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Seat Belt Fit a Mechanism of Injury During a Motor Vehicle Crash

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Walden University
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Abstract

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Dissertation Submitted in Partial Fulfillment

of the Requirements for the Degree of

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Abstract

Seat belts save lives; however, unintentional injuries are still the leading cause of death for those between 1 and 44 years in the United States. Seat belts also cause injuries during motor vehicle crashes (MVCs) and obesity changes how seat belts fit. The purpose of this retrospective causal inference quantitative study was to reduce the knowledge gap in scholarly research on seat belt fit in relation to blunt cerebrovascular injuries (BCVI) during MVCs and seat belt compliance. The theoretical framework used was based on H.W. Heinrich's domino theory. The research questions focused on the following dependent variables: BCVI, compliance, and seat belt fit; and independent variables: the size of the individual and seat belt fit. Secondary and primary data were used and analyzed using Spearman's Rank-Order Correlation. The results yielded no relationship between seat belt fit and BCVI in the secondary data (n = 97). In the primary data (n = 138), there was significance found between seatbelt fit and a) seat belt use, and b) BMI. The study contributed to positive social change by enhancing the awareness of the knowledge deficit regarding seat belt fit, and BCVIs sustained during MVCs, and that comfort was influenced by seat belt fit and had a role in compliance. Seat belts were not used by 5.3% and 9.5% or used incorrectly by 3.2% and 2.9% of the people in the primary data and secondary data sets. This knowledge may contribute to a) future seat belt testing to ensure it is done in such a manner that seat belts fit everyone; b) new seat belt laws to ensure that they are consistent across all states, and c) medical care focusing on seat belt fit as a mechanism of injury (blunt) to ensure screenings are done with the appropriate diagnostic tools.

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Dedication

I dedicate this achievement to my mother, Dappina Jacoba (Kotie) Viljoen. My mother supported me in all my endeavors, failures, and achievements. My mother instilled in me her passion for learning, caring, compassion to help others, and to strive for more. I know if she could, she would have continued her own education. Unfortunately, she will not see me graduate because she passed on December 20, 2017. She was my pillar of strength, and I miss her every day. I know she is with me and continues to support me even though she is not with me. A few days before she passed my mother told me how proud she was of me, which meant the world; however, I wish she could be with me right now to tell me how she felt.

I included a picture of my mother and her beloved dogs sitting where she was the happiest.

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Chapter 1: Introduction to the Study

Unintentional injuries are the leading cause of death for those between the ages of 1 and 44 years old in the United States, (National Safety Council [NSC], 2017). In 2015, motor vehicle crashes (MVCs) and poisoning were identified to be the leading causes of death in the unintentional group (Centers for Disease Control and Prevention [CDC], 2015a). The leading cause of death in the United States was MVCs (Han, Newmyer, & Qu, 2017); while trauma was the leading cause of death in the world (Maddineni, Marini, & Rozenblit, 2016). Long, April, Summers, and Koyfman (2017) found that trauma contributed to 10% of deaths in both high and low-income countries. Seat belt use was found to be the most effective in reducing injuries during MVCs (CDC, 2015a); however, it also caused injuries (Ogundele, Ifesanya, Adeyanju, & Ogunlade, 2013), and millions of people were not using their seat belts all the time (CDC, 2015a). Some people perceived seat belt laws in the United States as impeding on their rights, and some found seat belts uncomfortable to use, which contributed to noncompliance of use (Waters, Macnabb, & Brown, 1998). Obesity changed how seat belts fit which contributed to additional injuries sustained during MVCs (Reed, Ebert-Hamilton, & Rupp, 2012); body mass index was found to be a key factor in the changes in lap belt fit and associated injuries sustained during MVCs (Reed, Ebert, & Hallman, 2013).

Cerebrovascular accident (CVA) was found to be a severe complication sustained during MVCs (Fox, Numis, Sidney, & Fullerton, 2014). Patients with head and neck injuries were at a higher risk to develop ischemic CVA than those with other injuries

(Fox et al., 2014). According to the CDC (2014b), CVA cost the United States $36.5 billion in 2014; this includes the cost of care and loss of productivity and income.

Thus, seat belts saved lives and caused injuries, and MVCs were the leading cause of death for those between 1 and 44 years old (Appendices A &B); however, some people did not use seat belts, and in others, the seat belt fit changed (Reed at al., 2013). The purpose of this study was to determine whether any significant correlation exists between seat belt fit and (a) blunt cerebrovascular injuries (BCVI), which may lead to CVA, and (b) seat belt noncompliance.

In this chapter, I will introduce the problem of seat belts fit and the possibility of preventing BCVI by investigating the historical background of seat belts, as well as seat belt use, seat belt injuries, medical care for crash victims, and seat belt fit. I conducted an initial review of the literature to identify the gap that enabled me to formulate the problem statement. In this chapter, I will state the purpose of this study, the hypotheses, and research questions. I will introduce the theoretical framework and the nature of the study, define the terms, and state the assumptions, scope, delimitations, and limitations of this study. Lastly, I will describe the significance of this study, including the positive social change.

Background

It was essential to review the historical context of seat belts and people's attitudes toward seat belt use in order to understand the current seat belt challenges. The historical data included a brief history of seat belts, the background of seat belt fit, injuries caused by seat belts, and medical care provided after MVCs. Lastly, I discussed noncompliance of seat belt use in relation to seat belt fit.

Seat Belt History

The first MVC was recorded in 1771 when the inventor, Nicholas Joseph Cugnot, crashed his self-propelled steam vehicle in France (Vivoda & Eby, 2011). This vehicle was not equipped with seat belts and had a maximum speed of 2 miles per hour when it crashed. The crash resulted in no injuries (Vivoda & Eby, 2011). The first seat belt was invented in the 1800s by George Cayley (Vivoda & Eby, 2011). Edward J. Claghorn, a New Yorker, received the first patent for a seat belt in 1885. This seat belt patent was mostly for airplane use (Vivoda & Eby, 2011).

During the 1930s, a group of physicians in the United States realized the value of seat belts in regard to injury prevention during a crash (Vivoda & Eby, 2011). They requested that seat belts be installed in their vehicles (Vivoda & Eby, 2011). The physicians also urged vehicle manufacturers to install seat belts in all vehicles to ensure safety for all; however, this did not happen for another 20 years (Vivoda & Eby, 2011). Seat belts installation started in the 1950s (Vivoda & Eby, 2011); however, vehicles with seat belts were observed as not safe and resulted in low sales which continued the debate about whether seat belts were needed (Vivoda & Eby, 2011). During the 1960s, some states mandated that vehicles be equipped with seat belt anchors. This allowed the owners to decide whether to use the seat belts (Vivoda & Eby, 2011). The mandate was the precursor to the seat belt laws (Vivoda & Eby, 2011).

Many people died in MVCs; in 1965 it was considered to be the leading cause of death in the United States for people younger than 44 years old (Mashaw & Harfst, 1991). Consumer advocate Ralph Nader spoke out against vehicle design defects after which Congress, under the leadership of President Johnson, passed The National Traffic and Motor Vehicle Safety Act of 1966 (Peltzman, 1975). The outcome of this law led to the initiation of the National Highway Traffic Safety Administration (Peltzman, 1975). During the 1970s, airbags were introduced, and their installation was mandated in 1993 (Abbas, Hefny & Abu-Zidan, 2011).

New York passed the first seat belt law in 1984 (Vivoda & Eby, 2011), and was followed by New Jersey in 1985 (Farmer & Williams, 2014). All states but New Hampshire passed seat belt laws by 1996; however, 39 states had only secondary seat belt laws (Farmer & Williams, 2004). It was evident that MVCs were a problem that required the passing of laws for protective devices in an attempt to protect people; however, these laws were not welcomed by all.

Seatbelt laws were found to be inconsistent and different in each state. One such inconsistency was related to the primary and secondary seat belt laws. Primary and secondary seat belt laws dictate when law enforcement officials can stop vehicles for seat belt violations (Insurance Institute for Highway Safety/Highway Loss Data Institute [IIHS/HLDI], 2016). Primary seat belt laws allowed law enforcement officials to stop vehicles for a seat belt violation, while secondary seat belt laws required that the vehicle be stopped for another violation before seat belt violations could be addressed (IIHS/HLDI, 2016). Front and back-seat seat belt laws added to this confusion and inconsistency. Back-seat seat belt laws are present in 28 states, while the other 21 states addressed only front-seat, seat belt use (IIHS/HLDI, 2016). New Hampshire is the only state with no seat belt laws (Houston & Richardson, 2005). The seat belt laws increased seat belt use by 28%; with higher use in states with primary seat belt laws (Dee, 1998). It was evident that seat belt laws increased seat belt use, but mostly in states with primary seat belt laws. It was unclear why people were still not using their seat belts.

Seat Belt Use

Seat belt noncompliance was found to be an ongoing issue. In 2015, despite 85% front-seat, seat belt usage, 50% of fatalities in rural areas were attributed to people not using their seat belts compared to 46% in urban areas (NHTSA, 2017c). The most frequent reasons listed for not using seat belts were issues with comfort and people's freedom of choice. Kidd, McCartt, and Oesch (2013) found that comfort was the main reason given for not using a seat belt. Holdorf (2002), concluded that mandatory seat belt laws were regarded as impeding on people's freedom of choice. According to Holdorf, freedom of choice included people's rights as outlined in the Fourth, Fifth, and Ninth Amendments, as well as Civil Rights in the Fourteenth Amendment. Mandatory seat belt laws were viewed by some people as an intrusion by the government; denying people their right to choose health care standards (Holdorf, 2002). Seat belt laws were needed for injury prevention by ensuring compliance of use, one of the questions this addressed in this study was whether seat belt fit affected comfort and added to noncompliance and seat belt injuries.

Seat Belt Injuries

Seat belts reduced the risks of injury and death by 40% to 60%, during MVCs (Abu-Zidan, Abbas, Hefny, Eid, & Grivna, 2011); however, life-threatening injuries caused by seat belts were identified in the abdominal, thoracic, and neck regions (Afifi et al., 2015). Neck injuries included blunt injuries to the carotid resulting in intimal disruption, thrombosis, or carotid artery transection (Arthurs &Starnes, 2008). Thus, even though seat belts reduced the risk of injuries and death, they also caused injuries and death.

Injuries are often identified due to the presence of a seat belt sign. Langdorf et al. (2016) identified the seat belt sign as contusions or abrasions where the seat belt would have been present on the body during the MVC. Langdorf et al., stated that the seat belt sign is an indicator of underlying injuries, while Greingor and Lazarus (2006) stated that the absence of seat belt signs did not rule out injuries. Bromberg et al. (2010) discussed complications such as CVA as a result of BCVI that increased a traumatically injured individual’s morbidity and mortality. Purvis, Aldaghlas, Trickey, Rizzo, and Sikdar (2013) found that when traumatically injured victims with no seat belt sign or with no other symptoms of vascular injuries were screened for vascular injuries, the incidence of identifying vascular injuries increased from 0.1% to 2.7%. The presence or absence of a seat belt sign did not necessarily indicate the presence or absence of an underlying injury. It was also evident that seat belt injuries could result in additional injuries/complication. The authors did not specify whether seat belt fit contributed to the injuries sustained or the complication that developed later.

Medical Care for MVC Victims

Medical care for BCVI is inconsistent nationally; however, many guidelines are available for the care of traumatically injured individuals. The American College of Surgeons (ACS) best practice guidelines included treatments for geriatric injuries, massive blood transfusion, management of brain injury, and management of orthopedic trauma (ACS, 2017), but did not include guidelines for vascular injuries of the neck after a blunt insult. The Stanford Health Care Trauma Guidelines included BCVI care, which included identifying injuries by their signs and symptoms as well as the at-risk individuals according to the mechanism of injury and associated injuries (Stanford Health Care, 2016); however, seat belt fit was not identified as a mechanism of injury.

Jacobson, Ziemba-Davis, and Herrera (2015) found that relying on the risk factors alone were not feasible when deciding how to screen for injuries to the neck. Instead, the authors stated that more intensive screening practice would ensure that more patients could be diagnosed earlier with both internal carotid artery and vertebral artery injuries (Jacobson et al., 2015). However, ensuring cost-effective health care, screening should be timely and with the appropriate diagnostic tool (Laser et al., 2015). Long et al. (2017) cautioned against increased radiation exposure, and delayed interventions using whole-body computed tomography (CT) instead of being selective or utilized focused imaging. There was not a uniform guideline that addressed BCVI treatment protocols, or when and how to screen for BCVI. The concern for radiation exposure was inordinate which might be a factor for risks that could develop later; however, the immediate concern was to prevent CVA. The existing protocols also did not address seat belt fit as a possible mechanism of injury to the neck.

Seat Belt Fit

Seat belt fit may be a mechanism of injury that may result in BCVI of the neck. To ensure proper seat belt fit, the NHTSA (2017a) described how a seat belt should fit (Appendix C). However, Reed et al. (2012) found that obesity changed how seat belts fit and resulted in unexpected injuries during MVCs. Reed et al. (2013) found that an increased body mass index (BMI) was an important factor in how well the lap belt fit (Reed et al., 2013). The authors focused only on how obesity changed seat belt fit across the pelvis; by doing so, they ignored a significant number of other factors that could change the way seat belts fit in nonobese individuals. Seat belts that do not fit might add to discomfort when used and influence how people wore their seat belts to make it more comfortable.

Incorrect use of seat belts. An incorrect way people wore their seat belt was to put the cross-body belt behind their back or under their arm to be more comfortable or to relieve neck tension (Larkin, 2017). Some people clicked the seat belt before sitting to avoid the annoying sound of the audible reminder system when the seat belt was not used (Zaal, 2014). Incorrect use of seat belts added to the severity of injuries during MVCs (Abbas et al., 2011, Zaal, 2014). It would be beneficial to understand why people do not use their seat belt correctly in order to increase compliance and prevent injuries during MVCs. It also is essential to understand the correct way to use a seat belt to prevent or reduce injury.

The correct way to use a seat belt. The correct way to use a seat belt (Appendix C) was described by the NHTSA as follows:

1. Secure the lap and shoulder belt across the pelvis and rib cage (NHTSA, 2017c), with minimum slack (Safecar.gov, 2012).
2. The shoulder belt must be placed across the middle of the chest and away from the neck (NHTSA, 2017c).
3. The lap belt should be placed over the pelvis, not the stomach (NHTSA, 2017c).

Safecar.gov (2012) added that the correct seating position is upright with the person's back against the seat and the feet on the floor.

The NHTSA guidelines stated that when buying a car, it would be imperative to ensure the seat belt fit. According to these guidelines, seat belt fit could prevent or minimize injury (NHTSA, 2017c). To ensure seat belts fit correctly testing is done by the NHTSA using manikins/dummies.

Crash test dummies. The NHTSA ensured that seat belts in vehicles were safe and fit correctly by using anthropomorphic test devices (ATDs) also known as crash test dummies for vehicle crash tests (NHTSA, n.d. c). The ATDs used to test seat belts are called THOR, Test Device for Human Occupant Restraint (NHTSA, n.d. c). Each of the THOR ATDs has instruments in both the upper and lower neck to calculate force and momentum at the levels of (Oc-C1) the atlantooccipital junction and (T1) the first thoracic vertebrae (White, Moreno, Gayzik, & Stitzel, 2015). Although the measurements were important, there were limitations based on the type of ATDs available.

Two adult crash test dummies were used to test seat belt fit, one male and the other a female (NHTSA, n.d. c). The male test dummy, THOR 50th percentile male ATD, is 175 cm (5'9") tall standing, 88 cm (35 inches) seated and weighs 77 kg/170 lb. (NHTSA, n.d. c). The female test dummy, THOR 5th percentile female ATD, is equipped with the same technology as the male but is smaller. The THOR 5th percentile female ATD is 149 cm (4’9”) tall standing, 73 cm (29 inches) seated and weighs 49 kg/108 lb. (NHTSA, n.d. b). These two THORs do not represent the United States population.

Crash dummies representing vulnerable occupants, including the obese adult and elderly obese adult, have been developed (NHTSA, n.d. a). Obesity changes the way the lap belt fit; thus, obese individuals could potentially sustain more severe injuries to the lower extremities, while older people may sustain more severe and unexpected injuries due to osteoporosis (NHTSA, n.d. a). The obese and elderly dummies were not used to test the entire seat belt; however, the focus was on the slack of the seatbelt, which increases the risk for injury in the obese dummies (NHTSA, n.d. a). The elderly obese crash test dummy is still in the test phase and not currently used to test seat belt fit (NHTSA, n.d. a). Thus, by using only two and maybe four adult dummies to test seat belt fit, would not ensure that seat belts fit all body types and sizes of people in the United States.

Conclusion

During the initial review of the literature, it was evident that seat belt fit was not studied as a mechanism of injury related to BCVI. In my study, I attempted to bridge this identified gap regarding seat belt fit as a mechanism of injury. This study may increase the awareness that seat belt fit could cause BCVI that could lead to more studies in the future, while the new knowledge could lead to interventions that potentially could reduce or minimize injuries caused by a suboptimal fitting seat belt. Understanding this mechanism of injury may ensure early diagnosis of injuries and reduce secondary injuries/complications that could lead to disabilities. Ensuring seat belts fit correctly may increase seat belt compliance and use. If seat belt fit is found to be significant in causing injuries and non-compliance of use it may warrant that scarce healthcare resources could be used more appropriately elsewhere because more severe injuries, disabilities, or death could significantly be reduced.

Problem Statement

Seat belts were effective in reducing injuries; however, seat belts also caused injuries during MVCs (Afifi et al., 2015) and MVCs remain the leading cause of death for people between 1 and 44 years of age in the United States (CDC, 2015a). An initial review of the literature identified the following: a) seat belts saved lives and prevented serious injuries during MVCs, b) seat belts caused injuries during MVCs, and c) seat belt fit had a role in seat belt related injuries in obese individuals. Therefore, the problem is that while seat belts saved lives and prevented serious injuries, they also caused injuries and the fit of seat belts changed in obese individuals; the correlation between the seat belt related injuries and seat belt fit in people of all sizes is not known. No correlation could be established during my research whether seat belt fit caused BCVIs. It was difficult to establish seat belt fit with the secondary data set used; however, seat belts do not fit and were uncomfortable to use was found significant using the secondary data set. This finding did provide evidence that if seat belt fit could be improved compliance might improve as well.

Purpose of the Study

The purpose of this retrospective causal inference quantitative study was to first identify whether there was a significant correlation between seat belt fit as a causal inference factor during MVCs that cause injuries to the neck, such as BCVI, which in turn may lead to secondary injuries/complications such as CVAs. Secondly, the purpose of this study was to identify whether there is a significant correlation between seat belt fit and noncompliance of seat belt use. This knowledge will reduce the existing gap in the scholarly research regarding the influence of seat belt fit on injuries sustained during MVCs and seat belt use.

Research Questions and Hypotheses

After reviewing the existing literature regarding seat belt use, seat belt fit, seat belt related injuries, and seat belt complications the following research questions and hypotheses were formulated.

Research Question 1 (RQ1): What is the relationship between seat belt fit and BCVI to the neck during MVCs?

