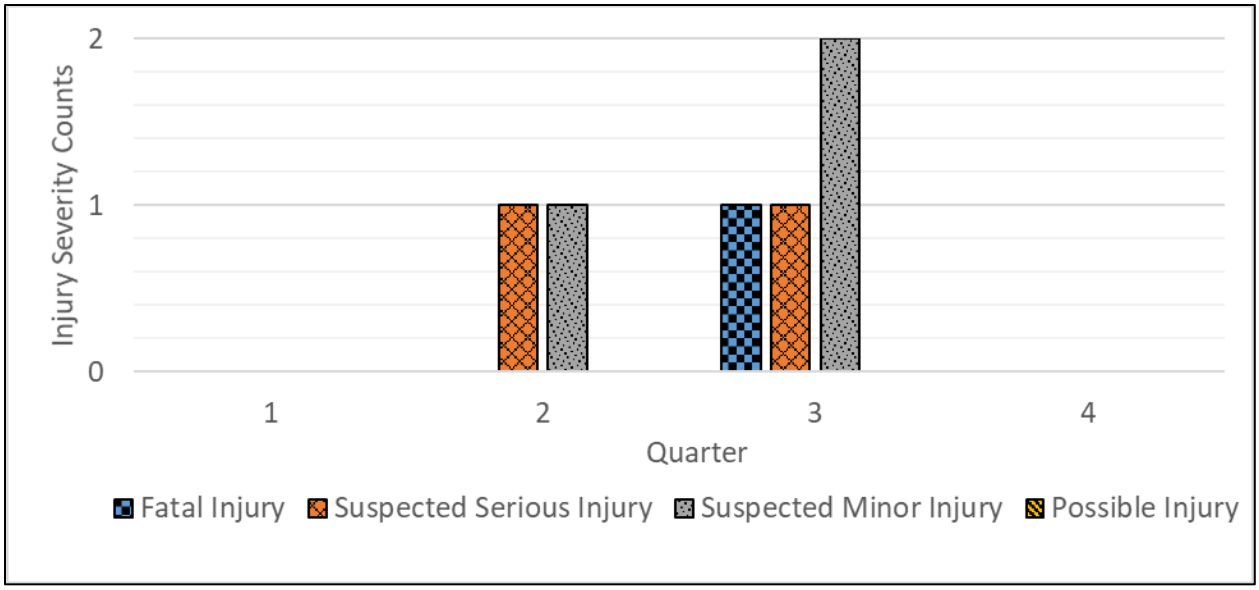

Figure 3.56 2019 counts of killed and injured motorcycle passengers wearing helmets

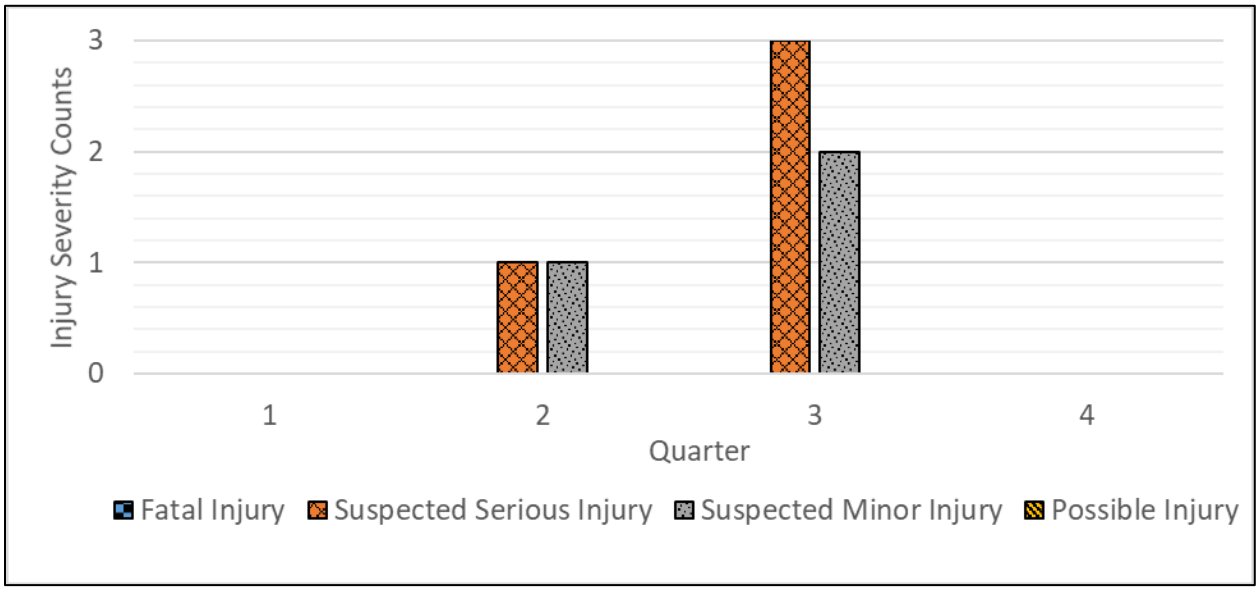

Figure 3.57 2019 counts of killed and injured motorcycle passengers not wearing helmets

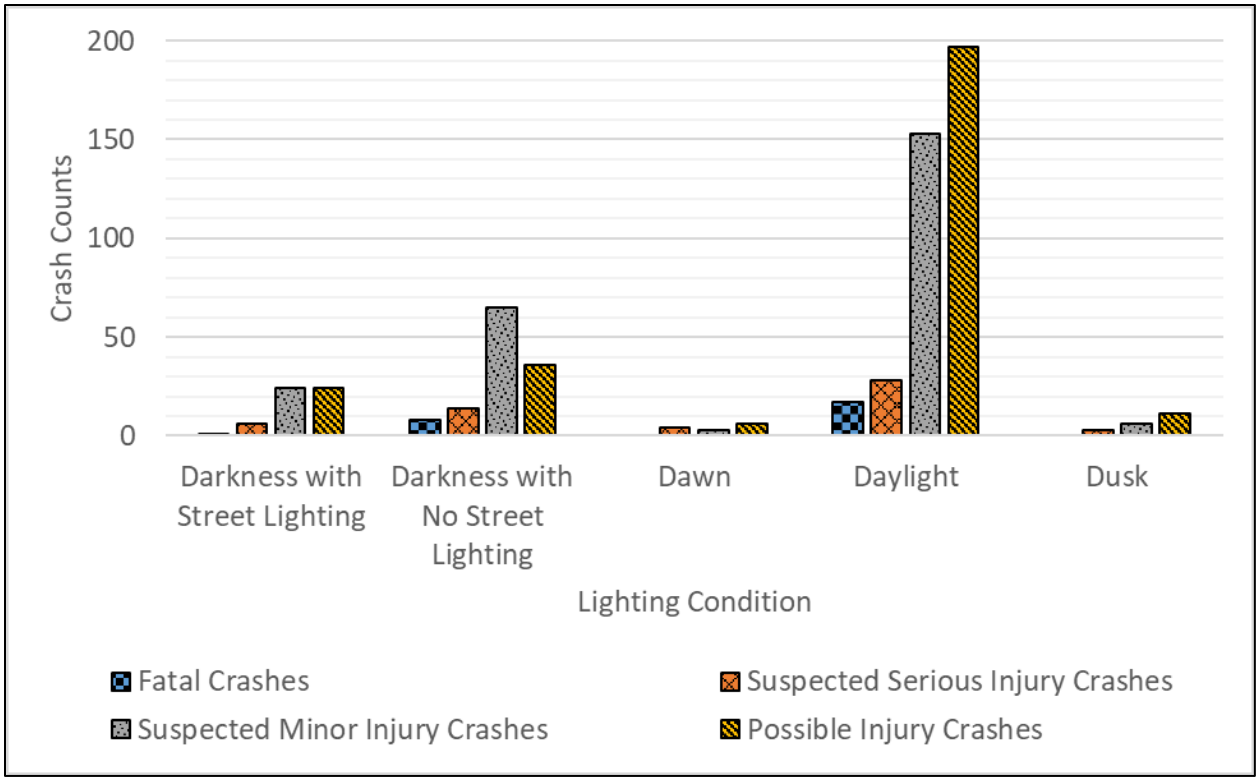

Figure 3.58 2019 counts of crashes by lighting condition in the first quarter

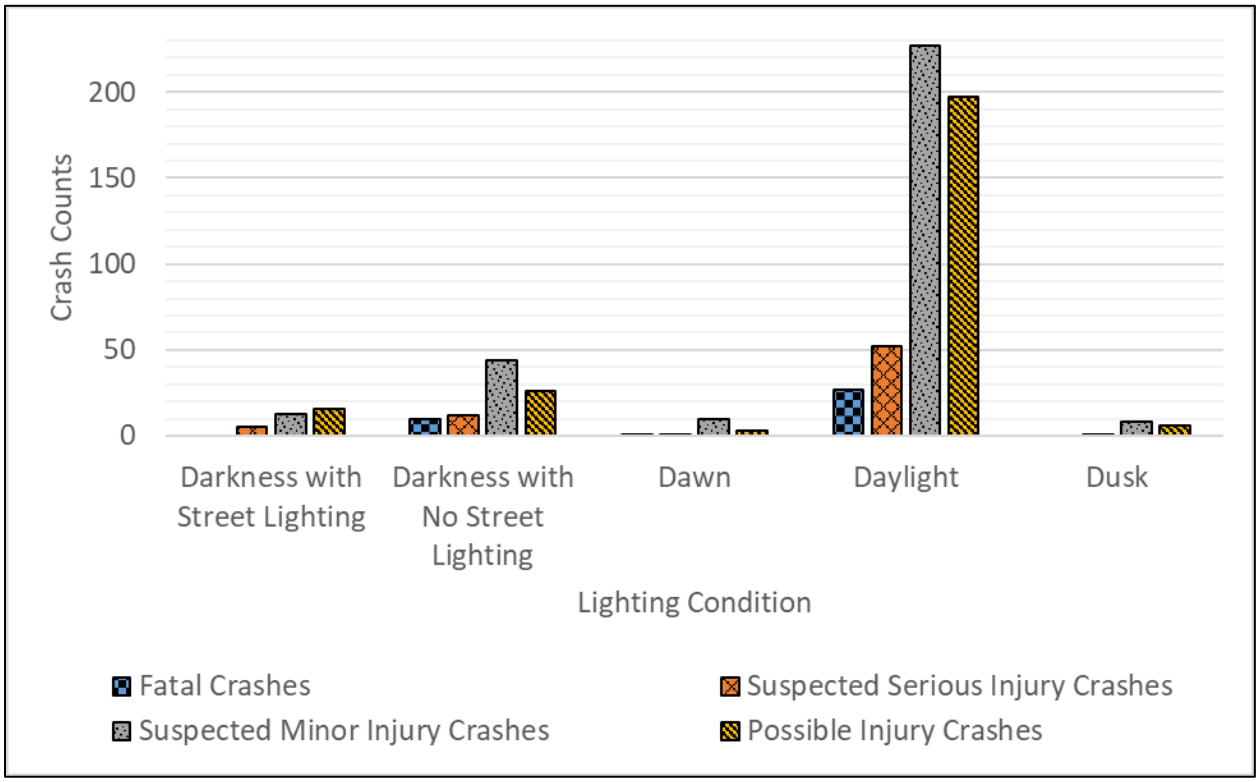

Figure 3.59 2019 counts of crashes by lighting condition in the second quarter

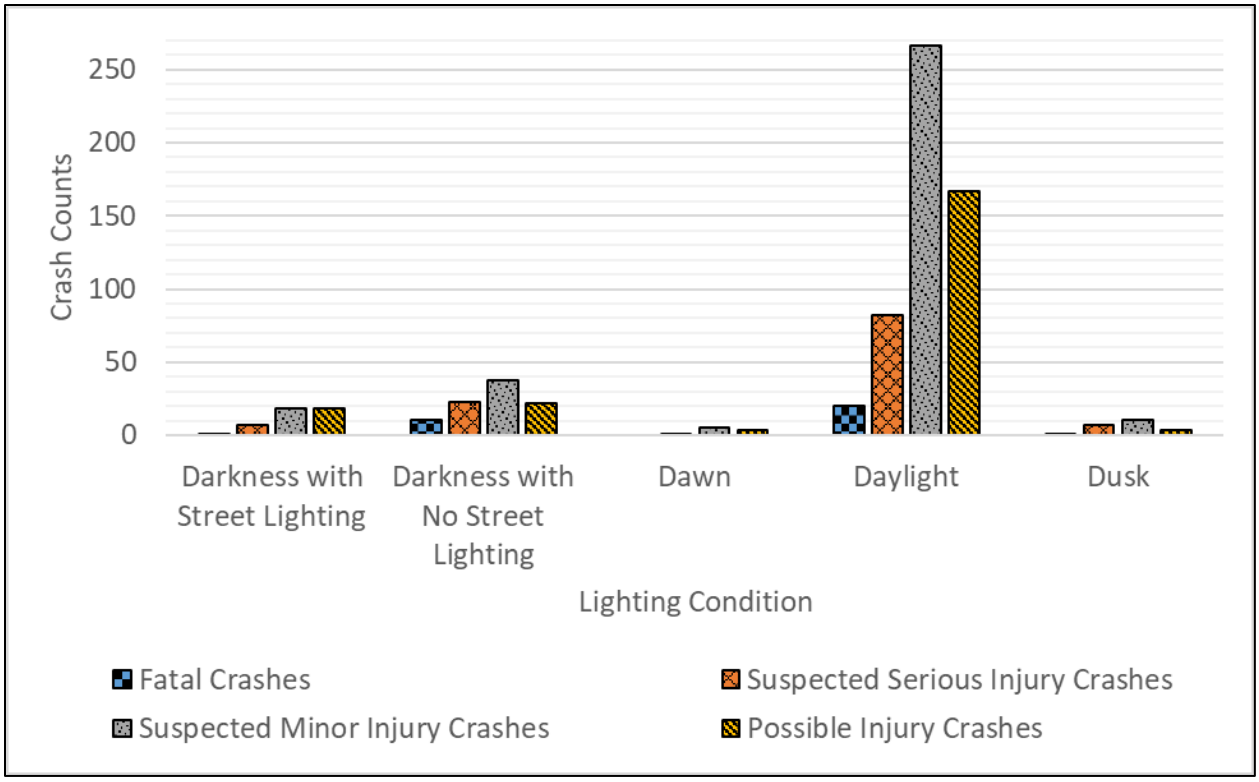

Figure 3.60 2019 counts of crashes by lighting condition in the third quarter

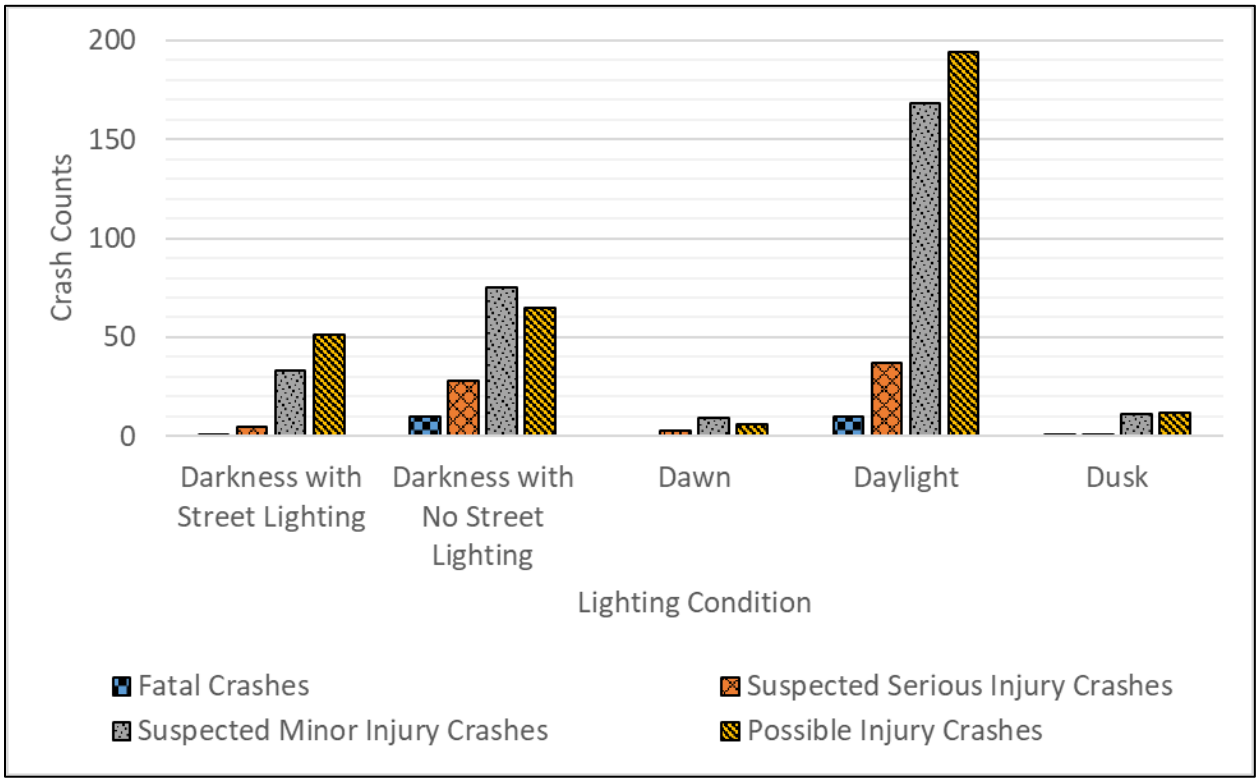

Figure 3.61 2019 counts of crashes by lighting condition in the fourth quarter

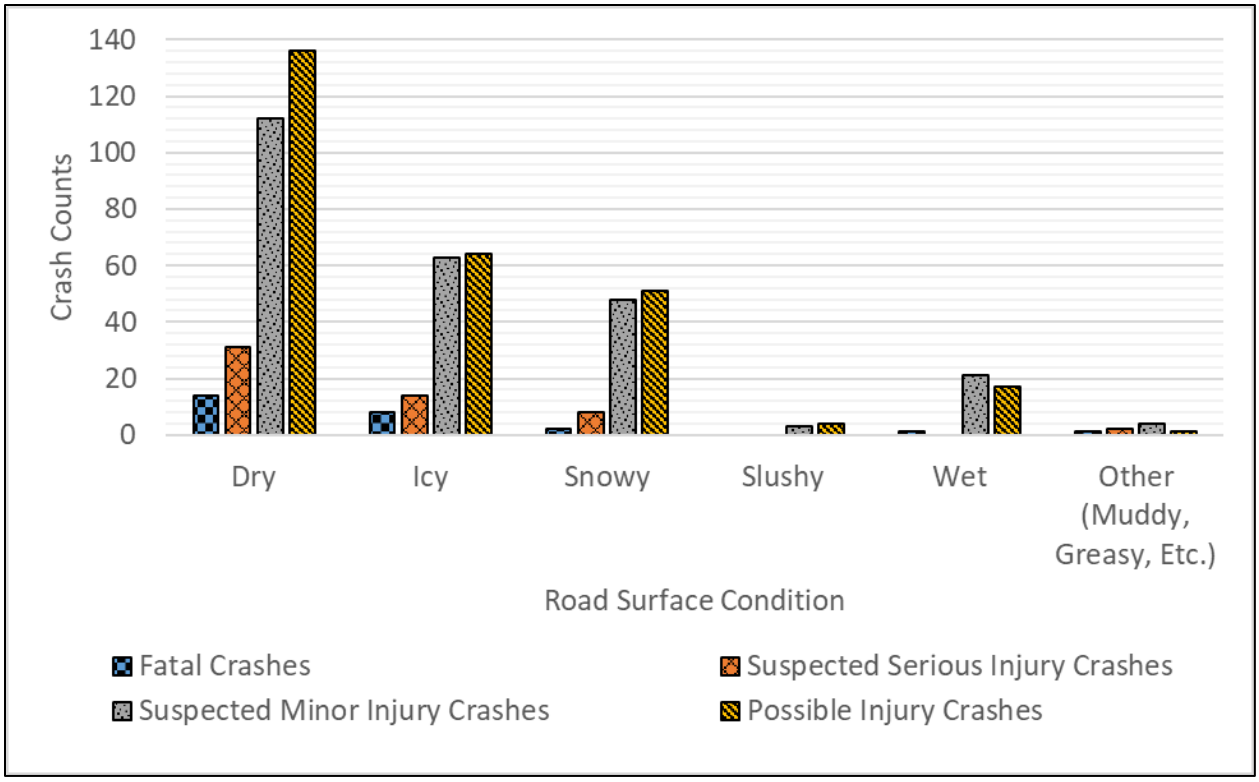

Figure 3.62 2019 counts of crashes by road surface condition in the first quarter

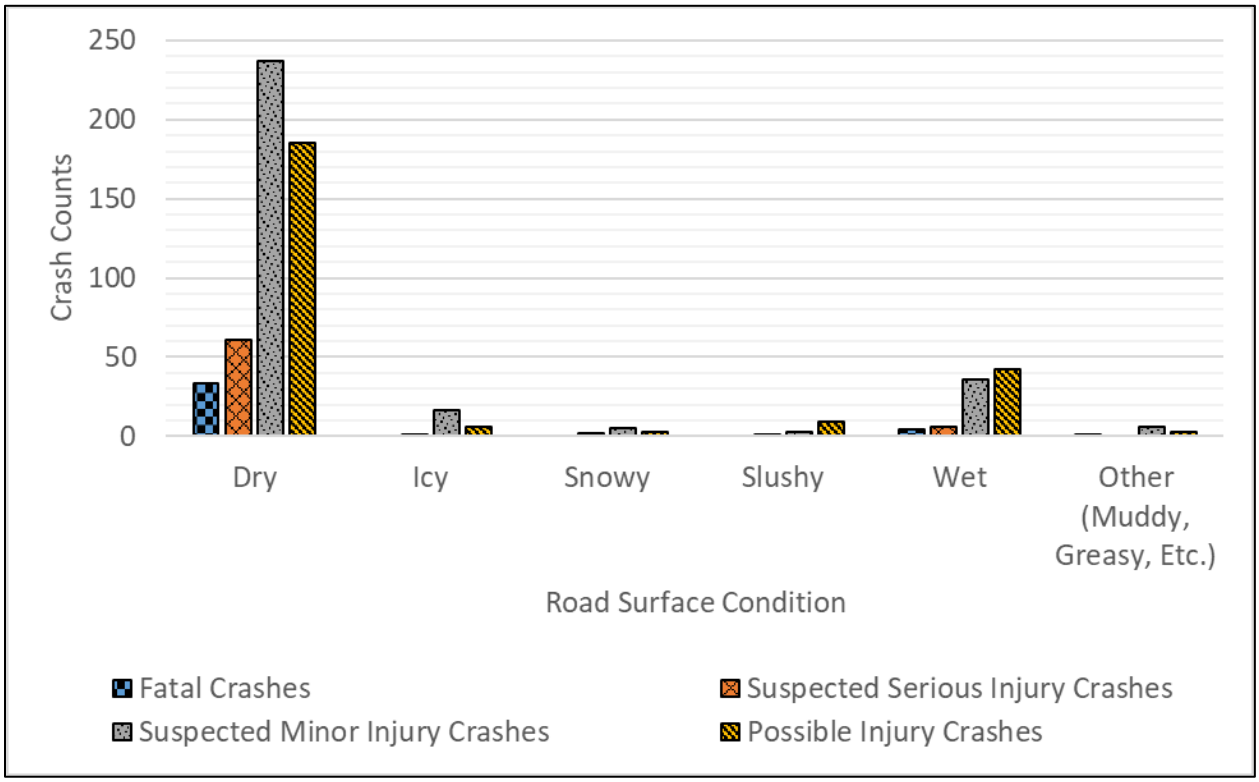

Figure 3.63 2019 counts of crashes by road surface condition in the second quarter

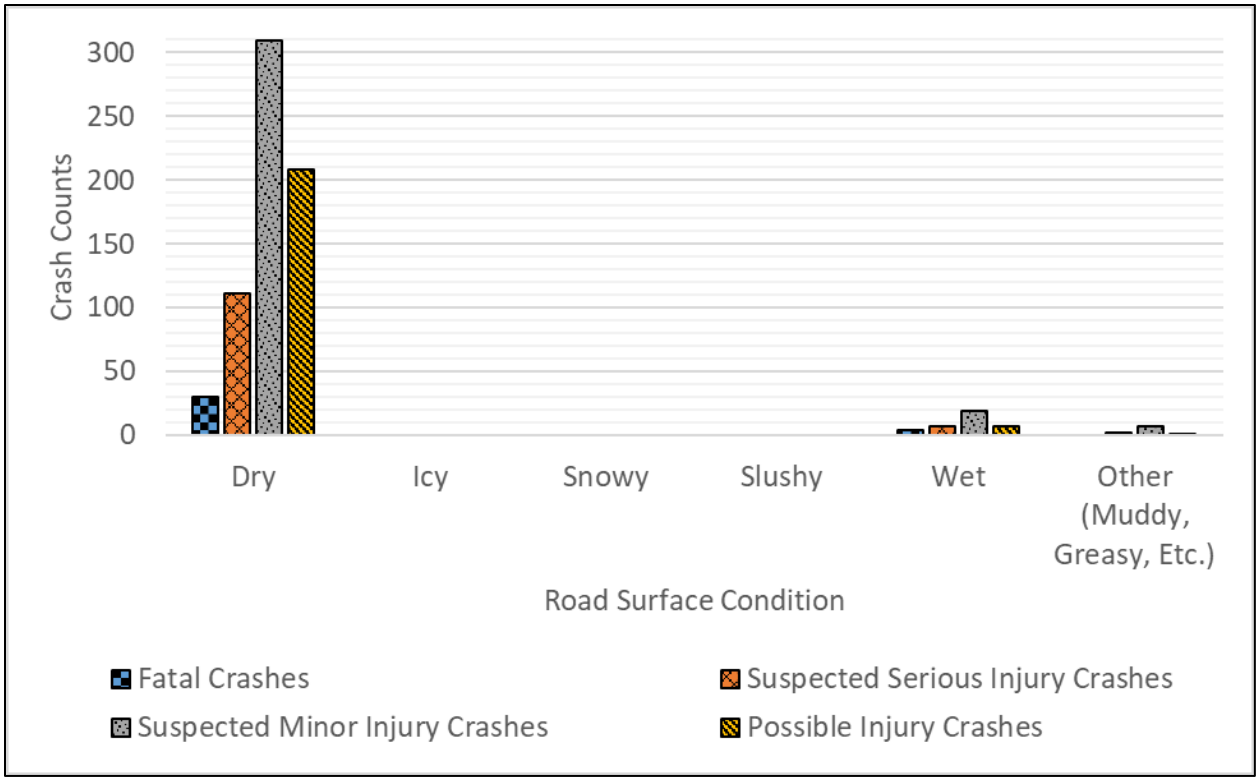

Figure 3.64 2019 counts of crashes by road surface condition in the third quarter

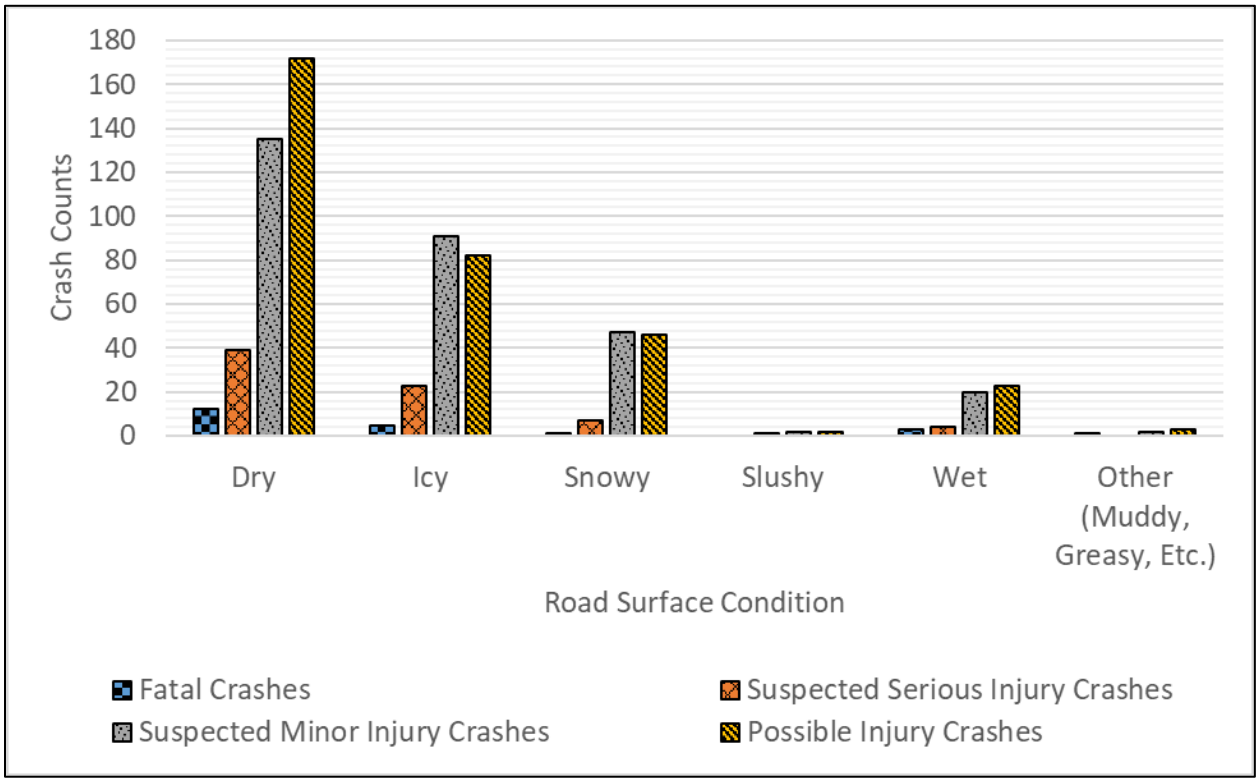

Figure 3.65 2019 counts of crashes by road surface condition in the fourth quarter

