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

By

Anas Alrejjal, Graduate Assistant
Doctoral Student Research Assistant, Wyoming Technology Transfer Center,
University of Wyoming, Laramie, WY 82071, aalrejja@uwyo.edu

Milhan Moomen, Ph.D.
Postdoctoral Research Associate, Wyoming Technology Transfer Center,
University of Wyoming, Laramie, WY 82071, aalrejja@uwyo.edu

Khaled Ksaibati, Ph.D., P.E.
Director, Wyoming Technology Transfer Center, University of Wyoming,
WY 82071, Tel: (307) 766-6230; khaled@uwyo.edu

Sponsored by:

Matt Carlson, P.E.
State Highway Safety Engineer
Wyoming Department of Transportation

October, 2019

1 INTRODUCTION

Road crashes have been a substantial concern for public highway agencies and societies for several decades. Traffic safety analysis is required to raise awareness about the effects of road crashes and traffic injuries, convince policy makers to take action, identify safety hot spots and recommend best measures to counter the occurrence of traffic crashes. To achieve this, reliable and accurate data are needed to identify factors impacting crashes, formulate strategies, set targets and monitor safety performance. Police-recorded crash data forms the primary source of information about crashes and the relation of the environment, human behavior and vehicle characteristics to the crashes.

The Wyoming Department of Transportation (WYDOT) is the main transportation agency responsible for traffic safety in the state. It is also the main source of highway safety and crash data, and it manages all traffic datasets using appropriate techniques to increase data quality. Therefore, WYDOT allocates substantial resources on traffic data in order to meet the main goals and strategies of partner agencies in providing high quality data to enhance traffic safety. Such a data driven approach ensures that significant safety issues can be identified and funding from WYDOT and other agencies for safety programs will be allocated more efficiently.

Traffic safety stakeholders and partner agencies in Wyoming rely on WYDOT to provide reliable and accurate data to fulfill their strategic goals. However, a gap exists between the expectations of the agencies in terms of data type and quality required, and what is provided by WYDOT. Also, because human factors form a significant proportion of the factors impacting crash frequency and severity, an analysis is required to identify these factors. The product of this study will be an identification of the safety data needs of partner agencies by identifying gaps in the type and quality of safety data provided by WYDOT through a survey questionnaire. Additionally, important human factors that play a significant role in crash severity and frequency will be identified through big data analysis and the frequency of reporting these factors to agencies will be determined. This will result in an improvement in the reporting of safety data to partner agencies so that effective countermeasures and policies may be implemented to improve traffic safety in Wyoming.

2 STUDY OBJECTIVES

The first objective of this study is to assess the data needs of WYDOT's safety partners and agencies, identify gaps in crash reporting, and recommend appropriate guidelines to present traffic safety data. The second goal of the study is to identify human factors that impact crash severity and frequency in Wyoming using big data analysis and determine reporting intervals for such factors.

The study will present recommendations that ensures that safety agencies have access to high quality safety data that helps them to formulate programs, policies and interventions to counter crashes in Wyoming. Identification of significant human factors that cause crashes and the required frequency of reporting will help in the targeting of risky behaviors by enforcement and influence effective implementation of countermeasures.

3 BACKGROUND

There are several agencies in Wyoming who partner WYDOT in issues of traffic or occupational safety. These agencies rely on safety data provided by WYDOT to conduct analyses and assess or monitor the impact of their programs. WYDOT utilizes the Wyoming Electronic Crash Reporting System (WECRS) to generate crash reports. This is a web based reporting system where details of crashes recorded in the field are stored in a database. However, differences exist between the data type and quality required by the agencies and what is provided by WYDOT. This difference in data expectations makes it difficult for the agencies to identify safety problems and target resources more effectively.

Also, human factors have been identified as major contributors to crash severity on highways. The Wyoming Department of Health has identified several human factors that are responsible for injury-related deaths in road crashes. Older adult drivers (drivers aged 65 and older) and teen/new drivers have been identified as the two groups most at risk to hospitalization and fatality (Wyoming Department of Health, 2019). Human factors related to the two groups include lack of experience, risk-taking, distracted driving, medication and low seatbelt use rate. Some partner agencies in the state focus on the role of human factors in traffic crashes. These include the Wyoming Association of Sheriffs and Chiefs of Police who focus on traffic safety overall; impaired driving, speeding and crash investigations. The Governor's Council on Impaired Driving whose aim is to reduce impaired driving, and the Wyoming Seatbelt Coalition whose mission is to increase seatbelt use. The frequency of reporting these human factors to the partner agencies is critical for decision-makers and implementation of countermeasures.

Safety data is pivotal in promoting evidence-based interventions on Wyoming highways as a means to promote safety. To this end, accurate and comprehensive data are required by safety partners to support the implementation and evaluation of highway safety strategies targeted at reducing crashes. This study therefore aims to identify and bridge the gaps between the data needs of WYDOT's partner agencies and the data currently available to them. The study also aims to identify significant human factors influencing crashes by big data analysis and to determine appropriate reporting intervals of these factors to partner agencies.

4 LITERATURE REVIEW

Traffic safety management is a shared responsibility of many agencies involving their strategies, interventions and the results of such measures. The goals and objectives of most safety agencies are mostly geared towards the reduction of final outcomes (deaths and serious injuries) or the effect of intermediate ones (e.g. mean traffic speeds, seat-belt use, drink-driving), and socio-economic costs associated with traffic injuries. Performance indicators and safety targets that stress the results of safety efforts in improving safety are set using outcomes as a benchmark. A key to achieving traffic safety targets is the data collection and analysis process. A comprehensive database and analysis system is essential for formulating effective safety strategies, determining countermeasures and monitoring program effectiveness. A comprehensive dataset enables the evaluation of several factors including final outcomes, exposure measures, intermediate outcomes, socio-economic costs and the impact of enforcement efforts (Australian Transport Council, 2008).