Alternative Hypothesis (H_a1): There is a relationship between seat belt fit and BCVI to the neck.

Null hypothesis (H_01): There is no relationship between seat belt fit and BCVI to the neck.

Research Question 2 (RQ2): What is the relationship between seat belt fit and seat belt use?

Alternative Hypothesis (*H*a2): Seat belt fit impacts seat belt use.

Null hypothesis ($H_0$2). Seat belt fit has no bearing on seat belt use.

Research Question 3 (RQ3): What is the relationship between an individual's height, weight, and seat belt fit?

Hypothesis (*H*a3). An individual's height and weight affect seat belt fit.

Null hypothesis ($H_0$3). Height and weight do not affect seat belt fit.

Theoretical Framework

Heinrich's (1950) domino theory was the theoretical basis for this study. According to the domino theory, an accident was one of five factors in a sequence that lead to an injury. This theory was used extensively in all aspects of industrial accidents (Cleveland State University [CSU], n.d.). The five factors described in this theory were depicted as five dominoes and if one falls all five will fall, causing a chain reaction that was impossible to stop unless the proximate cause or hazard was stopped/removed (CSU, n.d.). I decided to use the domino theory as the foundation for this study because it supported the linear approach to causation that is difficult to stop unless the seat belt fits as it should. In line with this theory, when a seat belt does not fit a chain reaction is started that may be difficult to stop unless the proximate cause (seat belt fit) is corrected (CSU, n.d.). This chain reaction, when a seat belt does not fit, may include unexpected injuries during MVCs or noncompliance of seat belt use.

The factors I identified for this study based on the domino theory were:

1. The seat belt does not fit the individual.
2. The second factor had two possible paths;
    a. The MVC and the injuries to neck sustained from the seat belt.
    b. Noncompliance or wrong use of the seat belt
3. The third factor had three possible paths;
    a. The injuries to the neck were not viewed as emergent in the presence of more severe injuries, or the absence of a seat belt sign, or the seat belt sign was delayed, ignored or not observed.
    b. The development of secondary injuries (complications) went unnoticed due to multiple factors, such as a heavily sedated patient.
    c. More severe injuries due to no seat belt used or incorrectly used.
4. The fourth factor was the delayed treatment for the BCVI.
5. The fifth factor was the development of complication and disabilities.

I used the domino theory was used to answer all three research questions and indicated whether there was a significant correlation between seat belt fit, noncompliance, injuries to the neck, and the outcomes. I will describe this theory in more detail in Chapter 2.

The domino theory also included corrective actions that could be used in the sequence of events to either prevent the injuries or improved the outcome (CSU, n.d.). I found a correlation between seat belt fit and seat belt comfort with the primary data which could lead to non-compliance. The corrective action will be to ensure seat belts fits everyone as described by the NHTSA in order to prevent discomfort that could lead to increased compliance of use.

Nature of the Study

In this retrospective causal interference quantitative study, I attempted to identify whether the independent variable (seat belt fit and size of the person) had a causal effect on the depended variable (injuries, seat belt fit, and seat belt use). Keeping the focus on the seat belt's causal interference of injuries and noncompliance was consistent with Heinrich's domino theory. I used quantitative analysis to identified whether the correlation between seat belt fit and injuries to the individual's neck sustained during an MVC existed.

Definition of terms

*The Abbreviated Injury Scale (AIS): "*AIS incorporates current medical terminology providing an internationally accepted tool for ranking injury severity. AIS is an anatomically based, consensus-derived, global severity scoring system that classifies an individual injury by body region according to its relative severity on a 6-point scale (1= minor and 6 = maximal). AIS is the basis for the Injury Severity Score (ISS) calculation of the multiply injured patient" (Association for the Advancement of Automotive Medicine [AAAM], 2017).

Anthropomorphic: "Described or thought of as having a human form and ascribing human characteristics to nonhuman things" (Merriam-Webster, n.d.).

Blunt Cardio Vascular Injuries (BCVI): Described as blunt carotid injury and blunt vertebral injury (Eastham, 2015).

Cerebrovascular accident (CVA): "The sudden death of brain cells due to lack of oxygen when the blood flow to the brain is impaired by a blockage or rupture of an artery to the brain. A CVA is also referred to as a stroke" (MedicineNet.com, 2013).

*Computed Tomography (CT): "*CT is an imaging procedure that uses special x-ray equipment to create detailed pictures, or scans, of areas inside the body. It is also called computerized tomography and computerized axial tomography (CAT)" (National Cancer Institute [NIH], 2017).

Computed Tomography Angiography (CTA): CTA is done by using "an injection of iodine-rich contrast material and CT scanning to help diagnose and evaluate blood vessel disease or related conditions, such as aneurysms or blockages" (RadiologyInfo.org, 2017).

Convenience sampling: A convenience sample is obtained by selecting the units that are conveniently available (Frankfort-Nachmias & Nachmias, 2008)

Emergency medical technician (EMT): A person that is skilled in providing emergency medical services to patients who are transported to a hospital in an ambulance (Merriam-Webster, n.d.).

Fiftieth percentile crash test dummy: "The HYBRID III Fiftieth Percentile crash test dummy, representing the average adult male, is the most widely used dummy in a frontal crash and automotive safety restraint testing… and is the required dummy in NHTSA's motor vehicle safety standards. This dummy's weight 172.3 pounds and height 69 inches with a sitting height of 34.8 inches" (NHTSA, n.d. c).

Fifth percentile crash test dummy: The fifth percentile crash test dummy is a smaller and adapted version of the fiftieth percentile crash test dummy. This dummy's pelvis is used to test the 3-point belt. This dummy is weight is 108 pounds, height 59.1 inches, and height seated 29 inches. A 5th percentile indicates that 5% of the adult population is smaller than the Dummy (NHTSA, n.d. a).

Lap belt: "A seat belt that fastens across the lap" (Merriam-Webster, n.d.). Also, known as, "A 2-point belt attaches at its two endpoints, and was invented in the early 1900s by Jack Swearingen of Louisville, Kentucky" (OMICS International, 2016).

Partially ejected: "Part of the occupant's body was outside the vehicle at some time during the crash sequence" (NHTSA, 2017c).

Total Ejection: "The occupant's body was entirely outside the vehicle but may be in contact with the vehicle" (NHTSA, 2017c).

Seat belt: A seat belt or 3-point seat belts are belts that go over the waist (lap) and the shoulder (sash) of the occupant.

Seat belt fit: Per the NHTSA (2010), the way to ensure proper seat belt fit is to place the shoulder belt across the middle of your chest and away from your neck, the lap belt across the pelvis below the stomach

*Seat belt sign: "*The seat belt sign is characterized by patterned bruising on the chest, or abdominal wall that is consistent with the position of the diagonal or horizontal strap of the seat belt and can extend to the neck indicating underlying vascular injury" (Agrawal, Inamadar, & Subrahmanyam, 2013, p. 288).

Test Dummy: “The Crash Test Dummy is a calibrated test instrument used to measure human injury potential in vehicle crashes” (Humanetics, 2015).

Assumptions

I had multiple assumptions in this study. They were:

1. Seat belts may not fit all people as described by the NHTSA. If a person’s size is different from the average male and the fifth percentile female dummy, used to test seat belts, the seat belt fit may not be optimal. Some people may have to add a device to keep the seat belt off their neck.
2. Use of an altering device to achieve better seat belt fit could potentially result in additional injuries during MVCs.
3. If seat belts do not fit during MVCs, people might sustain BCVI to their neck.
4. BCVI to the neck could lead to complications such as CVAs.
5. Injuries to the neck may go unnoticed because there might not be a seat belt sign indicating a potential underlying injury until it is too late to prevent complications.
6. Complications from underdiagnosed seat belt injuries may lead to severe disabilities and extended hospitalization.
7. Severe disabilities and extended hospitalization increase the cost of medical care.
8. People do not wear their seat belt or wear it incorrectly (with the cross-body portion either behind their back or under their arm) because it does not fit; therefore, they can sustain more injuries and more severe injuries during MVCs.

9. The last assumption is that if the seat belt fits correctly, there might be increased compliance in using seat belts, fewer injuries, and less severe injuries.

Scope and Delimitations

The scope of this study was limited due to using secondary data obtained from the crash injury research (CIREN) data bank and one questionnaire. The results were found to be significant for seat belt fit and discomfort, and it could be applied nationally as well as internationally, to reduce or eliminate injuries caused by noncompliance of use.

Limitations

This study's limitations include: (a) using archival (secondary) data due to privacy and other restraints, (b) the quality of the archival (secondary) data, (c) one questionnaire that was relying on accurate self-reporting, and (d) the research method selected. I used convenience sampling and by its nature, convenience sampling sacrifices generalizability; therefore, may not provide sufficient representation of the target population. Meaning that the data selected for the study may only partially represent the population being investigated. As such, replication may be necessary to fully validate study results. The study's efficacy could have been improved by doing a mix methods study with the victim, family, and health care professional interviews. No biases were identified for this study. Utilizing data from CIREN with a questionnaire about seat belt use and possible reasons for noncompliance addressed some of the identified limitations because it indicated that seat belts did not fit and caused discomfort. The data did not find any correlation between seat belt fit and injuries sustained during MVCs and also did not indicate whether the participants sustain any complication as a result of the BCVI.

Significance

Significance to Knowledge

With this study I addressed the gap in the literature regarding seat belt fit as a mechanism of injury during MVCs related to BCVI as well as the influence of seat belt fit on comfort which could be an indicator for the compliance of seat belt use. Both findings involve every person in the world using a motor vehicle that could potentially be involved in a crash. The study created a foundation for future research by identifying the gap in the literature regarding seat belt fit as a mechanism of injury.

Significance to Social Change

The significance to social change may have national and international implications on health care. By identifying the gap in the literature regarding seat belt fit as a mechanism of injury related to BCVI may change how health care professionals care for trauma patients involved in MVCs. This change in care may start at the scene of the crash, by EMTs, and continue in the emergency department (ED) and throughout the stay in the hospital. The change in care may include earlier screening for BCVI in order to prevent complications. The complications include CVAs with severe disabilities and an increase in medical cost.

In 2012, more than 2.5 million adult drivers and passengers were treated in hospitals as a result of an MVC, with a lifetime cost of $ 80 billion (CDC, 2014a). CVA cost the nation $36.5 billion, which includes the cost of care, loss of productivity, and income (CDC, 2014b). Even though injuries sustained in MVCs are not the only cause of strokes, the social change of stroke reduction in MVC victims will affect not only the individual but will extend outward to the nation and the world.

Significance to Practice

Currently, the decision to investigate the neck for injuries is dependent on the seat belt sign. In the presence of a seat belt sign, the ED physician may or may not order diagnostic tests to rule out BCVI. The ED physician's decision depends on additional signs and symptoms, such as the presence of a pulsation over the region of the carotid artery. When no seat belt sign is present, attention might shift away from the neck, and no diagnostic test might be ordered to investigate the neck vasculature which could lead to missed injuries resulting in secondary injuries/complications such as CVAs. By identifying the gap in the literature regarding seat belt fit as a mechanism of injury related to BCVI this study could contribute by shifting the focus back to the neck which may result in the development of new protocols for EMS, ED physician, and registered nurses (RN). The new protocols could change when and how to screening for BCVI in crash victims as well as the health care provided during the first 48 hours after the MVC, by all health care providers, with the focus of preventing or minimizing complications.

Significance to the Motor Vehicle Industry and Safety Testing

This study found that seat belts do not fit and cause discomfort. The results were also significant for increased BMI and seat belt fit. These findings could affect the design and testing of seat belts. At this time, the only test dummies used is THOR 50th percentile male, which is an average male and the THOR 5th percentile female. These two dummies do not represent all individuals in the United States or the world.

Summary

In this chapter, the focus was on introducing the problem of seat belts fit and the possibility of preventing BCVI. The initial review of the literature indicated that there was limited scholarly research available on seat belt fit as a mechanism of injury and no literature available on seat belt fit as a mechanism of injury that results in BCVI. Finding this gap enabled me to state hypotheses, research questions, establish the theoretical framework, and described the fundamental assumptions, scope, and limitations for this study. In Chapter 2, I will continue to outline the gap in the existing literature relevant to seat belt fit as a mechanism of injury by detailing the literature review with the focus on seat belt fit, injuries caused by seat belts, injuries prevented as a result of seat belt use, seat belt use, as well as the theoretical foundation. In Chapter 3, I will provide a detailed description of the methodology and possible threats to validity.

Chapter 2: Literature Review

The primary purpose of this retrospective causal interference quantitative study was to identify whether there was a significant correlation between seat belt fit, as a causal interference factor or mechanism of injury during MVCs, and injuries to the neck (BCVI). The secondary purpose was to identify whether there was a correlation between seat belt fit and seat belt noncompliance. The problem is that MVCs remain the leading cause of unintentional deaths for people between 1 and 44 years of age even though seat belt use was effective in reducing injuries during MVCs. An initial review of the literature identified two well-documented facts that seat belts saved lives and caused injuries during MVCs.

Ogundele et al. (2013) stated that seat belts saved lives and prevented serious injuries during MVCs, while Afifi et al. (2015) described higher incidents of injuries that occurred during MVCs because of seat belt use. Reed et al. (2012) found that obesity changed the fit of the seat belt consequently causing additional injuries during MVCs. Reed et al. (2013) indicated that BMI was a significant factor for how lap belt fits. Therefore, the problem is that seatbelts save lives and prevent serious injuries, but also cause injuries and the fit changed in some individuals; however, it is not clear what the correlation between injuries and seatbelt fit is in all individuals.

In this chapter, I will include the literature search strategies, and the literature review to identify the gap in the literature regarding seat belt fit as a mechanism of injury for BCVI and compliance of use. I will describe the theoretical foundations, the conceptual framework as well as the review and synthesis of the relevant literature for the problem I identified. My objective of this review is to critically analyze the seat belt's effectiveness in preventing or reducing injuries, identifying the injuries caused by seat belts, seat belt fit as a mechanism of injury, seat belt compliance, and whether size matter when using a seat belt, with the aim to identify and describe the gap in the scholarly research.

Literature Search Strategy

I retrieved the literature for this review from multiple sources. I conducted a comprehensive search of Walden University's online library, and the internet using combinations of the following key terms and phrases; seat belt, seat belt fit, seat belt injuries, occupant safety, seat belt history, seat belt sign in adults, seat belt sign, injuries sustained to the neck, vascular injuries, traumatic vascular injuries, carotid injuries, and blunt injuries to the neck, seat belt use, trauma care, emergency care, domino theory, crash dummies, seat belt compliance, seat belt, and blunt vascular injuries.

I started by using multiple search engines on the internet, including Google and Google Scholar, followed by applying the initial information found to focus the search on relevant, peer-reviewed articles from Walden University's library using the following databases: Academic Search Complete, ProQuest Central, Medline, and Science Direct. Using Google Scholar, I used citation chaining to find newer articles related to this topic. In addition, I used the references from key studies doing backward chaining to find additional articles not found during the previous searches. I used credible websites, such as the NHTSA, to find scientific material focused on their specialized subject matter.

The literature review included all seminal studies, peer-reviewed articles, and scientific information related to seat belts including saving lives, causing injuries, testing, fit, compliance with use, and medical care after MVCs. My focus in this study was on the 3-point seat belt, seat belt fit, testing seat belts, trauma care, injuries to the driver and front seat passenger's neck, and compliance of seat belt use. I focused on the past 5 years; however, it does include seminal articles that are older than five years, because there was limited research on seat belt fit as causal interference factor or a mechanism of injury. During this literature review, I focused on the key variables and concepts as well as Heinrich's domino theory as the theoretical foundation.

Theoretical Foundation

Heinrich's Domino Theory

Heinrich (1950) developed the domino theory in 1928 to describe the prevalence of industrial accidents and how to prevent them in a series of articles and a book between 1928 and 1950. Heinrich described accident prevention as control; control of the performance of an individual, control of the machine, and control of the environment. He used the domino theory to illustrate control (Heinrich, 1950).

The concept of control can be applied to this study in that the control of the individual is the decision made to use or not use their seat belt, the control of the machine is the seat belt fit, and control of the environment is the MVC. National laws for seat belt use and the manufacturer's guidelines for installing seat belts enforce control. This control did not address reducing injuries and the severity of injuries during MVCs to reduce health care costs and improve outcomes.

Heinrich (1950) explained that productivity would improve by eliminating the cause of accidents with subsequent improvement of the economy. The cause of the accident for this study is the seat belt fit. MVCs might be impossible to prevent, but if the seat belt fits correctly, additional injuries and more severe injuries could be reduced or prevented, which could improve outcomes and reduce the length of hospital stay, with little or no loss of income and subsequent reduction in the cost of healthcare.

The domino sequence for this study resembled the one Heinrich described for industrial accidents with some dissimilarities. Heinrich (1950) described the domino sequence or accident sequence as “the five factors of injury” with the preventable accident as one of the dominoes. Heinrich listed the five factors as follows: (a) “ancestry and social environment”, (b) “fault of the person”, (c) “unsafe act and/or mechanical or physical hazard”, (d) “accident”, and (e) “injury” (p. 12). The five factors for this study were the following: (a) seat belt fit; (b) injuries to the neck during the MVC or noncompliance of seat belt use or using the seat belt the wrong way; (c) developing secondary injuries (complications) or more severe injuries; (d) delayed treatment; and (e) developing complications and disabilities, extended hospital stay, loss of income, and increased health care costs. It was essential to study the sequence of events in order to find the one factor that could be changed to prevent injuries, increase compliance, and prevent secondary injuries.

The factor that must change to prevent injuries to the neck, increase compliance with seat belt use, and prevent secondary injuries, was seat belt fit. According to Heinrich (1950), an accident caused a preventable injury, and the accident was the result of a factor that preceded it. BCVI is the preventable injury, caused by the seat belt that does not fit, which is the factor that precedes the injury; thus, injuries to the neck may be minimized or eliminated if the seat belt fit.

When using a vehicle, the sequence of events is usually the same. The individual chooses to enter the vehicle, place the seat belt or not, start the vehicle, and drive to the destination. According to Heinrich (1950), the events and circumstances that caused a preventable injury were in a "fixed and logical order" and were interdependent (p. 13). Thus, the event is fixed and will take place in a specific order or sequence, resulting in preventable injuries, resembling a row of falling dominoes (Heinrich, 1950). Heinrich explained that when one domino falls the rest of the dominoes in the row will also fall in a specific order or sequence. The falling dominoes can be used to describe the events after the individual enters a vehicle to travel somewhere. The events in the sequence include the following: (a) the individual chooses to use or not use the seat belt, (b) the seat belt does not fit, (c) the vehicle crashes, (d) injuries ensue, (e) screening/treatment of the injuries may or may not occur, and (f) complications may or may not set in. Whether or not to use the seat belt was the only optional factor, the other events in the sequence were fixed and interdependent.

The question that this theory answered was whether unintentional injuries or BCVI, more severe injuries or complications as a result of the neck injuries could be prevented by improving seat belt fit. According to Heinrich (1950), injury prevention can occur by interrupting the sequence of events. Heinrich stated that removing any one of the preceding events before the accident will prevent the injury. The preceding events for this study were seat belt fit and noncompliance which according to the theory could prevent injuries to the neck (unintentional, more severe, or secondary injuries).