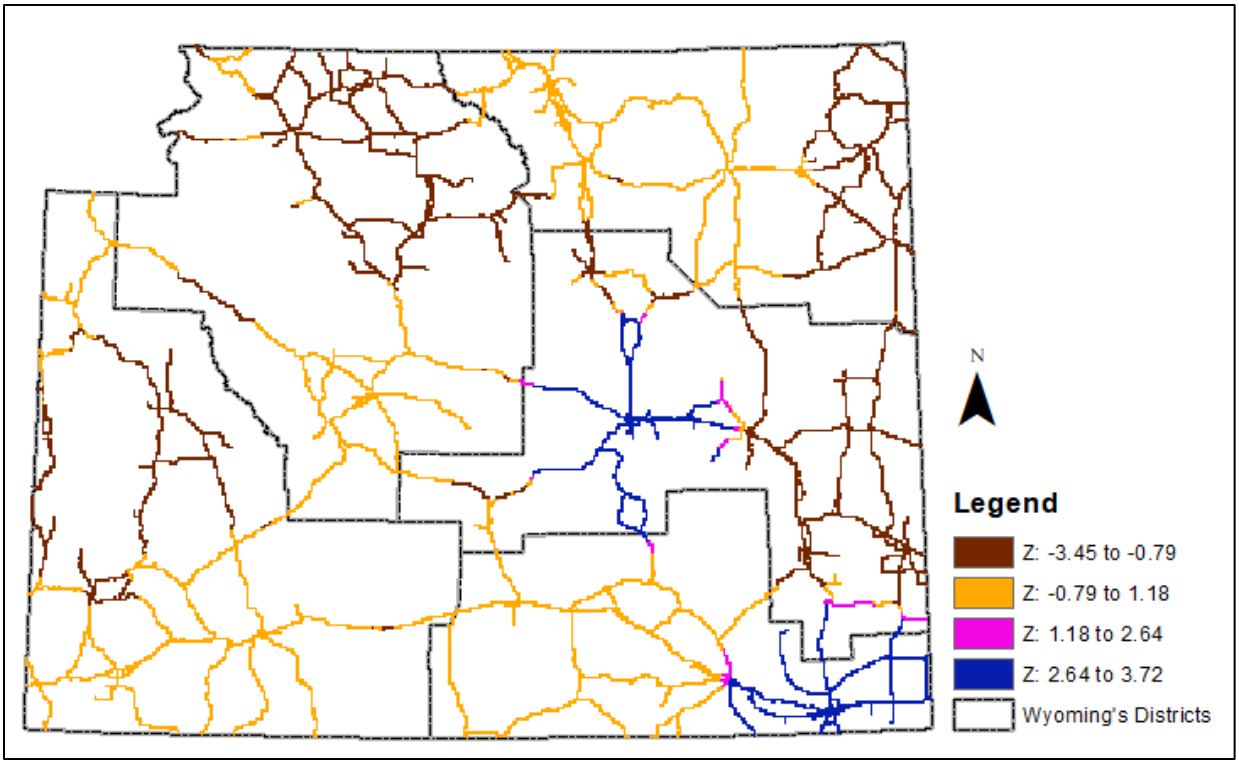

Figure 3.66 2017 heat map of fatal, suspected serious injury, and suspected minor injury crashes

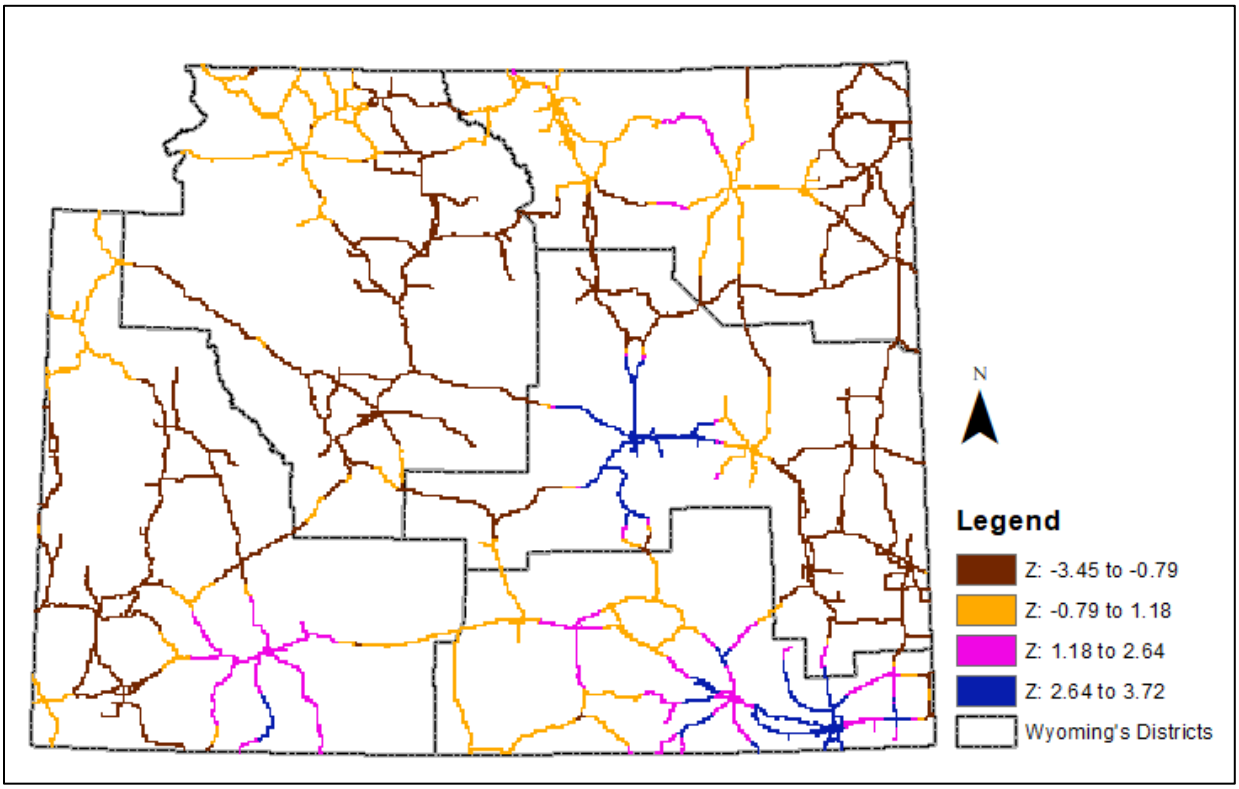

Figure 3.67 2017 heat map of speed-related crashes

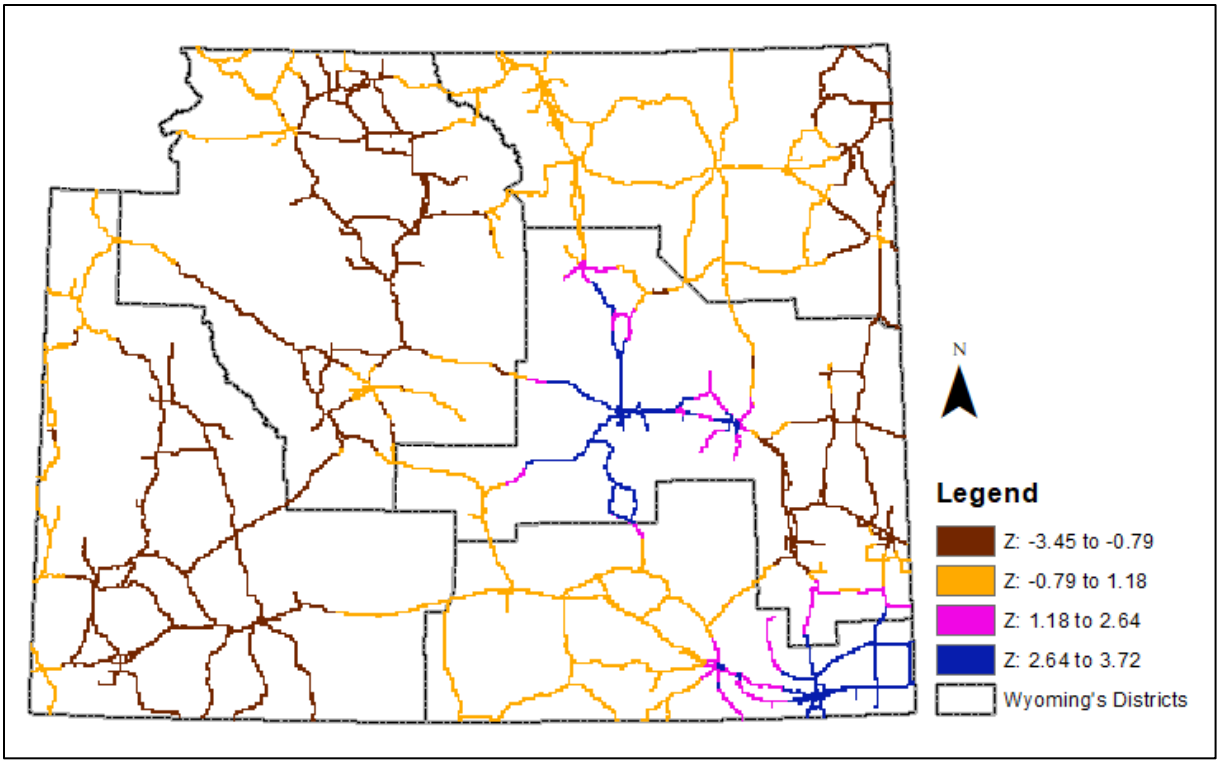

Figure 3.68 2017 heat map of speed-related fatal, suspected serious injury, and suspected minor injury crashes

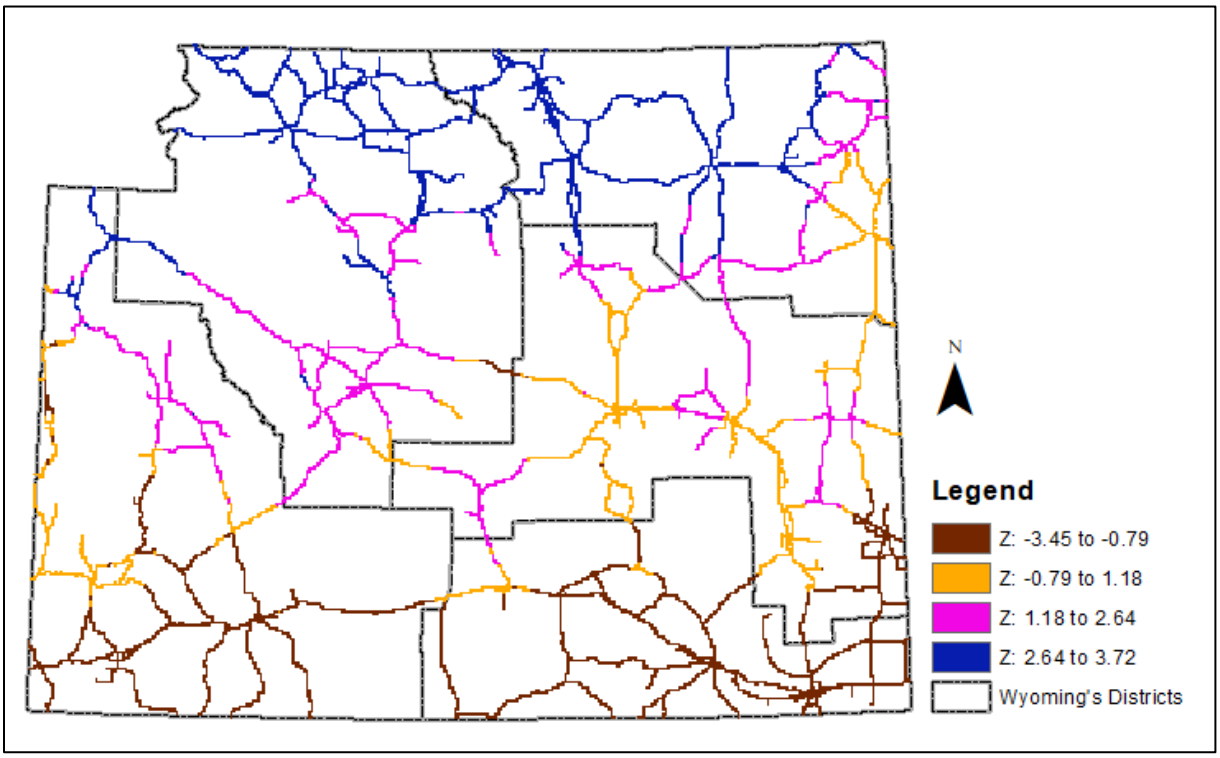

Figure 3.69 2017 heat map of wild animal crashes

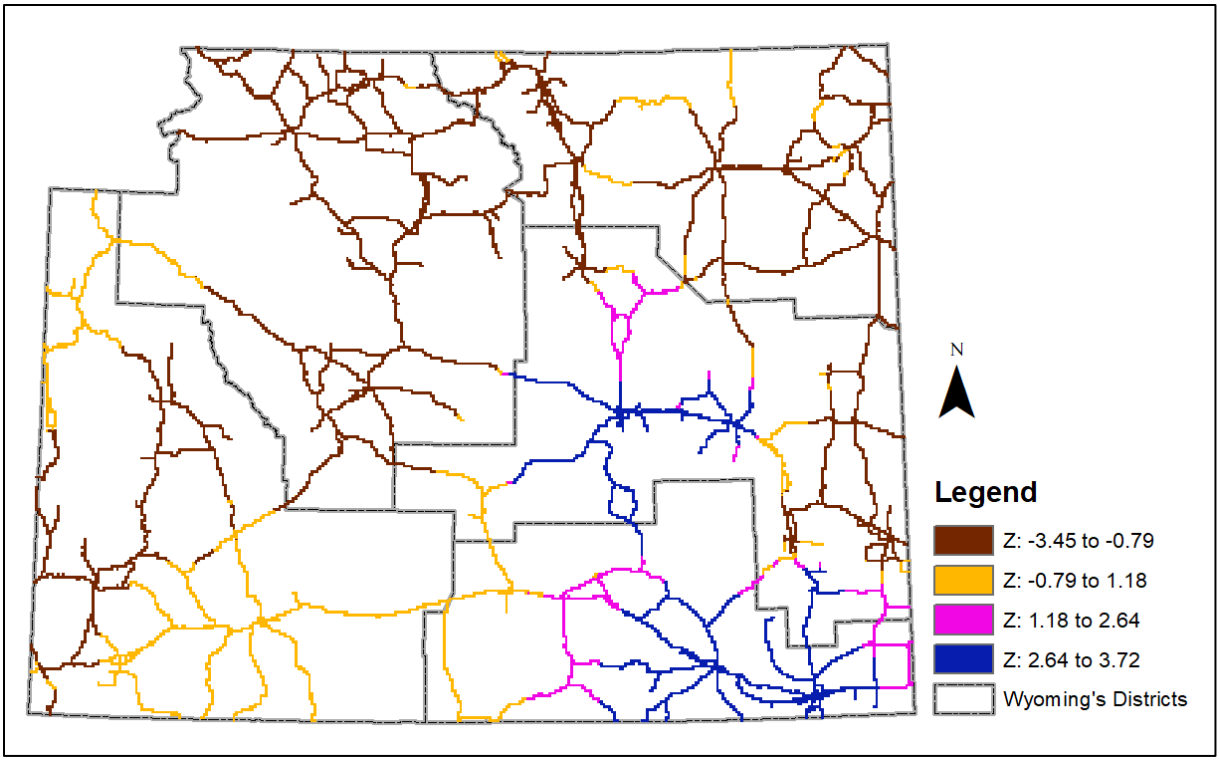

Figure 3.70 2017 heat map of adverse weather-related crashes

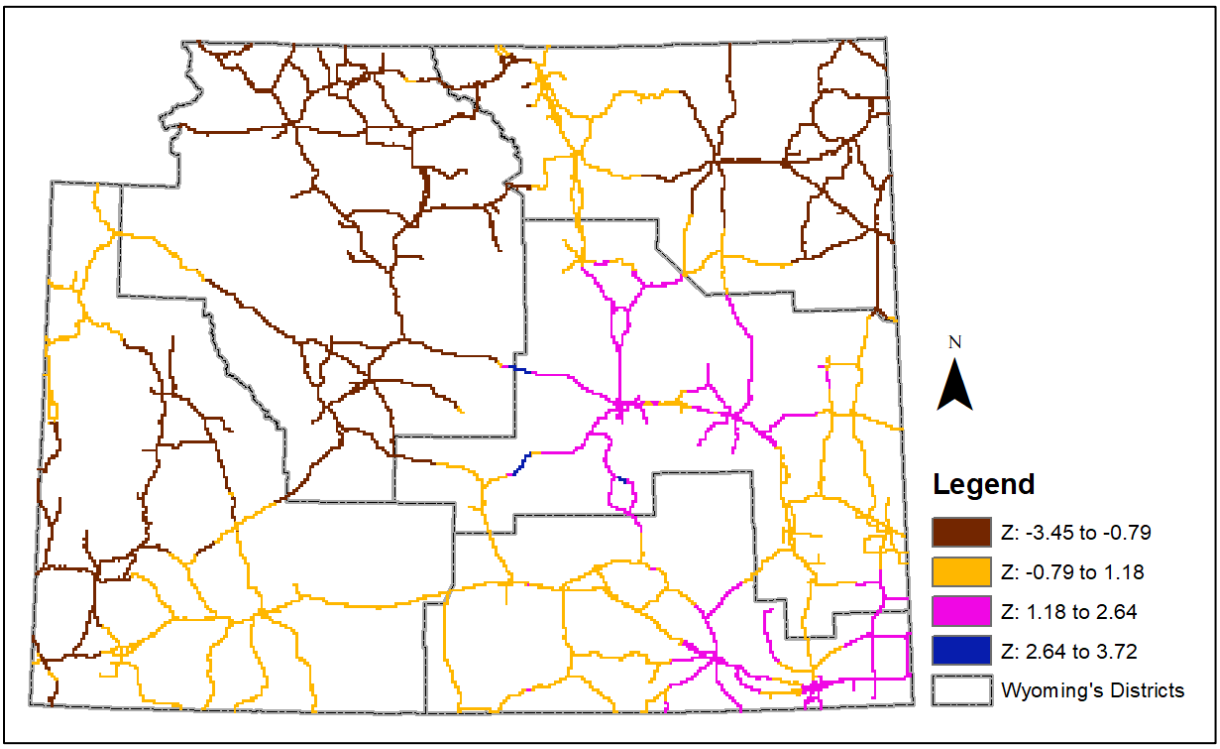

Figure 3.71 2017 heat map of fatal, suspected serious injury, and suspected minor injury adverse weather-related crashes

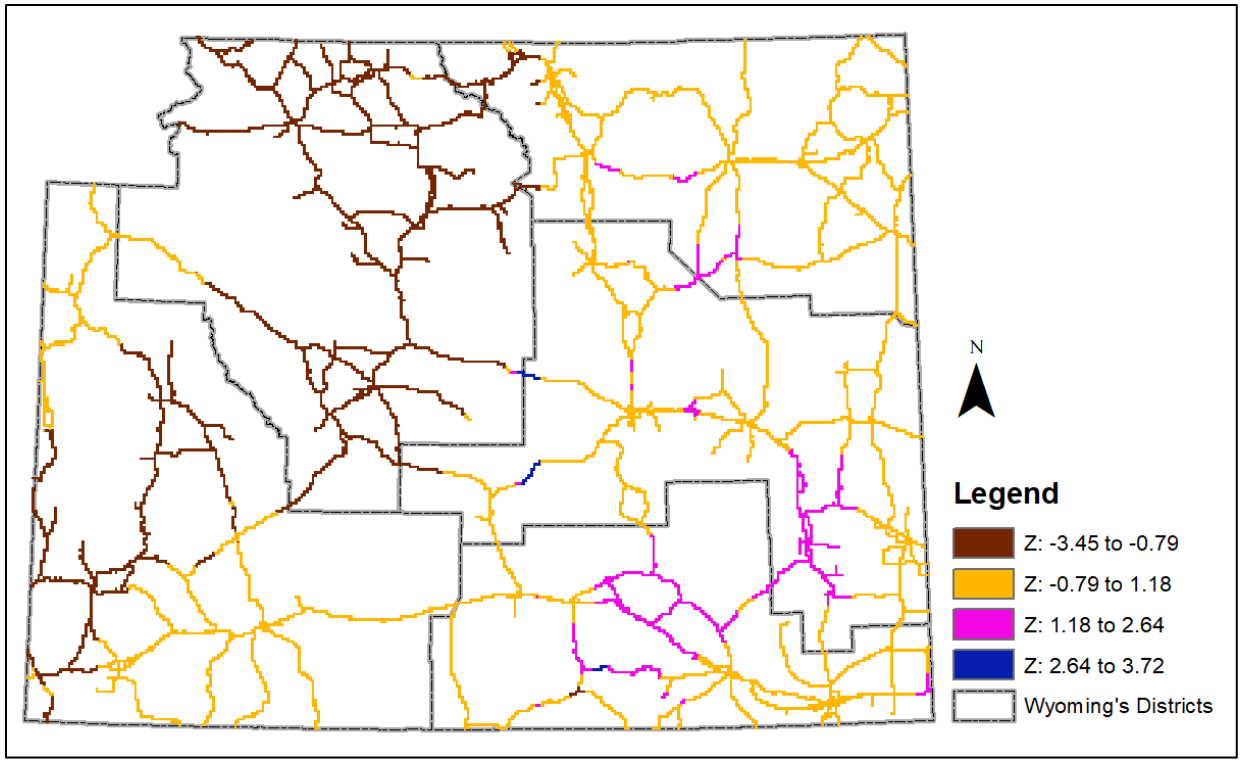

Figure 3.72 2017 heat map of driving under the influence crashes

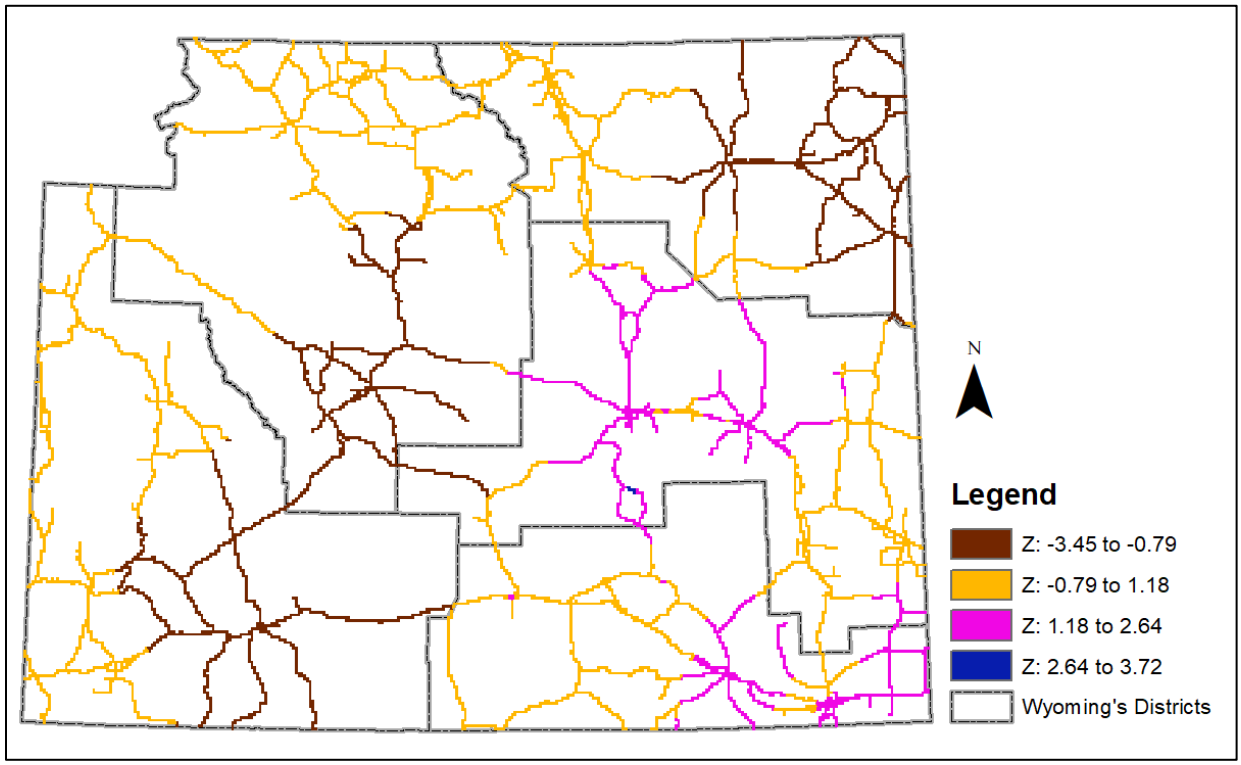

Figure 3.73 2017 heat map of driving under the influence fatal, suspected serious injury, and suspected minor injury crashes

Other than disseminated the crash summary statistics, it is recommended that WYDOT plan for future independent studies on citation records, particularly to obtain the following:

- Citation counts of unlicensed drivers
- Citation counts of drivers not wearing their prescription lenses if their licenses require so
- Citation counts of young drivers with licenses that are of lower rank than regular licenses (e.g., learner's permits, etc.)
- Citation counts by drivers' age groups
- Citation counts by gender
- Citation counts of seat belt use policy violations by county and year
- Citation counts of child restraint policy violations by county and year
- Citation counts of reckless drivers by county and year
- Citation counts of impaired drivers by county and year
- Speeding citation counts by county and year
- Information on locations that are characterized by considerable citation counts

It is also suggested that WYDOT plan for research activities on the following list of topics and document the results in reports.

- Effectiveness of DUI enforcement policies
- Effectiveness of speed enforcement policies
- Effectiveness of seat belt use enforcement policies
- Response times of emergency services, especially for fatal, suspected serious injury, and suspected minor injury crashes
- Effectiveness of traffic safety educational campaigns
- Effectiveness of other traffic violation enforcement polices (i.e., improper lane change, red light running, etc.)
- Effective methods of capturing motorcyclists committing traffic violations

3.6 Summary of the Wyoming Transportation Safety Coalition Survey Response Results

Similar to the cases of the previously discussed groups, a survey was drafted and disseminated to members of the Wyoming Transportation Safety Coalition. The survey targeted topics related to large commercial motor vehicles (CMVs). In the first section of the survey, the participants were asked generic questions related to the road safety data they received. When asked how often members of WTSC obtained crash summary reports/data from the WYDOT HSO, 40% claimed that they obtained them once a month while another 40% indicated that they did not obtain them in any respect. In addition, 60% stated that they received the reports/data via email, and 20% stated that they received them via online databases. With that, 80% of the respondents indicated that they preferred receiving the reports/data by means of email in the future. The majority of the respondents indicated that the information received fulfilled their needs. The respondents were also asked about the number of days it would take to receive relevant crash data of interest from the dates the crashes occurred and the ideal number of days preferred. One respondent claimed not to have received reports previously and preferred that crash data be provided five days after the crash occurrences. Another indicated receiving the data two days after the crash occurrences and that this would be the ideal number of days preferred. The third claimed that the crash reporting period was not applicable. The fourth respondent indicated that it would take 10 days to obtain such data and that this would be the ideal number of days. The fifth respondent skipped this question. Furthermore, the majority of the respondents declared their interest in road safety data in the form of pie charts/bar charts and summary statistics tables. In the following question, the participants were asked

about the preferred method of portraying locations of commercial motor vehicle (CMV) crashes. The answer choices were provided in the form of checkboxes to allow each participant to select multiple choices. From the survey results, 80% of the respondents favored narrative descriptions of the locations while 60% favored road and milepost information.

In the subsequent section of the survey, the participants were provided a list of road safety reports, most of which are available in the WYDOT HSO website. They are the following:

- Wyoming Statewide Crashes by Year
- Wyoming Statewide Crashes Involving Commercial Motor Vehicles by Year
- 2019 Highway Safety Crash Data Survey Final Report
- Wyoming Highway Safety Behavioral Program FY2020 Highway Safety Plan
- Wyoming Report on Traffic Crashes 2019
- Wyoming Occupant Seat Belt Usage by Year
- Wyoming Governor's Council on Impaired Driving – Strategic Plan to Reduce Impaired Driving in Wyoming
- Wyoming Drivers Survey, 2016
- Truck Driver Safety Investigation – A Survey of Truck Drivers: Cheyenne, Wyoming
- 2019 Pocket Guide to Large Truck and Bus Statistics
- Fatality Facts 2018 – Large Trucks

When asked about the familiarity of those reports and how often members of WTSC utilized them, only two respondents claimed that they frequently did so. In the following question, the respondents were specifically asked which of the listed reports they regularly used. The responses were as follows:

- "Wyoming Report on Traffic Crashes 2019"
- "We use custom reports and track fatalities yearly."
- "Highway Safety Plan and crash reports"
- "I would use all reports [listed]."

Also, three respondents indicated that the reports listed were useful to WTSC. With that, the majority of the respondents maintained that they were satisfied with the frequency at which those reports were released. None of the respondents suggested any additional reports to include in the list. A question was asked regarding whether surveys should be disseminated to CMV drivers and only two respondents agreed. This question was posed because the Wyoming Drivers Survey, 2016 report shows that, even though CMV crashes are severe, CMV drivers represent a small proportion of the driving population and that such drivers might have been underrepresented. In the end of this section of the survey, the participants were asked to include any additional information they would like to see in the reports. One respondent stated, "Seat belt use/non-use and distracted driving."

In the following section of the survey, members of WTSC were asked specific questions about CMV crash data in the form of charts, summary statistics tables or color-coded maps if applicable. More than half of the respondents indicated their interest in the following data:

- Whether the at-fault drivers were the CMV drivers
- At-fault drivers' ages
- At-fault drivers' genders
- At-fault drivers' states
- Travel speeds of the CMVs at the times of the crashes (i.e., too slow for the conditions, reasonable, or too fast for the conditions)
- Whether the CMV drivers were driving under the influence of alcohol/drugs
- Whether any vehicle occupant was ejected from the vehicle

- Traffic violations leading to the crashes (e.g., failure to yield the right-of-way, etc.)
- Times of the crashes
- Number of injured drivers and their injury severity levels
- Number of injured passengers and their injury severity levels
- Crash types (rear-end, sideswipe, etc.)
- Impact point information of each vehicle involved in the crash (hit from the side, hit from the front, etc.)
- Seat belt condition (good versus bad) information at the times of the crashes
- Difference in fatality/injury counts of victims involved in CMV crashes versus those of victims involved in non-CMV crashes
- Locations characterized by risks of encountering high severity (fatal, suspected serious injury, or suspected minor injury) CMV-related crashes in which the CMV drivers were at fault
- Locations characterized by risks of encountering high severity CMV-related crashes in which the CMV drivers were not at fault
- Locations characterized by risks of encountering possible injury or PDO CMV-related crashes in which the CMV drivers were at fault
- Locations characterized by risks of encountering possible injury and PDO CMV-related crashes in which the CMV drivers were not at fault

The participants were then asked questions related to citation record data of CMV drivers. Similar to the surveys that were distributed to the other groups, a disclaimer was provided stating that the WYDOT HSO would not maintain citation data; therefore, independent studies would have to be conducted on such data if required. Regarding the citation-related questions, the respondents maintained their interest in the following summary statistics:

- Association between the citations of CMV drivers and the counts of injuries, including fatal injuries, that were sustained due to CMV crashes
- CMV drivers' citations by type (i.e., failed to yield right of way, drove too fast for the conditions, DUI, driving while tired, violation of storage policies, etc.)
- Whether CMV drivers, cited for previous violations, attended drivers' education sessions

Finally, the respondents were asked to select research topics related to CMVs for detailed investigation involving data analyses, interpretation, and documentation of results in reports. The answer choices were provided in the form of checkboxes to allow for the selection of multiple choices. More than half of the respondents indicated their interest in the following topics:

- Effectiveness of CMV drivers' DUI enforcement policies
- Effectiveness of CMV speed enforcement policies
- Effectiveness of CMV driver's seat belt use enforcement policies
- Effectiveness of other traffic violation enforcement polices related to CMVs (i.e., improper lane change, red light running, etc.)
- Response times of emergency services, particularly for severe (fatal, suspected serious injury, and suspected minor injury) CMV crashes

3.7 Recommendations for the Wyoming Department of Transportation Regarding the Wyoming Transportation Safety Coalition

The results of the WTSC survey were examined and interpreted. Based on the survey's findings, it is recommended that WYDOT establish an email list to provide truck-related crash records data to a wider audience within WTSC. It is also suggested that surveys be disseminated to truck drivers asking about their driving habits and their perception of road safety. The survey results would be documented in a report, which would be made available on the WYDOT HSO website. In addition, it is recommended that summary statistics, similar to those illustrated in Figures 3.74 to 3.87, and Table 3.11, be provided to WTSC. It should be noted that Figures 3.86 and 3.87 depict heat maps of CMV crashes and severe (fatal, suspected serious injury, and suspected minor injury) crashes, respectively. The maps were generated using the same procedure implemented to obtain the ones for WSBC, WHP and WASCOP.