A traffic safety management system consists of the people, processes, hardware and software involved in collecting, processing and managing information related to road crashes (World Health Organization, 2010). A traffic safety management system serves as the main repository of safety data from is accessible to agencies for their safety analysis. An important part of the traffic management system is a crash reporting regime. This forms the basic way data is collected and processed for the safety management system. Crash reporting has generally been done manually which entails enforcement officers entering crash information on printed forms. However, electronic and online systems are being increasingly adopted by state agencies. Online reporting systems reduce data collection and transmission errors, resulting in more reliable data (Khattak, 2016). Also, online crash reports are verified before being uploaded and are almost immediately available for analysis.

4.1 WECRS

The WECRS utilizes the ReportBeam electronic crash reporting system. ReportBeam is a web based system compatible with the Microsoft windows operating system. ReportBeam is integrated with the Smart Roads diagramming tool that allows officers to easily draw precise diagrams in minutes which can be combined with reports.

The ReportBeam system is composed of two parts. These are the client system and server. The client system is where reports are filled and its layout is similar to email. This is done through a report manager which has got inbox, drafts and new report folders. The new report folder generates forms which are filled. Uncompleted reports are stored on the drafts folder while reports that have been uploaded but rejected are returned to the inbox. The server system makes up the second part of ReportBeam. It is web based and gives access to supervisors designated to approve reports. It enables generation, analysis, and distribution of prepared reports.

ReportBeam operates based on four main functions. These are filling reports, managing reports, analyzing data and distributing reports. Officers in the field quickly fill up the reports which are then submitted. The system works offline and does not require a network connection for filling the reports. A module within the reporting system called data clips makes it possible for driver license information to be automatically populated by scanning. Also, police officers are allowed to create profiles that populates reports automatically with the officer's information anytime a new report is opened, thereby speeding up the report filling process.

Report management is undertaken by supervisors who can either accept or reject reports. Submitted reports are transferred to a centralized database where supervisors can review reports for completeness and accuracy. Rejected reports are sent back to the officer who filled them along with notes. The system retains a transactional audit log to show everything done to the report along with the people who created, accessed and modified the report. Approved reports are indexed and data fields are then extracted from the uploaded report.

The crash data is available instantly after a report has been uploaded. Reports are immediately accessible to supervisors who can view map views that shows crash locations, statistical trends and officer locations. A built-in mapping engine integrated with the report beam system makes it possible to display all crashes, supplying a view of hotspots and other collision statistics. The system features a location-based analysis system that allows a quick location of high incident crash hot spots so that decision makers can deploy timely countermeasures. Other key features available with the data analysis module include a crash analysis tool, built-in reporting system with charting capabilities, and customizable reporting based on filter options. Statistics can be generated for locations or intersections for crash trends. These statistics can be displayed in the form of bar charts, pie charts or other format. Results from the data analysis module can be used for proactive policing. For instance, a report generated from the system can show an increase in alcohol related incidents within a two hour frame for a specific location (report beam ref).

4.2 Human Factors

Information from the WECRS is in three categories. These are vehicle characteristics, environmental factors and driver characteristics also referred to as human factors. Human factors comprise the main risk influences to crash injury severity. About 94% of the critical reason for crashes in 2018 was attributed to drivers (Singh, 2018). Dingus et al. observed five categories of human factors using naturalistic driving data (Dingus *et al.*, 2016). These were observable impairment (e.g. alcohol/drugs, fatigue), driver performance error (e.g. improper turn), driver judgment error (e.g. speeding, following too closely), and observable distraction (e.g. cell phone use, eating). Observable impairment was found to increase the odds of crashes by 5.2 times compared to when no impairment was observed. Driver performance error had the highest odds among the categories of 18.2 times compared to when no error was recorded.

The prevalence of high volume data generated from social networking, search queries, mobile phones, science data, search queries and health records has led to the development of big data analysis techniques. Big data analysis enables the examination of large amounts of data to reveal hidden trends, patterns, and correlations. Advanced analytical techniques are employed for very large, diverse data sets whose size is usually beyond the ability of traditional relational databases to manage and analyze efficiently. In the context of traffic safety analysis, data mining and machine learning algorithms are the predominant big data tools that have been employed in the literature.

Big data techniques have been applied to in the field of traffic safety in the last two decades. Many of the techniques classify severity by finding patterns and utilizing models to sort records from a large amount of data related to a specific class of severity such as non-injury, injury or fatal (Kashani and Mohaymany, 2011). This allows for the determination of factors causing a crash to be in a specific class of crash severity. Techniques commonly applied for crash severity studies include decision trees (Kashani and Mohaymany, 2011; Chan and Chien, 2013; Abellan *et al.*, 2015), support vector machines (Li *et al.*, 2008; Yu and Abdel-Aty, 2014; Chen *et al.*, 2016), and artificial neural networks (Delen *et al.*, 2006; Zeng and Huang, 2014).

Decision trees represent a non-parametric parametric method that does not depend on any functional form and require no prior probabilistic assumptions of the underlying relationship between the dependent and independent variables. Decision trees have been proven to be powerful tools in predicting and classifying factors impacting severity crashes. The decision tree technique employs a classification approach that ensures that entities within a group have homogeneous characteristics.

Support vector machines is another classification technique based on supervised learning and has increasingly been adopted for traffic safety research. Support vector machine models have been found to outperform traditional statistical approaches and some machine learning techniques. The strength of support vector machines has been attributed to its structural risk minimization and ability to efficiently fit training data (Vapnik, 1998).