A frequent complaint identified by Kidd et al. (2013) regarding seat belts was that they were uncomfortable to wear; however, the knowledge as to why seat belts were uncomfortable or why seat belts use resulted in injuries was not known. According to Heinrich (1928), accidents could only be reduced if there was knowledge about the causes of the accidents. Therefore, knowledge would increase awareness and potentially bring about change; thus, it is essential to study the causes of BCVI. If seat belt fit was found to be a mechanism of injury or a factor in making seat belts uncomfortable; improving the fit could reduce injuries and increase compliance.

Seat belt compliance could be mandated by establishing consistent laws or stricter penalties for existing laws. Heinrich (1928) found that insufficient safety enforcement was one of the causes of accidents. Consequently, seat belt law enforcement could potentially minimize injuries during MVCs; however, the inconsistent national legislation for seat belt use potentially adds to the problem of noncompliance (IIHS/HLDI, 2016). The inconsistent laws could potentially be another factor in the domino theory sequence that preceded the injury.

A possible solution for noncompliance could be to change seat belt laws, and seat belt fit to increase seat belt use and improve the outcome which includes reduced BCVI and increased compliance of seat belt use. According to the domino theory, it is possible to manipulate the cause of the injury or accident, but not the outcome (Heinrich, 1950). According to Heinrich (1929), it is possible to control the accidents, not the injury. Thus, by improving or controlling the seat belt fit, seat belt compliance, and health care delivery, additional or more severe injuries to the neck could be reduced or prevented.

Heinrich was a pioneer in safety and continues to have a profound impact on industrial injury prevention. Loud (2016), studied three well-known United States tragedies to identify what went wrong in preventing them. The tragedies Loud studied were the Texas City refinery explosion of 2005 that killed 15 and injured nearly 200, the Deepwater Horizon explosion that killed 11 and caused the biggest accidental oil spill in history, and the chemical exposure in Laporte, Texas, that killed four people in 2014. Loud used Heinrich's theory to highlight the influences on safety and to emphasize the fact that the causes of industrial accidents remained the same today and, in some cases, increased over time. Loud concluded that it was not beneficial to focus on the individual's behavior as the causative reason for an accident; but instead, the focus should be on the systems in place to prevent accidents and ensure improvement. This concept applied to seat belts because it is a system (manufacturing and testing) issue; however, compliance is still an individual decision.

Different accident causation theories can be used to analyze, support, or prevent MVCs; however, Thomas, Morris, Talbot, and Fagerlind (2013) described Heinrich's domino theory as a simple linear sequential model best used to identifying human behavior as one aspect of accident causation, while other models also consider mechanical and algorithmic factors for industrial accidents. The linear sequential nature of this model is the reason why I chose to work with Heinrich's theory for this study.

Using it helped me highlight seat belt fit as a component of injury causation. I addressed noncompliance of use, related to seat belt fit, not as a human factor in injury causation.

Key Variables and Concepts

Purpose and Benefit of Seat Belt Use

The purpose of seat belt use is to protect and prevent additional or more severe injuries. Manlove, Stanley, and Peck (2015) found that even though seat belts protected people during MVCs and more people used seat belts, compliance was only 87% nationwide. Broken down by states, the authors found that seat belt compliance was more than 90% in 19 states, but in Massachusetts, Mississippi, Montana, and South Dakota it was only 75% during 2013 (Manlove et al., 2015). Manlove et al. found that seat belt compliance was associated with road type, population density, and income and concluded that compliance was lower on roads other than the interstate, in smaller cities, lower income groups, and increased during precipitation. The authors did not address seat belt fit as a factor for noncompliance, but it was evident that compliance was still low in some states and that there was a need for education in the rural and low-income communities to increase compliance.

The benefit of seat belt use is to reduce the risk of injuries and severe injuries. Han et al. (2017) stated that seat belt use reduced the severity risk of injury by 50%. The authors found seat belt use saved 147,246 lives in the United States between 1975 and 2001 (Han et al., 2017). It was evident that seat belt use was the best way to protect an individual during an MVC. Thus, compliance will reduce injuries, and if injured, seat belts will reduce the severity of the injury. The authors stated that legislation was not enough to prevent injuries. Instead, legislation should be accompanied by education to ensure compliance (Han et al., 2017). Seat belt fit was not discussed as a factor; therefore, it is unclear whether seat belt fit will contribute to compliance and injury prevention the way that legislation and education might.

Seat belt use will protect occupants and thus contribute to lowering health care costs. Han et al., (2017) stated that in the United States, injuries sustained during MVCs cost $18,4 billion in 2012, for ED visits and inpatient care, and that seat belt use was the most efficient way to reduce injuries and health care costs by 50%. The authors did not address seat belt fit; however, if seat belts can reduce injuries by 50%, a seat belt that fits could hypothetically reduce it even further.

A benefit of seat belt use is that it prevents fatalities amongst drivers and passengers. Kwak et al. (2015) found that only 2/3 of the injured individuals in their study used seat belts resulted in a 2.8% fatality rate in the unbelted group and 0.4% for the belted group. It was evident that many people do not use their seat belts and more fatalities occur as a result; thus, seat belts will prevent fatalities if used.

Seat belt use increases with more consistent laws such as the primary laws. Lee et al. (2015) found that fatality rates were markedly lower in states with primary laws, 11.5 per 100,000 people, than in those with secondary laws, 14.0 per 100,000 people. However, Harper and Strumpf (2017) found that there was no difference in protecting against death between primary and secondary seat belt laws. It was clear that there were inconsistencies when just focusing on the laws. Harper and Strumpf did suggest that the upgrade from secondary to primary seat belt laws were not followed by enforcement which could have contributed to the fact that there was no difference in the fatality rate. Thus, stricter laws could make a difference if accompanied by stricter enforcement.

Seat belt reminders might be beneficial to increase seat belt compliance and reduce forgetfulness. Kidd et al. (2013) stated that seat belts saved 11,949 lives in 2011. The authors contributed the saved lives to a combination of advertisement campaigns and enforcement (Kidd et al., 2013). The authors stated that compliance increased to 86% in 2012; however, the increased use did not last after the advertisement campaign stopped (Kidd et al., 2013). The authors found that the main reasons given for not using seat belts were forgetfulness (60%), that it was a short trip (67%), and discomfort (77%) (Kidd et al., 2013). Kidd et al. found that technology such as audible and haptic seat belt reminders will reduce forgetfulness because it will not disappear as the advertisement campaign did. The authors stated that the seat belt reminder technology increased seat belt use by 13% (Kidd et al., 2013). The reason for the increased use was that the reminding tones tend to increase in intensity or continued indefinitely if ignored; thus, forcing the occupants to use their seat belts to remove the annoying sound (Kidd et al., 2013). It was clear that the audible reminders will improve compliance longer than just increasing law enforcement coupled with an advertisement campaign.

Obesity impact seat belt compliance. Behzad, King, and Jacobson (2014) found that obesity decreased seat belt use regardless of laws. Behzad et al. found that when obesity increased by 1% seat belt use reduced by 0.06% in states with primary seat belt laws and 0.55% without primary seat belt laws. It was clear that seat belt laws have an impact on seat belts used except for obese individuals. The authors did not indicate whether comfort and seat belt fit had a role in seat belt noncompliance with obese individuals.

Fear of a fine and detection of illegal substances in the vehicle ensured seat belt use. Harper, Strumpf, Burris, Smith, and Lynch (2014) stated that primary seat belt laws increase the use of seat belts for both low and high socioeconomic groups by 15 to 25%. Harper et al. continued by stating that the low socioeconomic group was more responsive to the seat belt laws, due to the fines or costs associated with interacting with enforcement agents. Adams, Cotti, and Ullman (2017) found that in states where marijuana use was legalized, seat belt use went down by 2.9% among male drivers aged 25 to 69-years old. The authors suggested that the legalization of marijuana use with the belief that enforcement will not be as strict as before was one of the reasons for the declined (Adams et al., 2017). It was evident that fear of law enforcement and accompanied fines have a more significant influence on seat belt compliance.

Seat Belt Fit

The effectiveness of seat belts depends on their fit. Reed et al. (2013) found that A person's age was a less significant factor than BMI when considering seat belt fit, while neither was a factor in shoulder belt fit. The factor that impacted the shoulder belt fit was the shoulder height or stature (Reed et al., 2013). Reed et al. stated that body size differences between men and women made gender effect challenging to study; however, BMI findings for lap belt fit were consistent regarding abdominal gird and lap belt displacement. Displacing the lap belt forward by an average of 64 mm was a significant finding for the increased BMI, which means that the body will move forward 64 mm more, during MVCs, before the lap belt stops the movement (Reed et al., 2013). This forward displacement will change the injury severity depending on the space available between the body and the steering wheel or knee bolster (Reed et al., 2013). Lap belt placement was essential to ensure a good fit, and minimize underlying organ damage (Reed et al., 2013). The evidence indicated that seat belt fit is vital in preventing additional injuries and more severe injuries; however, the authors did not address seat belt fit in relation to neck injuries.

According to Reed, Park, and Hallman (2015), BMI and age together did determine seat belt fit. The authors found that when the BMI is higher than 30, a young woman had a much smaller abdomen contour than an elderly man (Reed et al., 2015). This finding made it difficult to predict injuries and the severity of injuries (Reed et al., 2015); however, BMI and the presence of an obese abdomen should be considered when establishing the mechanism of injury and underlying injuries. The authors found that body shape is different in different ages even if the BMI is the same and this could make predicting injuries difficult; however, the authors did not address how body shape and BMI could influence seat belt fit across the shoulder and possible neck injuries.

Placement of the seat belt will affect the seat belt fit. Reed et al. (2013), stated that belt location could affect the restraint's performance, the upper anchorage location affects the shoulder belt fit but were not influenced by the BMI, age, or sex. Reed et al. (2012) studied the influence of the D-ring, seat back angle, stature, and BMI on the shoulder belt. Reed et al. found that the D-ring placement in the vehicle (Appendices D & E) anchoring the seat belt, influenced the seat belt fit, but was not influenced by the individual’s increased BMI. Thus, where the seat belt was anchored did affect seat belt fit regardless of BMI.

Seat belt fit adds to noncompliance with seat belt use as described in the study by Jehle, Doshi, Karagianis, Consiglio, and Jehle (2014). Jehle et al. found that obese drivers did not use seat belts because it is too difficult to buckle in, which increased their risk level, injury index, and death. The authors found that morbidly obese people had a 56% higher risk of dying during MVCs (Jehle et al., 2014). The authors also stated that the current crash testing and vehicle designs were not optimal because more than a third of the United States population is overweight (Jehle et al., 2014). It is evident that size will influence seat belt fit, and noncompliance, which could lead to more severe injuries.

Advanced age will affect posture and seat belt fit as described by Park, Ebert, Reed, Arbor, and Hallman (2016). Park et al. found that the mid-hip joint location was affected by age, which led to older people sitting lower in their seat. Fong, Keay, Coxon, Clarke, and Brown (2016) stated that only 35% good overall seat belt fit was demonstrated for people older than 75 years. Poor lap belt fit for nonobese elderly drivers was found to be 32% and increased as weight increased, while the shoulder belt fitted poorly in 45% of nonobese elderly drivers and increased as weight increased (Fong et al., 2016). The authors also found that the suboptimal seat belt fit, increased seat belt discomfort; especially among elderly female drivers that led to wrong seat belts use, which meant placing the seat belt either behind their back or under their arm (Fong et al., 2016). It is evident seat belt fit change as people age and leads to the wrong use of seat belts.

Anthropomorphic Test Devices used for Seat Belt Fit Testing

Different sized people will have different risks for injuries during MVCs. Davis, Vavalle, and Gayzik (2015) explored the effects of body habitus during MVCs found significant differences between the 50th and 95th percentile male crash dummies (Davis et al., 2015). The differences included a higher risk for injuries to the head and slightly lower risk for chest injuries in the 95th percentile male dummy (Davis et al., 2015). The authors did not discuss seat belt fit for the two dummies, and they did not discuss BCVI; however, they did find that different size individuals will have different patterns of injury.

There are different injury patterns between male and female victims. According to Baudrit, Petitjean, Potier, Trosseille, and Vallencien (2014), body mass drives the maximum forces, during MVCs, which caused injuries, not gender. Baudrit et al. stated that a small male would sustain the same injuries as a small female. Thus, size contributes to injuries during an MVC, not gender; the authors did not address the effect of size on seat belt fit.

The seat belt could create enough force to cause blunt trauma to the carotid artery or sheering injury to the vertebral arteries. White et al. (2015) did three simulations with a standard three-point seat belt and found that the standard three-point seat belt produced forces that increased gradually from the upper and lower neck toward the middle neck. The gradually increasing forces may indicate a rotation point of the head wrapping around the shoulder belt. The authors concluded the forces were not enough to cause injury to the spinal column; however, the different force indicated the possibility for

BCVI and sheering injuries (White et al., 2015). The authors did not use the simulations to measure the injuries to the carotid artery and vertebral arteries; they only measured the forces to the spinal column.

Seat Belt Related Injuries to the Neck

Seat belt related injuries are challenging to diagnose as described by Snyder (1970), Afifi et al. (2015), and Weinberg, Lightle, Patil, Durkin, and Webb (2017). Snyder stated that abdominal injuries were attributed to the steering wheel rather than the seat belt. Current evidence indicated abdominal injuries resulted from the lap belt (Afifi et al., 2015). Weinberg et al. found that BCVIs were not identified on admission, thus not treated, resulting in high CVA and mortality rates. Seat belt related injuries were difficult to diagnose; therefore, it was essential to consider all the possible mechanisms of injury including seat belt fit and the seat belt sign, to reduce all possible complications.

This study will only focus on seat belt fit as a mechanism of injury; however, it is essential to consider all the possible mechanisms of injuries such as airbag deployment that causes many injuries. Wallis and Greaves (2002) stated that airbags were "effective at saving lives and preventing serious injury, particularly if used with a well fitted three-point seat belt" (p 493). Wallis and Greaves listed many injuries caused by airbags including "facial trauma, temporomandibular joint injury, decapitation, cervical spine fractures, and injuries to the vasculature" (p. 491). The cause of the injuries to the vasculature was described as the overextension of the neck, not blunt trauma (Wallis & Greaves, 2002). The authors also described eye injuries especially when the crash victims were wearing glasses (Wallis & Greaves, (2002). The injuries to the eyes included orbital fractures, retinal detachment, and lens rupture (Wallis & Greaves, (2002). BVCI to the neck was not associated with airbag injuries; however, it was essential to consider all the possible mechanisms of injury including seat belt fit and the seat belt sign, to reduce all possible complications.

The seat belt sign was found to be an essential indication of underlying injuries. Sharma et al. (2006) stated that the seat belt sign was an indicator of hollow viscous injuries as well as injuries to solid organs and rib fractures. Langdorf et al. (2016) found that even though the seat belt sign was relevant for underlying injury, the urgency to screen should depend on the severity of the contusion. Agrawal et al. (2013) stated that the presence of a seat belt sign should not be used as the only indicator for underlying injury; however, they appreciated that the seat belt sign conveyed a higher risk for underlying injuries and should be an indicator for prompt and thorough examination. Christian (1976) described the seat belt sign as "soft-tissue damage," but described it as minor injuries to the face. It was evident that there was no consensus amongst health care professionals whether the seat belt sign was an indicator for injuries. The authors did not discuss whether seat belt fit was a mechanism of injury causing the seat belt sign and accompanied injuries.

Injuries to the neck, sustained during an MVC, may include vertebral artery and carotid injuries, collectively called BCVIs, that may result in CVAs. According to Foreman and Harrigan (2017), 10% -20% of BCVIs to the neck, sustained from blunt force trauma, did result in CVAs. The authors stated that MVCs were the most common cause of traumatic extracranial cerebrovascular injuries (TCVIs) and identified cervical seat belt bruising as one of fourteen risk factors for TCVI (Foreman & Harrigan, 2017). Eastham (2015) described BCVIs as trauma to the carotid or vertebral vasculature resulting in thrombus, dissection, and pseudoaneurysm formation. According to Dua et al. (2013), blunt carotid injuries account for only 1% of blunt trauma admissions yet had a 25% to 58% CVA rate and 31% to 59% mortality rate. According to Biffl et al. (2009), both blunt carotid injury and blunt vertebral injury were referred to as BCVI, and with increased screening, the incidence of BCVI was higher than 1% of all blunt trauma admissions. Galyfos, Stefanidis, et al. (2016) found that blunt vascular injuries were difficult to manage and occurred in 2% to 2.6% of all blunt trauma admissions. Galyfos, Stefanidis, et al. stated that a CVA rate of 60% and a mortality rate of 19% to 43% were associated with carotid injuries. The authors found that BCVIs were not symptomatic at first; therefore, detection was delayed and resulted in ischemic CVA (Galyfos, Stefanidis, et al., 2016). Injuries sustained to the neck had serious consequences that lead to secondary injuries or complications including CVA. It was also evident that a delay in screening resulted in CVA. Thus, it might be beneficial to consider seat belt fit as a mechanism of injury to ensure early screening for BCVI.

Pseudoaneurysms were a complication of BCVI and were difficult to diagnose. Ong and Jalaludin (2016) stated MVCs caused traumatic pseudoaneurysms; however, the incidence was only 0.08% of all trauma admissions. Ong and Jalaludin found that diagnosing pseudoaneurysm were often delayed, because patients were asymptomatic in 30% to 60% of the cases, resulting in ischemic CVA. BCVI was a serious finding with devastating consequences.

Diagnosing blunt neck injury depend on a grading scale called the Biffl or Denver grading scale (DGS). Biffl et al. (1999) realized the need for a grading scale to diagnose and manage blunt carotid injuries. This realization resulted in the development of the grading scale called the Biffl or DGS (Biffl et al., 1999). The DGS is used to diagnose the severity of the carotid injury (Biffl et al., 1999). The grading scale utilizes arteriographic imaging to grade the appearance of the lesion in the artery (Biffl et al., 1999). The grading scale consists of five different grades; grade I, indicate minor injury through grade V, which indicates the most severe injury with evidence of complete transection of the artery (Biffl et al., 1999). Each grade was succinctly described accompanied by radiographic examples (Biffl et al., 1999). Crawford et al. (2015) found that the Denver grading scale missed injuries during the initial imaging, due to its dependence on arteriography, which was an invasive study, and was used less frequently. The authors stated that computed tomography angiography (CTA) is used more frequently and capture the indeterminate BVCI findings during an initial CTA, which either resolved in 39% of the cases or required re-classification in 25.4% of the cases (Crawford et al., 2015). The indeterminate BVCIs were often reclassified, with the Biffl/Denver grading scale, as either a grade I or II during follow-up imaging (Crawford et al., 2015). Geddes et al. (2016) found that expanded screening criteria were needed to capture the remaining 20% of cases not identified by existing BVCI protocols. The authors found more incidents of BCVIs were diagnosed with the expanded screening criteria totaling 3% of all blunt trauma admissions (Geddes et al., 2016). Laser et al. (2015) stated that grade I and II will be found indeterminate by whole-body CT but will be accurately diagnosed by

CTA. The Biffl/Denver grading scale and CTA were both critical diagnostic tools to decide the treatment regimen; however, it was not always used. Thus, the injuries cannot be appreciated and treated promptly. It is evident diagnosing BCVI is complicated, but essential when contemplating care and preventing complications.