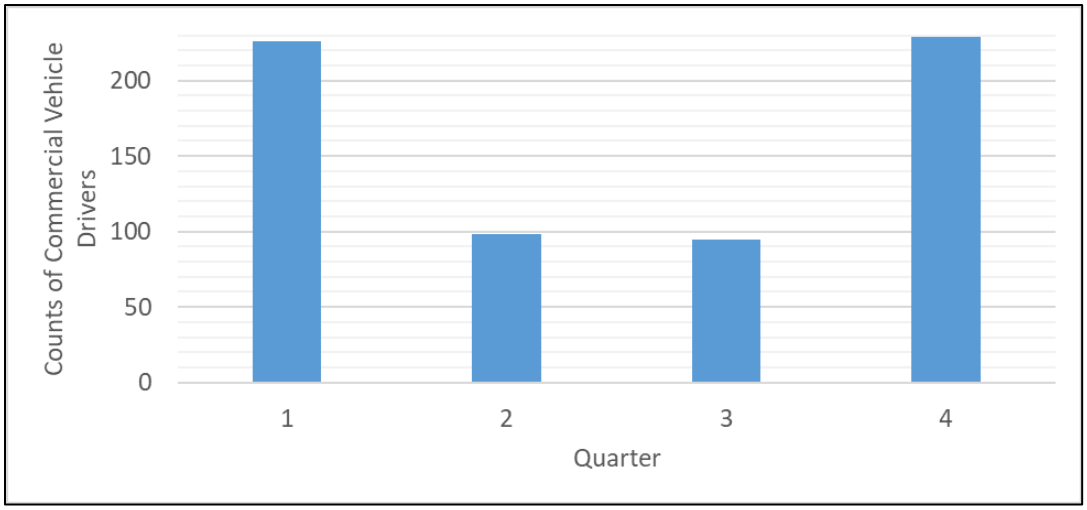

Figure 3.74 2019 counts of commercial vehicle drivers cited at the crash scenes

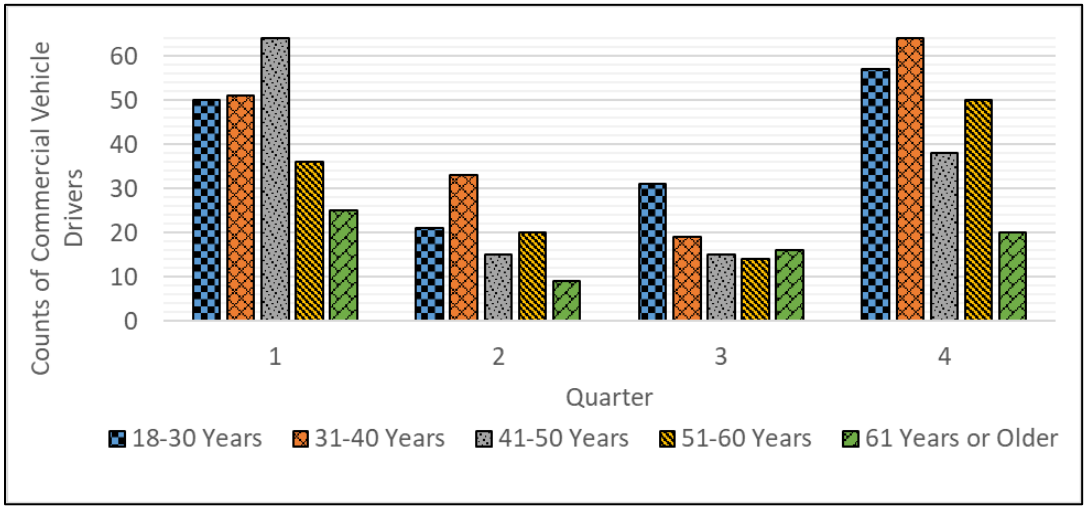

Figure 3.75 2019 counts of commercial vehicle drivers cited at the crash scenes by age

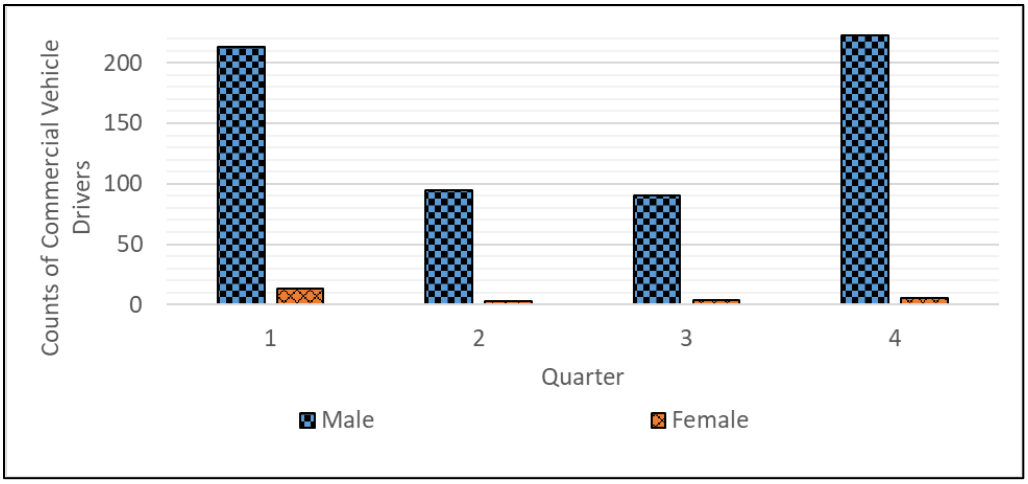

Figure 3.76 2019 counts of commercial vehicle drivers cited at the crash scenes by gender

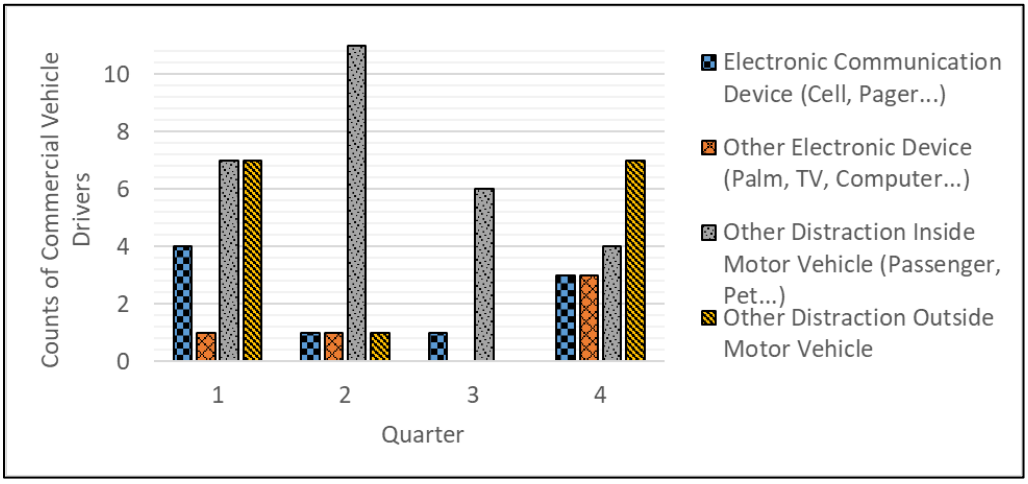

Figure 3.77 2019 counts of distracted commercial vehicle drivers by means of distraction

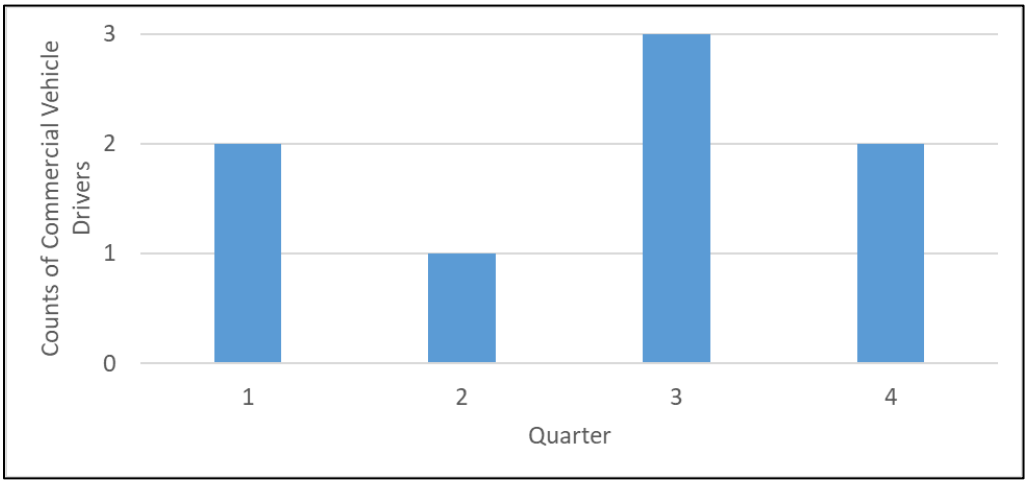

Figure 3.78 2019 counts of commercial vehicle drivers driving under the influence

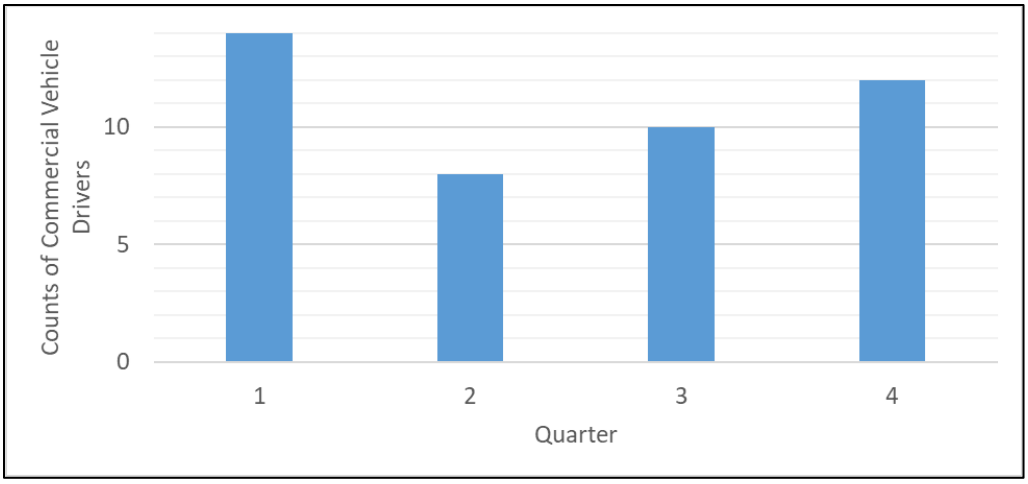

Figure 3.79 2019 counts of improperly belted or unbelted commercial vehicle drivers

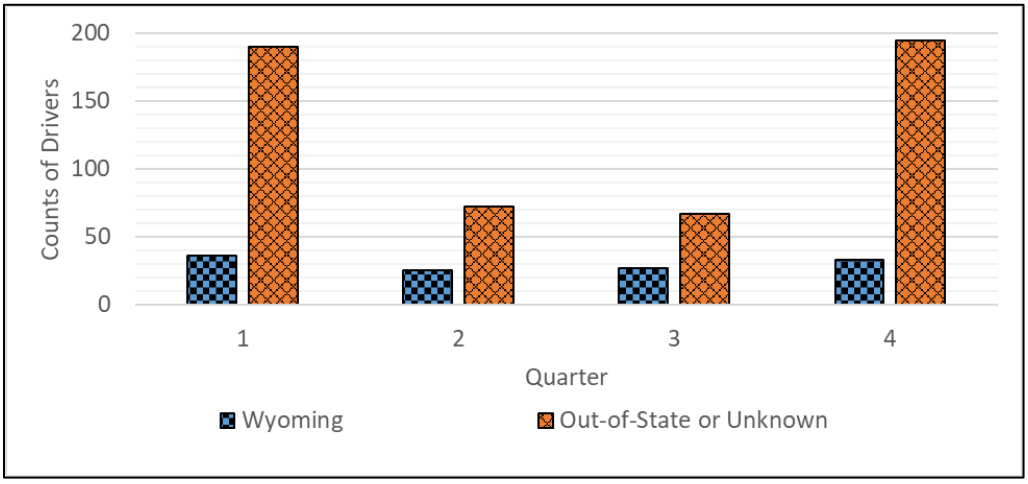

Figure 3.80 2019 counts of cited commercial vehicle drivers at the crash scenes by state

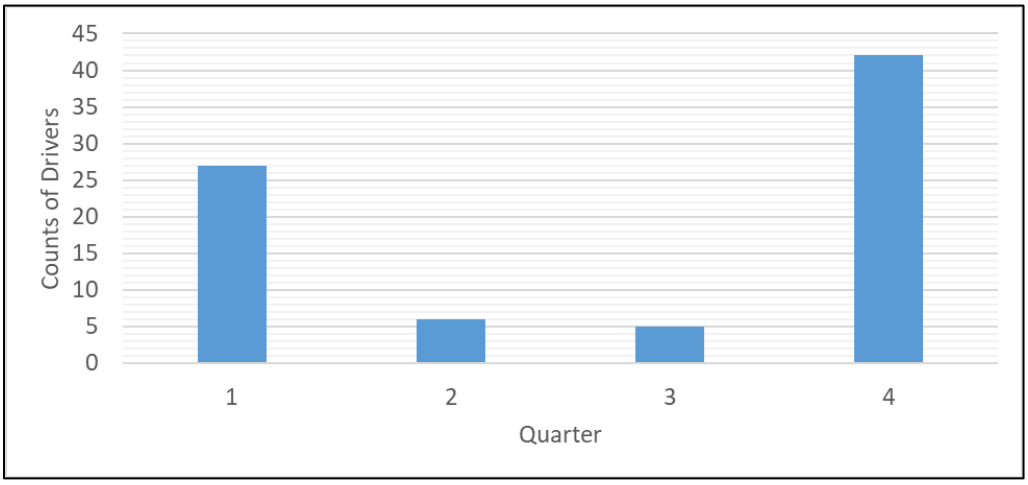

Figure 3.81 2019 counts of speeding commercial vehicle drivers

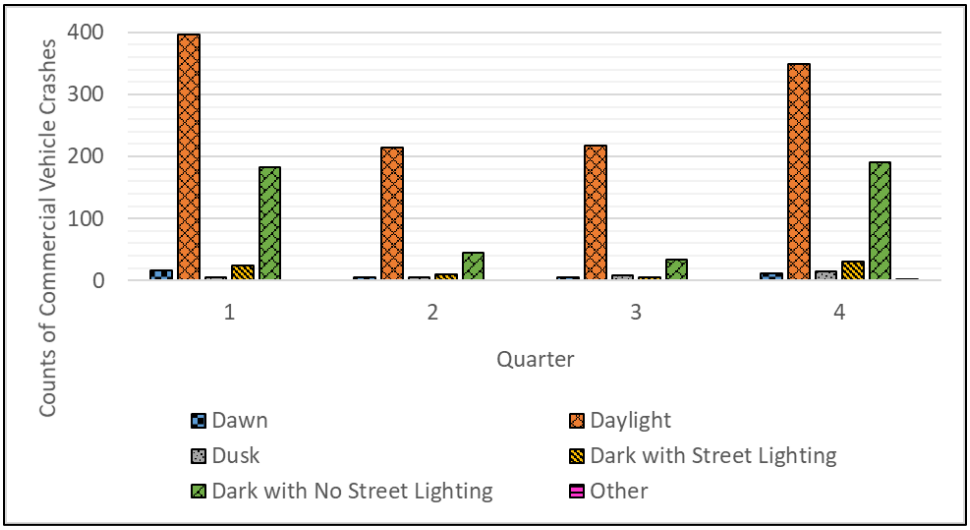

Figure 3.82 2019 counts of commercial vehicle crashes by lighting condition

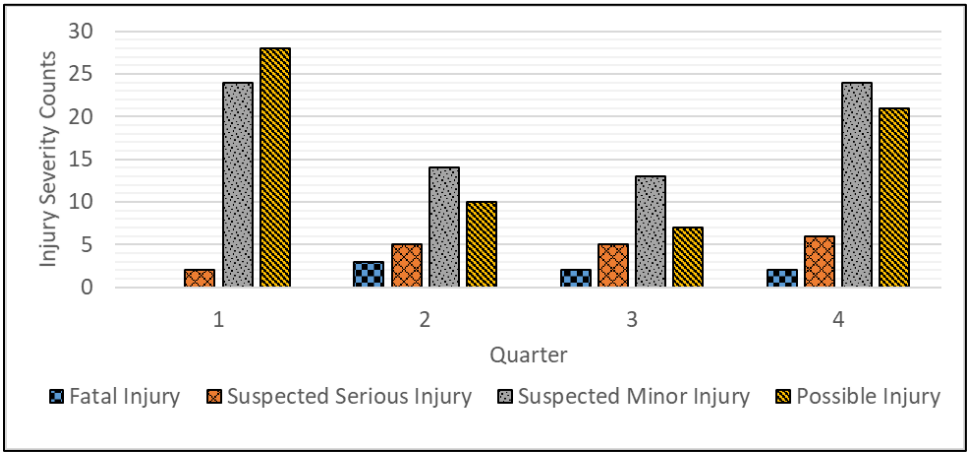

Figure 3.83 2019 counts of killed and injured commercial vehicle drivers

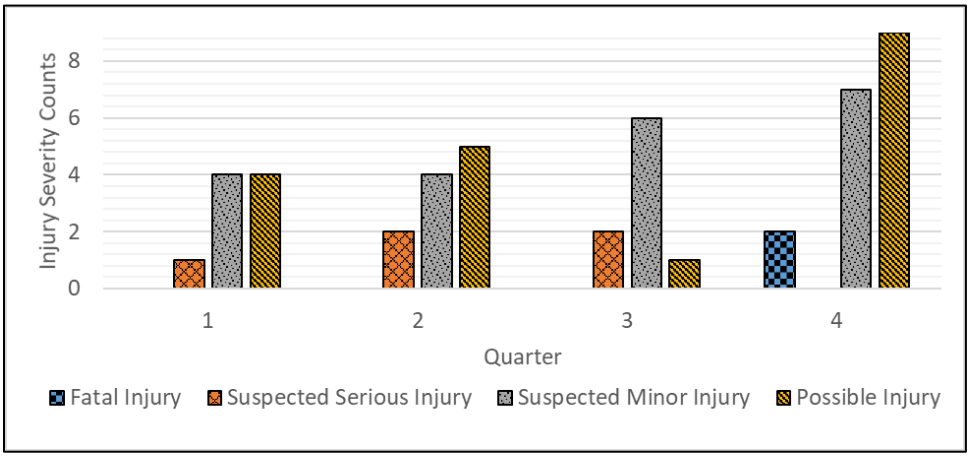

Figure 3.84 2019 counts of killed and injured commercial vehicle passengers

Table 3.11 2019 Counts of Commercial Vehicle Crashes by Manner of Collision

Manner of Collision	Quarter				
	1	2	3	4	Total
Angle (Front to Side), Opposing Direction	20	18	9	17	64
Angle Direction Not Specified	1	0	0	2	3
Angle Right (Front to Side, includes Broadside)	28	10	12	22	72
Angle Same Direction (Front to Side)	36	21	17	45	119
Head On (Front to Front)	5	4	4	10	23
Rear End (Front to Rear)	343	113	106	291	853
Rear to Front (Normally Backing)	91	39	46	84	260
Rear to Rear (Normally Backing)	5	2	5	8	20
Rear to Side (Normally Backing)	0	1	1	0	2
Sideswipe Opposite Direction (Meeting)	2	6	7	6	21
Sideswipe Same Direction (Passing)	14	9	6	11	40
Not a Collision with Two Vehicles in Transport	70	42	47	87	246
Other	11	14	11	14	50
Unknown	0	0	1	0	1
Total	626	279	272	597	1,774

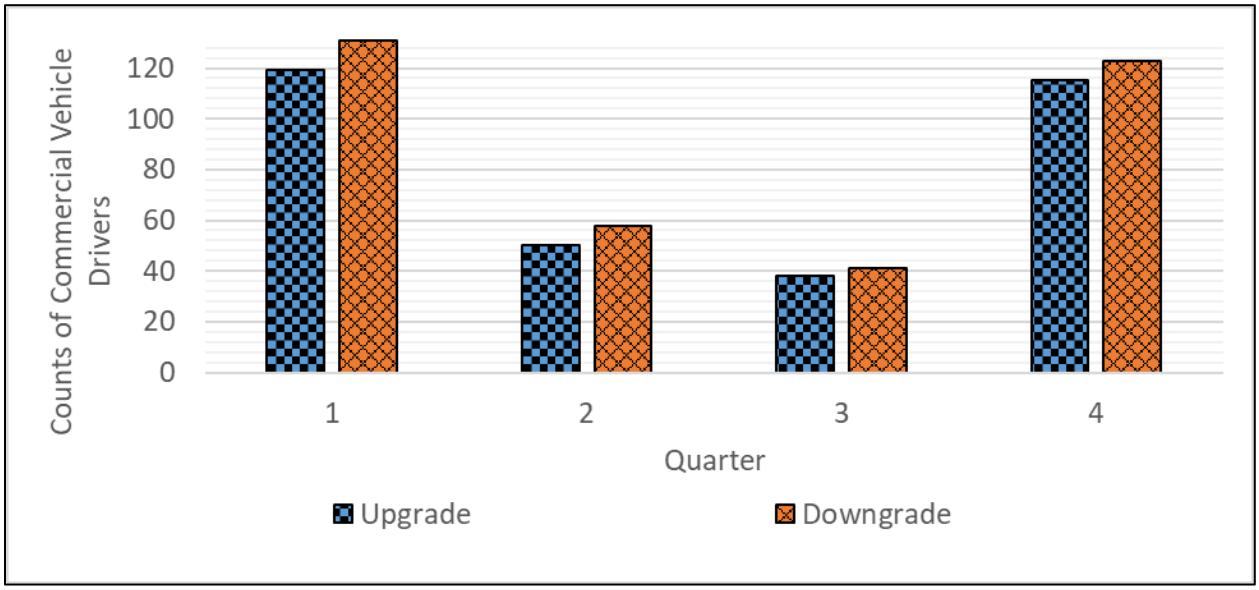

Figure 3.85 2019 counts of upgrade and downgrade conditions facing commercial vehicle drivers

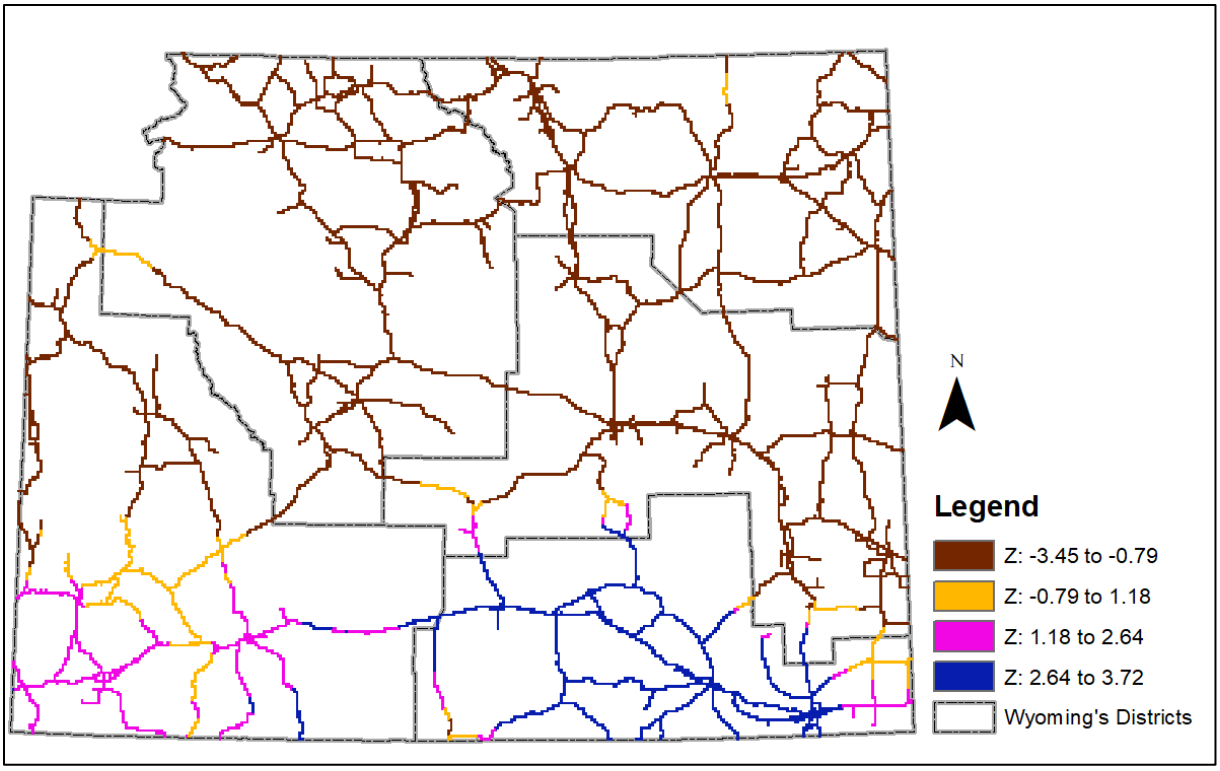

Figure 3.86 2017 heat map of commercial vehicle crashes

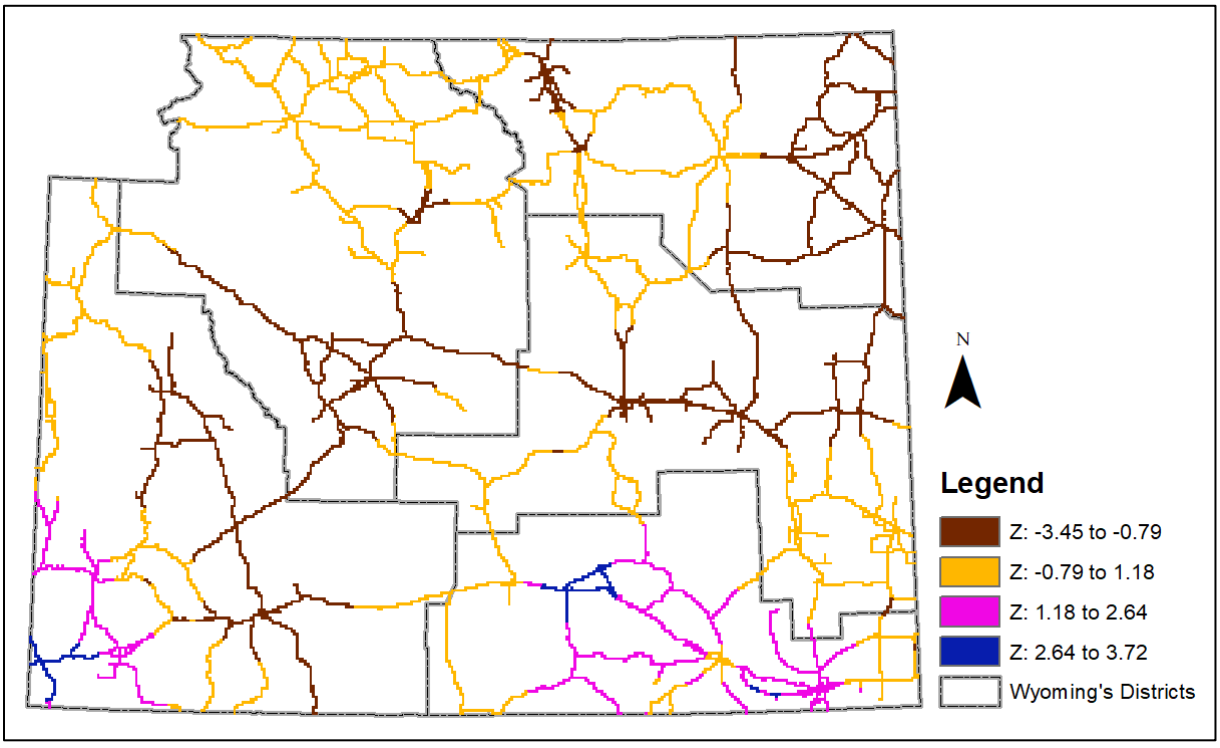

Figure 3.87 2017 heat map of fatal, suspected serious injury, and suspected minor injury commercial vehicle crashes

Other than the previously presented summary statistics, it is suggested that WYDOT conduct independent studies involving the collection and provision of statistics on the following CMV drivers' citation data to WTSC:

- Counts of CMV drivers' citations by type (i.e., failed to yield the right of way, drove too fast for the conditions, DUI, driving while tired, violation of storage policies, etc.) in the form of bar charts
- Proportions of CMV drivers, cited for previous violations, attending drivers' education sessions

Finally, the results of the WTSC survey indicated that this group's members were interested in research regarding specific CMV-related topics. As per the survey's results, it is suggested that WYDOT plan for research studies on the following topics:

- Effectiveness of CMV drivers' DUI enforcement policies
- Effectiveness of CMV speed enforcement policies
- Effectiveness of CMV drivers' seat belt use enforcement policies
- Effectiveness of other traffic violation enforcement polices related to CMVs (i.e., improper lane change, red light running, etc.)
- Response times of emergency services particularly for severe (fatal, suspected serious injury and suspected minor injury) CMV crashes

3.8 Summary of the Governor's Council on Impaired Driving Survey Response Results

A survey was disseminated to members of the Governor's Council on Impaired Driving and 10 responses were received. The common question asked in all surveys was how often did the respondents receive/secure road safety data/reports from the WYDOT Highway Safety Office? More than half of the respondents declared that they often obtained the relevant data from the WYDOT HSO once a year while some checked the option, "other," and specified the following:

- "I don't receive them but would like to."
- "When requested."
- "We don't."

When it comes to data transfer protocols, the respondents indicated that they received the data mostly via email and online databases (55% and 33%, respectively). In the follow-up question, almost 80% indicated that they preferred to receive such data via email. Also, the respondents were asked whether the current safety data provided to them from the WYDOT HSO fulfilled their needs on a scale of one (not at all) to five (absolutely). Two-thirds claimed that the data were indeed beneficial (selected four and five). More importantly, the respondents were asked about the ideal period during which they preferred to receive the crash data from the dates the crashes occurred. Almost half of the GCID members omitted this question while the other half provided the following responses:

- "Monthly would be fine."
- "Five [days]."
- "Quarterly."
- "Two [days]."
- "Fourteen days."

Regarding the preferred data format, almost 90% of the respondents indicated their interest in summary statistics tables, while over 40% indicated their interest in figures and another 40% indicated their interest in pie charts. Note that each respondent was provided the option of specifying multiple data formats from a list (i.e., checkboxes). The respondents were further asked about the preferred method of portraying the locations of DUI-related crashes. They included the following:

- Narrative descriptions of the locations
- Photos
- Color-coded maps
- Road and milepost information
- GIS coordinates
- Other (please specify)

More than three-quarters claimed their interest in color-coded maps while two-thirds claimed their interest in road and milepost information. The answer choices were provided in the form of checkboxes such that the respondents might have selected multiple options. Some respondents also selected the options, "narrative descriptions of the locations" and "photos." The respondents were then asked whether they would like to provide any suggestions regarding the data they would receive. One recommended data on where the impaired driver drank his or her liquor (home, bar, etc.). Another suggested the delivery of maps illustrating the locations of driving under the influence busts, crashes, mortalities, and other relevant information without specifying details.