Artificial neural networks, based on the nature of the human brain, are capable approximating non-linear models to determine the relation between dependent and independent variables (Moghaddam *et al.*, 2011). Artificial neural networks model injury severity as a pattern recognition problem (Abdel-Aty and Abdelwahab, 2004). An input vector of crash-related characteristics is mapped into an output space of the severity categories. Again, the artificial neural network approach has been found to outperform traditional statistical techniques.

4.3 Assessment of Crash Reporting Systems

According to the United States Government accountability office, crash data quality can be assessed by six measures. These are timeliness, consistency, completeness, accuracy, accessibility, and data integration (United States Government Accountability Office, 2004). Consistency relates to data uniformity such that timely merging of datasets and identification of traffic safety problems may be achieved (United States Government Accountability Office, 2004). Completeness of data assesses if all reportable crashes and crash variables have been captured. Data accuracy is an indicator of the degree to which there are no errors in critical data elements (Vandervalk *et al.*, 2017). Data accuracy is reliant on training officers to correctly capture crash information (Njord *et al.*, 2005). Accessibility refers to how readily and easily accessible the data is to the principal users of the safety data. Data integration gauges the capability of linking the crash data to other sources to make it possible to evaluate relationships between roadway, crash vehicle and human factors at the time of crash (United States Government Accountability Office, 2004). Timeliness refers to availability of data for analytical purposes within a useful time frame, preferably within 90 days of a crash. It is the duration between when a crash occurs and the time data for the crash becomes available (Australian Bureau of Statistics, 2019).

Timeliness is an essential part of data quality. Timely data is important for decision-makers to quickly identify and address crash risks. Out of date data may lead to the spending of resources on challenges that no longer exist or are no longer a priority, or employing ineffective countermeasures to address safety issues (Scopatz *et al.*, 2017). For example, Logan and McShane noted that clusters of crashes could develop quickly if crash data is not evaluated in a timely fashion (Logan and McShane, 2006). Techniques aimed at identifying such clusters will be ineffective unless data can be accessed quickly. Timely data allows for agencies to respond to rapidly emerging problems and is also important for supporting other data quality improvement efforts. A study by Mitchell et al. rated timeliness of data collection along with data availability, analysis and dissemination as being very important for injury data reporting (Mitchell *et al.*, 2009). The study suggests that systems in which data is accessible within a month of the data collection would rate as ‘very high’; one to two years as ‘high’, and more than two years as low.

Some studies have been conducted to evaluate the data quality of safety systems in several states including timeliness in reporting crash data. The United States Government Accountability Office reviewed the data systems in nine states using a survey. The results indicated that most of the state data systems reviewed did not have crash data available within one to 18 months with several exceeding the recommended 90 days (United States Government Accountability Office, 2004). Another study surveyed 26 state highway agencies to provide insights into the current practices in crash reporting and processing (Njord *et al.*, 2005). On data quality, 22 out of 26 states (85%) indicted that all crashes meeting the states threshold for reporting are collected. It was found that only 20% of responding states responded to data requests between 91 to 364 days.

Timeliness of a crash database is assessed through performance measures. These can include the time between the crash date and data submission; the time between data submission and resubmission (for data with errors); or the average time required for each step in data submission and verification process (Scopatz *et al.*, 2017). Automation of the processes of data collection and submission may improve the appearance of the crash record in the database. It is also important for performance measures of timeliness of submissions to be checked regularly to ensure that delays encountered are continuously reduced.

5 PARTNERS OVERVIEW

Several partner agencies are involved in safety in Wyoming. These include the Wyoming Highway Patrol (WHP), Wyoming Transportation Safety Coalition, Worker Safety Office (Occupational Safety and Health Administration), Wyoming Seatbelt Coalition, Wyoming Association of Sheriffs and Chiefs of Police (WASCOP), and the Governor Council of Impaired Driving (GCID). The following sections describes the agency objectives and projects related to safety.

5.1 Wyoming Highway Patrol

The WHP promotes safety on the state's highways by enforcing traffic laws, providing emergency assistance and other key services.

5.1.1 Objective and Functions of WHP

The objective of the WHP is to keep the safety of the public on all highways in Wyoming. The WHP engages in field operations and support services. Field operations refer to the patrolling of roads, traffic enforcement, and crash investigation among other duties. Support services provide dispatch services statewide, issuing and collection of fees from permits, as well as providing safety programs to schools and other safety-minded organizations across Wyoming. Key functions of the WHP include enforcing traffic laws, performing criminal interdiction, inspecting vehicles for safety-related equipment violations, regulating road closures, and directing motor vehicle traffic on public roadways.

5.1.2 Safety-Related Projects of WHP

WHP is involved in several safety programs in the state. These include the alive at 25 program, seatbelt survivor program, the Li'l Convincer program, the REDDI program, and a rollover simulator (Wyoming Highway Patrol, 2019). Others are the creation of highway-safety documentaries and numerous safety presentations.

Timely reports are necessary for WHP to assess performance benchmarks such as the reduction of highway fatalities, alcohol related and injury crashes. Late availability of data or inconsistency in crash will severely hamper WHP's ability to evaluate if they are meeting their strategic goals and objectives.

5.2 Wyoming Transportation Safety Coalition (WTSC)

The WTSC is supported by the Wyoming Trucking Association. The coalition is composed of a myriad of members who represent different commodities being hauled, various types of equipment and different operations (Wyoming Transportation Safety Coalition, 2019) . Other representatives from the energy industry, WYDOT, WHP, Homeland Security, governor's office, local government and other state agencies are part of WTSC.

5.2.1 Objective and Functions of WTSC

The objective of the WTSC is to reduce work related transportation fatalities through education, training and developing a working relationship with agencies overseeing transportation in Wyoming. WTSC works to develop processes which aid in reducing transportation fatalities on highways in the state.