Trauma Care Related to Seat Belt Injuries of the Neck

BCVI is not a rare occurrence and not easy to diagnose. According to Laser et at. (2015), BCVI occurred in 1% to 3% of victims with polytrauma and was difficult to diagnose and had a high morbidity and mortality incidence. Laser at al. stated that the left side was injured 65% of the time and the carotid was involved 60% of the time. The authors noted that the mechanism of injury was MVCs, not seat belt fit. It is evident that the occurrence is significant; thus, the screening should be done timely to prevent complications.

To ensure cost-effective health care screening should be timely and with the appropriate diagnostic tool. Laser et al., (2015) stated that a fast and accurate diagnosis of BCVI should be made to ensure minimizing associated complications such as CVAs. The authors stated that 20% of BCVI injuries occurred without anatomic injuries or a mechanism that indicated the need for screening; thus, liberal screening is needed to identify all the injuries (Laser et al., 2015). The authors diagnosed 319 BCVI in 227 patients with a whole-body CT followed by diagnostic CTA within 24 to 72 hours (Laser et al., 2015). Amongst the 227 patients, 151 (67%) had only one injury, 63 (28%) had two injuries, while 13 (6%) had 3 or 4 different injuries (Laser et al., 2015). The authors stated that only three patients required a second CTA due to non-diagnosis within the first

24 hours (Laser et al., 2015). Twenty injuries were missed by the whole-body CT, which was diagnosed later with a follow-up CTA (Laser et al., 2015). The authors found that the whole-body CT was a valid diagnostic tool even in the light of the missed injuries (Laser et al., 2015). The authors stated the whole-body CT screen for both, polytrauma patients and BCVI, which could decrease the need for a second diagnostic study (Laser et al., 2015). Long et al. (2017) found that whole-body CT exposed people to increased radiation, delayed interventions, and may increase health care costs. Long et al. stated by choosing selective or focused imaging instead of the readily available whole-body CT, will reduce radiation exposure that could lead to long-term complications. The authors suggested that a history and physical examination should drive decisions regarding imaging and that the whole-body CT should be reserved for people with suspected polytrauma (Long et al., 2017). It is evident that choosing the most appropriate diagnostic tool will allow for timely, safe, and cost-effective care by reducing unnecessary or less useful tools.

Symptoms of BCVIs are not apparent for 12 to 48 hours after the MVC. According to Galyfos, Filis, Sigala, and Sianou (2016), symptoms of ischemic CVA, after a direct blow to the anterolateral aspect of the neck, appeared after 12.5 hours in survivors and 19.5 hours in non-survivors. The authors emphasized early screening using the Denver grading scale together with CTA, CT, and/or MRI followed by prompt treatment (Galyfos, Filis, et al., 2016). Galyfos, Filis, et al. described treatment that varied widely from observation to advanced care, included anticoagulation or antiplatelet therapies. It is evident that vigilance for CVA symptoms and early screening is necessary to improve morbidity and mortality.

The seat belt sign on the neck may be an indicator of underlying vascular injury. Langdorf et al. (2016) found that no grading system was available to guide decision-making for imaging and care in the presence of a seat belt sign on the neck. Langdorf et al. identified that location, followed by size and color consecutively were the reason for concern and created a “suspicion of injury score” to help guide screening and treatment protocols. The authors stated CTA was the preferred imaging tool regardless of the severity of the seat belt sign (Langdorf et al., 2016). It was unclear whether this grading system will be used in clinical practice. It is apparent that there was no consensus on how to diagnosis and care for BCVIs to ensure timely intervention and preventing complications.

BCVIs were diagnosed after CVAs had occurred. Griessenauer et al. (2013) stated it was critical to have sound clinical evidence of a BCVI to justify diagnosis and treatment because it was impractical to do imaging on all suspected injuries. According to Griessenauer et al., 13.3% of carotid injuries did result in CVA, while only 8.2% of vertebral artery injuries did. The authors stated that CVA symptoms resulting from vertebral artery injuries did remain unnoticed and untreated and was only found after the CVA symptoms were apparent (Griessenauer et al., 2013). Lauerman et al. (2015) stated diagnosing BCVI had improved and were accompanied by sound treatment regimens; however, CVAs still occurred. Lauerman et al. indicated that CVAs continued to occur because BCVIs were usually accompanied by other injuries that complicated treatment, especially when antiplatelet and anticoagulation agents were required. The authors found that CVA developed soon after hospitalization in a Denver grade IV injury, which is further complicated by the presence of other injuries, such as a pelvic fracture or liver laceration, that could result in hemorrhaging and will complicate the BCVI treatment (Lauerman et al., 2015). It is clear that BCVI was discovered late and only after a CVA developed. Treatment regimens were also complicated in the presence of other injuries; thus, vigilance was necessary for early diagnosis and appropriate treatment.

Summary

Based on this synthesis of the literature, it is evident that seat belt fit was not considered as a mechanism of injury for BCVI or a factor for noncompliance of use. Taking into consideration the effect of seat belt fit during MVCs and seat belt use may ensure compliance (Manlove et al., 2015), and reduce additional injuries during MVCs (Han et al., 2017 and Kwak et al., 2015). Seat belt fit was only investigated in relation to obesity and the obese elderly, thus excluding a significant percentage of the population (Reed et al., 2013, Reed et al., 2015, Jehle et al., 2014, Park et al., 2016, and Fong et al.,2016). The ATD used for testing seat belt fit in vehicles are limited to two sizes except for the obese and elderly ATD, which does not test for neck injuries (Davis et al., 2015). There is also no difference in the injury pattern of same-sized male and female victims; thus, size matters, not gender (Baudrit et al., 2014).

When the mechanism of injury to the neck was identified as blunt injury during MVCs (Weinberg et al., 2017), seat belt fit was not investigated as the causative mechanism (Sharma et al., 2006, Langdorf et al., 2016, Agrawal et al., 2013, Foreman &

Harrigan, 2017, Eastman, 2015, Biffl et al., 2009, Galyfos, Filis, et al., 2016, Ong & Jalaludin, 2016, Biffl et al., 1999, and Crawford et al., 2016). Screening for BCVI was based on previously developed grading scales and not on a specific causative mechanism, and seat belt fit as a mechanism of injury was not considered (Geddes et al., 2016 and Laser et al., 2015). Seat belt fit, as a mechanism of injury, was also not considered when health care decisions regarding diagnosis and care were being planned (Long et al., 2017, Galyfos. Filis et al., 2016, Griessenauer et al., 2013, and Lauerman et al., 2015). Considering seat belt fit as a mechanism of injury could streamline protocols for health care with the best most appropriate diagnostic tool or imaging, designing and testing seat belts, and lastly establishing clear and consistent national seat belt laws.

In Chapter 3, I will provide a detailed description of the methodology which will be a quantitative, non-experimental correlational research design. I will also describe the rationale, population, sampling and sampling procedures. I will also discuss the different data sources I will use which include primary and secondary data. I will continue by describing the data analysis as well as the threats to validity and the ethical procedure that will be used to protect the rights of the research participants.

Chapter 3: Research Method

The purpose this retrospective causal inference quantitative study was to reduce the knowledge gap in scholarly research on seat belt fit in relation to BCVI during MVCs and seat belt compliance. The key predictor variables were seat belt fit and size of the individual using the seat belt. I statistically examine whether there is a significant correlation between seat belt fit and BCVI, seat belt fit, and seat belt compliance, and the size of the driver and front-seat passenger and seat belt fit. Establishing whether the seat belt fit may cause BCVI may have practical application in how and where seat belts are placed in the vehicle, how seat belts are tested, and how medical and nursing care is provided.

In this chapter I will outline the research design and methodology, focusing on the variables, the research questions and the connection to the research design. I will describe how the design choice is consistent with research designs needed to advance knowledge in all areas. In this chapter, I will identify the procedures for gaining access to the data and acknowledged possible threats to validity, with possible solutions to said threats.

Research Design and Rationale

In this study, I used a quantitative retrospective design with two independent variables (seat belt fit/size) and three dependent variables (injuries, seat belt fit, and seat belt use). This design was the most appropriate because my goal was to test the following three research questions:

Research Question 1 (RQ1): What, if any, is the relationship between seat belt fit (as defined by height and weight) and BCVI to the neck (as defined by the Denver

Grading Scale (DGS) and grade “0” indicating all degrees of bruising, using the secondary data) during MVCs?

Alternative Hypothesis (H_a1): There is a relationship between seat belt fit and BCVI to the neck.

Null hypothesis (H_01): There is no relationship between seat belt fit and BCVI to the neck.

Research Question 2 (RQ2): What, if any, is the relationship between seat belt fit and seat belt use (using the primary data)?

Alternative Hypothesis (H_a2): Seat belt fit impacts seat belt use.

Null hypothesis (H_02). Seat belt fit has no bearing on seat belt use.

Research Question 3 (RQ3): What, if any, is the relationship between an individual’s height, weight, and seat belt fit (using the primary data)?

Hypothesis (H_a3). An individual’s height and weight affect seat belt fit.

Null hypothesis (H_03). Height and weight do not affect seat belt fit.

The purpose of the study was to use a causal-comparative design where the independent variable was not manipulated. I did not use a true experimental design because of ethical and feasibility considerations; that is, it would be against the law and unethical to experiment with people’s lives in such a way. The alternative was to use crash dummies instead of humans; however, only two adult crash dummies are currently used to test seat belts and lack some degree of authenticity. Therefore, I used a correlation study with linear multiple regression analysis. The data I used was obtained from a questionnaire and existing archival injury data. The self-report questionnaire answered RQ 2 and 3, and archival data was used to answer RQ1.

Methodology

The nature of the study was a quantitative, non-experimental, correlational design employing secondary and primary data. Based on a lack of specific research on the topic, adequate information is needed to increase the knowledge of seat belt injury and seat belt fit. Leedy and Ormrod (2005) suggested that quantitative research "involves either identifying the characteristics of an observed phenomenon or exploring possible correlations among two or more phenomena" (p. 191). Cooper and Schindler (2008) defined a research design as the "blueprint for fulfilling objectives and answering questions" (p. 89). A quantitative design refers to the fact that the study uses deductive reasoning to answer the research questions (Creswell, 2009). Deductive reasoning is a logical process in which multiple premises, all believed true or found true most of the time, are combined to obtain a specific conclusion. Deductive reasoning stems from the positivist perspective where it is assumed that truth emanates from the five senses. If you cannot smell it, taste it, hear it, see it, or feel it, then it is not the truth (Popper & Miller 1983). The participant's injury grade and seat belt fit were measured via numerical values. As such, study findings represent the truth that exists at the time the study was conducted.

I used a correlational ex-post facto design to further guide the research. Correlational design refers to the fact that the predictor variables will relate to the dependent variable while ex-post facto refers to the fact that the predictor variables will not be manipulated. This means that participants were not assigned groups because seat belt fit is defined by environmental and biological conditions; that is, participants belong to a group via environmental/biologic circumstance rather than random placement. This approach did allow for both bivariate and multiple regression analysis that was aligned with the three hypotheses, which yielded both positive and negative correlation for both research question 2 and 3.

Population

The targeted population was front-seat occupants, drivers and passengers, that were at least 18 years old and resided in the United States. This included all licensed drivers and excluding children, who were less than 18 years old and possibly too short to sit in the front passenger seat. Back-seat passengers were not used for this study, because the recommendations and legislation for back-seat, seat belt use, is inconsistent. For example, the middle back-seat passenger often has only a lap belt instead of a 3-point seat belt that will exclude them automatically from this study.

The United States population was estimated to be 321,418,820 in 2015, of which 158,229,297 were men and 163,189,523 were women. Of these, there were approximately 256 million drivers in the United States with the number of female drivers slightly exceeding male drivers. The target population (18 years and older with a state driver license) was estimated to be 256 million for both sexes in 2015 of which 124 million were men and 131 million were women (United States Census Bureau, 2016). As such, my target population accounts for approximately 80% of the United States population as of 2015.

Sampling and Sampling Procedure

I used secondary data (archival data) and primary data (questionnaire). The secondary data was previously gathered for another purpose, obtained from the NHTSA's CIREN database stretching over a 5-year period. The mission of NHTSA is to implement research programs that further the Agency's goals in the reduction of crashes, fatalities, and injuries (NHTSA, 2017c). This data was used to establish whether there is a correlation between seat belt fit and BVCI.

It was difficult to do a true experiment to gather primary data for this study given that the random assignment to injury status was not feasible. Using pre-existing data ensured that all individuals' privacy and anonymity remained protected. No official permission was needed to view, write about, or conduct research with the published cases on the CIREN database.

I also used SurveyMonkey for the self-report questionnaire. SurveyMonkey is a private American company that enables users to create their web-based surveys and upload already published surveys. It allows users to design surveys, collect responses, and analyze data from responses. With the tools SurveyMonkey provides, I set specific inclusion criteria to ensure only the required population was involved. The inclusion criteria were:

1. Only people 18 years and older with a driver's license in the United States
2. Only people, 18 years and older driving a motor vehicle in the United States

3. Only people 18 years and older that are the driver or front seat passenger at least three times a week in the United States

The SurveyMonkey link was distributed to Walden University's participation pool as well as on Facebook to ensure an adequate sample size was obtained, after obtaining permission from Walden University's Institutional Review Board (IRB). My IRB approval number is 03-06-18-0183330. I used a non-probability, convenience sampling technique to extract the sample from the population.

There are several different types of purposeful sampling such as typical, unique, maximum variation, convenience, snowball, chain, and network. I used a convenience sampling because it encompasses the person that was readily available to be researched. Specifically, Merriam (1998) asserted that this type of sampling technique is used due to restrictions of "time, money, location, and availability of sites or respondents" (p. 63).

Convenience sampling is regularly used in research to collect data that are generally representative of the population being studied. According to StatPac "this method is often used during research efforts to get an estimate of results, without incurring the cost or time required to select a random sample" (p1). This sampling method enabled me to act within a specific period and under conditions that facilitate data collection. By its nature, convenience sampling sacrifices generalizability and therefore, may not provide sufficient representation of the target population. This means that those selected for the study may only partially represent the population being investigated. As such, replication may be necessary to fully validate study results (Keppel & Zedeck, 2001). Despite its deficiencies, convenience sampling is the best method of obtaining a sample from a population when time and conditions prohibit random sampling (Neuman, 2003). Thus, convenience sampling enabled me to seek an approximation of the truth when obtaining the truth (i.e., via random sampling) was conditionally prohibitive.

Sample Size

To answer the three main research questions, linear regression was used for the statistical analysis. The sample size was calculated for the three main research questions using G*Power 3.0.10 (a sample size power analysis program). Prior to conducting the power analysis, statistical parameters must be established to ensure a satisfactory sample size. For all hypotheses, a formal power analysis was conducted using the following parameters: (a) Power = .80, (b) Effect size = .30 and (c) alpha = .05. Thus, by using G*Power 3.0.10 it was established that I will need 68 participants to produce an 80% probability of finding a relationship if one exists (Faul, Erdfelder, Lang & Buchner, 2007). The relationship between power and sample size for a regression model that contains two predictor variables is represented in Figure 1.

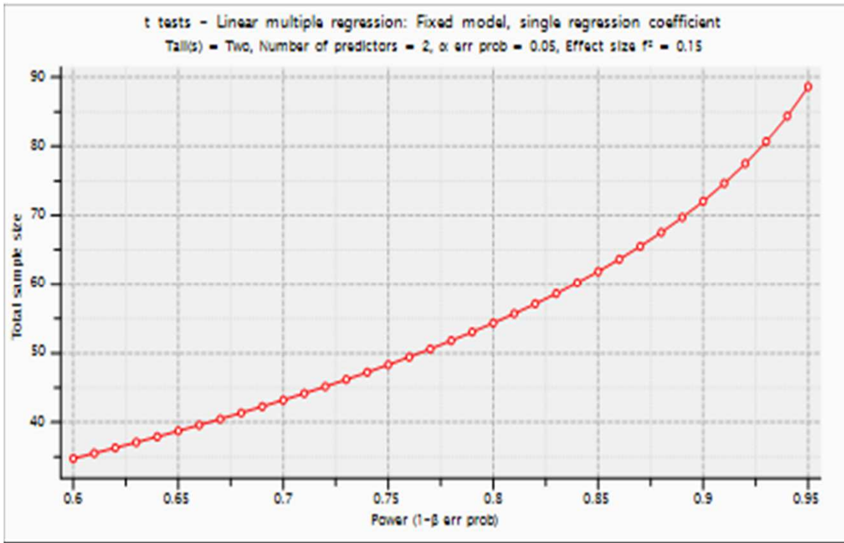

Figure 1. Parabolic plot depicting the relationship between power and sample size.

Procedures for Recruitment, Participation, and Data Collection

I collected archival data from CIREN's database, which is an NHTSA injury research database. Primary data was collected from participant panels using SurveyMonkey. NHTSA data is accessible to the general public at no cost to the user, and no additional permission needed.

Secondary Data

I obtained and downloaded the individual accident reports from the CIREN database. For research question 1, the dependent variable, injury severity, was identified by using the Denver Grading Scale (DGS), a value previously generated and extensively described by Biffl, Moore et al. (1999) and accepted as the current standard of care. The DGS is a set of screening criteria for BCVI. The DGS value is scaled from "I" to "V" where "I" represent a minor injury and "V" a severe injury resulting in death (Biffl, Moore, et al., 1999). For this study, I added grade "0" to indicate all degrees of bruising also described as contusion or external hematoma on the outer surface of the neck. It was necessary to add this additional grade because the DGS does not include external bruising as part of their grading scale. The DGS was used as an indicator of severity because CIREN identified the injuries to the neck using the DGS and a description of the bruising. Table 1 displays the DGS injury grade and associated prognosis.

Table 1

Denver Grading Scale

Injury Grade	Description	Prognosis
0	External bruising/contusion/hematoma	
I	Luminal irregularity or dissection with, 25% luminal narrowing	Good (7% progress)
II	Dissection or intramural hematoma with $25% luminal narrowing, intraluminal thrombus, or raised intimal flap	Fair with treatment (70% progress)
III	Pseudoaneurysm	Require intervention
IV	Occlusion	Outcome assured at time of diagnosis
V	Transection with free extravasation	Very poor, high mortality

Note. From "Blunt carotid arterial injuries: Implications of a new grading scale," by Biffl, Moore et al., 1999, *Trauma and Acute Care Surgery*, *47*, p. 4.

Primary Data

I used SurveyMonkey to collect primary data after approval received from Walden University's IRB (IRB approval number # 03-06-18-0183330). SurveyMonkey enabled me to use my previously designed survey to collect responses for analyzes.