In the following section of the survey, the respondents were asked about road safety reports pertaining to DUI-related crash data. The reports, most of which are available in the WYDOT HSO website, are the following:

- 2019 Highway Safety Crash Data Survey Final Report
- Wyoming Department of Transportation Highway Safety Behavioral Grants Office 2019 Annual Report
- Wyoming Highway Safety Behavioral Program FY2020 Highway Safety Plan
- Wyoming Report on Traffic Crashes 2019
- Wyoming Statewide Crashes by Year
- Wyoming Statewide Crashes Involving Alcohol or Drugs by Year
- Wyoming Strategic Highway Safety Plan 2017
- Wyoming Drivers Survey 2016
- Alcohol and Crime in Wyoming 2019

On a scale of one (not at all) to five (absolutely) describing whether the respondents were familiar with these reports and whether they frequently utilized them, 40% provided ratings of four and five. Remarkably, more than half declared that the listed reports were beneficial to GCID even though only 40% stated that they used them frequently. Perhaps after being informed about the reports, members of GCID briefly scanned them and became intrigued about them. In another question, more than half of the respondents declared their satisfaction with the frequency at which the reports were released. Roughly, 40% of the respondents stated that they either did not receive them or would like to receive them on a more frequent basis. One suggested that the reports be publicized quarterly and another suggested that they be publicized semi-annually. The respondents were also asked to recommend any reports they would like to receive in addition to the ones listed. One recommended a report on the statistics of the locations (bars, etc.) at which drunken drivers consumed their liquor prior to being involved in DUI-related crashes. This would aid members of GCID in targeting such bars in their outreach campaigns. Another respondent suggested a report with statistics on DUI busts, BAC levels, and locations of parties or concerts involving drinking. Members of GCID were also asked about the importance of certain summary statistics to be included in the reports. More than half selected the following:

- Effectiveness of DUI offender rehabilitation campaigns
- Effectiveness of implementing ignition interlocks in vehicles of DUI offenders in improving road safety

- Effectiveness of media outreach campaigns in raising awareness about DUI (impact and consequences of impaired diving slogans and/or relevant content disseminated via social media, television, radio, billboards)

In the subsequent section of the survey, the respondents were asked specific questions about DUI-related crash data in the form of summary statistics. More than half of them indicated their interest in the following elements collected from crash records:

- Types of substances involved in DUI-related crashes (alcohol, marijuana, etc.)
- BACs of impaired at-fault drivers by age and gender
- Injury severity levels of DUI-related crashes by BACs of impaired drivers
- Whether passengers were impaired at the times of the crashes
- BACs of the passengers if impaired at the times of the crashes
- Number of pedestrians and/or bicyclists involved in the DUI-related crashes
- Whether the pedestrians and/or bicyclists were impaired if found to be at fault
- BACs of the impaired pedestrians and/or bicyclists at the times of the crashes
- Whether motorcycles were involved and if the riders were impaired at the times of the crashes
- BACs of the impaired motorcycle riders at the times of the crashes
- Crash locations (on the road, on the shoulder, off the road, etc.)
- Crash times (morning, afternoon, etc.)
- Vehicle travel speeds preceding the crashes (i.e., too slow for the conditions, reasonable, or too fast for the conditions)
- Makes, models, and years of each vehicle involved in the DUI-related crashes
- Number of vehicles involved in the DUI-related crashes
- Whether the impaired at-fault drivers were properly wearing their seat belts at the times of the crashes
- Whether the passengers were properly wearing their seat belts at the times of the crashes
- Whether children were properly secured in their appropriate car seats at the times of the crashes
- DUI-related crashes resulting in ejected occupants
- Whether impaired drivers violated work zone regulations (i.e., exceeded the work zones' speed limits, failed to obey the traffic guards' signals, etc.)
- Driving errors leading to the DUI-related crashes that are not previously listed
- Number of injured drivers/motorcyclists and their injury severity levels
- Number of injured passengers and their injury severity levels
- Number of injured non-motorists and their injury severity levels
- DUI-related crashes that occurred at or near bars and liquor stores
- DUI-related crashes that occurred at or near concerts, sports events, or other special events
- DUI-related crashes that occurred during special holidays/events (4th of July, Labor Day weekend, Thanksgiving, Christmas, etc.)
- DUI-related crashes by day of the week (i.e., weekdays versus weekends)
- Types of DUI-related crashes (rear-end, sideswipe, etc.)
- Impact point information of vehicles involved in the DUI-related crashes (e.g., hit from the side, hit from the front, etc.)
- Comparisons of fatality/injury counts of victims involved in DUI-related crashes versus those of victims involved in non-DUI-related crashes
- Weather conditions (clear, cloudy, rainy, foggy, snowy) at the times of the DUI-related crashes
- Road surface conditions (dry, wet, icy, etc.) at the times of the DUI-related crashes

Furthermore, members of GCID were asked about the importance of color-coded maps presenting locations characterized by risks of encountering DUI-related crashes by category. More than 50% of the respondents indicated their interest in color-coded maps illustrating the following DUI-related crashes:

- High severity (fatal, suspected serious injury and suspected minor injury) crashes
- Possible injury and PDO crashes
- High severity crashes involving improperly buckled or unbuckled occupants
- High severity speed-related crashes

The respondents were then directed to another section asking about whether they were interested in specific information regarding DUI citation and other related data. Similar to the previous surveys, a disclaimer was presented to inform the respondents that independent studies would have to be conducted to collect and evaluate citation data since the WYDOT HSO would not maintain such data. At least half of the respondents maintained that they preferred the following summary statistics data:

- Citation counts of impaired (DUI, tired or not wearing prescription glasses/contact lenses) drivers by county
- Citation counts of impaired drivers by age
- Citation counts of impaired drivers by gender
- Number of impaired drivers who persistently violated impairment related policies even after being subjected to disciplinary action
- Association between impairment-related offenses and speeding
- Association between impairment-related offenses and other policy violation types except speeding (e.g., failure to yield, improper passing, etc.)
- Locations characterized by a considerable number of impairment-related citations issued

Finally, the GCID members were asked to select topics they might be interested in for further investigation (i.e., data analyses, interpretation, and documentation of results in reports). At least three-quarters of them were interested in the following topics:

- Effectiveness of DUI enforcement policies
- Effectiveness of impaired drivers' rehabilitation campaigns
- Effectiveness of other impairment enforcement policies (e.g., tired, not wearing prescription glasses/contact lenses)
- Effectiveness of educational campaigns addressing impaired driving
- Association between alcohol/drug use and crime

3.9 Recommendations for the Wyoming Department of Transportation Regarding the Governor's Council on Impaired Driving

Based on the interpretations of the Governors' Council on Impaired Driving's survey results, suggestions were made for WYDOT with regard to the data to be provided to GCID. One is to disseminate DUI-related crash data as soon as they are made available. Another is to provide processed quarterly DUI crash-related data in the form of tables and charts, similar to the ones presented in Figures 3.88 to 3.104, and Tables 3.12 to 3.17.

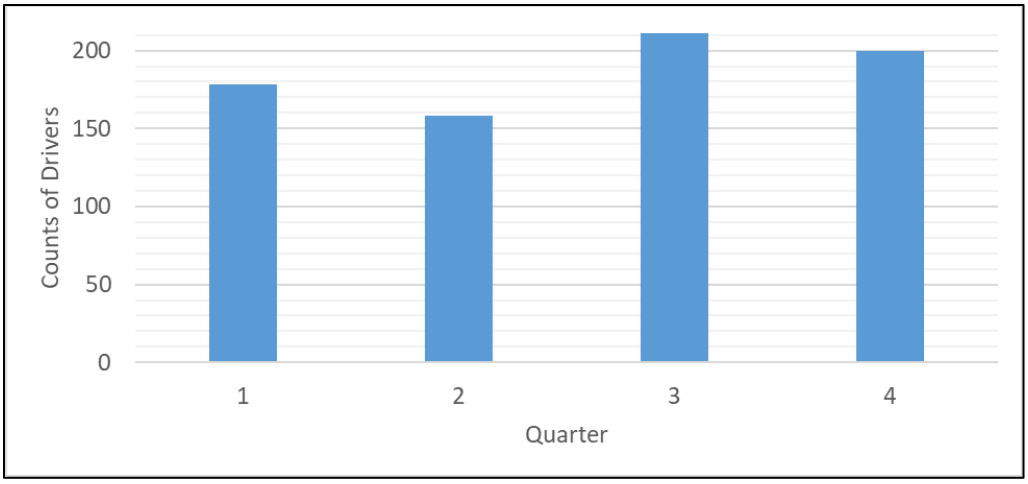

Figure 3.88 2019 counts of alcohol impaired drivers

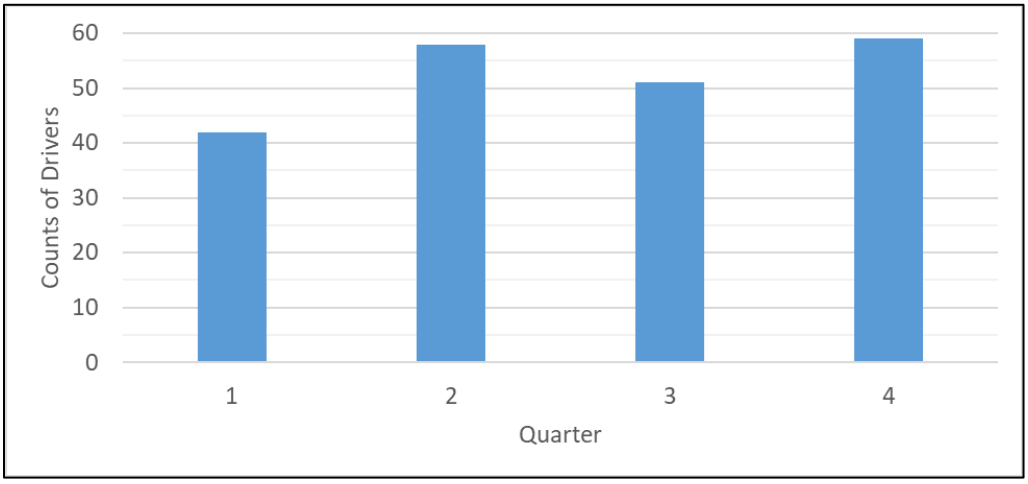

Figure 3.89 2019 counts of drug impaired drivers

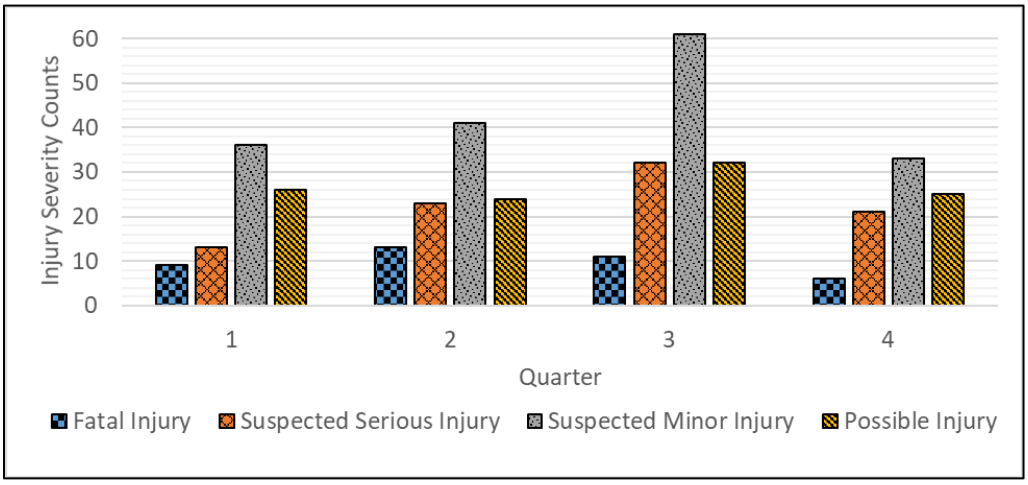

Figure 3.90 2019 counts of alcohol-related fatalities and injuries

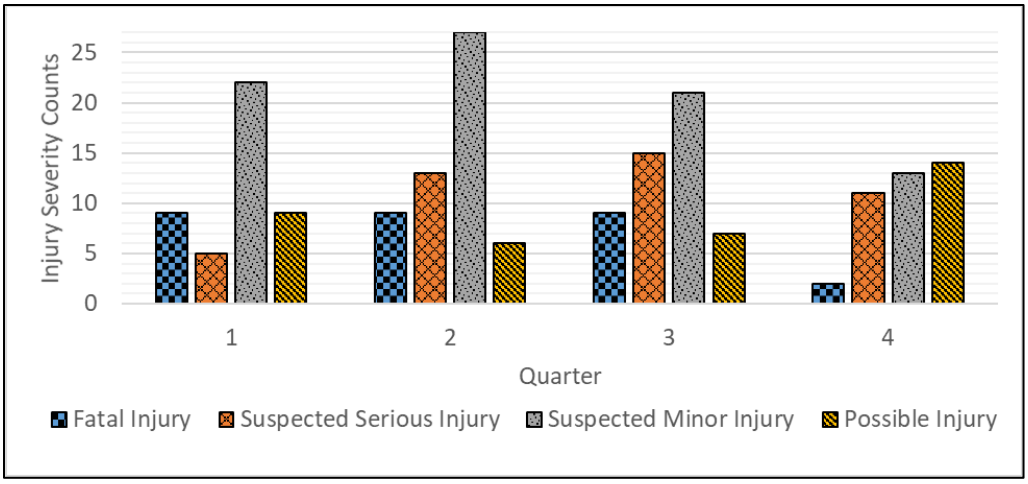

Figure 3.91 2019 counts of drug-related fatalities and injuries

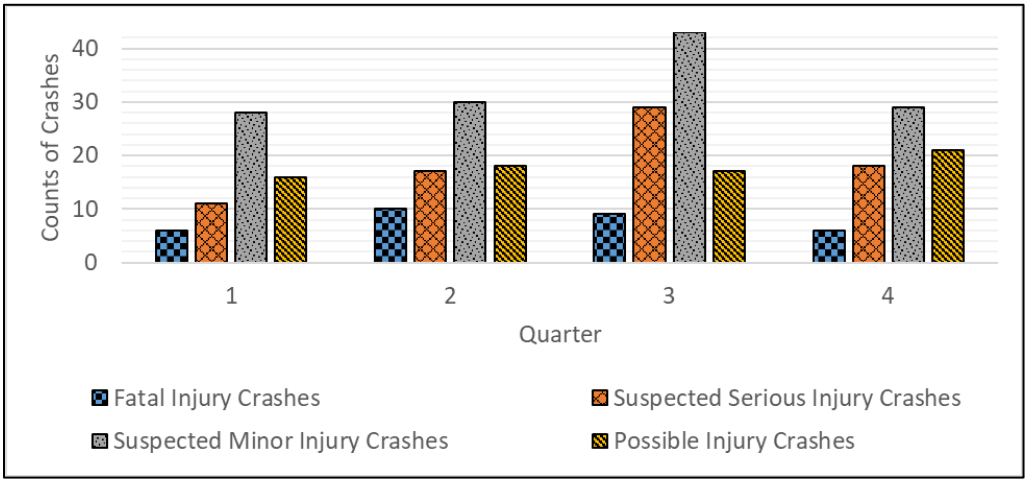

Figure 3.92 2019 counts of alcohol-related crashes

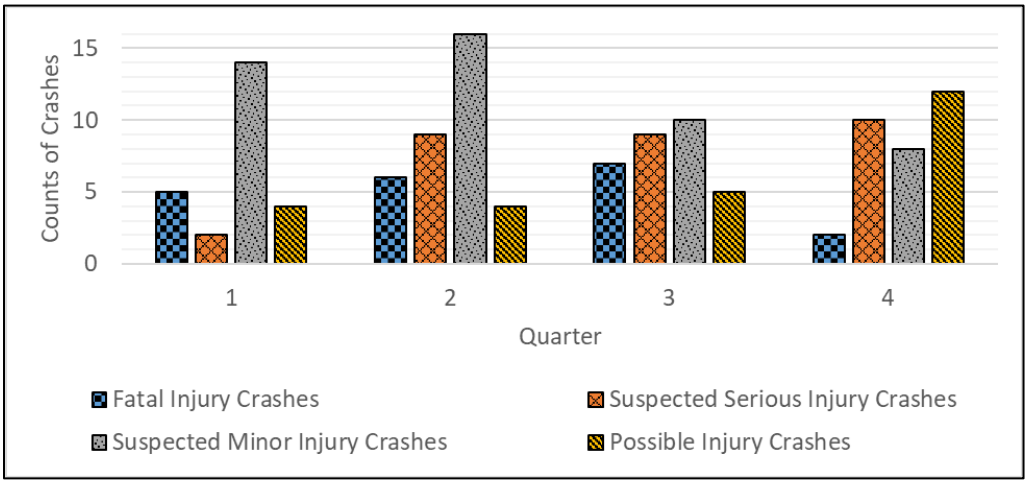

Figure 3.93 2019 counts of drug-related crashes

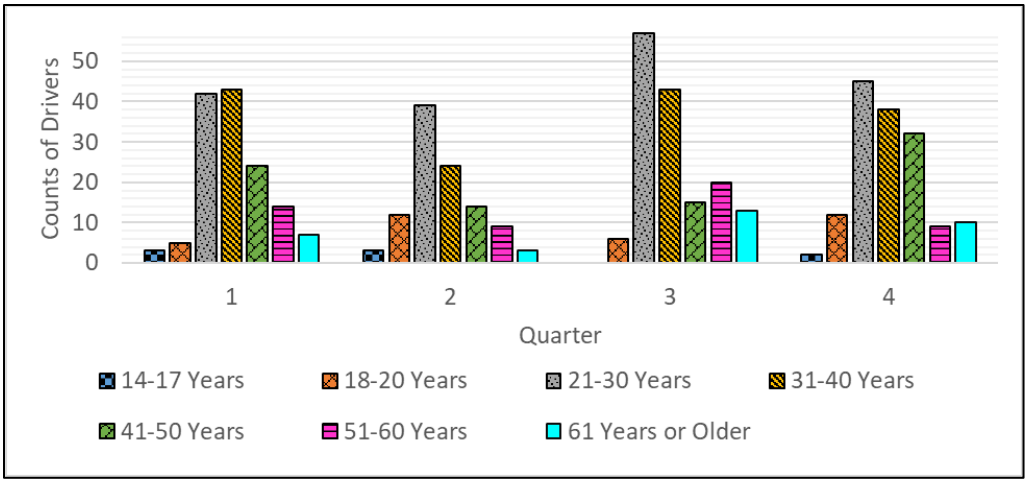

Figure 3.94 2019 counts of male drivers driving under the influence of alcohol by age

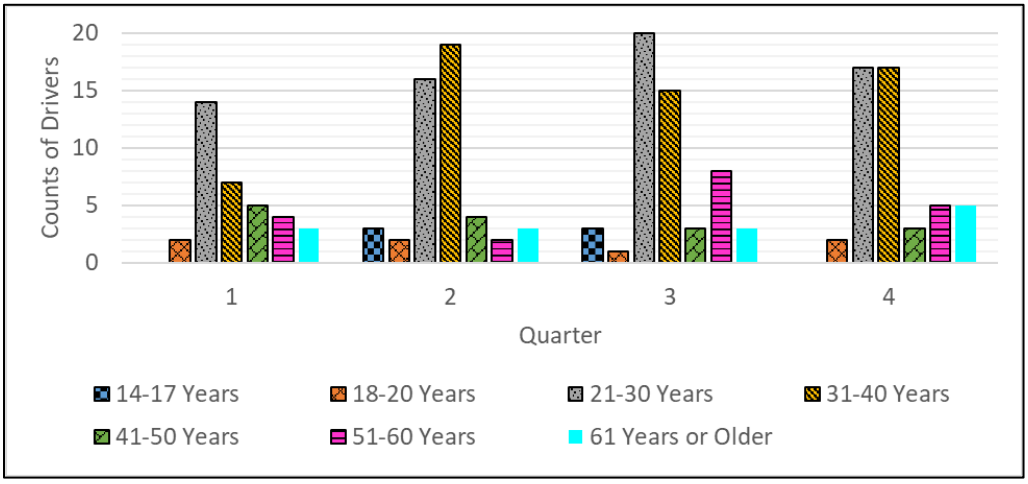

Figure 3.95 2019 counts of female drivers driving under the influence of alcohol by age

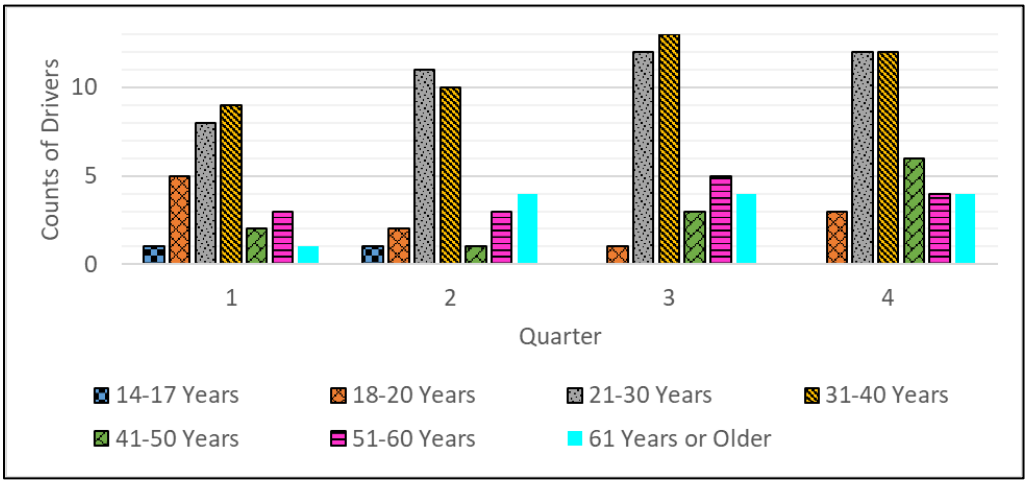

Figure 3.96 2019 counts of male drivers driving under the influence of drugs by age

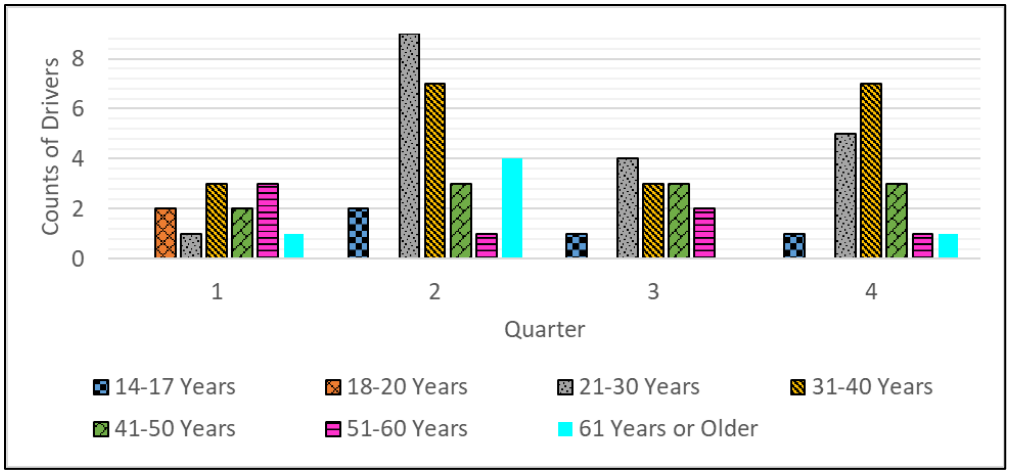

Figure 3.97 2019 counts of female drivers driving under the influence of drugs by age

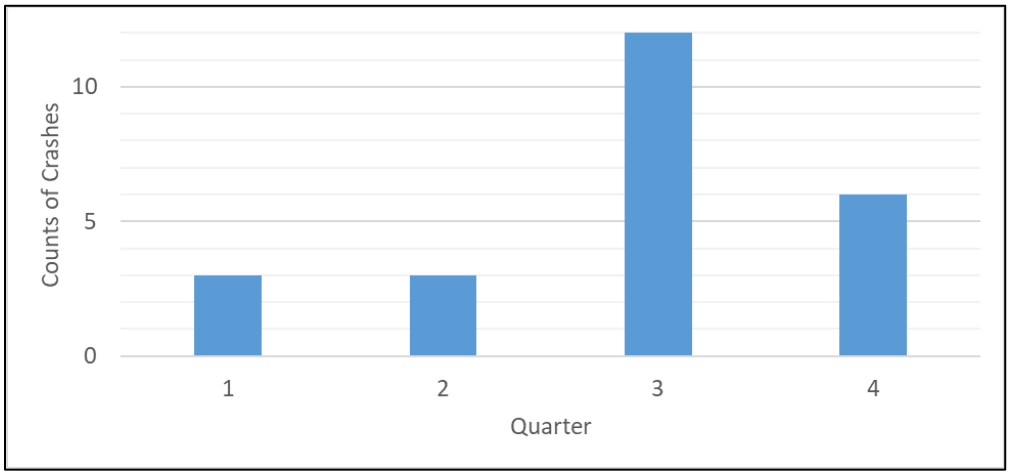

Figure 3.98 2019 counts of driving under the influence crashes involving pedestrians and/or bicyclists

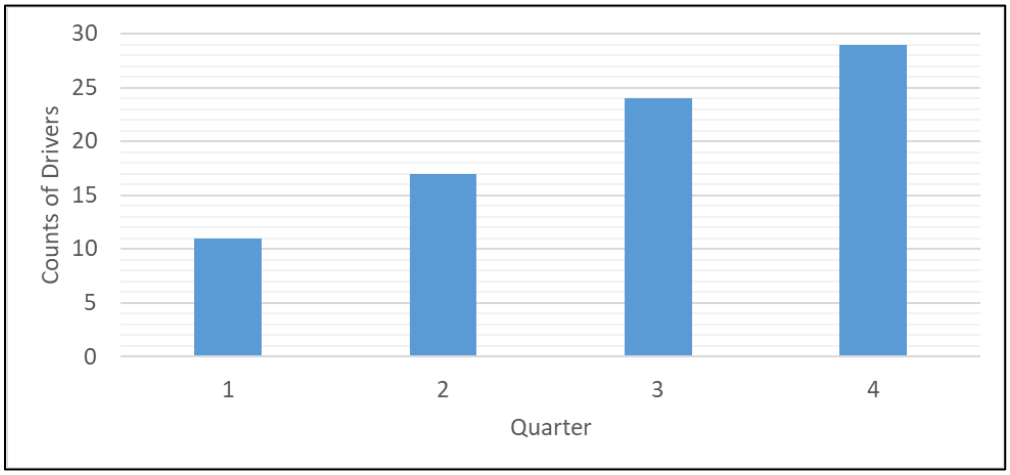

Figure 3.99 2019 counts of driving under the influence crashes involving speeding

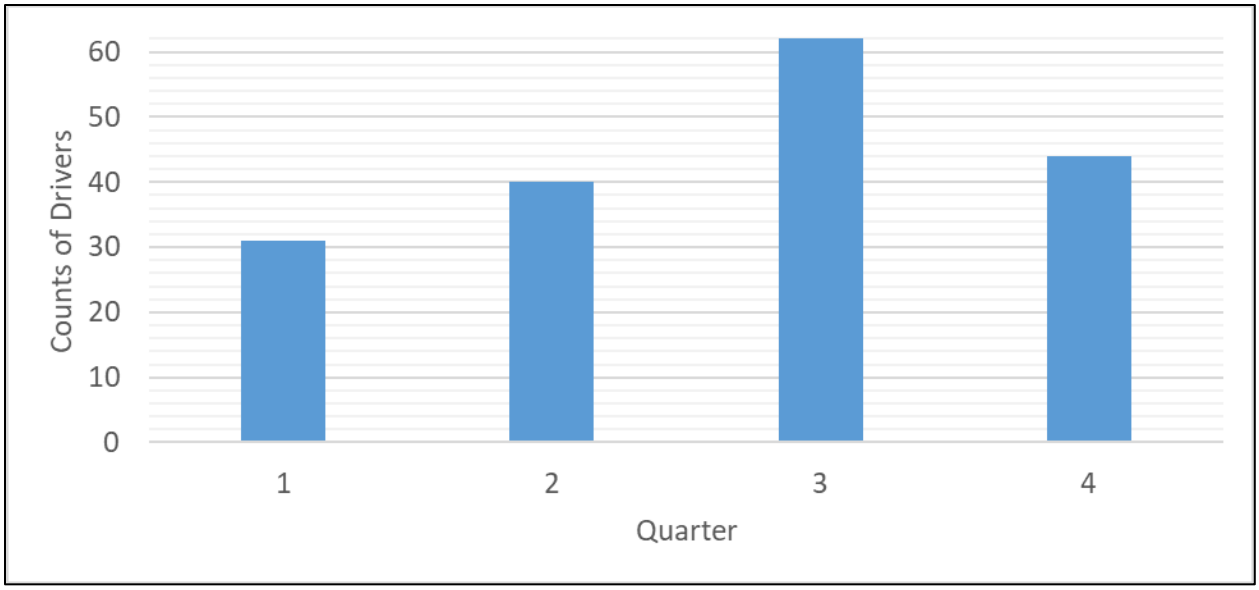

Figure 3.100 2019 counts of improperly belted or unbelted impaired drivers

Table 3.12 2019 Counts of Impaired Drivers' Citations Issued at the Crash Scenes

Citation	Quarter				Total
	1	2	3	4	
Careless Driving	20	31	65	55	171
Disregarding the Officer	2	3	4	5	14
Disregarding the Stop Light	5	8	8	1	22
Disregarding Stop Sign	9	6	13	4	32
Disregard Other	0	0	6	0	6
Drinking - (i.e., Open Container)	30	32	40	52	154
Failed to Grant the Right-of-Way to Other Motor Vehicle	6	10	4	19	39
Following Too Closely	16	13	15	16	60
Hitting-and-Running	62	71	79	103	315
Improper Backing	1	2	4	3	10
Improper Lane Use	83	92	150	120	445
Improper Turn	2	0	0	12	14
Improper or No Signal	0	0	0	2	2
Reckless Driving	13	26	16	42	97
No Insurance	44	94	104	60	302
Driver's License Violation	31	41	56	37	165
Vehicle Registration Violation	10	5	35	9	59
Vehicular Homicide	0	2	6	1	9
Wrong Side of Road	1	0	1	4	6
Other	64	80	150	100	394
Total	399	516	756	645	2,316