5.2.2 Safety-Related Projects of WTSC

The WTSC fulfills its objectives by identifying factors that contribute to transportation fatalities in the state. Minimization of the impacts of factors impacting fatalities is done through education, outreach and enforcement.

5.3 Occupational Safety and Health Administration (OSHA)

The Wyoming OSHA is part of the Wyoming Department of Workforce Services that is responsible for the enforcement of occupational safety and health standards. The administration inspects workplaces for hazardous conditions and issues citations where violations of occupational and health standards are found (United States Department of Labor, 2019).

5.3.1 Objective and Functions of OSHA

OSHA works to ensure that all Wyoming businesses are safe to work in. The OSHA team in Wyoming administers rules and regulations aimed at the prevention of accidents and occupational diseases. OSHA offers educational tools for industries, businesses and associations to prevent work-related injuries.

5.3.2 Safety-Related Projects of OSHA

Safety-related programs of OSHA include the Basic Safety and Health Program, Comprehensive Safety and Health Program, Occupational Epidemiology Program and Truck Driver Survey Report. These programs are aimed at quantifying the injury burden trends affecting the workforce. Strategies are then implemented to reduce the occurrence of these work-related injuries.

5.4 Wyoming Seatbelt Coalition

Wyoming residents are reported to have a history of low seatbelt use that is below the national average (Mead *et al.*, 2017). The Coalition undertakes educational and outreach programs in the state to encourage the use of seatbelts.

5.4.1 Objective and Functions of the Wyoming Seatbelt Coalition

The Wyoming Seatbelt Coalition's objective is to increase the use of seatbelt in Wyoming to prevent fatalities and decrease the number and severity of injuries in traffic crashes.

5.4.2 Safety-Related Projects of Wyoming Seatbelt Coalition

Wyoming Seatbelt Coalition delivers presentations and educational programs to encourage seatbelt use. The coalition also facilitates discussions at different meetings, and provides a forum for research and planning to reduce the incidence of injuries and fatalities due to unbelted passengers.

5.5 Wyoming Association of Sheriffs and Chiefs of Police (WASCOP)

WASCOP is an association representing members at the federal, state, and local level. Members of the association serve on boards, commissions and coalitions at the Wyoming State Legislature. The association fosters and develops professionalism and integrity within the Wyoming law enforcement community.

5.5.1 WASCOP Objectives and Functions

The objective of WASCOP is to deal with common problems included in the delivery of management services to the agencies of public law enforcement in the boundaries of Wyoming. Additionally, WASCOP offers information to committees and legislators as they consider policies and laws that affect the safety of public and law enforcement statewide.

5.5.2 Safety-Related Projects of WASCOP

WASCOP is involved in a number of safety projects including alcohol and crime in Wyoming, enforcement of underage drinking laws, and Wyoming youth and alcohol. WASCOP funds data collection for alcohol-related arrests over a 12 month period for the alcohol and crime in Wyoming program. The data collected is used to enhance public safety and reduce the dangerous effects of alcohol impairment.

The Wyoming Youth and Alcohol program assesses the efforts of law enforcement initiatives in reducing the incidence of underage drinking.

5.6 Governor's Council of Impaired Driving (GCID)

The GCID was formed to facilitate research and implement strategies as a means to reduce impaired driving. The Council launches campaigns and educates the public on the adverse effects of driving under the influence of alcohol and drugs, and the consequences of such actions.

5.6.1 Objective and Functions of GCID

The objective of the GCID is to spread awareness of the dangers of driving under the influence (DUI) of alcohol and prescription or illicit drugs. The GCID facilitates research discussion and planning to reduce impaired driving in Wyoming. The GCID also develops strategies, educational campaigns and assists in the enforcement of laws to reduce impaired driving. Statistics on impaired driving are also distributed by the Council.

5.6.2 Safety-Related Projects of GCID

GCID projects include chemical testing program, 24/7 sobriety program, drugged driving media program, enhanced DUI enforcement and physician/pharmacists partnership awareness program. Crash data for GCID is a combination of crash records from WYDOT and DUI arrest data from WASCOP.

6 STUDY METHODOLOGY

The methodology adopted for this study is aimed at meeting the goal of assessing the data needs of the safety partners of WYDOT, identify human factors impacting crashes, and recommending appropriate data reporting intervals for the critical variables. A flow chart of the methodology is shown in Figure 1. The first issue to be tackled will involve assessing the data needs of the safety agencies which helps them fulfill their mandates. This will be done through a survey which will require the agencies to identify road safety variables critical to their agency goals. These may include safety performance indicators (speeding, alcohol, seatbelt use), outcome indicators (number of crashes, fatalities, injuries), or social costs (medical costs, damage to property). The survey will help gain insights on agency expectations with regards to critical data issues such as availability, timeliness of the data, and frequency of reporting.

To improve traffic safety, most safety agencies focus on mitigating the impact of human factors. Reporting on the changing trends of human factors in relation to roadway crashes is thus a critical component of an effective crash reporting system. For the second phase, human factors impacting crash severity and frequency will be identified. This will be done using a big data analysis technique such as data mining and/or machine learning.   Also, big data analysis will be utilized to analyze long and short-term trends of the factors identified. From the analysis, factors that change significantly within short intervals will indicate the need for short-term reporting, while factors that show little fluctuation over time will suggest long-term reporting.

Based on the results from the survey and data analysis, a matching of the data needs and human factors identified will be undertaken. The matching will help to identify gaps in variables being currently reported to the safety agencies and what the agency needs are. Recommendations will then be made on how to bridge the gaps identified, propose other important human factors that need to be reported and recommend reporting intervals of the variables identified.