Participants were recruited from Walden University's participation pool via the office of the IRB and Facebook. I uploaded the survey to SurveyMonkey after which the link for the survey was broadcasted by mass email to the Walden University's participant pool's by the office of the IRB. I created a group in Facebook with specific keywords including; seat belt project, research, research study, MVC, doctoral student, participant, fun project, future, participate, injury prevention, safety when driving, to attract participants.

Informed consent was obtained before the survey started. Each participant was given the informed consent form, that was previously approved by Walden's IRB, as an introduction to the survey with the understanding that when they enter the survey, they gave their informed consent to participate in the study. The informed consent form advised each participant of the purpose of the study and what their involvement consists of (Appendix F). Additionally, the informed consent assured participants that no identifying information would be used or collected at any point during the process and all results will remain anonymous. Participation was voluntary; thus, if a participant refused to sign the informed consent form, he or she could not enter the survey and was automatically removed from the study. Once the informed consent was obtained, each participant was able to enter the survey. All data were collected and recorded using the SurveyMonkey platform. Statistical Package for the Social Sciences (SPSS), version 24, software program was used to analyze the data.

Instrument and Operationalization of Construct

One survey was used to obtain data through SurveyMonkey. The survey was called The Seat Belt Use and Fit Survey (SUFS), which was in four parts; part 1was a 9-item demographic survey, part 2 was SUFS with photos, part 3 is the 6-item SUFS, and part 4 was 6-item seat belt adjustable survey. The four-part surveys were combined, uploaded to SurveyMonkey, and presented to participants as a single seamless survey (Appendix G). All questions are forced-choice meaning that participants must select a response option from each question. This means that participants will not be given the freedom to skip to the next question.

Seat belt use and fit Survey (SUFS). A six-item seat belt use and fit survey was used to measure the two latent constructs of seat belt fit and seat belt use. Three questions were created to measure each latent construct. All questions were scaled continuously to provide a range of options that are mathematically related.

Seat belt fit. For seat belt fit, three Likert-type survey questions were developed using a six-point progressive scaling strategy to assess participants' seat belt fit. Participants were able to select one of the six options that best fit how they feel about seat belt fit. The 6-point Likert-type scale ranges from low to high, with 1= strongly disagree, 2 = *disagree,* 3 = *slightly disagree*, 4 = *slightly agree*, and 5 = *agree*, and 6 = *strongly agree*. As evidenced by the scale, no escape option is available.

Seat belt fit was measured by totaling the score from each participant and then creating an average score by dividing by 3. The highest average score a participant can receive is six, while the lowest score is one. The scale is considered a ratio level scale because the relationship between 1 and 2 is the same as the relationship between, for example, 2 and 3. Higher scores on the seat belt fit survey mean a better fit, while lower scores mean a worse fit.

Seat belt use. Three questions were created to measure this latent construct. For the seat belt use survey (SBU), three Likert-type survey questions were developed using a six-point progressive scaling strategy to assess participants' seat belt use. Participants were able to select one of the six options that best fit how they feel about seat belt use.

The 6-point Likert-type scale ranges from low to high, with 1= *strongly disagree*, 2 = *disagree*, 3 = *slightly disagree*, 4 = *slightly agree*, and 5 = *agree*, and 6 = s*trongly* agree. As evidenced by the scale, no escape option is available.

Overall SBU was obtained by adding the score up for each participant from the three questions. Subsequently, an average score was created by dividing the summated score by 3. The highest average score a participant could receive was six while the lowest score was one. The scale was considered a ratio level scale because the relationship between 1 and 2 is the same as the relationship between, for example, 2 and 3. Higher scores on the seat belt use survey mean greater use while lower scores mean lower use.

Threats to Validity

External Validity

The premise of external validity maintains that inferred statistical results can be generalized to the research population (Creswell, 2003). Threats to external validity were partially mitigated by aligning the research population with the targeted sample. The population under study was licensed drivers over the age of 18 years. Criteria for inclusion included being at least 18 years old and self-identify as a licensed driver in the United States. The sample size for this study consisted of 68 licensed drivers as derived from a formal power analysis was conducted using the following parameters: (a) Power = .80, (b) Effect size = .30 and (c) alpha = .05. Thus, using G*Power 3.0.10, 68 participants are needed to produce an 80% probability of finding a relationship if one exists (Faul, Erdfelder, Lang & Buchner, 2007. Participants must be willing to participate and must meet criteria qualification as specified in this paragraph. Thus, it will be assumed that the sample will be a representative sample of the population and therefore, can be generalized accordingly. The study incorporates a cross-sectional approach meaning that data will be collected at a single point in time rather than across time. This strategy reduces the effect of confounding variables that could influence a participant's attitudes toward the constructs being measured.

Internal Validity

I created the seat belt use and fit survey to measure public attitudes toward seat belt use and fit. To partially validate the survey, a content validity study was conducted on the instrument to measure the degree items in the survey represented seat belt use and fit by United States drivers (Cronbach & Meehl, 1955). Four subject matter experts (SME) were asked to rate each question on a scale from low-to-high to determine whether each item appropriately measured the latent construct. A Likert-type scale format was used where 1 = *Strongly Disagree*, 2 = *Disagree*, 3 = *Slightly Disagree*, 4 = *Slightly Agree*, 5 = *Strongly Agree*, and 6 = *Strongly Agree*.

Content validity estimates were obtained in two ways: through expert judge agreement using a Table of Specifications (Table 2) and by calculating Lawshe's Content Validity Ratio, which is a formula to quantify consensus among experts regarding the content of an instrument (Lawshe, 1975). The generally acceptable estimate with expert judges' agreement is .8, or 80% (Newman et al., 2011). There were two professors and two psychometric methodologists serving as "experts." For the Lawshe's content validity ratio, when all experts say the description is appropriate, the computed CVR is 1, which indicates total agreement. With four experts, a Lawshe's CVR of .80 is considered to be an acceptable standard. The formula is as follows:

$$CVR = \frac{n_e - N/2}{N/2}$$

Where n_e equals the number of experts who agreed on the relevance of the item, behavior, or question while N equals total members of the panel of expert judges

SME's responses were recorded and coded into the Table of Specification. Averages were calculated by row and by column. Column average scores greater than or equal to 4.00 (Somewhat Agree) represent the agreement threshold meaning that if a column score averaged greater than or equal to 4.00, SME's felt the item was somewhat relevant to the latent construct. Lawshe's content validity ratio test was performed based on the coded items. Results from the analysis indicated that the 6-item survey with two constructs was valid with a ratio of 1 where: CVR = (4 – (4/2))/4/2.

Table 2

Table of Specifications

SME	Q1	Q2	Q3	Q4	Q5	Q6	Total
1	6	6	5	6	6	6	5.88
2	6	6	5	5	5	6	5.50
3	4	6	5	6	6	6	5.50
4	5	5	4	5	5	6	5.70
Total Avg	5.25	5.75	4.75	5.50	5.50	6.00	

Statistical Conclusion Validity

Demographic survey. The demographic survey consisted of eight items and was used to profile participants across a range of demographic characteristics. The survey was focused on whether participants had a driver's license, their driving frequency, age, gender, education, ethnicity, weight, and height. Questions 1-6 were nominally scaled, while questions 7 and 8 were continuously scaled. All questions were forced-choice, meaning that an escape option was not offered; participants were required to respond to each question before they can move on to the next question.

Data analysis. Data analysis was consisting of descriptive statistics, means, standard deviation and frequency where appropriate. Histograms will be displayed as well as plots and z scores to support assumptions of normality if needed. A regression table and supporting figures will be presented provided a relationship or effect is found. In this analysis, alpha will be set at .05, meaning that the minimum confidence level will be 95%. Additional steps will be determined if these assumptions are violated.

A multiple regression model will be created to test all three hypotheses. The regression model is used as a means to assess the relationship between height, weight and seat belt fit and use. The structure of this model will be, for example:

$$(Y) = \beta 0 + \beta 1 \text{height } (X1) + \beta 2 \text{weight}(X2) + €.$$

The predictor variables are symbolized by an "X" and the criterion variable is symbolized by a "Y." The regression coefficients, βn, for the models will be based on the actual data gathered from participant responses. The symbol € represents an error term that is typically distributed around a mean of zero. The entry method will be used to enter predictor variables into the model, meaning that height will be entered first and weight will be entered second. Measures of effect will include R and R-squared. R represents the strength of relationship be the composite predictor variables while R-squared represents the amount of shared variance between the combined predictor variables and criterion variable.

Ethical Procedure

The aim was to protect the rights of the research participants during data collection and throughout this study. To do so, I complied with all principles and guidelines required by Walden University's IRB. Using pre-existing data ensured that all individual's privacy and anonymity remain protected. This data did not require obtaining permissions to use.

All participation was voluntary, and no participants were coerced into participating in the study. Prospective research participants were fully informed about the procedures and risks involved in the study and were provided an electronic consent form. All data will be stored on a USB flash drive in a secured locked file cabinet for five years and later destroyed securely to protect the privacy of the participants.

Participants were not being subjected to physical and psychological harm. Participants were assured of anonymity. No identifying information was collected and made available to anyone Because of the online data collection process, participants' information was anonymous, even to me. There was no compensation for participants in the study. Participants were allowed to withdraw from the survey at any time without fear of retribution or adverse recourse. Participants can contact the researcher for any reason before, during, or after data collection. Adverse events were not expected, but participants will be directed to emergency or social services if the need arises.

Summary

In this chapter, I outlined the quantitative, cross-sectional study involving a correlational research design, which involved collecting secondary and primary research data, and the rationale for the using this research method. I also described the convenience sampling technique using SurveyMonkey to obtain participants from the population to be a representation of the driver population at large. Additionally, I included the instrumentation and procedures for data collection. I explained the treatment of such data and statistical procedures used in addressing the hypotheses and included a rationale for the analyses and the presentation of results. Finally, I addressed limitations and ethical concerns, with special consideration of methods that may remedy these potential difficulties or harms. I adhered strictly to these procedures in gathering and analyzing data to cleanly and efficiently address the research problem.

In chapter 4, I will describe the data collection in regard to the timeframe, discrepancies, and report on the baseline descriptive and demographic characteristics of the sample. I will describe how representative my sample was and provide the results of this analysis in three different sections. These sections included a Demographic, a Detail of Analyses, and a Summary of Results sections. The Demographic section summarized a profile of participants who responded to the survey. The Detail of Analysis section represented an entire breakdown of the analysis conducted by hypothesis including the evaluation of appropriate assumptions and the final inferential results. The Summary of Results section included a review of the study, study design, results by hypothesis and a preview of what will be presented in chapter five of the study.

Chapter 4: Results

The purpose of this retrospective causal inference quantitative study was to reduce the knowledge gap in scholarly research on seat belt fit in relation to BCVI during MVCs and seat belt compliance. The key predictor variables were seat belt fit and size of the individual using the seat belt. Statistically, I examined whether there was a significant correlation between seat belt fit and BCVI, seat belt fit, and seat belt compliance, and the size of the driver and front-seat passenger and seat belt fit. Establishing whether the seat belt fit may cause BCVI may have practical application including seat belts placement within the vehicle, seat belt testing, and medical and nursing care.

The research questions were:

Research Question 1 (RQ1): What, if any, is the relationship between seat belt fit (as defined by height and weight) and BCVI to the neck (as defined by the Denver Grading Scale (DGS) and grade "0" indicating all degrees of bruising, using the secondary data) during MVCs?

Alternative Hypothesis (H_a1): There is a relationship between seat belt fit and BCVI to the neck.

Null hypothesis (H_01): There is no relationship between seat belt fit and BCVI to the neck.

Research Question 2 (RQ2): What, if any, is the relationship between seat belt fit and seat belt use (using the primary data)?

Alternative Hypothesis (H_a2): Seat belt fit impacts seat belt use.

Null hypothesis (H_02). Seat belt fit has no bearing on seat belt use.

Research Question 3 (RQ3): What, if any, is the relationship between an individual's height, weight, and seat belt fit (using the primary data)?

Hypothesis (H_a3). An individual's height and weight affect seat belt fit.

Null hypothesis (H_03). Height and weight do not affect seat belt fit.

I obtained data from the NHTSA's CIREN database. The mission of NHTSA is to implement research programs that further the agency's goals in the reduction of crashes, fatalities, and injuries (NHTSA, 2017). I also collected data using the survey questionnaire created to assess the relationship between seatbelt fit and seatbelt use.

In this chapter, I will describe how I collected the. I will also describe the results, including the descriptive statistics, and the statistical analysis findings. This chapter will conclude with a summary of the answers to the research questions.

Data Collection

Data were collected over a 3-month period after IRB (IRB approval number # 03-06-18-0183330) approval was obtained. I posted the link to the questionnaire located in SurveyMonkey on the Facebook group page created for this purpose and on Walden University participant pool site. I ensured that the Facebook group page was set to be visible to the public with specific keywords to ensure it is visible during searches. The keywords were: *research, graduatestudent, seatbeltfit, seatbeltinjuries, Nurse, nurse, nursinggraduatestudent, seatbeltcomfort, motorvehiclecrash, and MVC.* A mass email was sent to Walden University participant pool by the office or the IRB to announce available research studies; no actual recruiting was done. After 3 months and 100 responses, I closed the Facebook.

One hundred respondents completed the questionnaire and three were rejected due to not being front seat occupants. Ninety-seven participants were front seat occupants and completed the questionnaire; however, some did not answer all the questions; thus, I had to make small adjustments to the analysis for each hypothesis. From the questionnaire, 17 participants self-identified as male and 78 identified as female. The average age of the respondents was 41 years. The majority of participants identified as Caucasian and Hispanic; however, also included were African Americans, American Indians, Asians, and other.

The sample was skewed toward women (82.1%) compared to men (17.9%); however, more men than women die each year in MVC because more men are practicing risky driving behavior such as not using seat belts (Insurance Institute for Highway Safety/Highway Loss Data Institute [IIHS/HLDI], 2018). This study focused on seat belt related injuries to the neck; Baudrit et al. (2014) found that there was no difference in the injury pattern of same-sized male and female victims; thus, this was a representative sample looking at size, not sex.

Size was determined by calculating the BMI. Ninety-seven participants provided their height and weight. Two individuals were very heavy and subsequently identified as univariate outliers. Normality of the BMI distribution was also examined and determined to be normally distributed.

Age was represented by a normal distribution of ages; the average age was 41 years with fewer participants in the lower and higher age groups. Approximately 53.7% of participants were between the ages of 35 and 54 years. The sample was representative for age because unintentional injuries are the leading cause of death for those between the ages of 1 and 44 years in the United States, (National Safety Council [NSC], 2017).

Results

Descriptive Statistics

Gender. Only ninety-five participants reported their gender where 17 self-identified as male and 78 identified as female. Accordingly, the sample was skewed toward women (82.1%) compared to men (17.9%).

Table 3

Frequency and Percent Statistics for Gender

Gender	Frequency	Percent
Male	17	17.9
Female	78	82.1
Total	95	100

Age group. Age was represented by a normal distribution of ages, the average age was 41 years (M = 3.72, SD = 1.34) with fewer participants in the lower and higher age groups. Approximately 53.7% of participants were between the ages of 35 and 54 years; $N = 95$.

Table 4

Frequency and Percent Statistics for Age Group

Age Group	Frequency	Percent
18-24	6	6.3
25-34	12	12.6
35-44	21	22.1
45-54	30	31.6
55-64	17	17.9
65+	9	9.5
Total	95	100

Ethnicity. Ninety-five participants completed the ethnicity question. Most of the participants identified as Caucasian (*n* = 61, 64.2%) while the next largest group (13.7%) reported being Hispanic. Approximately 14.8% reported being either African American (9.5%), American Indian (2.1%) or Asian (3.2%). Seven participants reported being in the Other category; thus, they did not identify with the classification list provided (Table 5); *N* = 95.

Table 5

Frequency and Percent Statistics for Ethnicity

Ethnicity	Frequency	Percent
African American	9	9.5
American Indian	2	2.1
Asian	3	3.2
Caucasian	61	64.2
Hispanic	13	13.7
Other	7	7.4
Total	95	100

BMI. Body mass index was calculated by using the formula (Weight*703/(Height2). That is, "when using English measurements, BMI is calculated by dividing weight in pounds (lbs.) by height in inches (in) squared and multiplying by a conversion factor of 703" (CDC 2018). Ninety-seven participants provided their height and weight. Two individuals were very heavy and subsequently identified as univariate outliers. Univariate outliers were identified by converting raw scores to z-scores—z-scores exceeding +/-3.29 were considered outliers. After removing outliers, the average BMI was 27.95 (SD = 6.93). Normality of the distribution was also examined and determined to be normally distributed.

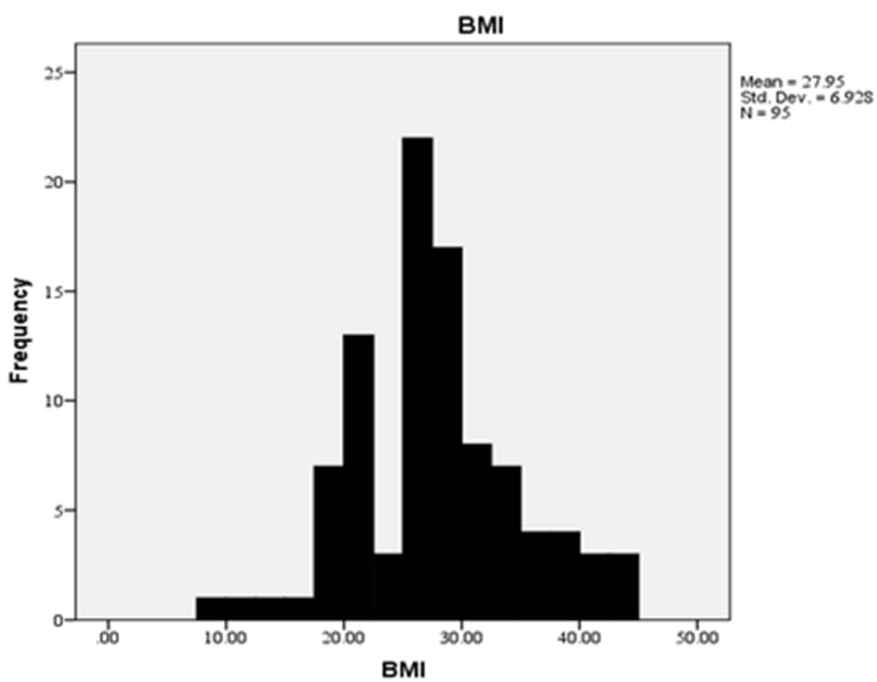

Figure 2. Histogram of participants BMI after removing univariate outliers $N = 95$

Seatbelt fit-pictures. Ninety-five participants completed the question related to seatbelt fit (as defined by pictures). Approximately 80% (n = 76) reported their seatbelt, in the vehicle they used to travel, fits well (Figure 3). This means the seat belt fit correctly across the middle of the chest and away from the neck. In contrast, approximately 11.6% of the subjects reported that their seatbelt fit high against their neck. Three participants reported they used their seat belt wrong by positioning it under their arm, and five participants did not use their seat belt.