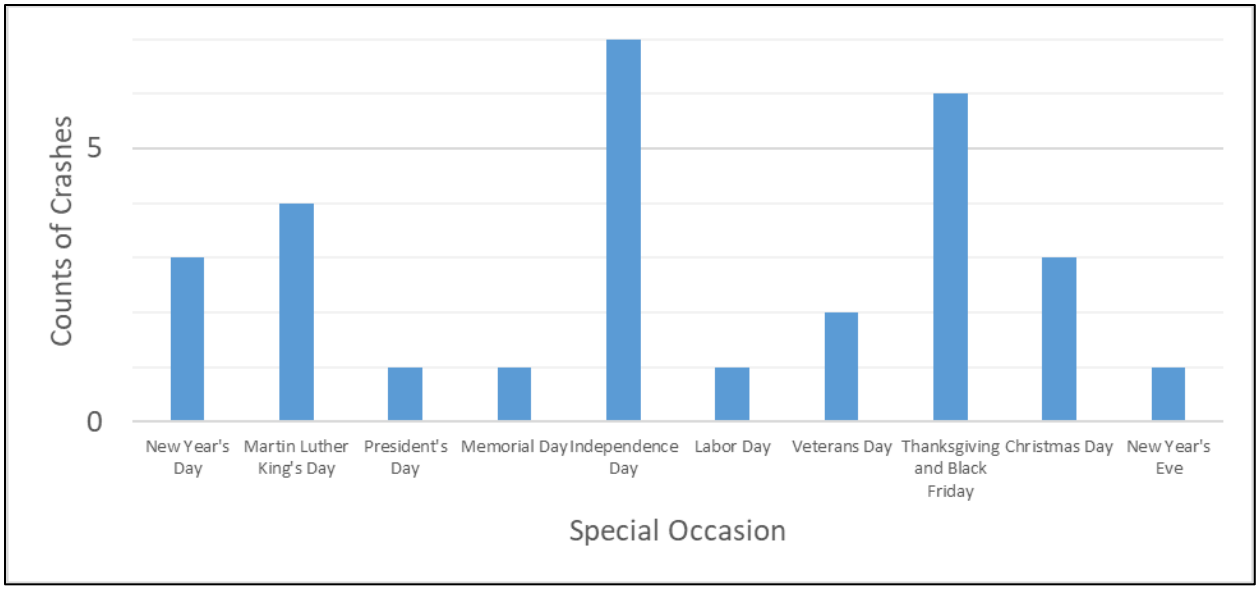

Figure 3.101 2019 counts of driving under the influence-related crashes during special occasions

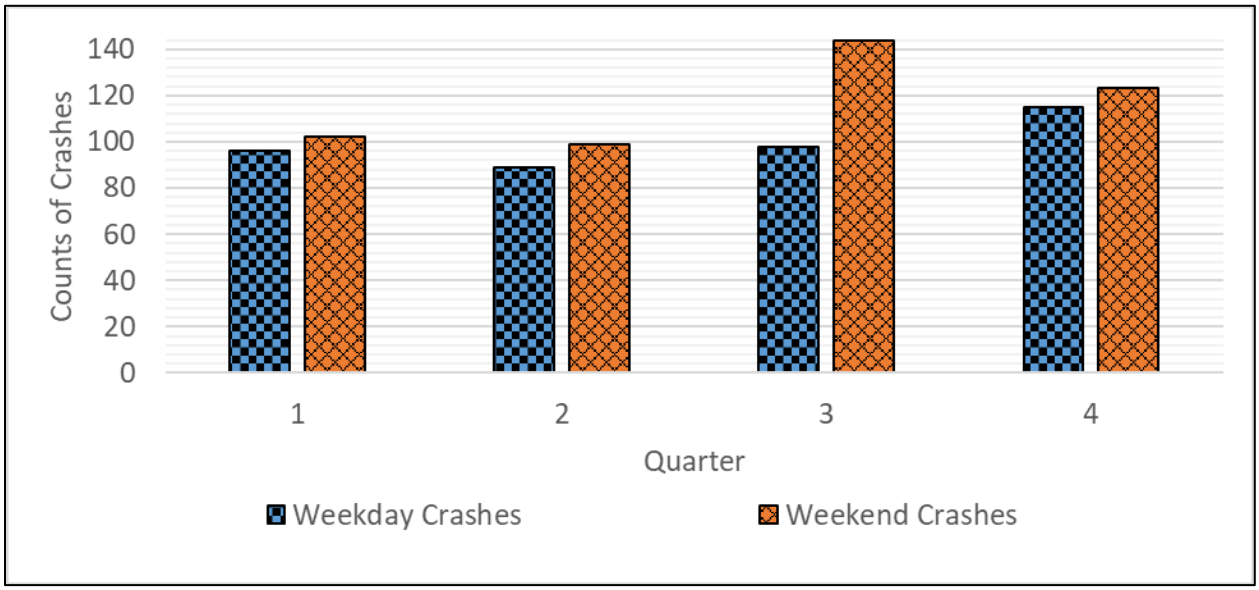

Figure 3.102 2019 counts of driving under the influence-related crashes by day of the week

Table 3.13 2019 Counts of Driving under the Influence Crashes by Manner of Collision in the First Quarter

Manner of Collision	Fatal Injury	Suspected Serious Injury	Suspected Minor Injury	Possible Injury	Total
Angle (Front to Side), Opposing Direction	2	0	2	3	7
Angle, Right (Front to Side, includes Broadside)	2	1	3	3	9
Angle, Same Direction (Front to Side)	0	0	3	1	4
Head-On (Front to Front)	2	2	1	1	6
Not a Collision with Two Vehicles in Transport	2	7	18	2	29
Rear-End (Front to Rear)	0	1	9	10	20
Rear to Front (Normally Backing)	0	0	0	0	0
Rear to Rear (Normally Backing)	0	0	0	0	0
Rear to Side (Normally Backing)	0	0	0	0	0
Sideswipe Opposite Direction (Meeting)	0	0	0	0	0
Sideswipe Same Direction (Passing)	0	0	1	0	1
Other	0	0	0	0	0
Total	8	11	37	20	76

Table 3.14 2019 Counts of Driving under the Influence Crashes by Manner of Collision in the Second Quarter

Manner of Collision	Fatal Injury	Suspected Serious Injury	Suspected Minor Injury	Possible Injury	Total
Angle (Front to Side), Opposing Direction	1	2	1	2	6
Angle, Right (Front to Side, includes Broadside)	0	1	2	2	5
Angle, Same Direction (Front to Side)	0	0	0	1	1
Head-On (Front to Front)	2	1	2	0	5
Not a Collision with Two Vehicles in Transport	8	14	32	12	66
Rear-End (Front to Rear)	0	2	4	2	8
Rear to Front (Normally Backing)	0	0	0	0	0
Rear to Rear (Normally Backing)	0	0	1	0	1
Rear to Side (Normally Backing)	0	0	0	0	0
Sideswipe Opposite Direction (Meeting)	0	0	2	0	2
Sideswipe Same Direction (Passing)	0	0	0	0	0
Other	0	1	0	0	1
Total	11	21	44	19	95

Table 3.15 2019 Counts of Driving under the Influence Crashes by Manner of Collision in the Third Quarter

Manner of Collision	Fatal Injury	Suspected Serious Injury	Suspected Minor Injury	Possible Injury	Total
Angle (Front to Side), Opposing Direction	0	2	2	2	6
Angle, Right (Front to Side, includes Broadside)	0	4	5	1	10
Angle, Same Direction (Front to Side)	0	0	1	0	1
Head-On (Front to Front)	4	1	2	1	8
Not a Collision with Two Vehicles in Transport	7	24	33	10	74
Rear-End (Front to Rear)	1	0	5	6	12
Rear to Front (Normally Backing)	0	0	0	0	0
Rear to Rear (Normally Backing)	0	0	0	0	0
Rear to Side (Normally Backing)	0	0	0	0	0
Sideswipe Opposite Direction (Meeting)	0	1	1	0	2
Sideswipe Same Direction (Passing)	0	0	0	1	1
Other	0	0	0	0	0
Total	12	32	49	21	114

Table 3.16 2019 Counts of Driving under the Influence Crashes by Manner of Collision in the Fourth Quarter

Manner of Collision	Fatal Injury	Suspected Serious Injury	Suspected Minor Injury	Possible Injury	Total
Angle (Front to Side), Opposing Direction	0	3	2	6	11
Angle, Right (Front to Side, includes Broadside)	1	2	3	4	10
Angle, Same Direction (Front to Side)	0	0	1	0	1
Head-On (Front to Front)	1	0	3	1	5
Not a Collision with Two Vehicles in Transport	4	15	20	12	51
Rear-End (Front to Rear)	0	1	2	5	8
Rear to Front (Normally Backing)	0	0	0	0	0
Rear to Rear (Normally Backing)	0	0	0	0	0
Rear to Side (Normally Backing)	0	0	0	0	0
Sideswipe Opposite Direction (Meeting)	0	0	0	1	1
Sideswipe Same Direction (Passing)	1	0	1	0	2
Other	0	0	0	0	0
Total	7	21	32	29	89

Table 3.17 2019 Counts of Driving under the Influence Crashes by Manner of Collision

Manner of Collision	Fatal Injury	Suspected Serious Injury	Suspected Minor Injury	Possible Injury	Total
Angle (Front to Side), Opposing Direction	3	7	7	13	30
Angle, Right (Front to Side, includes Broadside)	3	8	13	10	34
Angle, Same Direction (Front to Side)	0	0	5	2	7
Head-On (Front to Front)	9	4	8	3	24
Not a Collision with Two Vehicles in Transport	21	60	103	36	220
Rear-End (Front to Rear)	1	4	20	23	48
Rear to Front (Normally Backing)	0	0	0	0	0
Rear to Rear (Normally Backing)	0	0	1	0	1
Rear to Side (Normally Backing)	0	0	0	0	0
Sideswipe Opposite Direction (Meeting)	0	1	3	1	5
Sideswipe Same Direction (Passing)	1	0	2	1	4
Other	0	1	0	0	1
Total	38	85	162	89	374

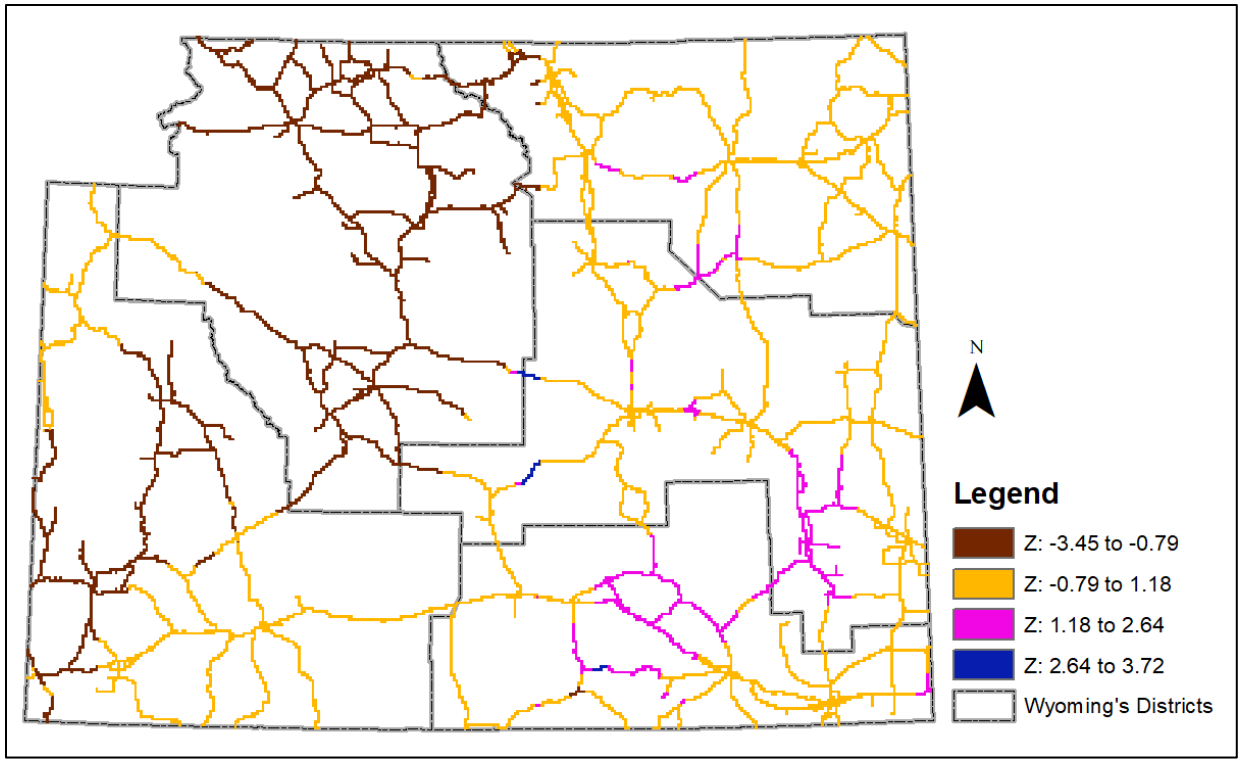

Figure 3.103 2017 heat map of driving under the influence crashes

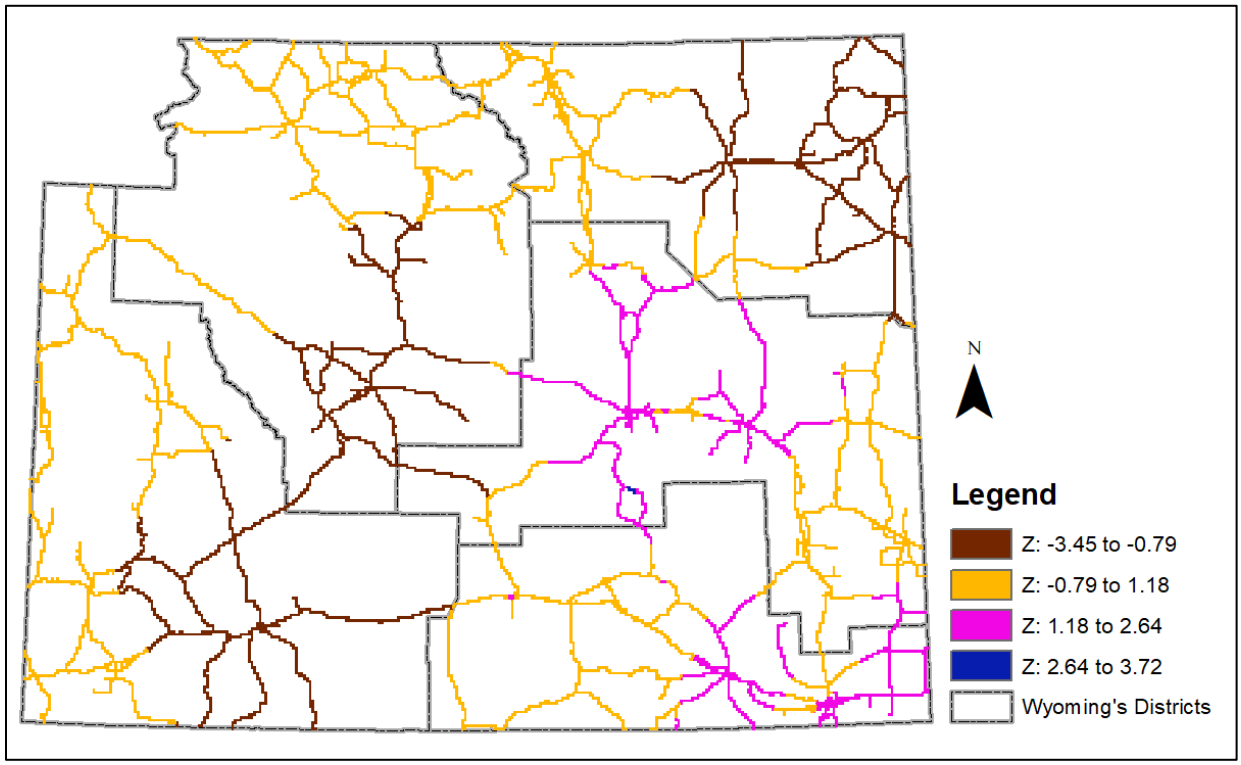

Figure 3.104 2017 heat map of driving under the influence fatal, suspected serious injury, and suspected minor injury crashes

It is also recommended that WYDOT plan for the following research studies:

- Effectiveness of DUI enforcement policies
- Effectiveness of impaired drivers' rehabilitation campaigns
- Effectiveness of other impairment enforcement policies (e.g., tired, not wearing prescription glasses/contact lenses)
- Effectiveness of educational campaigns addressing impaired driving
- Association between alcohol or drug use and crime

3.10 Summary of Wyoming's Counties Survey Response Results

A survey was disseminated to officials in Wyoming's counties, and 10 responses were received from multiple jurisdictions scattered around the state. The common question asked in all surveys was how often did the respondents receive/secure road safety data/reports from the WYDOT HSO? Among respondents, 90% indicated that they often obtained the relevant road safety information once a year from the Wyoming Technology Transfer Center, which collaborates with the WYDOT HSO. The remaining 10% indicated that they received the data once every six months. In the follow-up question, there were mixed responses regarding the ideal reporting period. Forty percent declared their willingness to receive the data semi-annually, 30% indicated their willingness to receive the data annually through the Wyoming Technology Transfer Center, and 20% indicated their willingness to receive the information once a month. One respondent, comprising the remaining 10%, stated a willingness to receive the road safety data as soon as the crashes occurred. That is to conduct road safety evaluations and propose mitigation measures promptly.

When it comes to data transfer protocols, the respondents declared that they secured reports/data mostly via mail and email (80% and 60%, respectively). The answer choices were provided in the form of checkboxes. In the subsequent question, most respondents indicated that they preferred receiving the reports/data via email. Also, the respondents were asked whether the current safety data provided to them fulfilled their needs on a scale of one (not at all) to five (absolutely). Sixty percent selected the options four and five. Regarding the preferred data format, more than half of the respondents selected the options, "pie charts/bar charts," "summary statistics tables," "figures" and "GIS maps." Note that the answer choices were provided as checkboxes to allow the respondents to select multiple choices. Furthermore, the county officials were asked to provide suggestions regarding the data or reports they would receive. One suggested that it would be beneficial to provide the data they needed in a GIS format such that the records would be efficiently incorporated into their GIS inventory; another recommended creating an email list for the prompt sharing of crash information whenever a crash would occur.

In the following section of the survey, the county officials were asked about road safety reports pertaining to crash data. The reports, most of which are available in the WYDOT HSO website, are the following:

- 2019 Highway Safety Crash Data Survey Final Report
- Wyoming Department of Transportation Highway Safety Behavioral Grants Office 2020 Annual Report
- Wyoming Highway Safety Behavioral Program FY2021 Highway Safety Plan
- Wyoming Report on Traffic Crashes 2019
- Wyoming Drivers Survey 2016
- 2020 Wyoming Statewide Seatbelt Survey Data Analysis
- Wyoming Statewide Crashes by Year
- Wyoming Statewide Speed Related Crashes by Year
- Wyoming Statewide Crashes Involving a Wild Animal by Year
- Wyoming Statewide Occupant Seat Belt Usage by Year
- Wyoming Statewide Crashes Involving a Pedestrian by Year

- Wyoming Statewide Crashes Involving Alcohol or Drugs by Year
- Wyoming Statewide Crashes Involving Commercial Motor Vehicles by Year
- Wyoming Statewide Distracted Driving Crashes by Year
- Wyoming Strategic Highway Safety Plan 2017

On a scale of one (not at all) to five (absolutely) describing whether the respondents were familiar with these reports and whether they frequently used them, more than half provided a rating of three, less than 15% provided a rating of four, and none provided a rating of five. In another question, the respondents were asked about the usefulness of the listed reports and half indicated that such reports were beneficial. Also, all respondents declared that they were satisfied with the frequency at which the reports were released.

The county officials were then asked specific questions about the importance of incorporating specific road safety summary statistics data in the listed reports. At least half of them indicated their interest in the following crash statistics:

- Drivers' improper actions/error information preceding the crashes (e.g., driving too fast, improper passing, following too closely, etc.)
- Aggressiveness of drivers who were at fault in traffic crashes
- Truck safety and truck policy violations at the times of the crashes (exceeded weight limit, improperly secured hazardous materials, etc.)
- Animal crash hot spots

In the subsequent section of the survey, the county officials were asked specific questions about crash data. At least half of them indicated their interest in the following data collected from crash records:

- Crash locations (on the road, on the shoulder, off the road, etc.)
- Crash times (morning, afternoon, etc.)
- Weather conditions at the times of the crashes
- Vehicle travel speeds preceding the crashes (i.e., too slow for the conditions, reasonable, or too fast for the conditions)
- Number of vehicles involved in the crashes
- Number of pedestrians and/or bicyclists involved in the crashes
- Types of animals involved in the crashes
- Whether the drivers were properly wearing their seat belts at the times of the crashes
- Whether the passengers were properly wearing their seat belts at the times of the crashes
- Whether children were properly secured in their appropriate car seats at the times of the crashes
- Whether the drivers were driving under the influence of alcohol/drugs at the times of the crashes
- Whether the drivers were tired at the times of the crashes
- Motorcycle crashes
- Whether work zone plans were implemented according to the standards when the crashes occurred at or near the work zones
- Whether workers were present when the crashes occurred at or near the work zones
- Shoulder and lane closure information when the crashes occurred at or near the work zones
- Whether drivers violated work zone regulations giving rise to the crashes (i.e., exceeded the work zones' speed limits, failed to obey the traffic guards' signals, etc.)
- Number of injured drivers/motorcyclists and their injury severity levels
- Number of injured passengers and their injury severity levels
- Number of injured non-motorists and their injury severity levels
- Crash types (rear-end, sideswipe, etc.)

- Impact point information of vehicles involved in the crashes (e.g., hit from the side, hit from the front, etc.)
- DUI-related crashes by day of the week (i.e., weekdays versus weekends)
- Injury severity levels of DUI-related crashes by BAC level of impaired drivers
- Crashes on roads with challenging geometric conditions (steep upgrades, steep downgrades, etc.)
- Crashes involving distractions by distraction method (use of electronic device, picking up an object from the vehicle's floor, etc.)
- Crash locations by injury severity level and lighting conditions (daylight, dawn, dark with street lighting, etc.) at the times during which the crashes occurred
- Crash locations by injury severity level and road surface conditions (dry, wet, icy, snowy, etc.) at the times during which the crashes occurred

In the subsequent section, the county officials were asked about the importance of color-coded maps presenting locations characterized by risks of encountering certain types of crashes. At least half of the respondents declared their interest in maps presenting the following:

- High severity (fatal, suspected serious injury, and suspected minor injury) crashes
- High severity crashes that occurred in the presence of adverse weather conditions (snow, fog, rain, etc.)
- High severity crashes where visual obstructions (vegetation, hill crests, sun glare, headlight glare, other vehicles, animals, fog, snow showers, etc.) posed hazards
- High severity crashes involving improperly buckled or unbuckled occupants
- High severity DUI-related crashes
- High severity speed-related crashes

In the second to the last question, the Wyoming county officials were asked to select from a list topics they might be interested in for research. At least half selected the following topics:

- Safety of low-volume paved and unpaved roads
- Assessing and updating strategic county road safety plans
- Optimization of road safety improvement budgets
- Effectiveness of speed enforcement policies
- Changes in Wyoming's road fatality toll rates (fatalities per hundred million vehicle-miles traveled) throughout the years

Finally, the respondents were asked whether they would like to provide any recommendation regarding the data they would receive in general. One suggested providing the GIS coordinates of the crash locations since they would typically receive narrative descriptions of the locations, which would otherwise be considered as imprecise.

3.11 Recommendations for the Wyoming Department of Transportation Regarding Wyoming's Counties

Based on the interpretations of the Wyoming counties' survey responses, it is suggested that WYDOT establish an email list for sharing road safety data with the counties on a quarterly basis. With that, it would also be beneficial for WYDOT to communicate with the county officials regarding whether some would be willing to receive such data within a shorter period after crash occurrences. The data, recommended for Wyoming's counties in the form of plots/tables, would be similar to those which were suggested for WHP and WASCOP (Figures 3.26 through 3.73, and Tables 3.6 through 3.10). Furthermore, since it was inferred from the counties' survey results that the county officials were interested in pedestrian injury and fatality statistics, it is recommended to provide such data to

Wyoming's counties. Pedestrian casualty statistics would be provided in the form similar to that depicted in Figure 3.105.

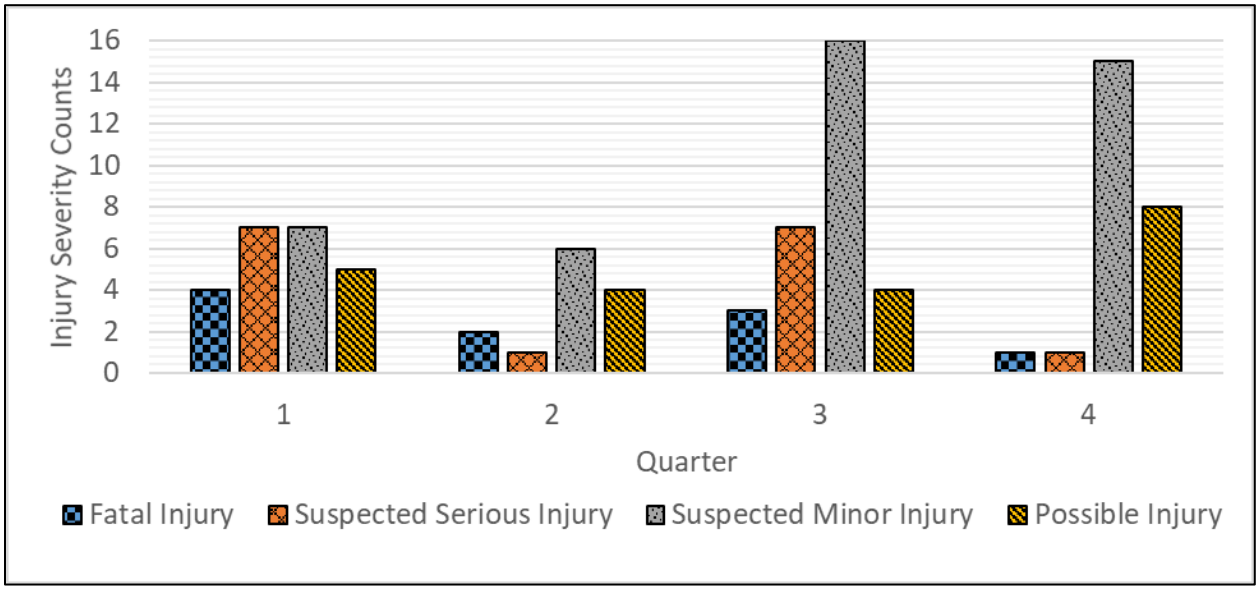

Figure 3.105 2019 counts of killed and injured pedestrians

In addition, it is suggested that WYDOT plan for conducting research on the following topics:

- Safety of low-volume paved and unpaved roads
- Assessing and updating strategic county road safety plans
- Optimization of road safety improvement budgets
- Effectiveness of speed enforcement policies
- Changes in Wyoming's road fatality toll rates throughout the last decade

3.12 Summary of the Wyoming Bicycle and Pedestrian System Task Force Survey Response Results

A survey was circulated among members of the Wyoming Bicycle and Pedestrian System Task Force and other interested parties. The survey asked about the frequency at which WBPSTF was receiving non-motorist safety data, whether members of WBPSTF were utilizing relevant safety reports available in the WYDOT HSO website, and additional data needed and non-motorist safety topics WBPSTF might be interested in for research. Three responses were received.

In the first section of the survey, WBPSTF members were asked how often they received pedestrian/bicycle safety data from the WYDOT HSO. One respondent indicated receiving them once every six months. Another indicated never receiving such data unless the data were requested, and the third indicated never receiving the data. In the results of the following question, which included answer choices provided in the form of checkboxes, one respondent declared that they would receive non-motorist safety data via online databases or reports. The option "email," was also selected. More importantly, one of the respondents stated that they would solicit non-motorist safety data and those would be provided in an Excel PDF format. The third question asked about the preferred means of data delivery and, similar to the previous question, checkboxes were provided to the respondents. Two-thirds of the respondents selected the options, "online databases and/or reports" and "email." The subsequent question asked whether the non-motorist safety data fulfilled the needs of WBPSTF on a scale of one (not at all) to five (absolutely). Two respondents checked option "two" and the third selected the option

"four." When it comes to the number of days it would take for the respondents to receive the safety data from the dates non-motorist crashes occurred, one respondent indicated that this duration would be a week. Another indicated one to two days, and the third preferred a duration less than a week. With that, the respondents stated that these were ideal reporting periods. The respondents also declared that they would prefer summary statistics tables and figures as means of presenting pedestrian/bicycle safety data. Furthermore, it was interpreted that the respondents would like the locations of pedestrian and bicycle crashes to be portrayed via narrative descriptions, GIS coordinates, or heat maps. At the end of the first section of the survey, the respondents were asked to provide any additional feedback. One suggested the provision of non-motorist facility budget information. That is, when pedestrian and bicycle casualties become substantial, it would be beneficial to have budget reports handy in order to plan for improving non-motorist safety accordingly. Another respondent recommended the provision of more accurate GIS coordinates of pedestrian and bicycle crash locations.

In the second section of the survey, the respondents were asked about the following reports:

- Wyoming Statewide Crashes Involving a Pedestrian by Year
- Wyoming Strategic Highway Safety Plan
- 2019 Wyoming Department of Transportation Highway Safety Behavioral Grants Office Annual Report
- 2019 Highway Safety Crash Data Survey Final Report
- Cyclist and Pedestrian Accident Statistics for Wyoming
- Wyoming Highway Safety Behavioral Program FY2020 Highway Safety Plan
- Wyoming Report on Traffic Crashes 2019
- Wyoming Bicycle & Pedestrian Transportation Plan
- Bicycle Friendly State Report Card Wyoming
- Wyoming Active Transportation Webinar Series
- A Resident's Guide for Creating Safer Communities for Walking and Biking
- Urban Bikeway Design Guide

The respondents were asked whether they were familiar with the aforementioned reports and if they frequently utilized them. Only one declared utilizing most of those reports often and that they were beneficial. Regarding the frequency at which the reports were released, one respondent indicated satisfaction with such frequency. At the end of the survey's second section, the respondents were asked to include any additional reports that might be of benefit to them. One respondent suggested a report of pedestrian and bicycle safety budgets.

The third section of the survey was aimed at specific questions concerning non-motorist safety data in which the respondents might be interested. At least two of the three respondents were interested in the following summary statistics data collected from crash records:

- Pedestrian/bicycle crash types (sideswipe, right turn at intersection, dooring, etc.)
- Whether any road users involved in the pedestrian/bicycle crashes were using an electronic device or distracted by any other means
- Whether the bicyclists were wearing helmets at the times of the crashes
- Pedestrian/bicycle crash locations (intersections, mid-block locations, road shoulders, or parking lots)
- Whether the drivers maintained an adequate distance between their vehicles and the bicyclists on the shoulder or bicycle lane
- Whether the pedestrian/bicycle crashes occurred within school zones
- Traffic violation details at the times of the pedestrian/bicycle crashes
- Weather conditions at the times of the pedestrian/bicycle crashes (clear, cloudy, foggy, rainy, snowy etc.)

- Road surface conditions at the times of the pedestrian/bicycle crashes (dry, wet, icy, snowy, or slushy)
- Crash times

In addition, two respondents declared they agreed that non-motorist injury severity levels (fatal, suspected serious injury, suspected minor injury, and possible injury) should be further categorized. Also, one respondent indicated interest in color-coded maps depicting the high-risk non-motorist crash locations.