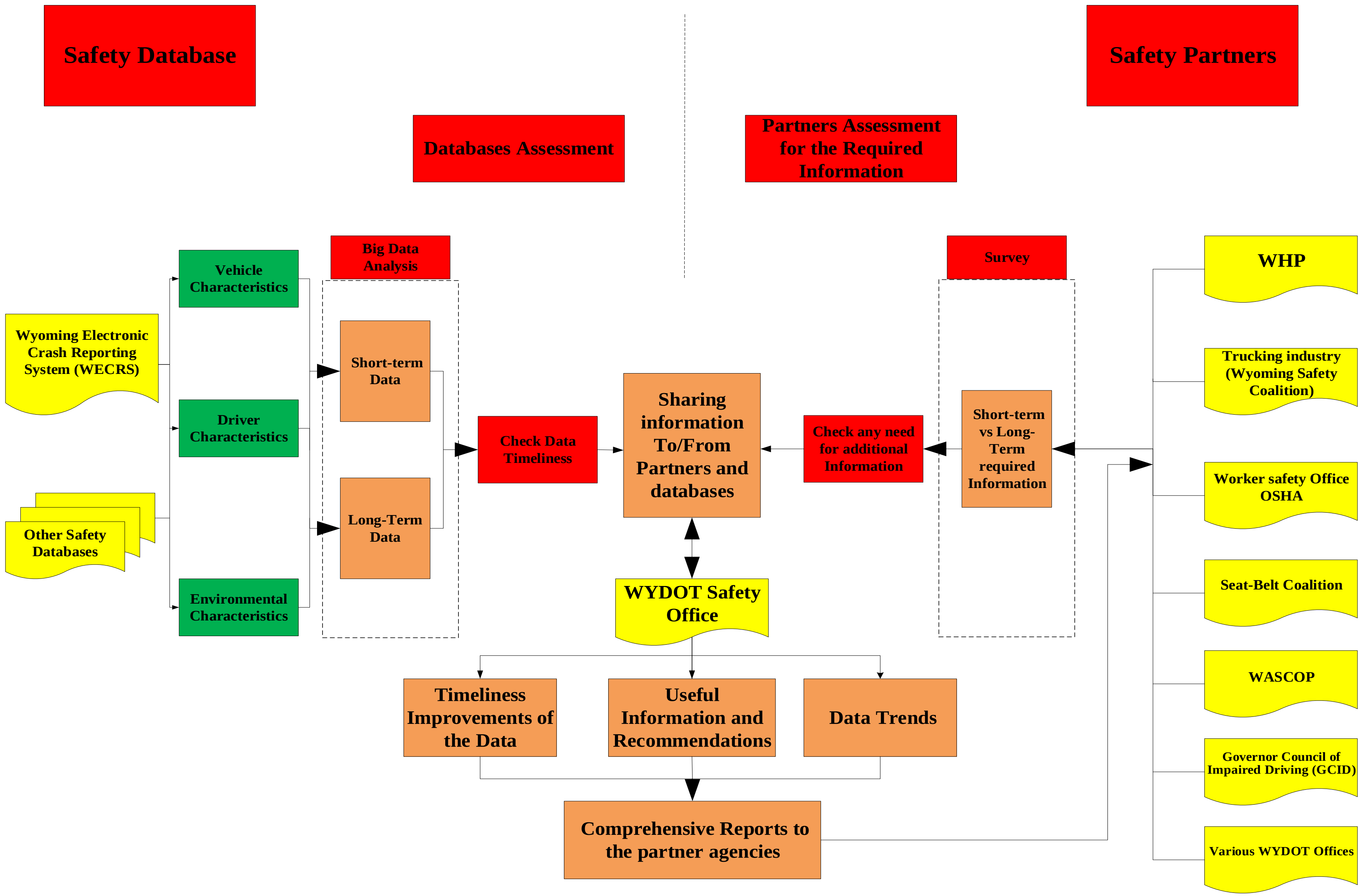

Figure 1 Study Flow Chart

6.1 Study Tasks

The study tasks required to successfully implement the study are discussed as follows:

Task 1: Literature Review

The literature review will be undertaken to identify human factors that have been found to significantly impact crash frequency and severity from past studies. This task will also review how data related to the identified factors are reported in crash systems (long-term reporting, short-term reporting). Importantly, the literature review will also be aimed at reviewing how big data analysis methodologies have been adopted in past studies to identify significant human factors that impact crash frequency and severity. The literature review will also allow for a review of the current state of crash data reporting as it exists in the United States, issues and solutions adopted by different agencies.

Task 2: Identify and Assess WYDOT Safety Reports/Databases

Existing WYDOY safety reports will be assessed and reviewed as a means to identify the current reporting format of the reports presented to the safety partners. This assessment will be important to identify the typical reporting format, investigate issues with the report formats and present appropriate recommendations to WYDOT. In addition, all safety datasets within WYDOT will be identified along with the departments that own the datasets. This identification will help the safety office in integrating all relevant datasets to provide better data utilization and crash reporting to the safety partners.

Task 3: Comprehensive Data Needs Assessment of Agencies

An extensive survey will be conducted to assess the safety-related data needs and reporting requirements of safety agencies in Wyoming. This forms part of the safety partners' assessment of the WECRS crash reporting system as shown on Figure 1. This task will help in defining the expectations of the agencies to enable them derive their desired output from the safety data. The data needs assessment outcome will also ensure that the concerns of the safety agencies are incorporated in recommendations to improve crash reporting from the WECRS. Based on results of the survey carried out, the evaluation will ascertain whether safety data available from the WECRS directly matches the data needs of safety agencies and conforms to data quality standards. This task will therefore help to clearly identify the gaps in crash reporting in terms of the minimum required variables and timeliness of reporting from the agencies' point of view. An update of data needs will then be undertaken based on responses to the survey.