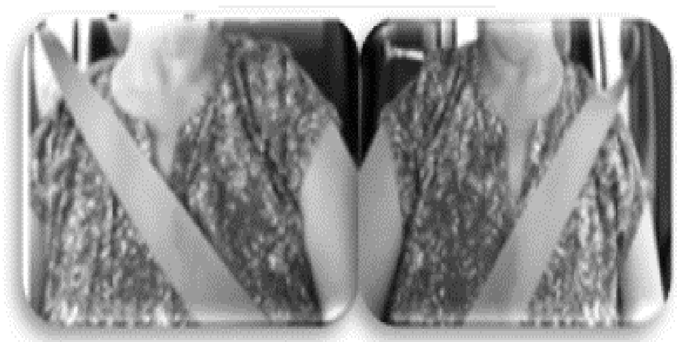

Figure 3. Group 1 displaying seat belts that fit well.

Table 6

Frequency and Percent Statistics for Picture of Seatbelt Fit

Picture Fit	Frequency	Percent
Good Fit	76	80.0
Fit against the neck	11	11.6
Positioned seat belt under the arm	3	3.2
No Seat Belt	5	5.3
Total	95	100.0

Seatbelt fit was recoded to produce a distribution of fit scores from low (positioned under the arm) to high (fit against the neck); such that, lower scores represented seatbelts that were used incorrectly by positioning the seat belt under the arm while higher scores reflected seatbelts that do not fit; thus, resting against the neck. Individuals that reported that they did not wear a seatbelt were removed from the distribution because linearity would be affected even though this was a significant finding, see Table 7.

Table 7

Frequency and Percent Statistics for Picture of Seatbelt Fit Recoded

Picture fit Recoded	Frequency	Percent
Positioned under the arm (low)	3	3.2
Good fit (medium)	76	80
Fit on the neck (high)	11	11.6
Total	90	94.7
System Missing	5	5.3
Total	95	100

Statistical Analysis Findings

Research Question 1: What is the relationship, if any, between front seat adult occupants A. Body Mass Index, B. Height, C. Seated height, D. The difference between seated high of the participant and the test dummies (seat belt fit) and injuries to the neck?

Null hypothesis (*H_0*1A): There is no relationship between BMI (seat belt fit) and injuries to the neck. Crash victim's BMI did not predict severity of injury; r_s (1, 121) = 0.023, p = 0.799. The null hypothesis was retained

BMI and injury severity data were sourced from the CIREN database, which is managed by the NHTSA. Height, weight, and the injury severity as defined by the Denver Grading Scale (DGS) were collected and subsequently used to test $H_0$1A. The DGS injury severity to the neck was re-scaled from high to low meaning that low scores indicate a less severe injury while higher scores indicate a greater neck injury; score values ranged from 1-6. The Denver grading scale and re-coded depicted in Table 8.

Table 8

Denver Injury Severity Grading Scale and Re-coding Score Values

Injury Grade	Description	Score Values
0	External bruising/contusion/hematoma	1
I	Luminal irregularity or dissection with, 25% luminal narrowing	2
II	Dissection or intramural hematoma with $25% luminal narrowing, intraluminal thrombus, or raised intimal flap	3
III	Pseudoaneurysm	4
IV	Occlusion	5
V	Transection with free extravasation	6

Height and weight were converted to BMI score where low scores represented low body mass, and higher scores represented higher body mass. The average score for BMI was 28.95 (SD = 7.32) while the average score for injury severity was 2.20 (SD = 1.73). Listwise, I sourced 122 participants from the data.

Table 9

Descriptive Statistics from CIREN Sourced Data on BMI and Injury Severity

Variable	N	Minimum	Maximum	Mean	Std. Deviation
BMI	137	18.340	67.130	28.950	7.322
Injury Severity	122	1.000	6.000	2.221	1.732
Valid N (listwise)	122				

Pearson's correlation via the general linear model in SPSS version 24 was the method planned to test H_01A. For H_01A, one dependent variable was identified from the CIREN sourced data: Injury Severity. The dependent variable was tested for normality, linearity, and homoscedasticity. Finding from the test revealed that the distribution was not normally distributed. BMI was operationalized as the predictor variable. Normality, linearity, and homoscedasticity were tested and found to be normally distributed. Because the dependent variable was not normally distributed, I will use Spearman rho to test the association between the dependent variable and predictor variable. The Spearman's rank-order correlation is the nonparametric version of the Pearson product-moment correlation. Spearman's correlation coefficient, (ρ, also signified by r_s) measures the strength and direction of the association between two ranked variables. Results from the non-parametric Spearman rho test indicated a non-significant, positive correlations. That is, crash victim's BMI did not predict severity of injury; r_s (1, 121) = 0.023, $p = 0.799$.

Null hypothesis (*H_0*1B): There is no relationship between participant height (seat belt fit) and injuries to the neck. Crash victim's height did not predict severity of injury; r_s (1, 121) = 0.003, $p = 0.972$. The null hypothesis was retained.

Pearson's correlation was planned to test $H_0$1B. For $H_0$1B, Injury Severity was the dependent variable specified from the CIREN sourced data. The dependent variable was tested for normality, linearity, and homoscedasticity. Finding from the test revealed that the distribution was not normally distributed. Height was operationalized as the predictor variable. Normality, linearity, and homoscedasticity were tested and found to be normally distributed. Because the dependent variable was not normally distributed, Spearman rho was used to test the association between the dependent variable and predictor variable. Descriptive Statistics were run to provide basic information about each variable used in the analysis, Table 10. Listwise, 122 participants, were sourced from the data.

Table 10

Descriptive Statistics for Injuries Severity and Participant Height

Variable	N	Minimum	Maximum	Mean	Std. Deviation
Height	137	57	78.000	66.416	3.867
Injury Severity	122	1.000	6.000	2.221	1.732
Valid N (listwise)	122				

Results from the non-parametric Spearman rho test indicated a non-significant relationship. That is, crash victim's height did not predict severity of injury; r_s (1, 121) = 0.003, $p = 0.972$.

Null hypothesis ($H_0$1C): There is no relationship between participant seated height (seat belt fit) and injuries to the neck. Crash victim's seated height did not predict severity of injury; r_s (1, 121) = -0.004, $p = 0.969$. The null hypothesis was retained.

Pearson's correlation via the general linear model in SPSS was the method planned to test $H_0$1C. For $H_0$1C, injury severity was the dependent variable specified from the CIREN sourced data. The dependent variable was tested for normality, linearity, and homoscedasticity. Finding from the test revealed that the distribution was not normally distributed. Seated height was operationalized as the predictor variable. Normality, linearity, and homoscedasticity were tested and found to be normally distributed. Because the dependent variable was not normally distributed, Spearman rho was used to test the association between the dependent variable and predictor variable. Descriptive Statistics were run to provide basic information about each variable used in the analysis, Table 11. Listwise, I sourced 98 participants from the data.

Table 11

Descriptive Statistics for Injury Severity and Participant Seated Height

Variable	N	Minimum	Maximum	Mean	Std. Deviation
Injury Severity	122	1	6	2.221	1.732
Seated Height	108	21	35	27.460	3.294
Valid N (listwise)	98				

Results from the non-parametric Spearman rho test indicated a non-significant relationship. That is, crash victim's seated height did not predict severity of injury; r_s (1, 97) = 0.044, p = 0.969.

Null hypothesis ($H_0$1D): There is no relationship between the difference in participant seated height and testing dummy seated height (seat belt fit) and injuries to the neck. Results indicated no significant relationship between the differences in participant seated height and testing dummy seated height (seat belt fit) and injuries to the neck. The null hypothesis was retained.

Pearson's regression (via SPSS) was used to test $H_0$1D. For $H_0$1D, Injury Severity was the dependent variable specified from the CIREN sourced data. The dependent variable was tested for normality, linearity, and homoscedasticity. Finding from the test revealed that the distribution was not normally distributed. Transformation of the variable using severe positive skewness equation rendered the variable normal. The seated height difference was operationalized as the predictor variable. Normality, linearity, and homoscedasticity were tested and found to be normally distributed. Because the dependent variable was not normally distributed, regression was used to test the association between the dependent variable and predictor variable. The seated height difference was derived by obtaining the seated height difference between the participant and the testing dummy. Difference scores were then re-coded to obtain a value that ranged from low to high. Lower scores represented seated height differences that were less than higher scores; that is, lower scores meant that the seated height difference between participant and testing dummy was smaller or less while higher scores meant that the seated height score was greater or larger.

Descriptive statistics were run to provide basic information about the two variables used in the analysis, Table 12. Listwise, 98 participants, were sourced from the data.

Table 12

Descriptive Statistics for Seat Belt Fit and Transformed Severe Positive Skew Severity

Variable	N	Minimum	Maximum	Mean	Std. Deviation
Seated Difference	108	0	10	4.280	2.490
Injury Severity	122	1	6	2.221	1.732
Valid N (listwise)	98				

Results from the parametric regression test indicated a non-significant relationship (where critical value was set at 0.05). That is, crash victim's seated height difference did not predict severity of injury; R = .143, R-squared = .021, F (1, 97) = 2.013, $p = 0.159$.

Research Question 2: What is the relationship between seatbelt fit and seatbelt use in front seat adult occupants?

Null hypothesis (*H_0*2): There is no relationship between seatbelt fit and seatbelt use. This null hypothesis was partially rejected.

Pearson's correlation via the general linear model in SPSS was the method planned to test $H_0$2. For $H_0$2, one dependent variable was identified from the primary sourced survey (Question 9 - pictures): Cross-body seat belt fit. Cross-body seat belt fit was defined in two ways, (a) placed under the arm (low), fit good (medium), and fit against the neck (high), and (b) fit or does not fit. In addition, six independent variables were sourced from Question 10 on the survey: "Please choose a response to each question about seatbelt use." The dependent variable was tested for normality, linearity, and homoscedasticity. Finding from the test revealed that the distribution was not normally distributed; Shapiro-Wilk = .469, $p < 0.001$.

The six independent variables were also tested for normality, linearity, and homoscedasticity. Findings revealed that they also did not meet parametric assumptions. For that reason, Spearman rho rather than Pearson's r was used to test the relationship between specified variables. The Spearman's rank-order correlation is the nonparametric version of the Pearson product-moment correlation. Spearman's correlation coefficient, (ρ, also signified by r_s) measures the strength and direction of the association between two ranked variables. Accordingly, a zero-order bivariate correlation test using Spearman rho was used to test the $H_0$2.

Prior to testing, Question 10 on the survey was organized by the type of question asked. That is, questions 10-1, 10-2, 10-4, and 10-6 were identified as seatbelt fit, while question 10-3 and 10-5 were identified as seatbelt use questions.

Results from the first tests, where the dependent variable was defined from seat belt placed under the arm, fit good, and fit against the neck, indicated several significant positive and negative correlations. That is, three of the six tests conducted were found to be significant. Specifically, a negative correlation was found between Picture Fit Recoded and Seat Belt Fit question 1 (“The seat belt I use fits me very well”). That is, when the seat belt fit against the neck response to question 1 decreases; r_s (1, 89) = - 0.314, $p = 0.003$.

A negative correlation was found between Picture Fit Recoded and Seat Belt Fit question 2 (“The seat belt I use is very comfortable”). That is, when the seat belt fit against the neck, seatbelt comfort decreases; r_s (1, 89) = - 0.246, $p = 0.020$.

A positive correlation was found between Picture Fit Recoded and Seat Belt Fit question 6 (“The seat belt I use does not fit me very well”). That is when the seat belt fit against the neck, seatbelt discomfort increases; r_s (1, 89) = 0.231, $p = 0.029$.

The two, seat belt use questions 10-3 and 10-5 were found to be not associated with cross-body seat belt fit; $p > .05$. Finally, no association was found between crossbody seat belt fit recoded and question 10-4 (Seat belts are not very comfortable); $p > .05$

Table 13

Spearman rho Test of Cross-Body Fit (Low to High) by Seat Belt Use

Variable	Picture Fit	Seat Belt Fit 1	Seat Belt Fit 2	Seat Belt Use 3	Seat Belt Fit 4	Seat Belt Use 5	Seat Belt Fit 6
Cross-body seat belt fit	1	-.314**	-.246*	0.013	0.194	-0.099	.231*
Seat belt I use fits me very well (1)		1	.917**	-0.159	-.318**	.352**	-.559**
Seat belt I use is comfortable (2)			1	-0.144	-.371**	.267**	-.588**
I often do not use a seat belt while driving or sitting in the from the passenger seat (3)				1	0.194	-.342**	0.15
Seat belts are not very comfortable (4)					1	-0.09	.673**
I would never drive a car without using a seat belt (5)						1	-0.088
Seat belt I use does not fit me very well (6)							1

Note. ** Correlation is significant at the 0.01 level (2-tailed), * Correlation is significant at the 0.05 level (2-tailed).

Results from the second tests (where the dependent variable was defined as no or yes crossbody seat belt fit) indicated a significant positive or negative correlation for all six tests. That is, five of the six tests conducted were found to be significant. Specifically, a negative correlation was found between crossbody seat belt fit (no, yes) and Seat Belt Fit question 1 (“The seat belt I use fits me very well”). That is, as “The seat belt I use fits me very well,” increased, the dependent variable decreased from fits to does not fit; r_s (1, 89) = -0.487, $p < 0.01$.

A negative correlation was found between crossbody seat belt fit (no, yes) and Seat Belt Fit question 2 (“The seat belt I use is very comfortable”). That is, when the seat belt fit against the neck (no, yes), seatbelt comfort decreased; r_s (1, 89) = - 0.402, $p <$ 0.001.

A positive correlation was found between crossbody seat belt fit (no, yes) and Seat Belt Fit question 6 ("The seat belt I use does not fit me very well"). That is, as when the seat belt fit against the neck (no yes), seatbelt discomfort increased; r_s (1, 89) = 0.278, $p = 0.026$.

The two seatbelt use questions 10-3 (I often do not use a seat belt while driving or sitting in the from passenger seat) and 10-5 (I would never drive a car without using a seat belt) were found also to be associated with cross-body seat belt fit (no, yes); r_s (1, 89) = 0.228, $p = 0.006$; r_s (1, 89) = -0.388, $p < 0.001$ respectively.

Table 14

Spearman rho Test of Cross-Body Fit (No, Yes) by Seat Belt Use

Correlations	1	2	3	4	5	6
Cross-body seat belt fit (No, Yes)	-.487**	-.402**	.228*	0.121	-.388**	.278**
Seat belt I use fits me very well (1)	1	.917**	-0.159	-.318**	.352**	-.559**
Seat belt I use is very comfortable (2)		1	-0.144	-.371**	.267**	-.588**
I often do not use a seat belt while driving or sitting in the from the passenger seat (3)			1	0.194	-.342**	0.15
Seat belts are not very comfortable (4)				1	-0.09	.673**
I would never drive a car without using a seat belt (5)					1	-0.088
Seat belt I use does not fit me very well (6)						1

Note. ** Correlation is significant at the 0.01 level (2-tailed), * Correlation is significant at the 0.05 level (2-tailed).

Research Question 3: What, if any, is the relationship between an individual's height, weight (BMI), and seat belt fit?

Null hypothesis (*H_0*3). There is no relationship between an individual's Body Mass Index and seatbelt related fit. This null hypothesis was also partially rejected.

Pearson's correlation via the general linear model in SPSS was the method planned to test $H_0$3. For $H_0$3, BMI was identified from the survey as the dependent variable. In addition, six independent variables were sourced from Question 10 on the survey: "Please choose a response to each question about seatbelt use." The dependent variable was tested for normality, linearity, and homoscedasticity. Finding from the test revealed that the distribution was normally distributed; Shapiro-Wilk = .979, $p < 0.127$.

The six independent variables were also tested for normality, linearity, and homoscedasticity. Findings revealed that all variables did not meet parametric assumptions. For that reason, Spearman rho rather than Pearson's r will be used to test the relationship between specified variables. Accordingly, a zero-order bivariate correlation test using Spearman rho was used to test the $H_0$3.

Results from the tests indicated two significant positive correlations. That is, two of the six tests conducted were found to be statistically significant. Specifically, a positive correlation was found between BMI and Seat Belt Fit question 4. That is, when responses to question 4 ("seat belts are not very comfortable") increases, BMI increases; r_s (1, 89) = 0.256, p = 0.003.

A positive correlation was found between Seat Belt Use question 6 (“The seat belt I use does not fit me very well”) and BMI. That is when responses to “The seat belt I use does not fit me very well” increased, BMI increases; r_s (1, 89) = 0.320, p = 0.001.

Table 15

Zero-order Correlation Matrix of BMI by Seat Belt Fit Using Spearman Rho

Variable	BMI	Seat Belt Fit 1	Seat Belt Fit 2	Seat Belt Use 3	Seat Belt Fit 4	Seat Belt Use 5	Seat Belt Fit 6
BMI	1	-0.088	-0.082	-0.078	.256*	0.066	.320**
Seat Belt Fit 1		1	.917**	-0.159	-.318**	.352**	-.559**
Seat Belt Fit 2			1	-0.144	-.371**	.267**	-.588**
Seat Belt Use 3				1	0.194	-.342**	0.15
Seat Belt Fit 4					1	-0.09	.673**
Seat Belt Use 5						1	-0.088
Seat Belt Fit 6							1

Summary

Chapter Four presented a summary of the purpose and problem statement to contextualize the results prior to discussing the analyses. I presented sample characteristics and descriptive statistics. I then described and presented detailed analyses in order of the relevant research questions and hypotheses. Finally, I examined the hypotheses so that they could be either accepted or rejected and concluded with a summary of the results. I will discuss the implications of these results in the next chapter in the context of the existing literature and practice.

For research question 1, seat belt fit was operationalized in four different ways by using BMI, height, seated height and the difference between participant and test dummy’s seated height. All four indices indicated a non-significant relationship to neck injuries. A primary sourced seat belt fit questionnaire was used to show whether seat belt fit correlated with seatbelt use and whether BMI related to seatbelt fit. Mixed results were found for the six questions in relation to the pictures used. Table 16 display all the findings.