The third section of the survey comprised questions about miscellaneous topics regarding non-motorists. The respondents were asked to select the type of summary statistics citation data they were willing to receive. Yet, a disclaimer was incorporated stating that the WYDOT HSO would not maintain citation data and, hence, independent studies would have to be conducted on such data if needed. At least two of the three respondents indicated that they would like to receive summary statistics data on the following:

- Traffic violations posing hazards to pedestrians and bicyclists (e.g., failure to yield the right-of-way to pedestrians and bicyclists)
- Whether drivers, cited for previous violations against pedestrians and bicyclists, attended drivers' education sessions
- Whether pedestrians/bicyclists, cited for previous violations, attended traffic education sessions

Other than citation data, two of the three respondents stated their interest in information on projects geared toward providing pedestrian and bicyclist friendly facilities (e.g., providing a designated bicycle lane or widening a sidewalk, etc.). Also, at least two respondents recommended that the WYDOT HSO carry out research on the following topics:

- Assessing the adequacy of the existing pedestrian and bicycle infrastructure
- Assessing the health benefits of walking and biking
- Assessing the economic impact of walking and biking; this would include special bicycle events
- Assessing the environmental impact of walking and biking

3.13 Recommendations for the Wyoming Department of Transportation Regarding the Wyoming Bicycle and Pedestrian System Task Force

Based on the Wyoming Bicycle and Pedestrian System Task Force's survey results, noteworthy recommendations are made for WYDOT. As such, it is recommended that WYDOT deliver non-motorist crash data to WBPSTF as promptly as the data become available. It is also suggested that WYDOT share information with the group regarding its bicycle and pedestrian facility budgets, especially when having a considerable rate of non-motorist crashes. Other suggestions include disseminating a survey to schools asking about school zone and school bus safety concerns from the viewpoints of non-motorists. Another survey may be circulated among bicyclists asking about their safety concerns. Results from both surveys would be documented in official reports and shared with WBPSTF. In addition, it is recommended that WYDOT provide quarterly summary statistics of non-motorist crash data, similar to the ones presented in Figures 3.102 through 3.119, and Table 3.18. Note that Figure 3.116, which is a heat map of non-motorist crashes, was produced using 2017 data since this was the latest year during which accurate GIS coordinates of the crash locations were provided. The mapping procedure implemented was the same as that employed for generating the heat maps of the other road safety groups.

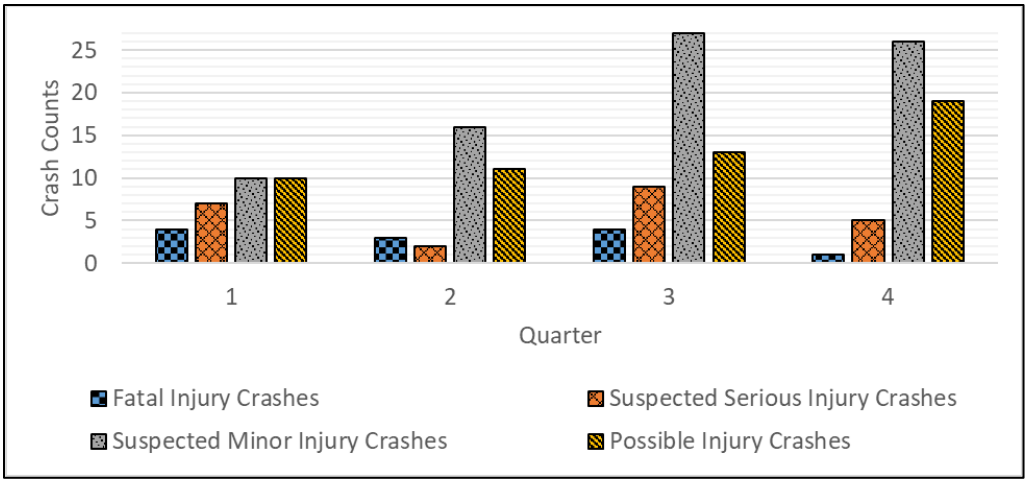

Figure 3.106 2019 counts of pedestrian and bicycle crashes

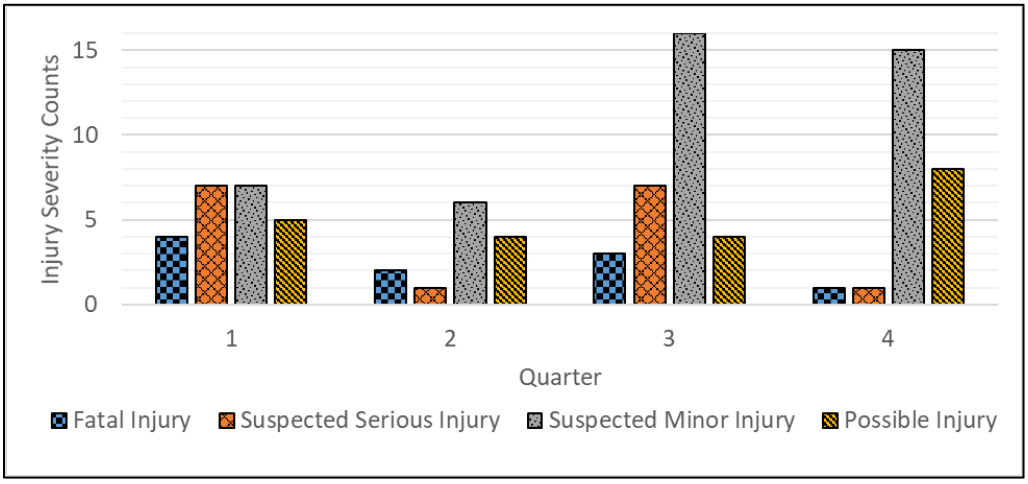

Figure 3.107 2019 counts of killed and injured pedestrians

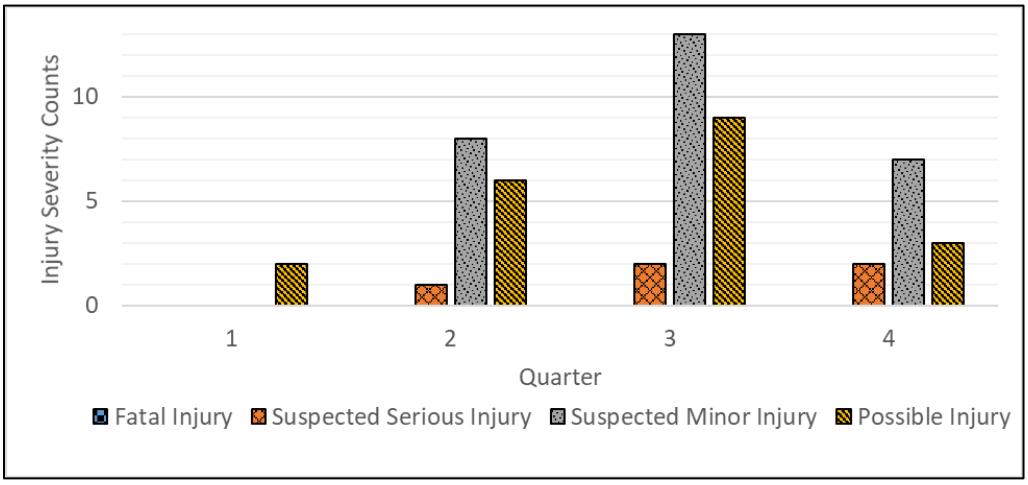

Figure 3.108 2019 counts of killed and injured bicyclists

Table 3.18 2019 Counts of Pedestrian and Bicycle Crashes by Manner of Collision

Manner of Collision	Quarter				Total
	1	2	3	4	
Angle (Front to Side), Opposing Direction	1	1	1	1	4
Angle, Direction Not Specified	0	0	0	1	1
Angle, Right (Front to Side, includes Broadside)	0	0	0	1	1
Angle, Same-Direction (Front to Side)	3	4	0	2	9
Head-On (Front to Front)	0	0	0	1	1
Not a Collision with Two Vehicles in Transport	19	26	51	31	127
Rear-End (Front to Rear)	6	4	4	9	23
Rear to Front (Normally Backing)	0	1	1	4	6
Rear to Rear (Normally Backing)	1	1	0	0	2
Rear to Side (Normally Backing)	1	1	1	0	3
Sideswipe-Opposite Direction (Meeting)	0	1	2	0	3
Sideswipe-Same Direction (Passing)	7	4	7	10	28
Other	2	0	0	0	2
Total	40	43	67	60	210

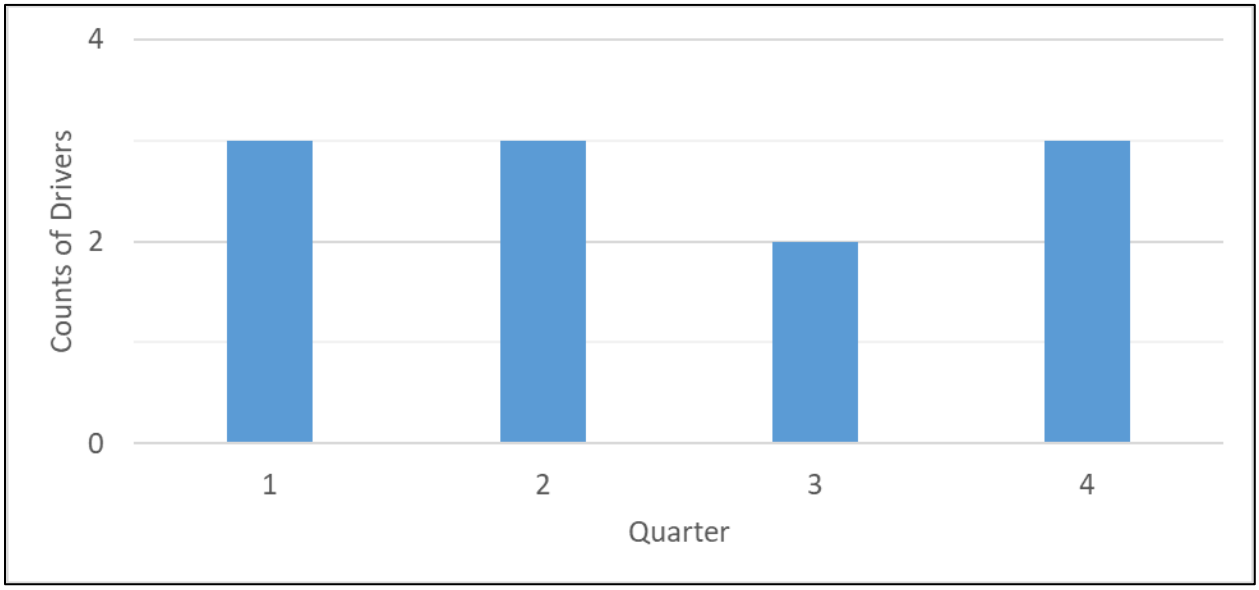

Figure 3.109 2019 counts of distracted drivers involved in pedestrian and/or bicycle crashes

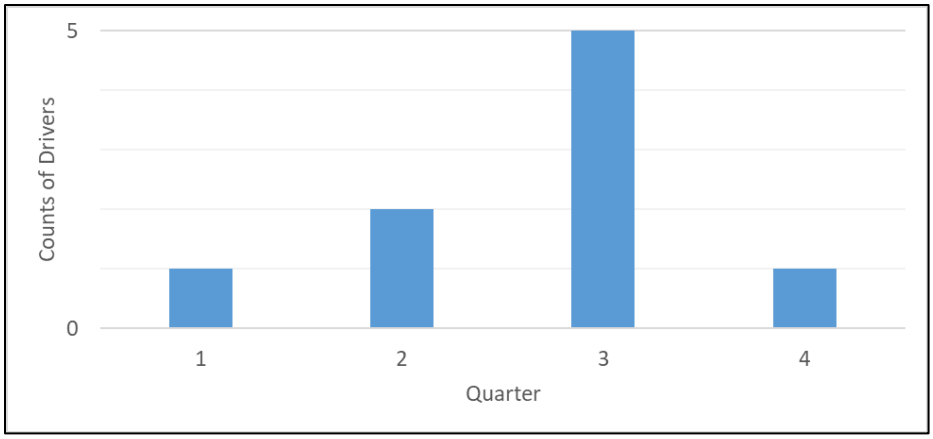

Figure 3.110 2019 counts of impaired drivers involved in pedestrian and/or bicycle crashes

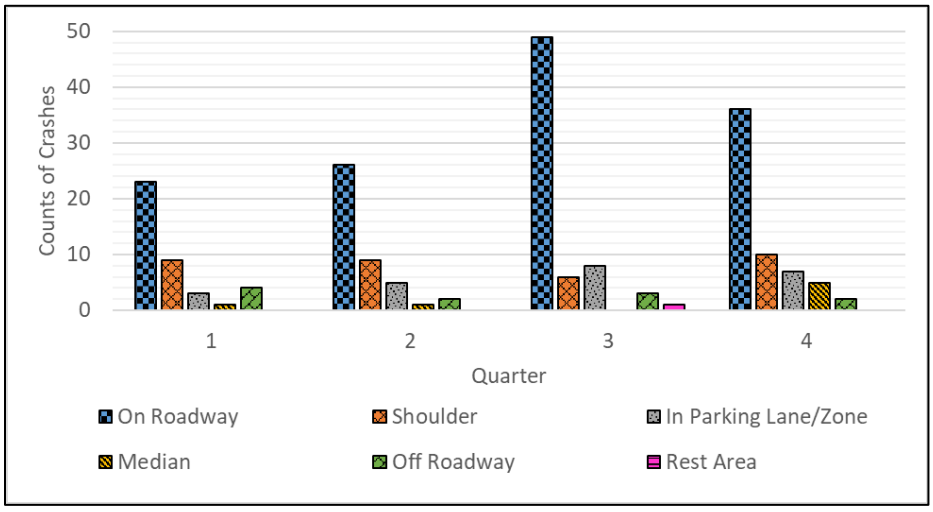

Figure 3.111 2019 counts of pedestrian and bicycle crashes by first harmful event location

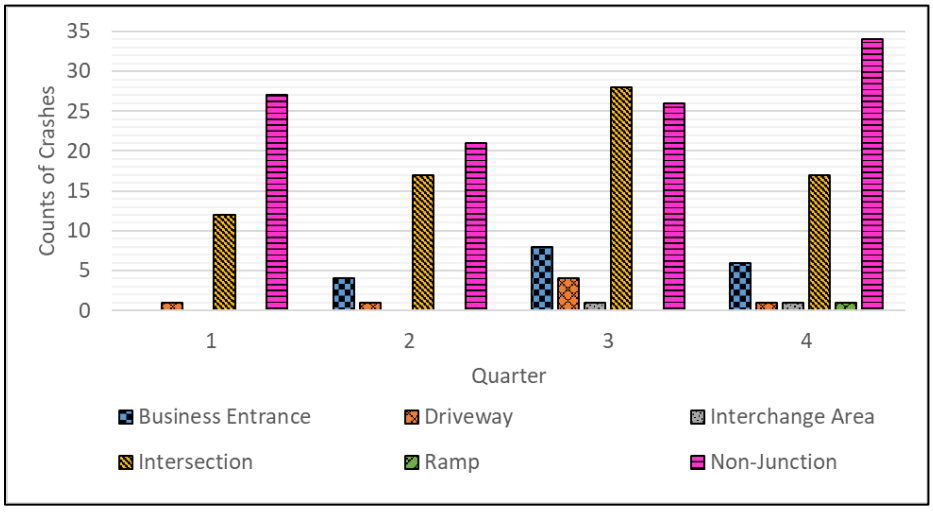

Figure 3.112 2019 counts of pedestrian and bicycle crashes for segments and junctions

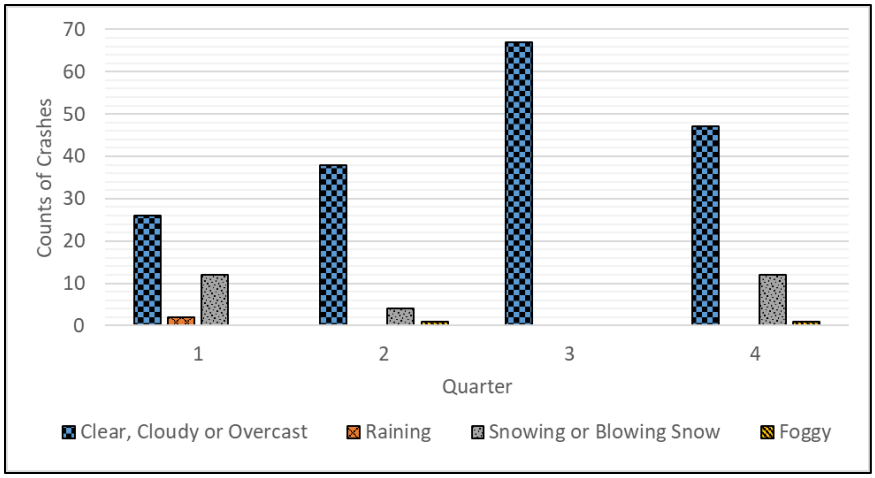

Figure 3.113 2019 counts of pedestrian and bicycle crashes by weather condition

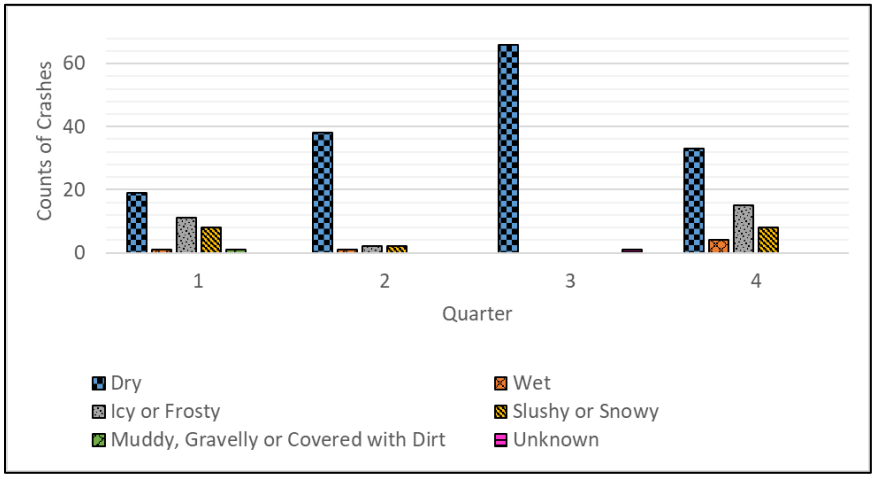

Figure 3.114 2019 counts of pedestrian and bicycle crashes by road surface condition

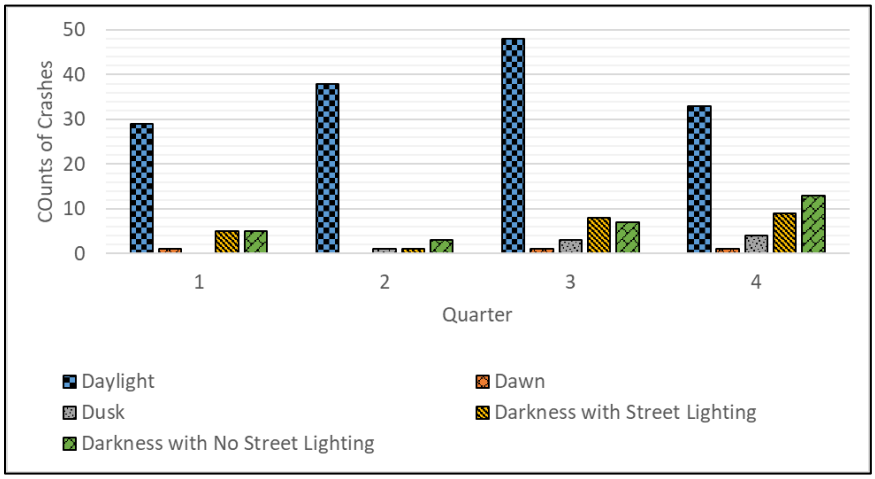

Figure 3.115 2019 counts of pedestrian and bicycle crashes by lighting condition

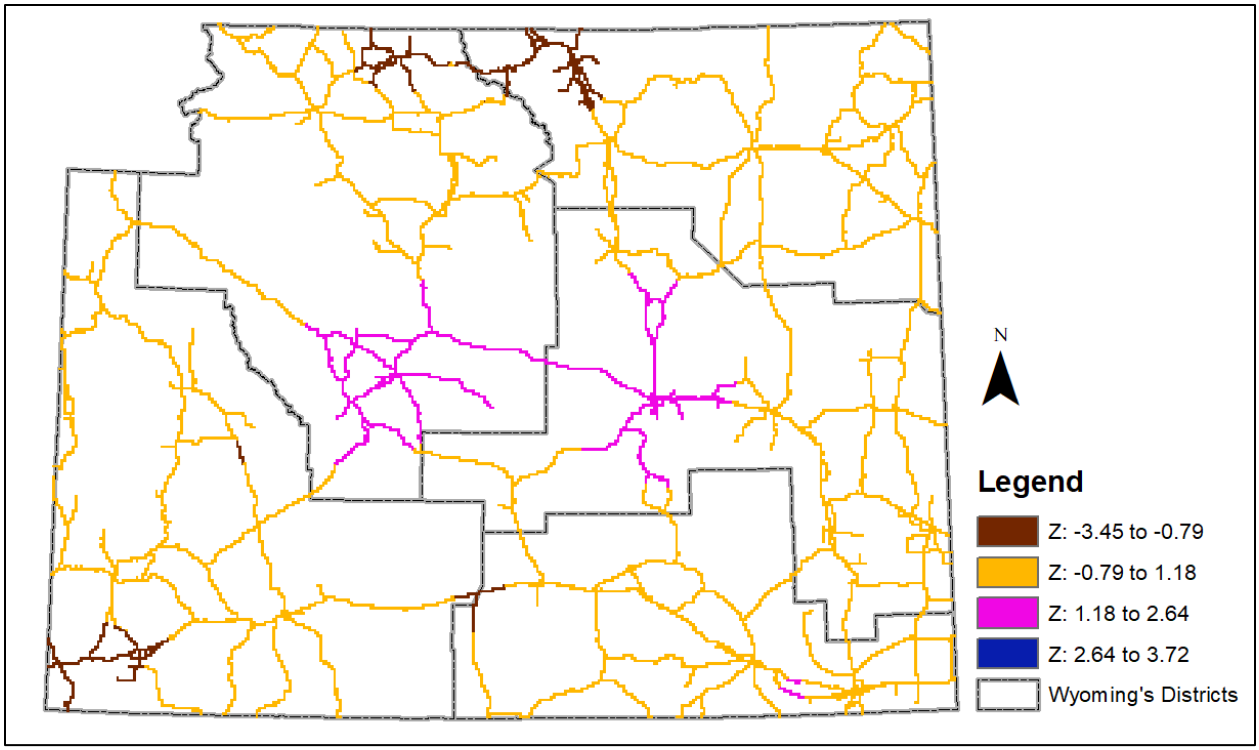

Figure 3.116 2017 heat map of pedestrian and bicycle crashes

Another suggestion is to conduct independent studies to collect, summarize, and present data of the following:

- Citations issued to drivers for posing hazards to pedestrians and bicyclists (e.g., failure to yield the right-of-way to pedestrians and bicyclists)
- Whether drivers, cited for previous violations against pedestrians and bicyclists, attended drivers' education sessions
- Whether pedestrians/bicyclists, cited for previous violations, attended traffic education sessions

Other than the citation data suggestions, it would be recommended that WYDOT plan for research on the following topics:

- Assessing the adequacy of the existing pedestrian and bicycle infrastructure
- Assessing the health benefits of walking and biking
- Assessing the economic impact of walking and biking; this would include special bicycle events
- Assessing the environmental impact of walking and biking

3.14 Summary of the Results of the Motorcycle Groups' Survey

A survey was distributed to multiple motorcycle groups, including the Wyoming Central ABATE and the Harley-Davidson motorcycle groups. Yet, no responses were received after multiple attempts to reach out to the groups. Therefore, recommendations were made to WYDOT concerning the provision of pertinent road safety data to the motorcycle groups in the state based on experiential knowledge and a prior reasoning.

3.15 Recommendations for the Wyoming Department of Transportation Regarding the Motorcycle Groups

It is recommended that WYDOT provide quarterly summary statistics data extracted from motorcycle crash records to motorcycle groups in Wyoming. The data would be similar to those presented in Figures 3.120 through 3.133, and Tables 3.22 and 3.23, which belonged to 2019. It should be noted that Figure 3.130 presents a map of motorcycle crash hot spots representative of the year 2017 since this was the most recent year during which precise GIS coordinates of crash locations were available.

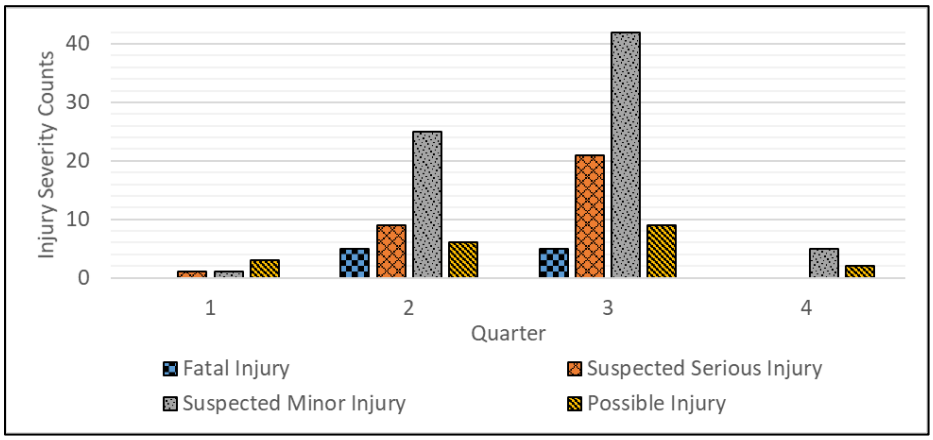

Figure 3.117 2019 counts of killed and injured motorcycle operators

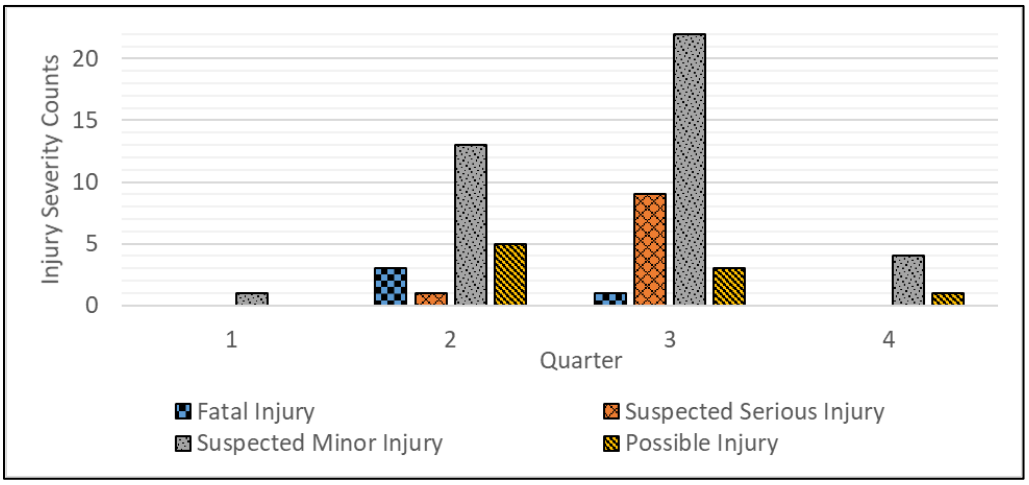

Figure 3.118 2019 counts of killed and injured motorcycle operators wearing helmets

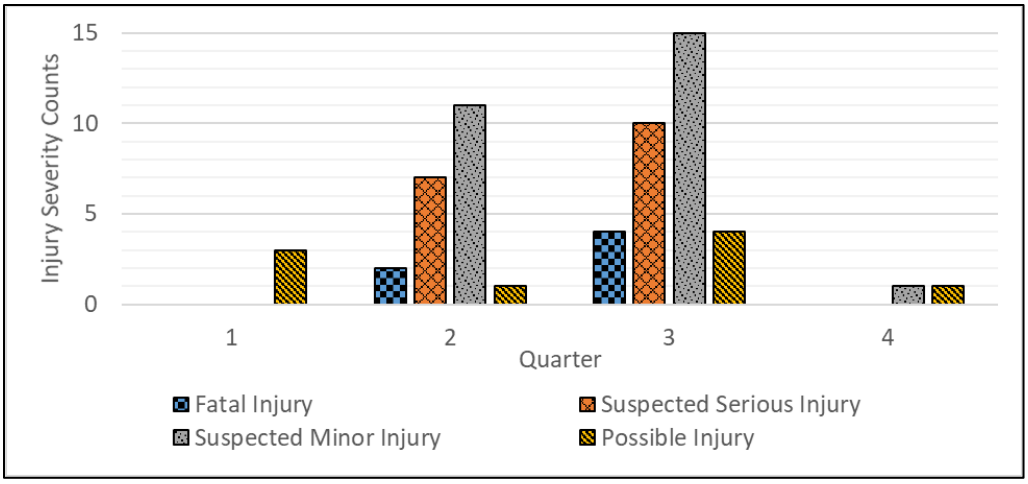

Figure 3.119 2019 counts of killed and injured motorcycle operators not wearing helmets

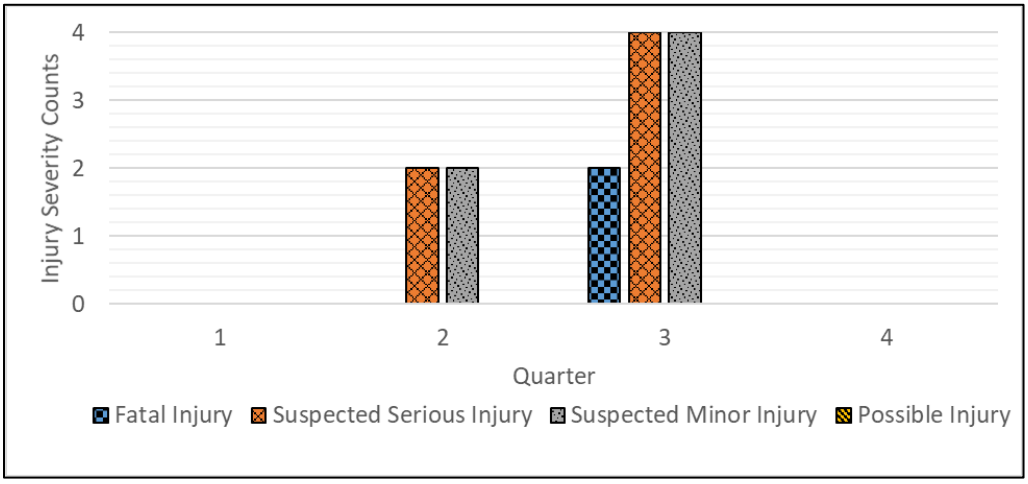

Figure 3.120 2019 counts of killed and injured motorcycle passengers

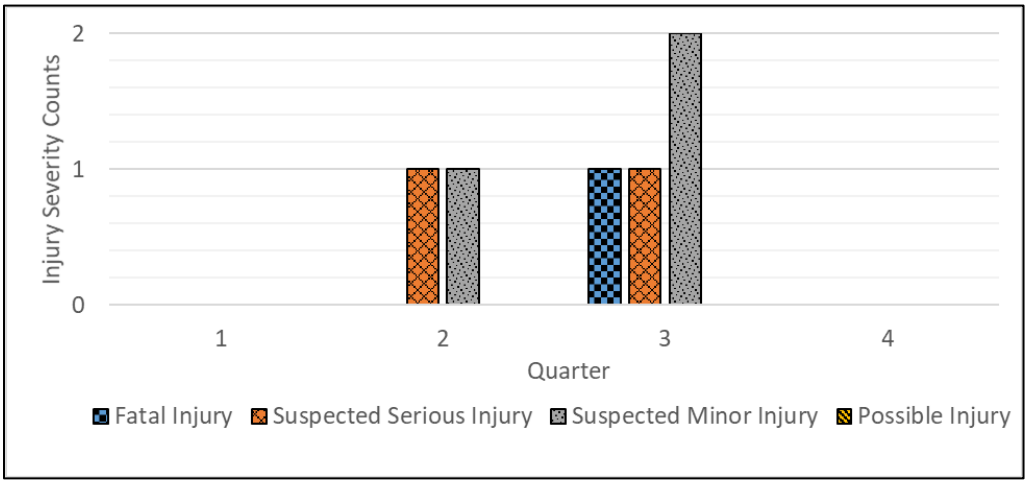

Figure 3.121 2019 counts of killed and injured motorcycle passengers wearing helmets