Task 4: Communicate with Safety Partners about the Objectives of this Study

It will be important for WYDOT/research team to communicate with the safety partners on what this study will cover. Communication will be through meetings, consultations, discussions and emails and will highlight what the study seeks to achieve. Also, this communication will facilitate important interaction between WYDOT and the partners to incorporate their input into the study.

Task 5: Identify Human Factors Impacting Crash Severity and Frequency

Safety partner agencies in Wyoming focus on human factors to control driver behavior and reduce crash severity. This is because human factors account for about 94 percent of the causes for crashes. These include impaired driving from alcohol use, use of seatbelts, and inattentive driving. Several years of historical crash data from the WECRS will be compiled into a comprehensive database. An evaluation will then be conducted to identify human factors impacting crash severity and frequency using currently available big data analytic tools. The use of big data analysis will allow for a thorough investigation of human behavior and actions. Results from this task will be matched to the agency data needs from the survey. This will help to update critical human factor data requirements of the agencies.

Task 6: Determine Reporting Frequency of Human Factors

This task will determine the reporting frequency of the human factors identified in the previous task. Timely reporting of human factors is required to quickly identify issues as they occur and apply appropriate countermeasures. Determination of the frequency of reporting of human factors to the safety agencies will be done by analyzing the trends and fluctuations of the factors over time. This will be done by analyzing the long and short duration trends of the historical data compiled using big data analysis. Significant fluctuations during short periods will indicate the need to report such factors in the short term while factors that do not change over short periods can have longer intervals of reporting. A similar analysis will be undertaken for vehicle and characteristics as part of the study. Based on statistical evaluations using big data analysis, normal variations in the data will be used to specify upper data thresholds for each human factor found to significantly impact crash injury severity and frequency. Spikes in the number of crashes related to the factor above the specified threshold indicates the need for that factor to be reported more frequently. For example, the alcohol-related fatalities in Wyoming shown in Figure 2 indicates that the normal variation of this factor is below 100 fatalities per year. Suppose the analysis shows that 100 alcohol-related fatalities is the upper threshold, a spike in crashes attributed to this factor exceeding the threshold indicates the need for close attention to be paid to the factor. This would imply that the frequency of reporting data related to alcohol-involved incidents should be in short intervals (e.g. bi-weekly). Frequent reporting of such a variable will help in choosing and implementing an appropriate countermeasure.

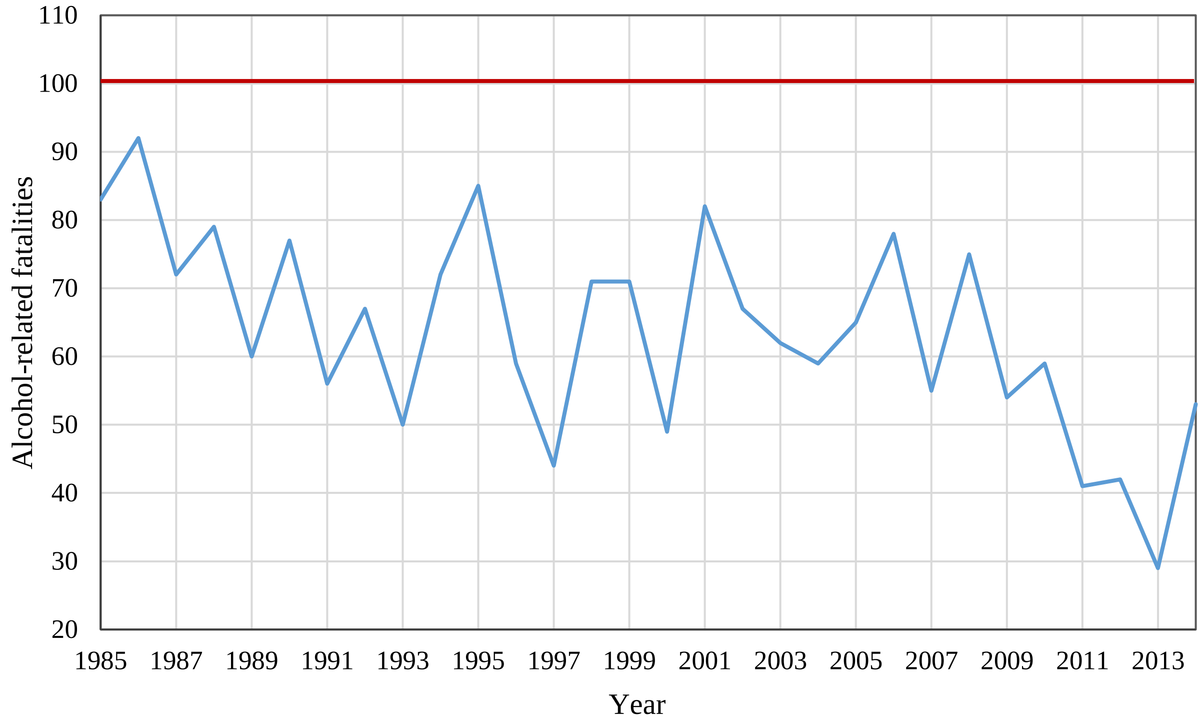

Figure 2 Trend of Alcohol Involvement in Fatalities in Wyoming (Data from Alcohol Alert, 2019)

Task 7: Recommend Best Formats and Intervals to Report Crash Data

Following an analysis of the survey results and assessment of human factors impacting crash severity and frequency, the data needs and reporting frequency of reporting of important variables will be recommended. Determining the frequency of generating crash reports for human factors impacting crash frequency is important for a number of reasons. All identified safety partners in Wyoming rely wholly or partly on human factors. Partner agencies formulate strategies or deploy countermeasures in response to the effects of these factors. Late reporting of these critical factors may result in ineffective countermeasures being applied, or countermeasures being deployed when that factor is no longer a priority.