Table 16

Findings For All Tests Conducted

Hypothesis	IV	DV	Test	r_s
$H_0$1A	BMI	Injury Severity	Spearman Rho	0.023
$H_0$1B	Height	Injury Severity	Spearman Rho	0.003
$H_0$1C	Seated Height	Injury Severity	Spearman Rho	0.004
$H_0$1D	Seated Height Difference	Injury Severity	Pearson's Regression	0.159
$H_0$2A	Seat belt I use fits me very well	Cross-body seat belt fit	Spearman Rho	**-0.314
$H_0$2B	Seat belt I use is comfortable	Cross-body seat belt fit	Spearman Rho	**-0.246
$H_0$2C	I often do not use a seat belt	Cross-body seat belt fit	Spearman Rho	0.013
$H_0$2D	Seat belts are not very comfortable	Cross-body seat belt fit	Spearman Rho	0.194
$H_0$2E	I would never drive a car without using a seat belt	Cross-body seat belt fit	Spearman Rho	-0.099
$H_0$2F	Seat belt I use does not fit me very well	Cross-body seat belt fit	Spearman Rho	*0.231
$H_0$2G	Seat belt I use fits me very well	Cross-body seat belt fit	Spearman Rho	**-0.487
$H_0$2H	Seat belt I use is comfortable	Cross-body seat belt fit	Spearman Rho	**-0.402
$H_0$2I	I often do not use a seat belt	Cross-body seat belt fit	Spearman Rho	*0.228
$H_0$2J	Seat belts are not very comfortable	Cross-body seat belt fit	Spearman Rho	0.121
$H_0$2K	I would never drive a car without using a seat belt	Cross-body seat belt fit	Spearman Rho	**-0.388
$H_0$2L	Seat belt I use does not fit me very well	Cross-body seat belt fit	Spearman Rho	**0.278
$H_0$3A	Seat belt I use fits me very well	BMI	Spearman Rho	-0.088
$H_0$3B	Seat belt I use is comfortable	BMI	Spearman Rho	-0.082
$H_0$3C	I often do not use a seat belt	BMI	Spearman Rho	-0.078
$H_0$3D	Seat belts are not very comfortable	BMI	Spearman Rho	*0.256
$H_0$3F	I would never drive a car without using a seat belt	BMI	Spearman Rho	0.066
$H_0$3G	Seat belt I use does not fit me very well	BMI	Spearman Rho	**0.320

In Chapter 5 I will concisely summarize key findings. The summary will include the interpretation of the findings and the limitations of the study. Recommendations and the implications of the study will also be described.

Chapter 5: Discussion, Conclusions, and Recommendations

MVCs remain the leading cause of death for people between 1 and 44 years of age in the United States (CDC, 2015a). Seat belts have been found to reduce injuries across the spectrum of MVCs; however, in a small percentage of cases, seatbelts have been implicated in causing injuries during an MVC (Afifi et al., 2015). Based on a review of the literature, seat belt fit had a role in seat belt related injuries and seat belt fit changed in obese individuals who were linked to injuries sustained during MVCs, meaning that while seat belts saved lives and prevented serious injuries, they also caused injuries. The relationship between seat belt related injuries and seat belt fit in all people has not been examined. If a relationship could be established between injury and fit, it may provide evidence to improve seat belt fit across the spectrum of human shapes and sizes to reduce injuries and increase compliance with seat belts use.

The purpose of this retrospective quantitative study was to (a) identify whether there was a significant correlation between seat belt fit and injuries to the neck and (b) identify whether there was a significant correlation between seat belt fit and seat belt use. Based on this, I developed three hypotheses from the research.

Null hypothesis ($H_0 1$): There is no relationship between seat belt fit and injury to the neck.

Null hypothesis ($H_0 2$): Seat belt fit has no bearing on seat belt use.

Null hypothesis ($H_0 3$): Height and weight do not affect seat belt fit.

For $H_0 1$, seat belt fit was operationalized as BMI, participant height, participant seated height, and the difference between participants seated height and dummy seated height. Findings supported the null hypothesis; that is, there was no relationship found between iterations of seatbelt fit and injury to the neck.

For $H_0 2$, seat belt fit was operationalized as seat belt positioning across the body (cross-body fit). This variable was then further operationalized as a continuously scaled variable (from low to high) and a nominally scaled variable (No, Yes). Seat belt use was operationalized as responses to six individual questions about seat belt use. Accordingly, I conducted two sets of six Spearman Rho tests.

In the first set of six tests, three of the six tests were significant. Specifically, “seatbelt fits me very well,” “The seat belt I use is comfortable,” and “seat belt I use does not fit me very well” were significantly negatively related to the continuously scaled cross-body fit variable where $p < .05$. This means that as “seatbelt fits me very well” and “the seat belt I use is comfortable” decreases, cross-body fit increases (seat belt rest against the neck). Moreover, as “seat belt I use does not fit me very well” increases cross-body fit increases (seat belt rest against the neck).

In the second set of six Spearman Rho tests, where the DV was dichotomously scaled, five of the six tests were significant. Specifically, “seat belt I use fits me very well,” “seat belt I use is comfortable,” and “I would never drive a car without using a seat belt” were negatively related to cross-body fit (no, yes). Further, “I often do not use a seat belt seat belt” and “seat belt does not fit me very well” were positively related to Cross-body fit (no, yes). This means that as cross-body fit increases from no to yes, responses to “I often do not use a seat belt seat belt” and “seat belt does not fit me very well” increases.

For $H_0 3$, BMI was specified as the dependent variable, and seat-belt fit (sourced from the six survey questions) was specified as the independent variable. Accordingly, six Spearman Rho tests were conducted. Results from the six tests yielded two related significant findings. Seat belt comfort and seat belt fit were both found to be related to BMI. That is, as seat belt comfort decreased BMI increased, and as seat belt fit decreased, BMI increased. Table 17 was used to display a summary of findings across all stated hypotheses.

Table 17

Summary of Findings For All Tests Conducted

Hypothesis	IV	DV	Test	r_s
$H_0$1A	BMI	Injury Severity	Spearman Rho	0.023
$H_0$1B	Height	Injury Severity	Spearman Rho	0.003
$H_0$1C	Seated Height	Injury Severity	Spearman Rho	0.004
$H_0$1D	Seated Height Difference	Injury Severity	Spearman Regression	0.159
$H_0$2A	Seat belt I use fits me very well	Cross-body fit (Low to High)	Spearman Rho	**-0.314
$H_0$2B	Seat belt I use is comfortable	Cross-body fit (Low to High)	Spearman Rho	**-0.246
$H_0$2C	I often do not use a seat belt	Cross-body fit (Low to High)	Spearman Rho	0.013
$H_0$2D	Seat belts are not very comfortable	Cross-body fit (Low to High)	Spearman Rho	0.194
$H_0$2E	I would never drive a car without using a seat belt	Cross-body fit (Low to High)	Spearman Rho	-0.099
$H_0$2F	Seat belt I use does not fit me very well	Cross-body seat belt fit (No, Yes)	Spearman Rho	*0.231
$H_0$2G	Seat belt I use fits me very well	Cross-body seat belt fit (No, Yes)	Spearman Rho	**-0.487
$H_0$2H	Seat belt I use is comfortable	Cross-body seat belt fit (No, Yes)	Spearman Rho	**-0.402
$H_0$2I	I often do not use a seat belt	Cross-body seat belt fit (No, Yes)	Spearman Rho	*0.228
$H_0$2J	Seat belts are not very comfortable	Cross-body seat belt fit (No, Yes)	Spearman Rho	0.121
$H_0$2K	I would never drive a car without using a seat belt	Cross-body seat belt fit (No, Yes)	Spearman Rho	**-0.388
$H_0$2L	Seat belt I use does not fit me very well	Cross-body seat belt fit (No, Yes)	Spearman Rho	**0.278
$H_0$3A	Seat belt I use fits me very well	BMI	Spearman Rho	-0.088
$H_0$3B	Seat belt I use is comfortable	BMI	Spearman Rho	-0.082
$H_0$3C	I often do not use a seat belt	BMI	Spearman Rho	-0.078
$H_0$3D	Seat belts are not very comfortable	BMI	Spearman Rho	*0.256
$H_0$3F	I would never drive a car without using a seat belt	BMI	Spearman Rho	0.066
$H_0$3G	Seat belt I use does not fit me very well	BMI	Spearman Rho	**0.320

Interpretation of the Findings

The theoretical premise to support the three hypotheses was derived from Heinrich (1950), who created the domino theory in 1928 to explain industrial accidents. The five factors described in this theory were depicted as five dominoes that if one falls all five will fall; thus, causing a chain reaction that was impossible to stop unless the proximate cause (hazard) was stopped/removed (CSU, n.d.). The decision to use the domino theory, as the foundation for this study, supported the linear approach to causation that is difficult to stop unless the seat belt fits as it should. In line with this theory, when a seat belt does not fit a chain reaction is started, that may be difficult to stop unless the proximate cause (seat belt fit) is corrected.

Findings from this study were supported by the theory aforementioned assertions in that a negative correlation was found between Picture Fit Recoded and Seat Belt Fit question 1 ("The seat belt I use fits me very well"). That is when the seat belt fit against the neck response to "the seat belt I use fits me very well," decreases. The theory also supported the two findings in relationship to comfort. A negative correlation was found between Picture Fit Recoded and Seat Belt Fit question 2 ("The seat belt I use is comfortable"). That is, when the seat belt fit against the neck, seatbelt comfort decreases. A positive correlation was found between Picture Fit Recoded and Seat Belt Fit question 6 ("The seat belt I use does not fit me very well"). That is when the seat belt fit against the neck, seatbelt discomfort increases. Thus, drivers or front-seat passengers will a) decide to ride in a motor vehicle, b) use their seat belt, c) the seat belt fitted on the neck, and d) caused discomfort.

The domino theory also includes corrective actions that could be used in the sequence of event to either prevent the injuries or improved the outcome (CSU, n.d.). The corrective sequence could include (a) removing the hazard by improving seat belt fit, (b) improved health care to minimize or eliminate complications and ensure improved outcomes, and (c) possibly stricter enforcement to ensure compliance with seat belt use. In the aforementioned assertions of the findings that seat belts did not fit and caused discomfort, is supported by the theory in that seat belt fit could be viewed as a potential hazard.

Seat belts being uncomfortable to wear was a frequent complaint by drivers (Kidd et al., 2013); however, the knowledge as to why seat belts were uncomfortable or why seat belts use results in injuries was unknown. Heinrich (1928) advised that accidents can only be reduced if there was knowledge about the causes of the accidents. The results supported Kidd's findings regarding seat belt fit and comfort; however, the results indicated no significant relationship between seat belt fit and injuries to the neck.

The effectiveness of seat belts depends on fit. Reed et al. (2013) found that a person's age was a less significant factor than BMI when considering seat belt fit, while neither was a factor in shoulder belt fit. The factor that impacted shoulder belt fit was shoulder height or stature (Reed et al., 2013). Reed et al. affirmed that body size differences between men and women made gender effect challenging to study; however, Baudrit et al. (2014) found that there was no difference in the injury pattern of same-sized male and female victims, thus size matters, not sex. BMI findings for lap belt fit were consistent regarding abdominal gird and lap belt displacement. Displacing the lap belt forward by an average of 64 mm was a significant finding for increased BMI, which means that the body will move forward 64 mm more, during MVCs, before the lap belt stops the movement (Reed et al., 2013). This forward displacement will change the injury severity depending on the space available between the body and the steering wheel or knee bolster (Reed et al., 2013).

Findings from this study do not implicitly support Reed et al.'s (2013) aforementioned assertions; however, partial support, based on findings from $H_0 2$ and $H_0 3$, is provided given that people who use seat belts and find them uncomfortable or ill-fitting are more likely to report their seat belt fits higher on the body (resting on their neck), did not fit at all, or had higher BMI. This intuitively corresponds with Reed et al.'s (2013) findings that the factor that impacted shoulder belt fit was shoulder height or stature. If shoulder height is less or more than average or an individual is obese, one could extrapolate that the cross-body belt may become more uncomfortable.

Moreover, findings related to $H_0 3$ partially support research published by Behzad, King, and Jacobson (2014). Behzad et al. found that when obesity increased by 1% seat belt use reduced by 0.06% in states with primary seat belt laws and 0.55% without primary seat belt laws. Provided I assume that seat belt use by obese subjects is related to comfort than my findings corroborate this fact, meaning that as comfort decreases, BMI increases.

Limitations of the Study

Several limitations in this study may have contributed to the ambiguous findings. Specifically, sample size, instrument sensitivity, and data collection strategy may have constrained variation of data. For quantitative data analysis, it is essential to ensure that the type of participant is well defined, and the quantity of participants is sufficient enough to detect a relationship between variables. For this study, the sample size was determined by a formal power analysis. When conducting a power analysis, it is beneficial to refer to research for appropriate effect size. For this study, effect size was estimated based on Cohen's standards (Cohen, 1988) due to lack of research on the topic. Effect size was estimated to be .30 (medium), but actual effect size was generally less. The sample size was established as 68 participants, and 95 actual participants were obtained for the survey, and 127 were obtained from the secondary data; however, a higher number of participants might have resulted in different findings.

Further, for $H_0 2$, participants were obtained from SurveyMonkey, which is a for-profit entity that entices individuals to participate in studies for a benefit. Although the benefit is small and not directly given to participants, a confounding effect may be present. That is, SurveyMonkey participants may be well seasoned and very familiar with common personality trait inventories. This seasoning may be dulling the variation of responses and can be, perhaps, contributing to an effect called regression toward the mean. This theory, developed by Galton in 1886, suggests that extremes do not survive (Galton, 1886). As applied to this study, if participants are repetitively surveyed (as in the case of SurveyMonkey participants) extreme scores are likely to creep toward the mean—extreme scores do not survive. This phenomenon effectively reduces the variation in scores and therefore makes it harder to find a relationship if one exists in the data. To mitigate this effect, researchers should ask participants (especially SurveyMonkey participants) how many self-report surveys they have participated in.

Another consideration is the fact that this study incorporated a cross-sectional design. This means that participants were asked to complete the survey at a single time point rather than obtaining data across time. This strategy may have reduced the likelihood of obtaining true seat belt usage and seat belt fit data. This means that participants may not have self-reported seat belt usage and seat belt fit based on extemporaneous factors that were affecting their attitudes and sensibilities at the time the data were collected.

An additional limitation was that the archival (secondary) data I used was primarily used for another purpose and did not provide robust information that was required for this study. The quality of the archival data was unknown and limited in the conclusion of injury causation. Furthermore, the data did not reveal enough information to discover whether there was correlation between injury severity and causation. This data also did not provide outcome information regarding whether people developed additional injuries such as CVAs because of the BCVI they sustained. For future studies, it would be beneficial to obtain primary data together with interviews with the victims and family members to ascertain whether there is a correlation between injury causation (seat belt fit) and injuries sustained during MVCs.

The chosen research method together with the secondary data was problematic; a mixed method approach with interviews could have been more beneficial for this study. I used convenience sampling and, by its nature, convenience sampling sacrifices generalizability; therefore, the data did not provide sufficient representation of the target population. This means that the data selected for the study may only partially represent the population being investigated. As such, replication may be necessary to fully validate study results (Keppel & Zedeck, 2001).

Moreover, seat belt usage and seat belt fit may be a sensitive subject to some, meaning that participants may view the subject as culturally sensitive, i.e., illegal. Although participants may not frequently wear their seat belt, their willingness to honestly divulge the information may be affected. Further, cognitive dissonance may also be affecting their ability to fully divulge seat belt usage and seat belt fit. That is, they may not be using their seat belt very often but reporting high usage and good fit to maintain a sense of self as perceived by others.

Recommendations

Researchers should focus on operationalizing seat belt fit prior to conducting additional research on the topic. In this study, I operationalized seat belt fit from the nonaccidental driver perspective. Specifically, I operationalized seat belt fit using multiple methods such as (a) BMI, (b) height, (c) seated height, and (d) the difference between seated high of the person and the test dummies and the survey with a series of three pictures that illustrated cross-body seat belt fit. Technically, this was a gross estimation of fit given the many ways that a seat belt may strap across the body. Given this, researchers may want to incrementally parameterize cross-body fit in a way that would quantify fit via an ipsative progressive scale from low to high (used wrong, fit as it should, or resting on the neck). This approach may facilitate data analysis via the general linear model. For example, researchers may want to develop a scale that technically measures fit in relation to seated body height. Thus, rather than a “low (wrong use),” “correct,” and “high (resting on the neck),” fit index, a 10-point scale could be developed (perhaps using millimeters) to assess seat belt fit above recommended placement and then, separately, below recommended placement. The manifest question then becomes: (a) What is the relationship between seat belt fit above recommended placement (resting on the neck) and frequency of use or (b) What is the relationship between seat belt fit below-recommended placement (used wrong) and frequency of use.

For this study, the best method to operational seat belt fit would be actually to fit people of all ages and sizes in their own vehicle with multi-directional cameras and predetermined measuring points using laser measuring devices together with engineers and software to analyze findings. Previous studies accomplished only one of these components at a time with great limitations. One such study was when Fong et al. (2016) measured people 75 years and older in their own vehicles and found that the cross-body belt did not fit 45% of the people with normal BMIs. The authors did observe associations between comfort, gender, and stature; however, they found that visual assessment of the cross-body belt was not reasonably reliable (Fong et al., 2016). Another study was done by Reed et al. (2012) working with engineers in a laboratory environment with a simulation of a vehicle environment to measure seat belt fit. The limitation identified was the static environment without the vehicle motions one experience when in an actual vehicle (Reed et al., 2012). Thus, efforts should be combined to measure actual fit while the vehicle is in motion with advanced software and 3-D reconstruction to ensure more accurate findings.

In addition, seat belt use was measured by individual questions about how participants used their seat belt during vehicle operation. For this reason, researchers may want to develop a latent construct that empirically measures seat belt use. This might entail a construct or criterion analysis approach where the construct is empirically defined by observed data. Researchers may want to use exploratory or confirmatory factor analysis to discover the dimensional structure of the hypothesized latent construct.

Finally, accident victims (when possible) should be surveyed to discover how their seat belt fitted and whether it was uncomfortable or not, prior to the crash. Seat belt comfort could be measured using an ipsative, Likert-type intensity scale measured from low to high. This approach may provide the means to quantitatively test important questions. Alternatively, or in addition to the previous survey, actual crash and hospital records should be investigated to establish the correlation between seat belt fit and BCVI during MVCs and whether secondary injuries such as CVAs resulted.

Implications

Loud (2016), studied three well-known United States tragedies to identify what went wrong in preventing them. Loud used Heinrich's theory to highlight its influence on safety and emphasized the causes of industrial accidents remain the same over time. Loud concluded that it is not beneficial to focus on the individual's behavior as the causative reason for an accident, but instead, the focus should be on the systems in place to prevent accidents and ensure improvement. This notion may be true for seat belts use because this study provided support that ill-fitting seat belts and uncomfortable seat belts affect use.

Kidd et al., (2013) found that the main reason given for not using seat belts was discomfort (77%). Kidd et al. asserted that technology, such as audible and haptic seat belt reminders, reduced forgetfulness but it may not necessarily affect seat belt use due to discomfort. These facts suggest that researchers and practitioners should look to expand occupant protection via some other systems approach or ensure that seat belts fit all people not just those that fall in the 50th or 5th percentile range that is used to test seat belt fit currently. This study affirms that fit and comfort affect seat belt use. Fit and comfort are perhaps inherently aligned; meaning that if seat belt fit can be resolved via some novel approach, then comfort will likely be resolved too.

Other experimental research is ongoing to find alternatives to the current three-point seat belt in use today. Alternatives discussed but not yet implemented is devices such as suction cup technology to be used without a seat belt (Gorakhpur, 2015). Others include aircraft survival innovation by simply removing the occupants from the vehicle before the actual crash, and technology that allows for vehicle to vehicle communication to avoid MVCs has been in development for two decades and is yet to be completed (Butler, 2016). The last and more feasible is the four-point seat belt designed by Volvo engineers and introduced in 2003. This four-point seat belt will distribute the forces more evenly and hold the body in place, but they had more engineering challenges to iron out before using it in their vehicles (Johnston, 2003), one might think it could be more comfort issues as well. These studies are still in their infancy, even though some had been in the developmental stages for as long as two decades. Therefore, the focus should be on improving seat belt fit for all people in order to reduce injuries caused by seat belts during MVCs, while attempting to increase compliance of use and discouraging wrong use that may reduce the severity of injuries in the event of an MVC.