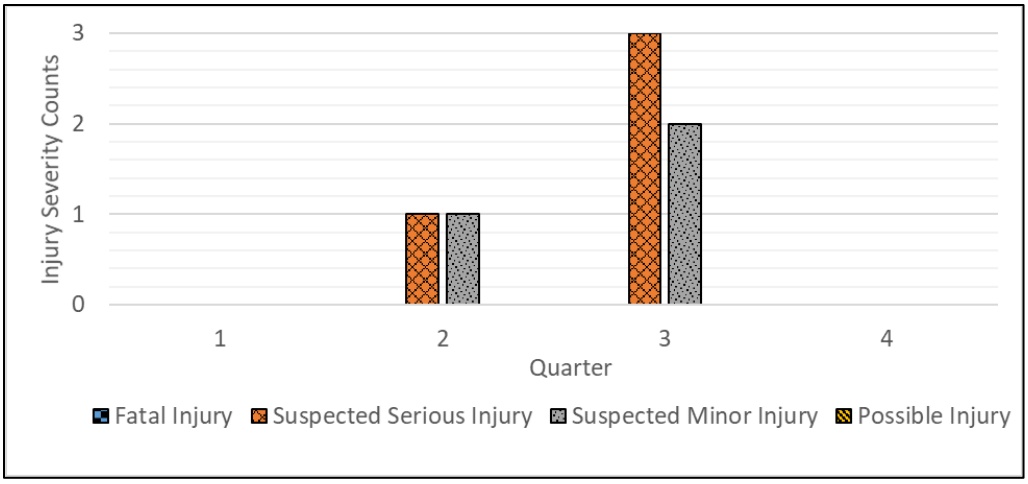

Figure 3.122 2019 counts of killed and injured motorcycle passengers not wearing helmets

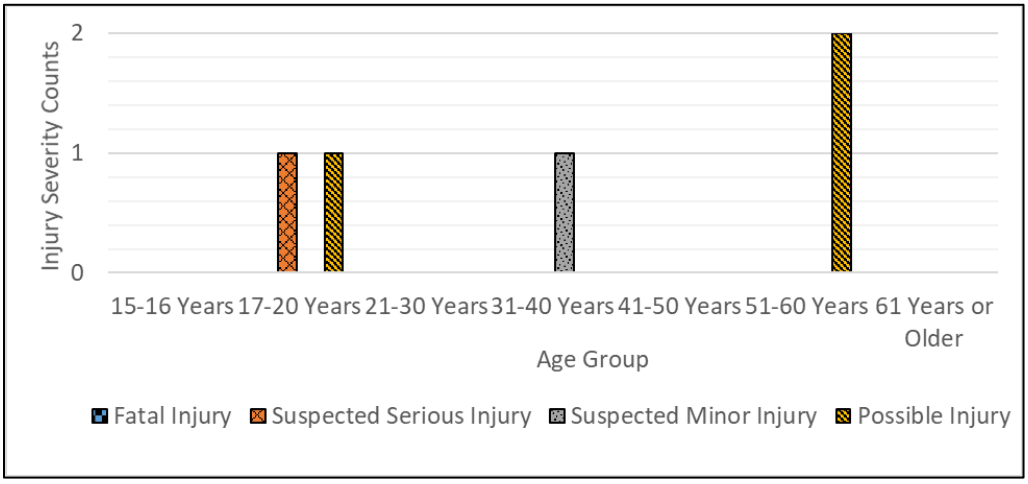

Figure 3.123 2019 counts of killed and injured motorcycle operators by age in the first quarter

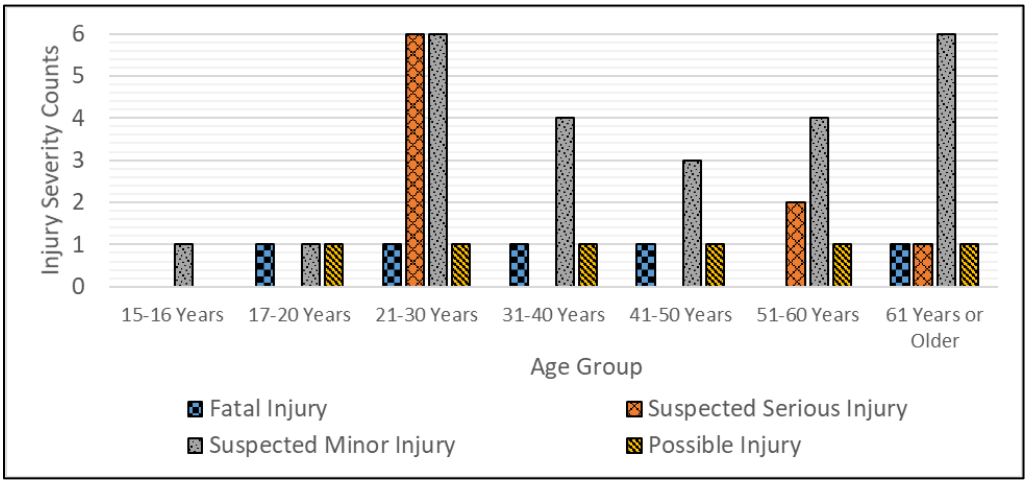

Figure 3.124 2019 counts of killed and injured motorcycle operators by age in the second quarter

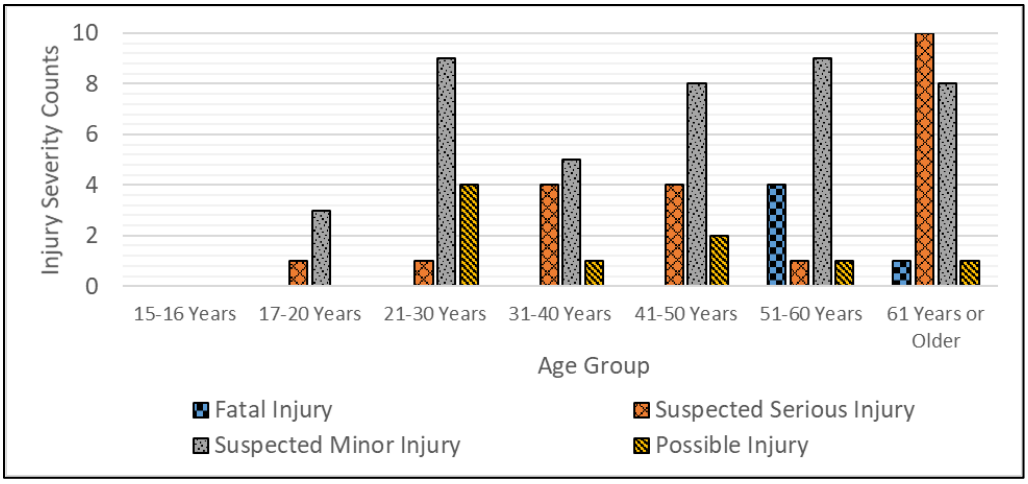

Figure 3.125 2019 counts of killed and injured motorcycle operators by age in the third quarter

Figure 3.126 2019 counts of killed and injured motorcycle operators by age in the fourth quarter

Table 3.19 2019 Counts of Motorcycle Crashes by Manner of Collision

Manner of Collision	Quarter				Total
	1	2	3	4	
Angle (Front to Side), Opposing Direction	0	3	4	0	7
Angle Right (Front to Side, includes Broadside)	2	4	4	0	10
Angle Same Direction (Front to Side)	1	1	0	0	2
Head On (Front to Front)	0	1	3	0	4
Rear End (Front to Rear)	0	3	12	1	16
Sideswipe Opposite Direction (Meeting)	0	1	1	0	2
Sideswipe Same Direction (Passing)	1	2	1	0	4
Not a Collision with Two Vehicles in Transport	3	37	68	7	115
Other	0	2	0	0	2
Total	7	54	93	8	162

Table 3.20 2019 Counts of Citations Issued to Motorcycle Operators at the Crash Scenes

Citation	Quarter				Total
	1	2	3	4	
Exceeding the Speed Limit	0	0	1	0	1
Failed to Grant Right-of-Way to Motor Vehicle	0	0	2	0	2
Following Too Closely	0	0	5	0	5
Improper Lane Use	0	1	4	0	5
Improper Passing	1	0	1	0	2
Improper Turning	0	1	0	0	1
Disregarding the Stop Sign	0	1	0	0	1
Careless Driving	0	5	3	0	8
Reckless Driving	0	1	1	1	3
Disregard the Officer	0	1	1	0	2
Hitting-and-Running	0	1	0	0	1
Driver's License Violation	1	9	11	1	22
No Insurance	2	5	7	1	15
Vehicle Registration Violation	1	1	6	1	9
Other	1	2	6	0	9
Total	6	28	48	4	86

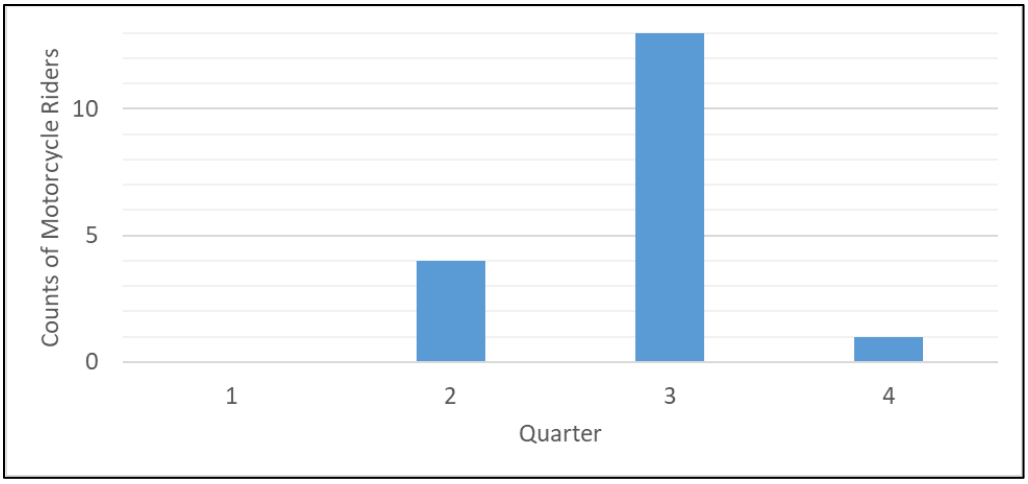

Figure 3.127 2019 counts of impaired motorcycle operators

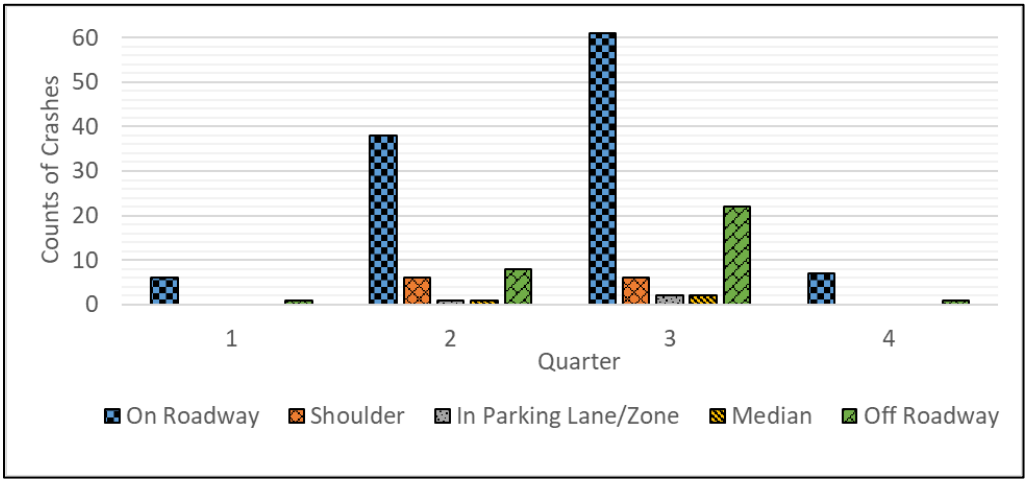

Figure 3.128 2019 counts of motorcycle crashes by first harmful event location

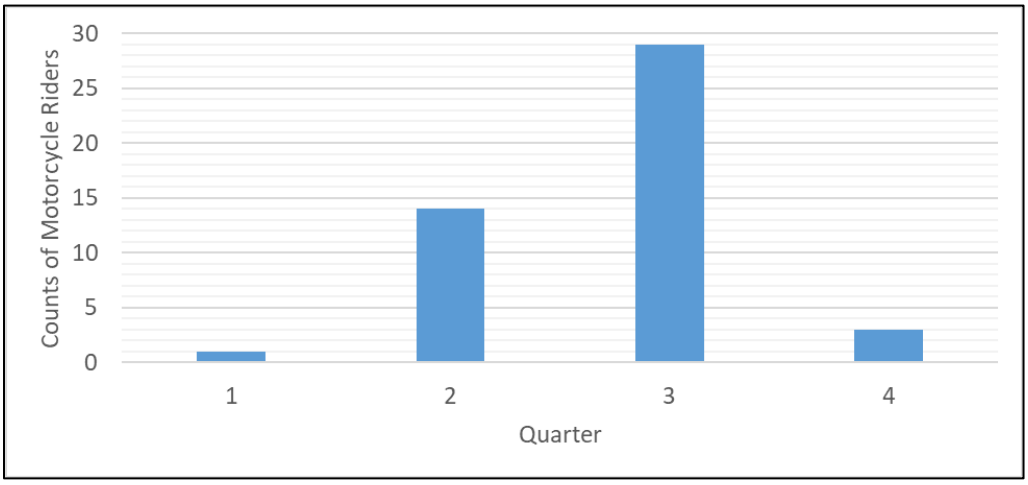

Figure 3.129 2019 counts of motorcycles involved in horizontal curve-related crashes

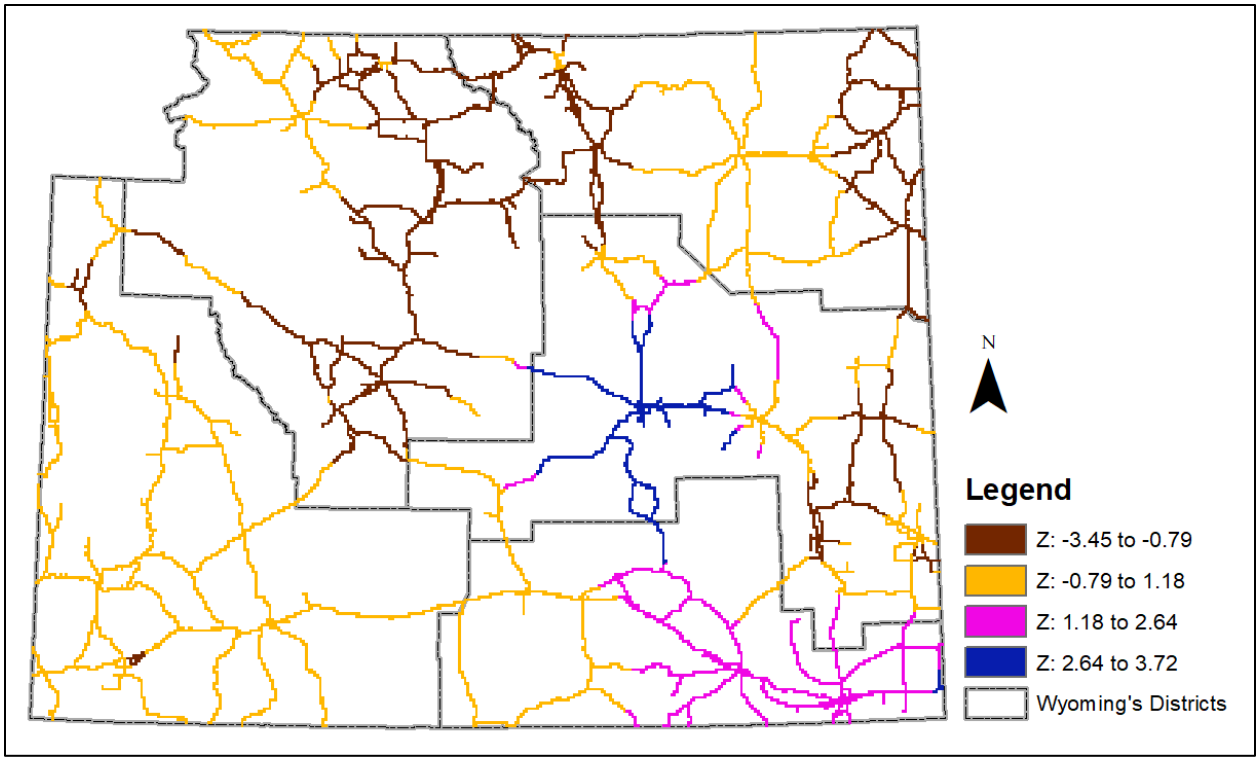

Figure 3.130 2017 heat map of motorcycle crashes

4. IDENTIFYING CRITICAL HUMAN FACTORS AND APPROPRIATE CRASH DATA REPORTING TIME FRAMES

The second objective of this study was to identify the human factors influencing road safety in Wyoming and crash data reporting periods by employing advanced big data analytics methods. An analysis was conducted to assess the impact of several human factors on crash severity in Wyoming via logistic regression and random forest modeling. Ascertaining appropriate periods to share road safety data is equally important. That is to diagnose road safety concerns and address them promptly. For instance, if crashes from which data were delivered to WYDOT's partner groups six months after their occurrences, the groups may identify specific problems, such as low seat belt use rates among a specific age group, at a belated time. Yet, as per the survey results of most groups, it is preferred that crash data from police reports be circulated at WYDOT's earliest convenience in addition to the sharing of processed quarterly road safety data summary statistics. Nevertheless, analyses were conducted to detect variations in crash counts throughout the days in order to ascertain appropriate road safety data delivery periods.

4.1 Identifying the Critical Human Factors

Multiple human factors were examined, including the driver's age, the driver's gender, driving too fast for the conditions, safety restraint use status, driving recklessly, driving under the influence of alcohol or drugs, driving while distracted, driving while exhausted or sleepy, and leaving the crash scene. A sample of crash records was extracted from WYDOT's road safety database for the years 2018 and 2019 to explore the influence of the human factors on crash severity. The descriptive statistics of the sample's parameters are presented in Table 4.1. Note that there were records of 21,837 crashes collected.

Table 4.1 Descriptive Statistics of the 2018 and 2019 Crash Records' Sample

Parameter	Frequency	Percent
Fatal or Suspected Serious Injury Crash	799	3.66
Driver Aged 20 Years or Younger Involved in the Crash	4,838	22.16
Driver Aged 61 Years or Older Involved in the Crash	4,974	22.78
Female Driver Involved in the Crash	10,265	47.01
Speed Related Crash	1,403	6.42
Improper or Non-Use of Safety Restraints Citation(s) Issued at the Crash Scene	349	1.60
Reckless Driving Related Crash	1,213	5.55
Driving under the Influence Related Crash	1,584	7.25
Distracted Driving Related Crash	1,756	8.04
Hit-and-Run Crash	1,680	7.69

As shown in Table 4.1, severe (fatal and suspected serious injury) crashes represented 3.7% of the data. Drivers aged 20 years or younger and those above 60 were involved in 22.2% and 22.8% of the crashes, respectively. Female drivers were involved in almost half of the crashes. Also, crashes related to speed, reckless driving, DUIs, and distracted driving and hit-and-run crashes comprised considerable proportions of the crash records. The WYDOT database included information on the driver's status, whether sound or not. With that, data records included drivers whose statuses were described as exhausted, sleepy, or unconscious. It was possible that the drivers were subject to blackouts due to trauma. Therefore, the driver's status variable was omitted to avoid biasing the analysis results. Instead, a separate analysis was conducted on this variable. That is, a contingency table test, also known as a $\chi 2$ test, was carried out to compare the injury severities of awake drivers with those of drivers who were exhausted, sleepy, or fell unconscious using data of the WYDOT database belonging to the years 2010 through 2019. The results are presented in Table 4.2. They indicated that driving while exhausted, drowsy, or experiencing a blackout may give rise to a fatal or serious injury.

Table 4.2 Results of the Driver's Status-Injury Severity Contingency Table Test

	Driver's Injury Severity	
Driver's Status	Suspected Minor Injury, Possible Injury or No Injury	Fatal or Suspected Serious Injury
Awake	236,891 (Row Proportion = 98.53%)	3,538 (Row Proportion = 1.47%)
Exhausted, Drowsy or Fallen Unconscious	8,472 (Row Proportion = 87.89%)	1,167 (Row Proportion = 12.11%)
χ^2	5,678.406	
Degrees of Freedom	1	
P-Value	< 0.001	

Preliminary analysis was conducted on the human factors data (Table 4.1) using the logistic regression structure. In particular, the severity of the crash records (fatal or suspected serious injury versus suspected minor injury, possible injury, and property damage only) was modeled as a function of the human factors. Under the logistic regression model, the probability of incurring a severe injury, P_i, is defined for each crash, i, as follows (*45*):

$$P_i = \frac{\exp\left(\beta_0 + \beta_1 X_{1i} + \beta_2 X_{2i} + \cdots + \beta_p X_{pi}\right)}{1 + \exp\left(\beta_0 + \beta_1 X_{1i} + \beta_2 X_{2i} + \cdots + \beta_p X_{pi}\right)} \quad (1)$$

The terms, X's, are the human factor attributes that give rise to the crashes and the β's are their respective regression coefficients obtained using maximum likelihood estimation. The model is assessed using the log-likelihood ratio test. It involves computing a χ^2 value, which is equivalent to the difference between the model's log-likelihood and that of a model with the constant term, β_0, only, also known as the null model. The degrees of freedom are considered as the count of the model's parameters excluding the constant. Another metric used for evaluating the goodness of fit of logistic regression models is the area under the receiver operating characteristic (ROC) curve. It is a measure of the model's ability to distinguish between severe and non-severe crashes. The influence of the parameters on crash severity is interpreted using odds ratios. An odds ratio is the ratio of the odds of witnessing a severe crash provided that a parameter is in effect to those of encountering the severe crash assuming that the parameter is not in effect.

The logistic regression model was run using the logistic procedure (*46*) of the SAS software package. The 95th percentile confidence interval was selected as the basis for ascertaining the parameters' statistical significances. The model's results are presented in Table 4.3 and the parameters' odds ratios are presented in Table 4.4.

Table 4.3 Logistic Regression Model's Results

Parameter	Estimate	P-Value
Constant	-3.246	< 0.001
Driver Aged 20 Years or Younger Involved in the Crash	-0.310	0.004
Driver Aged 61 Years or Older Involved in the Crash	0.216	0.015
Female Driver Involved in the Crash	-0.651	< 0.001
Speed Related Crash	-	-
Improper or Non-Use of Safety Restraints Citation(s) Issued at the Crash Scene	1.399	< 0.001
Reckless Driving Related Crash	-	-
Driving under the Influence Related Crash	1.851	< 0.001
Distracted Driving Related Crash	-	-
Hit-and-Run Crash	-2.123	< 0.001
Model Fit Summary		
Log-Likelihood	-3,113.115	
Log-Likelihood of Null Model	-3,427.293	
χ^2	628.358	
Degrees of Freedom	6	
P-Value	< 0.001	
Area under ROC Curve	0.717	

Note: - = statistically insignificant parameter at the 95th percentile confidence interval removed.

Table 4.4 Logistic Regression Model's Odds Ratios

Parameter	Odds Ratio	95th Percentile Confidence Limits	
		Lower Limit	Upper Limit
Driver Aged 20 Years or Younger Involved in the Crash	0.734	0.596	0.903
Driver Aged 61 Years or Older Involved in the Crash	1.241	1.042	1.477
Female Driver Involved in the Crash	0.522	0.445	0.611
Improper or Non-Use of Safety Restraints Citation(s) Issued at the Crash Scene	4.051	2.961	5.542
Driving under the Influence Related Crash	6.366	5.343	7.586
Hit-and-Run Crash	0.120	0.072	0.199

Each parameter's effect on crash severity was interpreted assuming all else was controlled. As shown in Table 4.4, the involvement of a driver aged 20 or younger in the crash reduced the odds of resulting in fatalities or suspected serious injuries considerably. Perhaps, young drivers are inexperienced and hence are less inclined to execute risky driving maneuvers. Yet, as per Braitman et al. (2008), teenage drivers are likely to commit traffic violations which lead to crashes (*47*). The presence of an elderly driver, aged 61 or above, raised the odds of sustaining severe injuries possibly because of the deteriorated health conditions of elderly drivers (*48*). The involvement of female drivers substantially curtailed the odds of giving rise to fatalities and suspected serious injuries. Plausibly, male drivers are more aggressive than female drivers (*49*). Thus, crashes solely involving male drivers are likely to be severe relative to those involving female drivers. Other than age and gender, being cited for not properly buckling up substantially elevated the risk of incurring fatalities and suspected serious injuries, a result consistent with that of the National Highway Traffic Safety Administration (*50*). Likewise, a crash involving driving under the influence of alcohol or drugs would drastically increase the odds of giving rise to severe consequences, a finding in line with Holdridge et al. (*51*). On the contrary, a hit-and-run crash was found to be less likely to lead to fatalities and suspected serious injuries possibly because such crashes incur damages to property that are worth less than the minimum reporting thresholds. Speeding, reckless driving, and distracted driving were not found to be associated with crash severity. Imprialou et al. (2016) maintained that speeding gives rise to severe crashes (*52*). Also, aggressive-driving-related crashes represented a considerable proportion of fatal crashes according to the Insurance Information Institute (*53*). Regarding distracted driving, Lym and Chen (2021) investigated distracted-driving-related crashes and concluded that their severities varied by the nature of the crash site, whether roundabouts or work zones, among others (*54*).

The random forest modeling method (*34*), which is a data mining method, was selected to ascertain the importance of the human factor parameters influencing crash severity in Wyoming as an accompanying subtask. The random forest method is a modification of the decision tree method. It entails the application of bootstrapping. Bootstrapping is a resampling technique in which data points are drawn from the original dataset with replacement and the collected records comprise a new set, termed the bootstrapped set. Several bootstrapped sets are generated and a decision tree is developed for each set. However, when the trees are fitted, the tree nodes are split based on calculations performed on a randomly selected number of parameters. This number is equivalent to the square-root of p, the data's parameter count. The random forest model may also be implemented to estimate the relative importance of the parameters in terms of their effects on the outcome crash severity. James et al. (2013) elaborate on the random forest regression method (*34*).

The random forest model was developed using the randomForest package (*55*) of the R software package. The default number of 500 bootstrapped samples was selected for the model. The model's variable importance chart is presented in Figure 4.1. As shown in the figure, the importance of each variable was gauged using the mean decrease in the Gini index measure (*34*). The Gini index indicates the purity of the tree leaves where a pure leaf is one of which observations are all allocated to the same class of the outcome (severe crash versus non-severe crash). The top three influential variables were identified as DUI, improper or non-use of safety restraints, and leaving the crash scene.

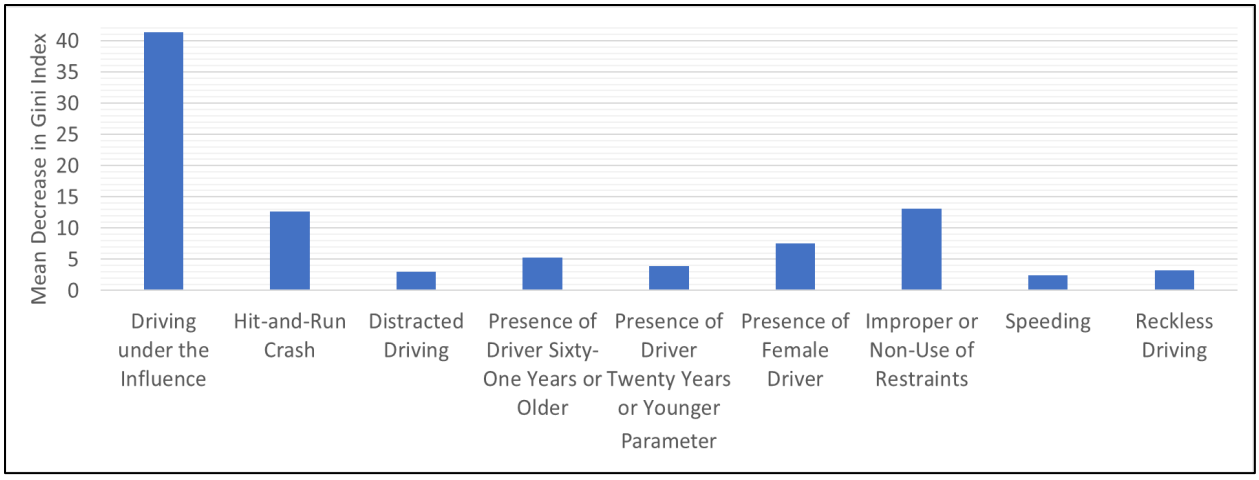

Figure 4.1 Random forest model's variable importance chart

It is worth comparing the human factors' analysis results with those of multiple studies related to this project. The studies were related to safety restraint use (*56*), bicycle safety (*57*), truck safety (*58*), and crashes involving child passengers (*59*). Each study is discussed in the following content.

Rezapour and Ksaibati (2021) employed observational safety restraint use survey data collected in 2019 from several Wyoming counties (*56*). A total of 18,286 drivers participated in the survey. The data variables were restraint use status, driver's gender, area type (urban or rural), weather condition (clear or not), vehicle class (van, sport utility vehicle, pickup truck, or other), time of day, roadway facility type, vehicle registration (Wyoming or out of state) and day of week (weekday or weekend). The authors implemented the multinomial logit model, latent class multinomial logit model, and latent class multinomial logit model with decision rules. The latent class model with decision rules exhibited the best fit. Also, it was concluded that gender, vehicle class, time of day, and roadway facility type would all influence the driver's inclination to buckle up.

In another effort, Rezapour and Ksaibati (2021) utilized bicycle crash data from WYDOT belonging to the years 2011 through 2019 (*57*). The data variables were alcohol use, age of the bicyclist, whether the bicycle crash was a hit-and-run crash, driver's action prior to the crash (turning or not), number of travel lanes, lighting conditions, speed limit, the injury severity of the bicycle crash, and others. The authors applied a Hamiltonian Monte Carlo method to investigate the influence of the bicycle crash contributing factors on crash severity. According to the study's conclusions, elderly bicyclists, a large number of lanes, dark conditions, high speed roads, alcohol use, and other parameters were associated with a greater risk of incurring severe injuries. The authors suggested the establishment of an educational campaign addressing bicycle safety.