Task 8: Integrate Report Generation with WYDOT Format

This task will involve recommendations on the generation of crash reports such that they can be integrated with existing WYDOT report formats. This will ensure that new reports generated will be compatible with the format of available WYDOT software. Communication with the WYDOT safety office for their inputs on how to integrate the reports will be useful for this task.

Task 9: Prepare Final Report and Present Study Findings

A final report that presents the study findings and recommendations will be prepared and submitted to WYDOT. The final report will include recommended sample formats for crash data reporting for the partner agencies. This will ensure that crash reports are prepared in formats that has all the required information for the partner agencies.

7 TIMELINE

The entire study is expected to be completed in 24 months beginning January 1, 2020. The administering and evaluation of survey questionnaires and assessment of human factors impacting crash severity and frequency will be done over 18 months. A final report and presentations to officials from WYDOT and partner agencies are anticipated at the conclusion of the study. The proposed timeline of the study is shown in Figure 3.

8 BUDGET

Although the total budget for this study is $183,512, WYDOT is responsible for only $117,879. Table 1 shows the breakdown of the budget which includes the matching funds provided by the Mountains Plains Consortium (MPC).

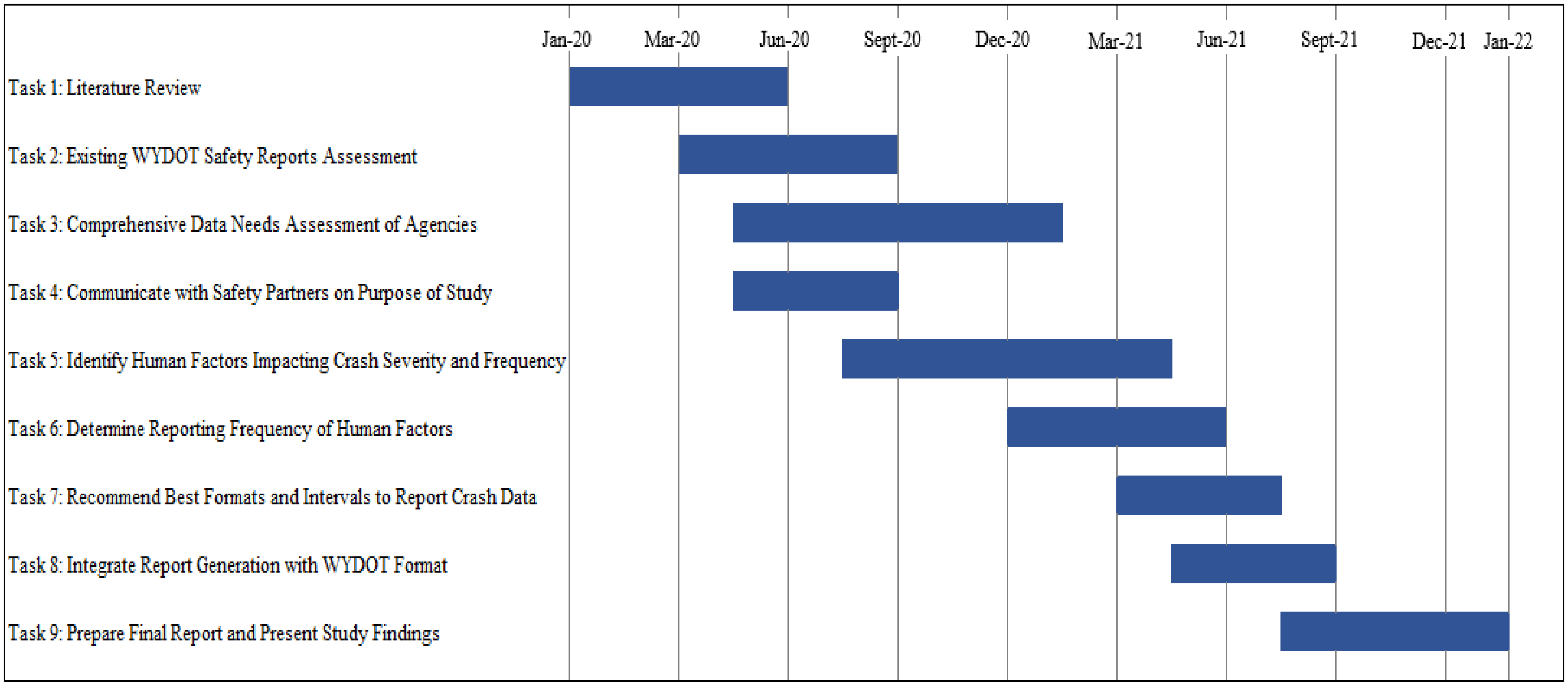

Figure 3 Proposed Timeline for the Study.

Table 1 Budget for the Study

Categories	MPC	WYDOT	Total
Center Director Salary			
Faculty Salaries	$10,000	$21,000	$31,000
Engineer/ Post Doc	$6,500	$22,500	$29,000
Faculty/Engineer Fringe Benefits (43.3%)	$7,145	$18,836	$25,980
Student Salaries	$16,000	$23,000	$39,000
Student Fringe Benefits (3.9%)	$624	$897	$1,521
Total Personnel Salaries	$32,500	$66,500	$99,000
Total Fringe Benefits	$7,769	$19,733	$27,501
TOTAL Salaries & Fringe Benefits	**$40,269**	**$86,233**	**$126,501**
Travel	$500	$2,000	$2,500
Equipment	$0	$0	$0
Supplies	$500	$2,000	$2,500
Contractual			
Construction			
Other Direct Costs (Specify)*	$6,000	$8,000	$14,000
TOTAL Direct Costs	**$47,269**	**$98,233**	**$145,501**
F&A (Indirect) Costs	$18,364	$19,647	$38,011
TOTAL COSTS	**$65,633**	**$117,879**	**$183,512**

- Students Tuitions and etc.