The social change derived from this study includes a contribution to the existing literature by emphasizing the knowledge deficit regarding seat belt fit and neck injuries sustained during MVCs. Secondly, the significance found that seat belts do not fit and are perceived to be uncomfortable to many could add to the current medical knowledge regarding the consequence of seat belt fit during MVC. This knowledge may accentuate the impact seat belts, as a mechanism of injury, has during MVCs when seat belts were utilized. Thus, greater focus may be placed on injuries and possible injuries to the neck in crash victims when grading injuries with appropriate screening for BCVIs. Screenings should be completed with the best screening method available to rule out BCVIs that could lead to secondary injuries such as CVAs, as described by Weinberg et a. (2017). Thirdly, it was clear in this study that comfort was influenced by seat belt fit, and that comfort had a role in the decision to use a seat belt or not. In the primary data collected 5.3% of the participants self-reported not using seat belts while 3.2% reported they used seat belts wrong such as placing it under the arm. In the secondary data, it was found that 9.5% of the victims did not use their seat belts while 2.9% used it wrong. Therefore, in addition to ensuring seat belt fit, it would be beneficial to ensure that seat belt laws are consistent in all states for front- and back-seat occupants and much steeper penalties (fines/jail time) for not using seat belts. Finally, while waiting on alternative protective devices to seat belts, the NHTSA could change how they test seat belt fit to ensure it will fit everyone and not just those that fall in 50th and 5th percentile ranges. At the same time, motor vehicle manufacturers should investigate how to ensure that the seat belt in their vehicle will fit all sizes equally by either placement or improving the current adjustability of the seat belt height to ensure that the seat belts will fit everyone.

Conclusion

The purpose of the study was to narrow the knowledge gap regarding seat belt fit as a mechanism of injury and pursued to answer three questions related to seat belt injury, seat belt fit, and compliance. Data obtained from archival sources did not support the hypothesis that seat belt fit related to seat belt injury because it was statically challenging to determine seat belt fit from just height, weight, and seated height. However, results obtained from a primary source did indicate that seat belt use and seat belt comfort related to seat belt use and seat belt fit. Although the results from this study partially supported that seatbelt fit and comfort affect seatbelt use more research is needed to fully understand the influence of seat belt fit on motor vehicle occupants before, choosing to use their seatbelt or not, and during MVCs.

Seat belts save many lives and significantly reduces morbidity during MVCs (CDC, 2015a); however many people are still severely injured or killed during MVCs (Ogundele et al., 2013), others developed secondary injuries such as CVA as a result of injuries sustained during MVCs (Fox et al., 2014), some people do not use their seat belts (CDC) or use it wrong (Larkin, 2017), and the seat belts fit changed in obese people (Reed et al., 2012). Although seat belt technology has been improving slowly for many years, sufficient progress has yet to be made that fully protects occupants from injury, and further research is necessary to fully understand how and why injuries occur during MVCs.

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Appendix A: 10 Leading Causes of Death by Age Group, United States 2015

Rank	<1	1-4	5-9	10-14	15-24	25-34	35-44	45-54	55-64	65+	Total
1	Congenital Anomalies 4,825	Unintentional Injury 1,235	Unintentional Injury 755	Unintentional Injury 763	Unintentional Injury 12,514	Unintentional Injury 19,795	Unintentional Injury 17,818	Malignant Neoplasms 43,054	Malignant Neoplasms 116,122	Heart Disease 507,138	Heart Disease 633,842
2	Short Gestation 4,084	Congenital Anomalies 435	Malignant Neoplasms 437	Malignant Neoplasms 428	Suicide 5,491	Suicide 6,947	Malignant Neoplasms 10,909	Heart Disease 34,248	Heart Disease 76,872	Malignant Neoplasms 419,389	Malignant Neoplasms 595,930
3	SIDS 1,568	Homicide 369	Congenital Anomalies 181	Suicide 409	Homicide 4,733	Homicide 4,863	Heart Disease 10,387	Unintentional Injury 21,499	Unintentional Injury 19,488	Chronic Low. Respiratory Disease 131,804	Chronic Low. Respiratory Disease 155,041
4	Maternal Pregnancy Comp. 1,522	Malignant Neoplasms 354	Homicide 140	Homicide 158	Malignant Neoplasms 1,469	Malignant Neoplasms 3,704	Suicide 6,936	Liver Disease 8,874	Chronic Low. Respiratory Disease 17,457	Cerebro-vascular 120,156	Unintentional Injury 146,571
5	Unintentional Injury 1,291	Heart Disease 147	Heart Disease 85	Congenital Anomalies 156	Heart Disease 997	Heart Disease 3,522	Homicide 2,895	Suicide 8,751	Diabetes Mellitus 14,166	Alzheimer's Disease 109,495	Cerebro-vascular 140,323
6	Placenta Cord. Membranes 910	Influenza & Pneumonia 88	Chronic Low. Respiratory Disease 80	Heart Disease 125	Congenital Anomalies 386	Liver Disease 844	Liver Disease 2,861	Diabetes Mellitus 6,212	Liver Disease 13,278	Diabetes Mellitus 56,142	Alzheimer's Disease 110,561
7	Bacterial Sepsis 599	Septicemia 54	Influenza & Pneumonia 44	Chronic Low Respiratory Disease 93	Chronic Low Respiratory Disease 202	Diabetes Mellitus 798	Diabetes Mellitus 1,986	Cerebro-vascular 5,307	Cerebro-vascular 12,116	Unintentional Injury 51,395	Diabetes Mellitus 79,535
8	Respiratory Distress 462	Perinatal Period 50	Cerebro-vascular 42	Cerebro-vascular 42	Diabetes Mellitus 196	Cerebro-vascular 567	Cerebro-vascular 1,788	Chronic Low. Respiratory Disease 4,345	Suicide 7,739	Influenza & Pneumonia 48,774	Influenza & Pneumonia 57,062
9	Circulatory System Disease 428	Cerebro-vascular 42	Benign Neoplasms 39	Influenza & Pneumonia 39	Influenza & Pneumonia 184	HIV 529	HIV 1,055	Septicemia 2,542	Septicemia 5,774	Nephritis 41,258	Nephritis 49,959
10	Neonatal Hemorrhage 406	Chronic Low Respiratory Disease 40	Septicemia 31	Two Tied: Benign Neo. /Septicemia 33	Cerebro-vascular 166	Congenital Anomalies 443	Septicemia 829	Nephritis 2,124	Nephritis 5,452	Septicemia 30,817	Suicide 44,193

Data Source: National Vital Statistics System, National Center for Health Statistics, CDC.
Produced by: National Center for Injury Prevention and Control, CDC using WISQARS™.

Centers for Disease Control and Prevention
National Center for Injury Prevention and Control

(CDC, 2015a)

Appendix B: Leading Cause of Injury Deaths by Age Group Highlighting Unintentional Injury Deaths, United States 2015

	Age Groups										
Rank	<1	1-4	5-9	10-14	15-24	25-34	35-44	45-54	55-64	65+	Total
1	Unintentional Suffocation 1,125	Unintentional Drowning 390	Unintentional MV Traffic 351	Unintentional MV Traffic 412	Unintentional MV Traffic 6,787	Unintentional Poisoning 11,231	Unintentional Poisoning 10,580	Unintentional Poisoning 11,670	Unintentional Poisoning 7,782	Unintentional Fall 28,486	Unintentional Poisoning 47,478
2	Homicide Unspecified 135	Unintentional MV Traffic 332	Unintentional Drowning 129	Suicide Suffocation 234	Homicide Firearm 4,140	Unintentional MV Traffic 6,327	Unintentional MV Traffic 4,686	Unintentional MV Traffic 5,329	Unintentional MV Traffic 5,008	Unintentional MV Traffic 6,860	Unintentional MV Traffic 36,161
3	Homicide Other Spec., Classifiable 69	Homicide Unspecified 153	Unintentional Fire/Burn 72	Suicide Firearm 139	Unintentional Poisoning 3,920	Homicide Firearm 3,996	Suicide Firearm 2,952	Suicide Firearm 3,882	Suicide Firearm 3,951	Suicide Firearm 5,511	Unintentional Fall 33,381
4	Unintentional MV Traffic 64	Unintentional Suffocation 131	Homicide Firearm 69	Homicide Firearm 121	Suicide Firearm 2,461	Suicide Firearm 3,118	Suicide Suffocation 2,219	Suicide Suffocation 2,333	Unintentional Fall 2,504	Unintentional Unspecified 5,204	Suicide Firearm 22,018
5	Undetermined Suffocation 50	Unintentional Fire/Burn 100	Unintentional Other Land Transport 32	Unintentional Drowning 87	Suicide Suffocation 2,119	Suicide Suffocation 2,504	Homicide Firearm 2,197	Suicide Poisoning 1,835	Suicide Poisoning 1,593	Unintentional Suffocation 3,837	Homicide Firearm 12,979
6	Unintentional Drowning 30	Unintentional Pedestrian, Other 75	Unintentional Suffocation 31	Unintentional Other Land Transport 51	Unintentional Drowning 504	Suicide Poisoning 769	Suicide Poisoning 1,181	Homicide Firearm 1,299	Suicide Suffocation 1,535	Unintentional Poisoning 2,198	Suicide Suffocation 11,855
7	Homicide Suffocation 24	Homicide Other Spec., Classifiable 73	Unintentional Natural/ Environment 24	Unintentional Fire/Burn 41	Suicide Poisoning 409	Undetermined Poisoning 624	Undetermined Poisoning 699	Unintentional Fall 1,298	Unintentional Suffocation 777	Adverse Effects 1,721	Unintentional Unspecified 6,930
8	Unintentional Fire/Burn 22	Homicide Firearm 50	Unintentional Pedestrian, Other 20	Unintentional Poisoning 36	Homicide Cut/Pierce 312	Unintentional Drowning 445	Unintentional Fall 492	Undetermined Poisoning 828	Unintentional Unspecified 696	Unintentional Fire/Burn 1,171	Unintentional Suffocation 6,914
9	Undetermined Unspecified 21	Homicide Suffocation 31	Unintentional Poisoning 17	Unintentional Suffocation 26	Undetermined Poisoning 234	Homicide Cut/Pierce 399	Unintentional Drowning 374	Unintentional Suffocation 469	Homicide Firearm 681	Suicide Poisoning 1,005	Suicide Poisoning 6,816
10	Four Tied 12	Unintentional Fall 30	Unintentional Struck by or Against 17	Suicide Poisoning 23	Unintentional Fall 217	Unintentional Fall 324	Homicide Cut/Pierce 291	Unintentional Drowning 450	Two Tied: Undet. Poisoning, Unint. Fire/Burn 565	Suicide Suffocation 908	Unintentional Drowning 3,602

Data Source: National Center for Health Statistics (NCHS), National Vital Statistics System.
Produced by: National Center for Injury Prevention and Control, CDC using WISQARS™.

Centers for Disease Control and Prevention
National Center for Injury Prevention and Control

(CDC, 2017)

Appendix C: Top 5 Things You Should Know About Buckling Up

Seat belts save over 13,000 lives every year.

One of them could be yours…

The top 5 things you should know about buckling up.

1 Buckling up is the single most effective thing you can do to protect yourself in a crash.

In 2008, seat belts saved more than 13,000 lives nationwide. From 2004 to 2008, seat belts saved over 75,000 lives — enough people to fill a large sports arena. During a crash, being buckled up helps keep you safe and secure inside your vehicle, whereas being completely thrown out of a vehicle is almost always deadly. Seat belts are the best defense against impaired, aggressive, and distracted drivers.

2 Air bags are designed to work with seat belts, not replace them.

In fact, if you don't wear your seat belt, you could be thrown into a rapidly opening frontal air bag; a movement of such force could injure or even kill you. See www.safercar.gov for more on air bag safety.

3 How to buckle up safely:

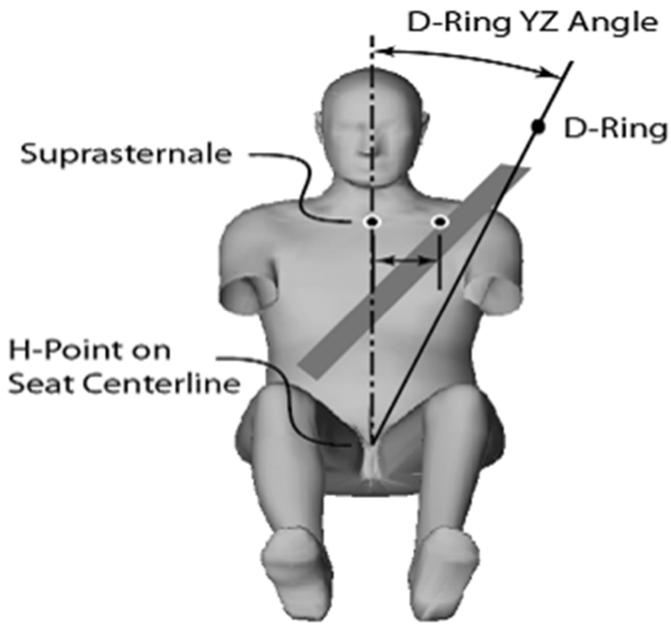
Follow the guidelines shown in the photo to the right. As you can see, the lap belt and shoulder belt are secured across the pelvis and rib cage, which are more able to withstand crash forces than other parts of your body.

4 Fit matters.

- Before you buy a new car, check to see that its seat belts are a good fit for you.
- Ask your dealer about seat belt adjusters, which can help you get the best fit.
- If you need a roomier belt, contact your vehicle manufacturer to obtain seat belt extenders.
- If you drive an older or classic car with lap belts only, check with your vehicle manufacturer about how to retrofit your car with today's safer lap/shoulder belts.

(NHTSA, 2010)

Appendix D: The Definition of the D-Ring YZ Angle



Appendix E: Permission to Use "The Definition of D-ring YZ Angle"

From:
Sent: Sunday, July 16, 2017 10:07 AM
To:
Subject: Re: Permission to use your graphics

Sure, you can use that image. However, note that it has appeared in copyrighted publications (journal articles) so you should not use it in something you submit for publication, for example a journal article. If you want to create your own similar picture, you could use the body shape models at humanshape.org to create an appropriate human figure to draw over.

On Jul 15, 2017, at 11:20 PM, Bloubul een < > wrote:

Good evening Dr.,

Your studies on seatbelt fit intrigued me; therefore, I am doing my dissertation on seatbelt fit as a mechanism of injury. I read and refer to all your studies in my dissertation.

I hope that will you give me permission to use this graphic in my document.

<2E0D7D2A1BA24D7F9C787869701BC512.gif>

Thank you in advance

Appendix F: Survey Cover Letter

Date: _____________

My name is Jacoba Viljoen, and I am a doctoral candidate at Walden University. For my dissertation, I am examining the role that seat belt fit has on drivers and front seat passengers during a motor vehicle crash, and why people are not using their seat belts. Because you are a motor vehicle driver and/or front seat passenger at least twice a week, I am inviting you to participate in this research study by completing a short survey.

The survey will require approximately 15 minutes to complete. There is no compensation for completing the survey, and there are no known risks associated with completing it.

To ensure that all information will remain confidential, please *do not* include any personal information. Copies of the project will be provided to my Walden University instructor and the IRB.

If you choose to participate in this project, please answer every question because only fully completed surveys can be used. Participation is strictly voluntary, and you may refuse to participate at any time. If there are questions you do not want to answer, you may discontinue the survey at any time.

The data collected could provide useful information regarding the effects of seat belt fit. The result will be posted on my Facebook page and available for your review.

Accessing the questionnaire will indicate your willingness to participate in this study and serve as your informed consent.

If you require additional information, have questions, or are not satisfied with the manner in which I conduct this study, please contact me via this email: If you have questions about your rights as a participant you may contact the university's

Sincerely,

Appendix G: Seat Belt Use and Fit Survey (SUFS)

This questionnaire is intended to collect data about seat belt fit and seat belt use and will require approximately 15 minutes to complete.

To ensure that all information will remain confidential, please *do not* include any personal information.

Answer every question and answer as honestly as possible. If there is a question(s) you do not want to answer you can stop at any time.

Jacoba Viljoen.

Part 1

Gender:	□ Male	□ Female				
Age:	□ 18 - 24	□ 25 - 34	□ 35 - 44	□ 45 - 54	□ 55 - 64	□ 65+
Education:	□ Less than a Bachelors	□ bachelor's or greater				
Ethnicity:	□ African American	□ American Indian	□ Asian	□ Caucasian	□ Hispanic/Latin American	□ Other

Weight in Pounds: ______________

Height in Inches: ______________

Do you have a valid State driver's license? □ Yes □ No

Do you drive a car in the United States at least two times a week and/or do you sit in the front passenger seat, of a car, at least two times a week? □ Yes □ No □ N/A

Please choose one. I am mostly a □ Driver. I am mostly a □ Passenger

If yes to both questions, please continue to Part 2 of the questionnaire.

Part 2

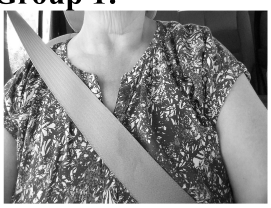
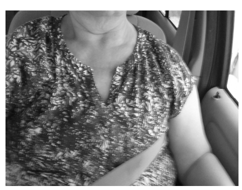
Please choose a response to each question by placing an "X" under the corresponding number next to the question using the following key.

1 = Strongly disagree, 2 = disagree, 3 = slightly disagree, 4 = slightly agree, 5 = agree, 6 = Strongly agree

	1	2	3	4	5	6
The seat belt I use fits me very well						
The seatbelt I use is comfortable						
I often do not use a seat belt while driving or sitting in the front seat as a passenger						
Seat belts are not very comfortable						
I would never drive a car without using a seat belt						
The seat belt I use does not fit me very well						

Part 3

Please choose one (1) group of pictures that closely resembles how your seatbelt sit on your chest by placing an "X" next to the photos under strongly agree.
Please leave any comments (optional).

My seatbelt sits on my chest just this way.		**Strongly agree**
Right (Passenger)	Left (Driver)	Comments
Group 1: 		
Group 2: 		
Group 3 		
Group 4 	**No seat belt**	

Part 4

Please answer the following questions about adjusting the height of your front seat shoulder belt.

1. Is the front seat shoulder belt height adjustable in your car?	☐ Yes	☐ No	☐ Unknown
If you answered "*no or unknown*" you do not need to complete the next questions.			
2. Did you adjust the height of your front seat shoulder belt?	☐ Yes	☐ No	
If you answered "*yes*", please respond to the following statements by selecting either true or false for each.			
3. The seat belt is comfortable after adjusting the height.	☐ True	☐ False	
4. The seat belt still does not fit after adjusting the height.	☐ True	☐ False	
5. The seatbelt is still uncomfortable after adjusting the height.	☐ True	☐ False	
6. The seat belt's fit improved after adjusting the height.	☐ True	☐ False	

This concludes the survey.

Thank you for your participation.