Other than the bicycle safety study (*57*), Rezapour et al. (2021) conducted analyses that culminated in suggesting safety mitigation measures aimed at improving truck safety (*58*). Data of crashes involving trucks having a gross weight vehicle rating exceeding 10,000 pounds were collected from WYDOT, and the crash years were 2011 through 2014. Also, truck drivers' ticketing data were collected from the Wyoming Highway Patrol. The authors focused on Interstate-80, I-25, portions of US-30 with heavy truck traffic, and sections of US-26 with considerable truck traffic. In particular, the data variables were weather condition (clear or not), road surface condition (dry or not), crash season (winter or not), ticket issuance season (winter or not), crash day of the week (weekend or not), crash time (off-peak or not), ticket issuance time (off-peak or not), speed limit, whether the speed limit was exceeded, whether the truck driver was the culpable driver in the crash, and crash type (single vehicle or multiple vehicle), among others. As per the results, the majority of truck crashes on I-80 and I-25 were witnessed in the

winter. For those highways, wet, icy, or snowy conditions raised the risk of observing higher truck crash counts. Hence, the authors suggested directing attention to winter-weather-related truck crashes. The authors also recommended tighter enforcement policies targeting truck drivers traveling along I-80 and I-25 since the analysis results indicated that truck drivers were the ones who were blameworthy in a considerable number of truck crashes on those highways. Other suggestions included addressing low visibility conditions, educating truck drivers (Wyoming and out-of-state truck drivers) on the hazards of traversing mountainous terrain, tightening the enforcement of speeding policies, tightening the enforcement of tailgating policies, tightening the enforcement of erroneous lane change policies, and deploying rumble strips along both aforementioned interstates. The suggestions stated might be discussed in truck drivers' periodicals and newsletters.

Rezapour and Ksaibati (2021) carried out a study on crashes involving children in Wyoming. Data of crashes involving 12,209 children aged nine and younger were obtained from WYDOT (*59*). The crash years were from 2013 to 2019. With that, the data parameters were the safety restraint use status of the driver, road surface condition (icy/snowy or not), alcohol or drug use, weather condition (rainy, snowy, or other), child restraint use status by type of restraint (booster seat, forward-facing seat, rear-facing seat, etc.), crash type (rear-end, angle, etc.), and crash severity, among others. The authors selected an ordinal finite mixture modeling approach to conduct their analyses. As per the study's results, incorporating random effects into the modeling improved the goodness of fit. Furthermore, child restraints would reduce crash injury severity and multiple-vehicle crashes would be less severe than single-vehicle crashes. Driving under the influence of alcohol or drugs and the involvement of unbelted drivers would contribute to a higher chance of sustaining severe injuries. Also, icy or snowy road surfaces would decrease the chance of incurring severe injuries, possibly because drivers would compensate by traveling vigilantly on non-dry roads. Based on the study's findings, the authors suggested raising the civil fine amounts of intoxicated drivers with child passengers and drivers with unrestrained child passengers to protect children from excessive harm. The authors also shared their concerns about the likelihood of unrestrained drivers with children being involved in severe crashes.

4.2 Identifying Appropriate Crash Reporting Time Frames

Other than identifying the crucial human factors influencing crash severity in Wyoming, it is essential that crash-reporting time frames be established. Providing WYDOT's safety partners the relevant data promptly would enable them to diagnose and address safety problems in a timely fashion. WYDOT's 2019 road safety data were utilized to estimate the appropriate reporting periods. As such, assessments were made on the changes in counts of specific crash types from one day to the other throughout 2019. The crash types were:

- total crashes
- crashes involving fatalities, suspected serious injuries, or suspected minor injuries
- crashes involving the issuing of citations for improper use or non-use of restraints
- speeding-related crashes
- adverse-weather-related crashes
- animal crashes
- DUI-related crashes
- crashes involving non-motorists
- motorcycle crashes

The bcp package of R was employed to evaluate such fluctuations (*60*). It implements Markov chain Monte Carlo analyses. Details of the package's procedure are available in Wang et al. (*60*). The analysis results are presented in Figures 4.2 through 4.10.

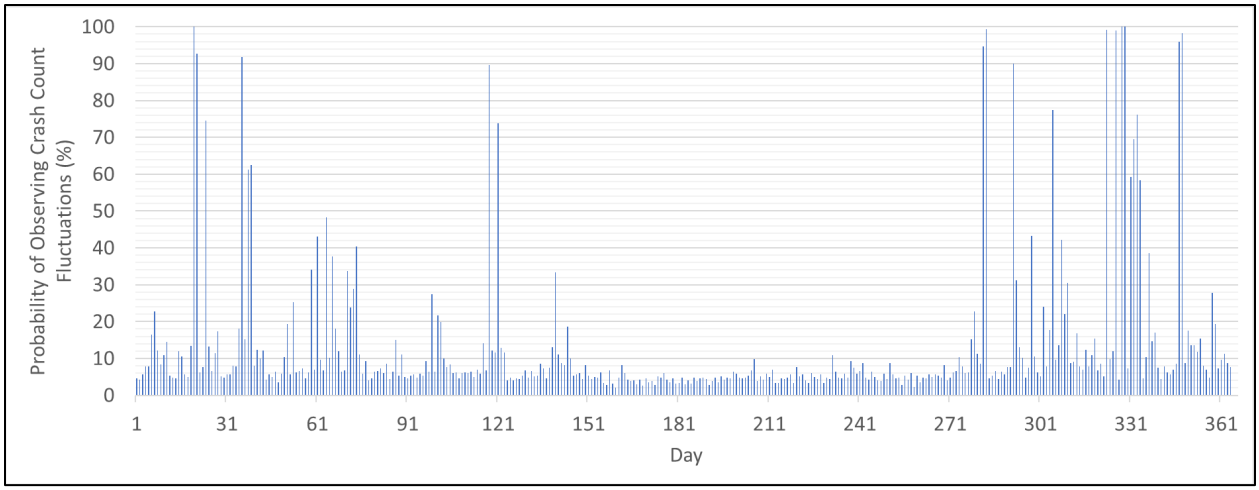

Figure 4.2 Estimated probabilities of observing fluctuations in crash counts throughout 2019

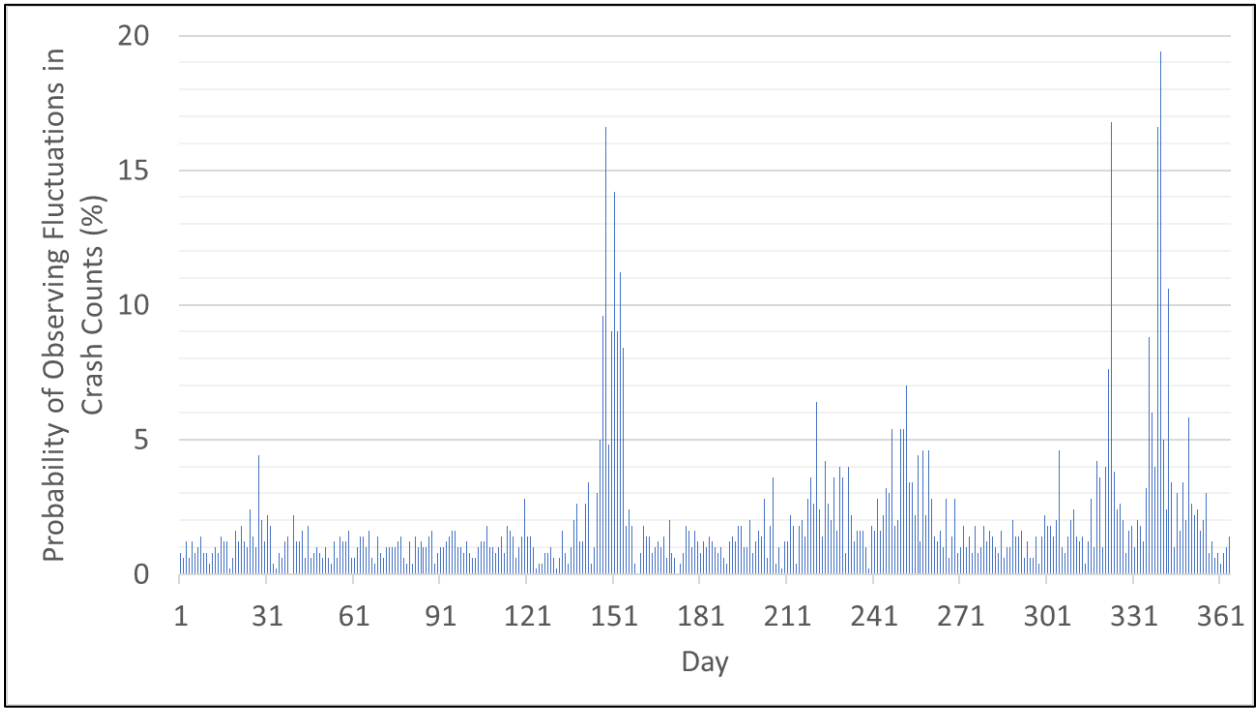

Figure 4.3 Estimated probabilities of observing fluctuations in counts of fatal, suspected serious injury, and suspected minor injury crashes throughout 2019

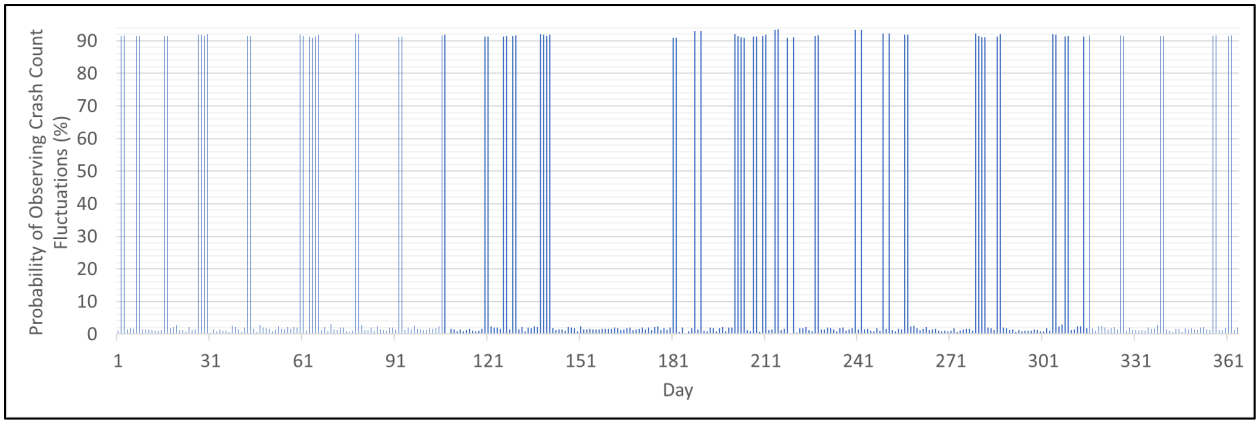

Figure 4.4 Estimated probabilities of observing fluctuations in counts of crashes involving improper or non-use of safety restraints throughout 2019

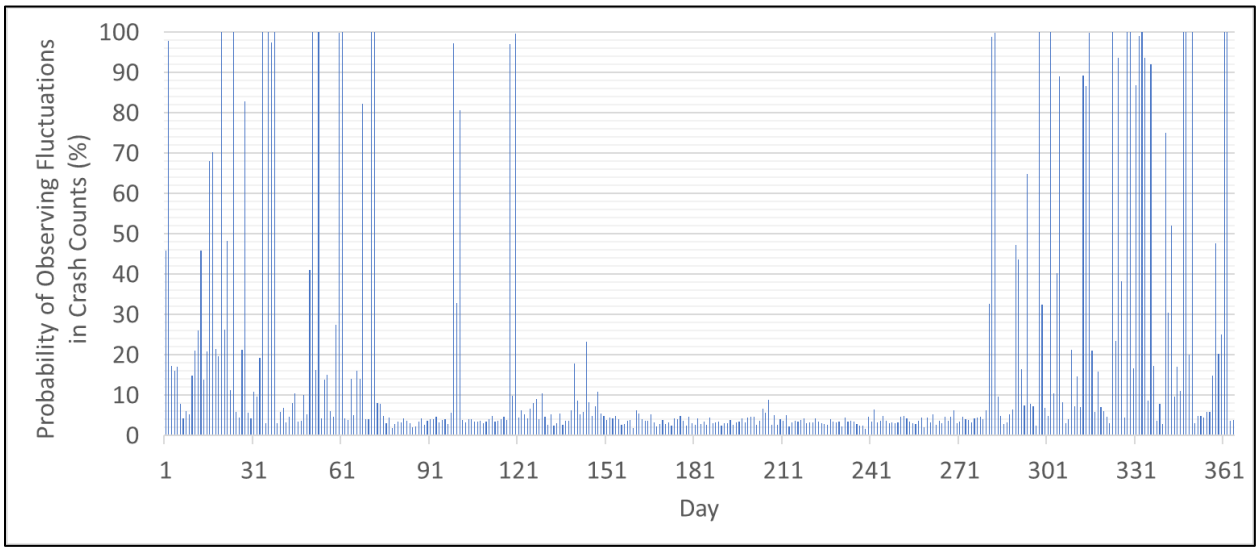

Figure 4.5 Estimated probabilities of observing fluctuations in counts of speed-related crashes throughout 2019

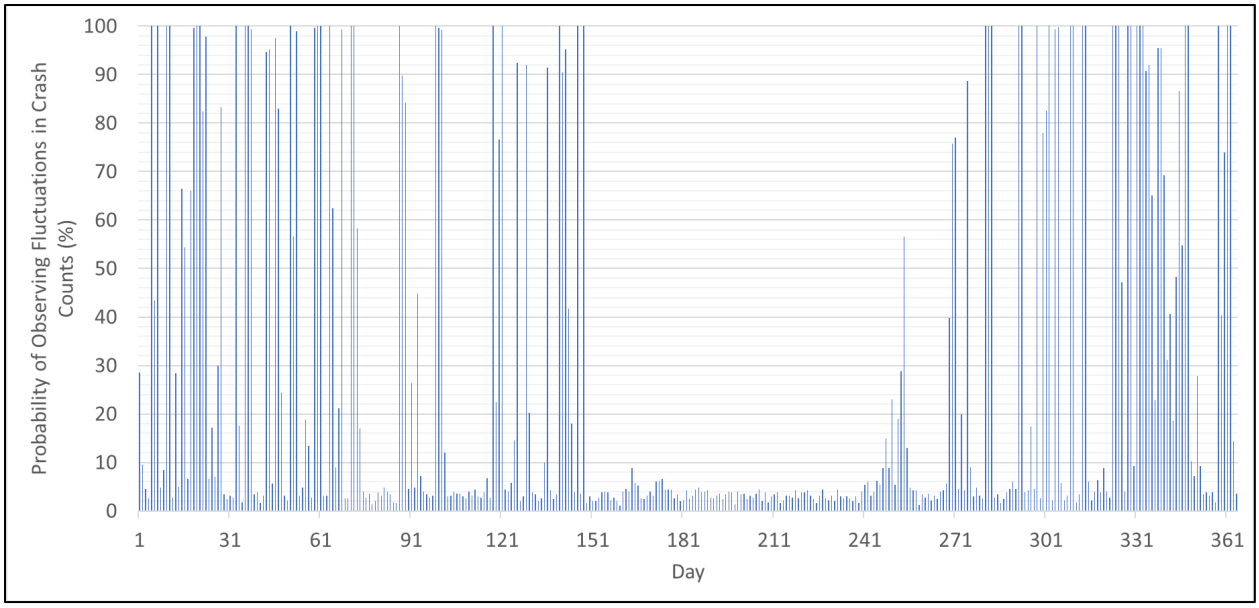

Figure 4.6 Estimated probabilities of observing fluctuations in counts of adverse-weather-related crashes throughout 2019

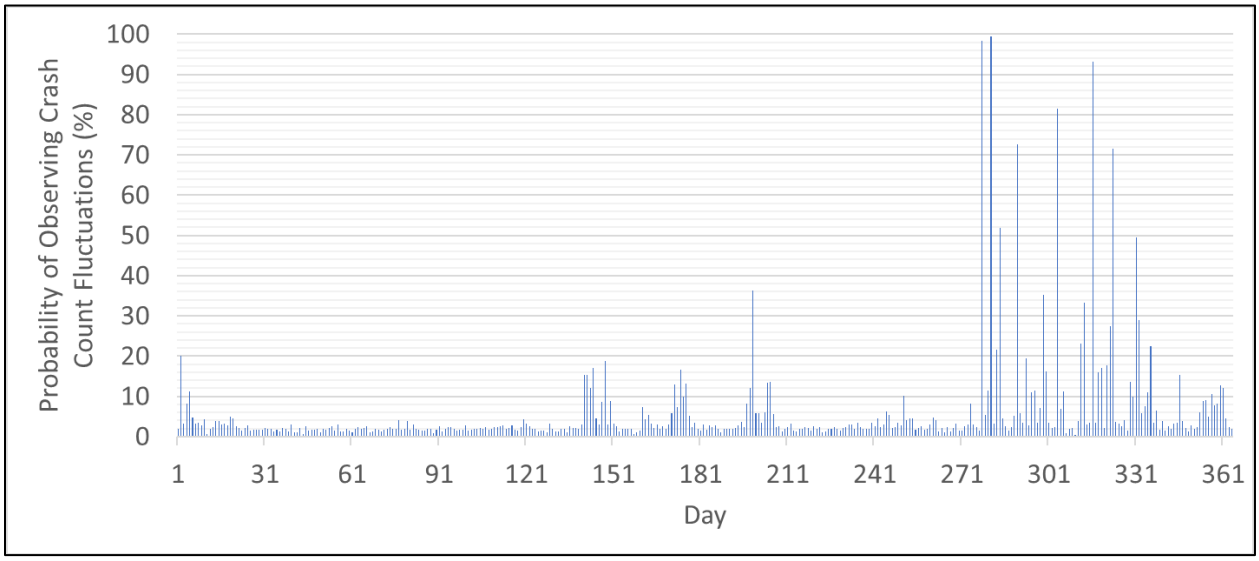

Figure 4.7 Estimated probabilities of observing fluctuations in counts of animal crashes throughout 2019

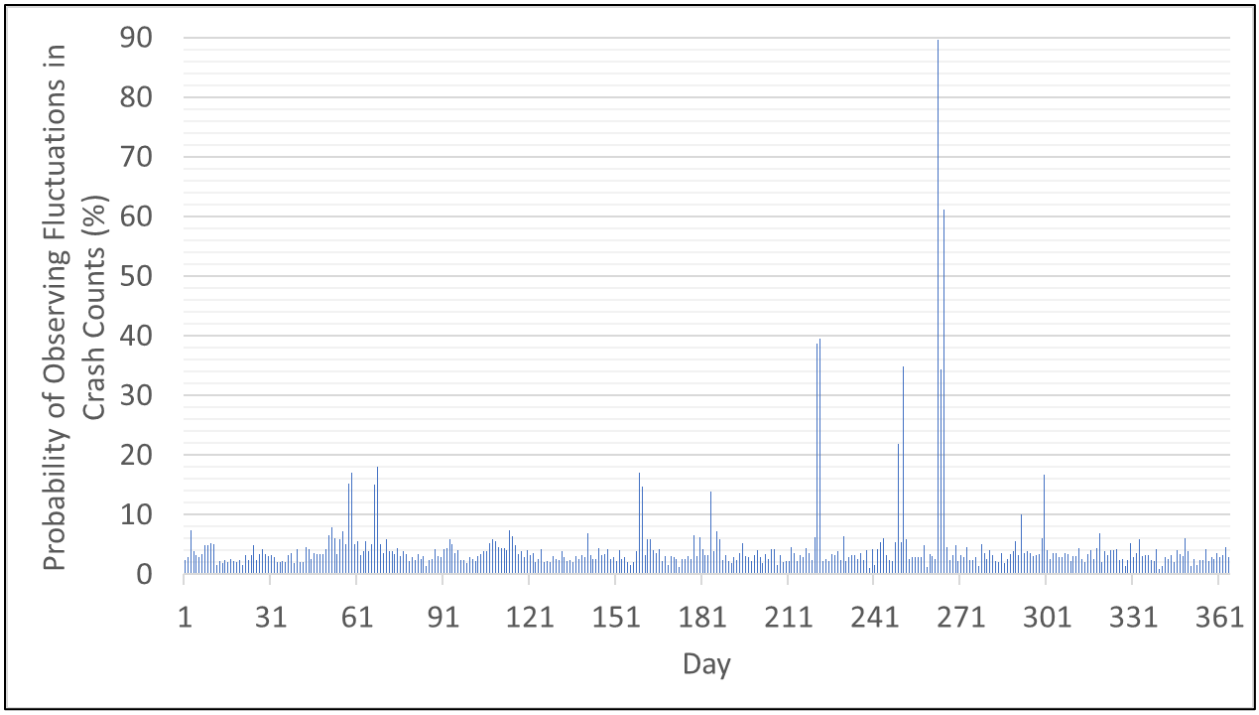

Figure 4.8 Estimated probabilities of observing fluctuations in counts of driving under the influence crashes throughout 2019

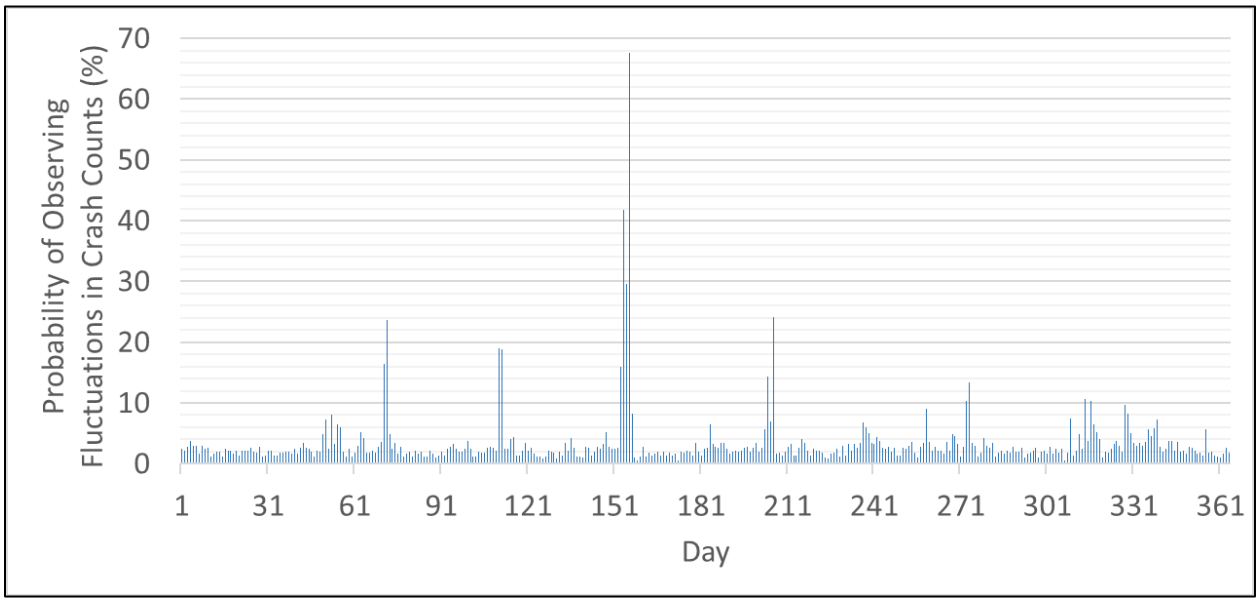

Figure 4.9 Estimated probabilities of observing fluctuations in counts of non-motorist crashes throughout 2019

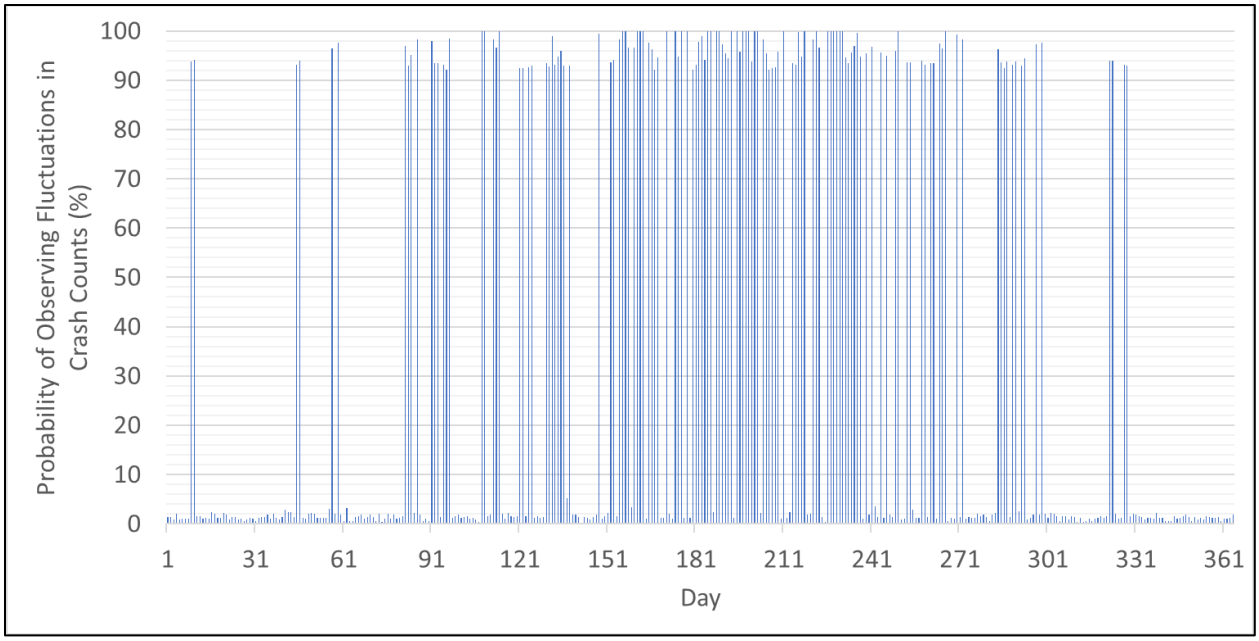

Figure 4.10 Estimated probabilities of observing fluctuations in counts of motorcycle crashes throughout 2019

As shown in Figure 4.2, there were large, estimated probabilities of observing fluctuations in crash counts except for the period between June and September. As previously stated, the recommendation is to report crashes, regardless of type, at the earliest convenience to WHP, WASCOP, and the counties.

When it comes to fatal, suspected serious injury, and suspected minor injury crashes (Figure 4.3), changes in their observed frequencies from one day to the other did not exceed 20%, indicating a steady trend. Similar to the case of total crashes, sharing data of fatal, suspected serious injury, and suspected minor injury crashes to WHP, WASCOP, and the counties as soon as they are ready for circulation is satisfactory.

The trends of crashes in which citations were issued for improperly buckling up or not buckling up had high estimated likelihoods of fluctuating on a day-to-day basis for multiple months as shown in Figure 4.4. Hence, it is suggested that data of crashes involving improper use or non-use of safety restraints be provided to the Wyoming Seat Belt Coalition as soon as they are prepared for dissemination. This suggestion is consistent with that provided according to the inferences drawn from the WSBC survey results.

Speeding-related crashes exhibited varying trends. The counts of such crashes would fluctuate intermittently except for the period May to September, as shown in Figure 4.5. Reporting speed-related crashes to WHP, WASCOP, and Wyoming's counties at the earliest convenience is recommended. Adverse-weather-related crash patterns were likely to vary erratically except for the months June to August, as shown in Figure 4.6. It is suggested that data of such crashes be shared with WHP, WASCOP, and the counties as soon as they are ready for circulation.

Animal crash trends exhibited a low probability of fluctuation except during October and November (Figure 4.7). The delivery of animal crash data to WHP, WASCOP, and Wyoming's counties as soon as practically possible, especially during this period, is recommended.

The trends of DUI-related crashes had low likelihoods of constantly fluctuating, as shown in Figure 4.8. Thus, disseminating data of those crashes to WHP, WASCOP, the counties, and GCID as promptly as potentially possible is recommended. This recommendation is consistent with those provided according to the interpretations of the corresponding survey results.

Pedestrian and bicycle crash trends exhibited a low probability of continuously oscillating within a week (Figure 4.9). As previously stated, the surveys' results indicated that it is best to deliver crash data to WHP, WASCOP, and Wyoming's counties as rapidly as practically possible. According to the results of the WBPSTF survey, it is also suggested that the WYDOT HSO share its non-motorist crash data to WBPSTF as soon as the data become available.

Unlike non-motorist crash patterns, those of motorcycles were predisposed to vary intermittently from one day to the other. As such, providing motorcycle crash data to WHP, WASCOP, Wyoming's counties, and motorcycle groups as promptly as potentially possible is a recommended course of action.

5. CONCLUSIONS AND RECOMMENDATIONS

Ultimately, this study was aimed at assessing the road safety data needs of WYDOT's partner groups, which are the Wyoming Seat Belt Coalition, the Wyoming Highway Patrol, the Wyoming Association of Sheriffs and Chiefs of Police, the Wyoming Transportation Safety Coalition, the Governor's Council on Impaired Driving, Wyoming's counties, the Wyoming Bicycle and Pedestrian System Task Force, and motorcycle groups in the state. Even though the aforementioned groups already receive data from WYDOT either in the form of summary statistics documented in reports or database files, there was a dire need to assess the groups' data requirements. This was to inquire about the quality of the data, especially when it came to crash data reporting time frames and gaps in reporting. Surveys were drafted and disseminated to those groups seeking information on their data needs. The surveys were collected, and their results were inferred in order to suggest recommendations for WYDOT regarding road safety data reporting. In particular, the recommendations pertained to specific data elements to be reported, crash data reporting intervals, and appropriate formats for presenting the data. Once WYDOT implements the recommendations, its partners would have access to comprehensive data delivered to them in a timely manner and thus would be able to achieve their objectives efficiently.

Suggestions made for WYDOT include the provision of the following data for WHP, WASCOP, and Wyoming's counties:

- Crash statistics by crash type
- Crash injury severity levels statistics by age/gender
- Seat belt use statistics
- DUI statistics
- Fatigued-driving-related crash statistics
- Distracted-driving-related crash statistics
- Traffic violation statistics
- Truck policy violation statistics
- Crash statistics by weather condition
- Crash statistics by lighting condition
- Crash statistics by day of the week
- Crash statistics by time of day
- Motorcycle crash statistics
- Hot spots by crash severity level and description (seat belt improper use or non-use, CMV-related, etc.)

Other noteworthy suggestions entail the planning for research studies relating to the following topics:

- Effectiveness of speed, seat belt use, and other violation enforcement policies
- Effectiveness of traffic safety educational campaigns
- Response times of emergency services, particularly for fatal, suspected serious injury, and suspected minor injury crashes

For the other groups—the Wyoming Seat Belt Coalition, Wyoming Transportation Safety Coalition, Governor's Council on Impaired Driving, Wyoming Bicycle and Pedestrian System Task Force, and the motorcycle groups—the recommendations are similar. Yet, they are tailored to seat belt use, truck safety, impaired driving, non-motorist safety, and motorcycle safety, respectively. Human factors influencing crash severity—including driving under the influence, leaving the crash scene, distracted driving, the involvement of a young driver aged 20 or below, the involvement of an elderly driver aged 61 or above, the involvement of a female driver, improper or non-use of safety restraints, speeding, and reckless driving—were investigated using two techniques. They were the logistic regression framework and the

random forest data mining method. Most of those parameters were found to be influential except for speeding, reckless driving, and distracted driving. Furthermore, an analysis was conducted to gauge fluctuations in crash trends. With that, road safety data sharing time frames were suggested. Finally, it is anticipated that WYDOT will not only implement the aforementioned recommendations, but also develop a strategy to conduct follow-up studies on the aforementioned suggested research topics (e.g., effectiveness of traffic safety educational campaigns).

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