9 REFERENCES

Abdel-Aty, M., Abdelwahab, H. (2004) Predicting Injury Severity Levels in Traffic Crashes: A Modeling Comparison. *Journal of Transportation Engineering*. **130**(2), 204–210.

Abellan, J., Lopez, G., de Ona, J. (2015) Analysis of traffic accident severity using Decision Rules via Decision Trees. *Expert Systems with Applications*. **40**(15), 6047–6054.

Alcohol Alert (2019) Wyoming Driving Statistics. [online]. Available from: http://www.alcoholalert.com/drunk-driving-statistics-wyoming.html.

Australian Bureau of Statistics (2019) Quality Declarations-Timeliness. *Quality Declarations*. [online]. Available from: https://www.abs.gov.au/websitedbs/d3310114.nsf/4a256353001af3ed4b2562bb00121564/429ef5357ff40788ca25734f001218c4!OpenDocument.

Australian Transport Council (2008) *National Road Safety Action Plan 2009 and 2010*.

Chan, L.-Y., Chien, J.-T. (2013) Analysis of driver injury severity in truck-involved accidents using a non-parametric classification tree model. *Safety Science*. **51**(1), 17–22.

Chen, C., Zhang, G., Qian, Z., Tarefdar, R.A., Tian, Z. (2016) Investigating driver injury severity patterns in rollover crashes using support vector machine models. *Accident Analysis & Prevention*. **90**(May), 128–139.

Delen, D., Sharda, R., Bessonov, M. (2006) Identifying significant predictors of injury severity in traffic accidents using a series of artificial neural networks. *Accident Analysis & Prevention*. **38**(3), 434–444.

Dingus, T.A., Guo, F., Lee, S., Antin, J.F., Perez, M., Buchanan-King, M., Hankey, J. (2016) Driver crash risk factors and prevalence evaluation using naturalistic driving data. *Proceedings of the National Academy of Sciences of the United States of America*. **113**(10), 2636–2641.

Kashani, A.T., Mohaymany, A.S. (2011) Analysis of the traffic injury severity on two-lane, two-way rural roads basedon classification tree models. *Accident Analysis & Prevention*. **49**(2011), 1314–1320.

Khattak, A.J. (2016) *Safety Managment System Needs Assessment*. Lincoln, Nebraska.

Li, X., Lord, D., Zhang, Y., Xie, Y. (2008) Predicting motor vehicle crashes using Support Vector Machine models. *Accident Analysis & Prevention*. **40**(4), 1611–1618.

Logan, M., McShane, P. (2006) Emerging Crash Trend Analysis. In *Proceedings of the Australasian Road Safety Research, Policing and Education Conference*. Brisbane, Australia.

Mead, M.H., Carlson, M.D., Ledet, K. (2017) *Wyoming's Highway Safety Behavioral Grants Program Highway Safety Plan Report*. Cheyenne, Wyoming.

Mitchell, R.J., Williamson, A.M., O'Connor, R. (2009) The development of an evaluation framework for injury surveillance systems. *BMC Public Health*. **9**, 1–14.

Moghaddam, F.R., Afandizadeh, S., Ziyadi, M. (2011) Prediction of accident severity using artificial neural networks. *International Journal of Civil Engineering*. **9**(March).

Njord, J.R., Capka, R.J., Meyer, M.D., Horsley, J.C., Skinner Jr, R.E., Townes, M.S., Walton, M.C. (2005) *NCHRP Synthesis 350 Crash Records Systems-A Synthesis of Highway Practice*. Washington D.C.: Transportation Research Board of the National Academies.

Scopatz, R., Brown, R., Zhou, Y., Benac, J., Peach, K., Bryson, M., Lefler, N. (2017) *Crash Data Improvement Program Guide*. Washington D.C.

Singh, S. (2018) *Critical Reasons for Crashes Investigated in the National Motor Vehicle Crash Causation Survey*. Washington D.C.

United States Department of Labor (2019) Wyoming State Plan. *Occupational Safety and Health Administration*. [online]. Available from: https://www.osha.gov/dcsp/osp/stateprogs/wyoming.html.

United States Government Accountability Office (2004) *Highway Safety: Improved Monitoring and Oversight of Traffic Safety Data Program are Needed*. Washington, D.C.

Vandervalk, A.D., Snyder, D., Hajek, J.K. (2017) *Guide for State Department of Transportation Safety Data Business Planning FHWA Safety Program*. Washington D.C.

Vapnik, V. (1998) *Statistical Learning Theory*. Wiley, ed. New York, NY.

World Health Organization (2010) *Data systems: A Road Safety Manual for Decision-Makers and Practitionera*. Geneva, Switzerland.

Wyoming Department of Health (2019) Motor-Vehicle Traffic Injuries. *The Wyoming Injury and Violence Prevention Program*. [online]. Available from: https://health.wyo.gov/publichealth/prevention/wivpp/injurymvtui/.

Wyoming Highway Patrol (2019) Safety Eduction. *Safety Education*. [online]. Available from: http://www.whp.dot.state.wy.us/home/safety_education.html [Accessed August 27, 2019].

Wyoming Transportation Safety Coalition (2019) Welcome to the Wyoming TSC. [online]. Available from: https://wyotsc.com/.

Yu, R., Abdel-Aty, M. (2014) Analyzing crash injury severity for a mountainous freeway incorporating real-time traffic and weather data. *Safety Science*. **63**(March), 50–56.

Zeng, Q., Huang, H. (2014) A stable and optimized neural network model for crash injury severity prediction. *Accident Analysis & Prevention*. **73**(December), 351–358.