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Cooper, Christa M., <u>Wyoming Transportation Event Occupational Fatalities and Emergency Medical Service Accessibility</u>, MSW/ENR, Division of Social Work, Haub School of Environment and Natural Resources, May 2011.

Abstract (250 words)

PURPOSE: This study explored police and EMS response times and hospital distances in occupational motor vehicle crash fatalities – the leading cause of occupational fatalities in Wyoming.
OBJECTIVES: Identify police and EMS travel distances and response times correlated with victim survival for transport to a medical facility versus death on site.
METHODS: A database was created from WYDOT 2003-2007 crash reports previously identified in occupational fatality surveillance (Anderson, et al. 2010). Estimated time of incident, police and EMS notification, and scene arrival times were used to analyze response times in relation to event outcome. ArcGIS was used to analyze distances from crash sites to hospitals. Statistical tests included descriptive, Chi-Square's and ANOVAs.
RESULTS: Significant difference was found between EMS notification time and on-scene arrival in relation to event outcome. Significance was found for travel distances between 21-40 miles of crash site to nearest hospital. Significance did not exist between police response times and population demographics including vehicle type, ejection/entrapment, and state of victim residence.
IMPLICATIONS: The results of this study have the potential to impact policy and emergency healthcare services in Wyoming. A map was created portraying the 21-40 mile radius surrounding Wyoming hospitals indicating distances in which event outcome may be influenced. Regional Trauma Centers were only third in the trauma level designation of hospitals nearest crash sites indicating the majority of accident victims were not nearest to the highest level of trauma care providers in the state.

**Wyoming Transportation Event Occupational Fatalities
and Emergency Medical Service Accessibility**

by
Christa M. Cooper

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This paper is dedicated to those who live and work on our nation's highways, to those who lost their lives on the road and to their loved ones, and to Mike Gannon, may you never be forgotten – rest in peace.

assistance and comic relief in the data acquisition process as well as Tom Gallagher of the Wyoming Department of Employment for his insights into the study area.

I would also like to thank all of the faculty in both of my majors for their time, hard work, and commitment to providing higher education. I would like to thank the Division of Social Work for taking on the challenge of making a social worker out of a biologist, I am truly grateful. I would also like to thank the Haub School of Environment and Natural Resources for their continued growth and education for a sustainable future.

Last of all, I would like to thank my friends and family for their support, encouragement and patience over the past few years. Most of all, I would like to thank my social work cohorts whom I shared most of this journey with. I could not have done it without you. I applaud you all. We did it!

Thank you.

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CHAPTER ONE

Introduction

1.1 Background of the Problem

     1.1.1 Occupational and environmental health. Approximately 139 million

civilians are employed in the United States (pending June 2010, Bureau of Labor

Statistics). These workers are exposed to an array of health and injury risks related to

their employment. In 2008, 3.7 million workers reported work-related injuries and

illnesses (BLS, 2008). Occupational and environmental health addresses the health and

wellness of workers including risk and exposure recognition, prevention, and treatment.

Occupational hazards include both equipment safety hazards as well as health hazards

due to chemical, physical, biomechanical, biological and psychosocial exposures (Levy,

Wegman, Baron, & Sokas, 2006). Major categories of occupational illness and injury

include musculoskeletal, respiratory, neurologic, psychiatric, skin, reproductive and

developmental, cardiovascular, hematologic, hepatic, and renal and urinary tract (Levy,

Wegman, Baron, & Sokas, 2006).

     The Occupational Health Surveillance Work Group, comprised of representatives

of the Council of State and Territorial Epidemiologists (CSTE) and the Centers for

Disease Control – National Institute of Occupational Safety and Health (CDC-NIOSH),

compiled a list of Occupational Health Indicators (Table 1.1.1) to be used by the States in

monitoring occupational safety and health of the workforce (Stinson, et al., 2010;

Thomsen, McClain, Rosenman, & Davis, 2007). Such surveillance allows each state to be

aware of the health risks being faced by their workers and provides information to be

used for intervention and prevention measures.

Table 1.1.1: Occupational Health Indicators

1. Non-fatal injuries and illnesses
2. Work-related hospitalizations
3. Fatal work-related injuries
4. Amputations reported by employers
5. Amputations identified in State Workers' Compensation
6. Hospitalizations for work-related burns
7. Musculoskeletal disorders reported by employers
8. Carpal Tunnel Syndrome cases identified in State Workers' Compensation
9. Pneumoconiosis hospitalizations
10. Pneumoconiosis mortality
11. Acute work-related pesticide poisonings reported to poison control centers
12. Incidence of malignant mesothelioma
13. Elevated blood lead levels among adults
14. Workers employed in industries with high risk for occupational morbidity
15. Workers employed in occupations with high risk for occupational morbidity
16. Workers in occupations and industries with high risk for occupational mortality
17. Occupational health and safety professionals
18. OSHA enforcement activities
19. Workers' Compensation awards

Source: Stinson, et al., 2010

1.1.2 Burden of injury. Occupational injuries and illnesses have a wide range of consequences not only to the injured worker but also to others associated with the worker including family, friends, employer, the community and society. These costs are referred to as the cost or burden of injury and the extent of these costs are demonstrated in

Aaltonen, et al.'s (1996) Accident Consequence Tree (Figure 1.1.2). Economic costs of injuries and fatalities include both direct costs and indirect costs. Direct costs are costs accrued in treatment and compensation of the injury such as medical expenses, insurance costs, and workers' compensation payments as well as potential earnings lost to the individual. Indirect costs may not pertain directly to the individual but are a result of the accident chain of events. Indirect costs can include hiring and training of replacement employees, equipment repairs, investigative fees, lower workforce morale, and lower productivity (Brunette, 2006).

Accident Consequence Tree

Accident Consequence Tree – Consequences to Individuals branch
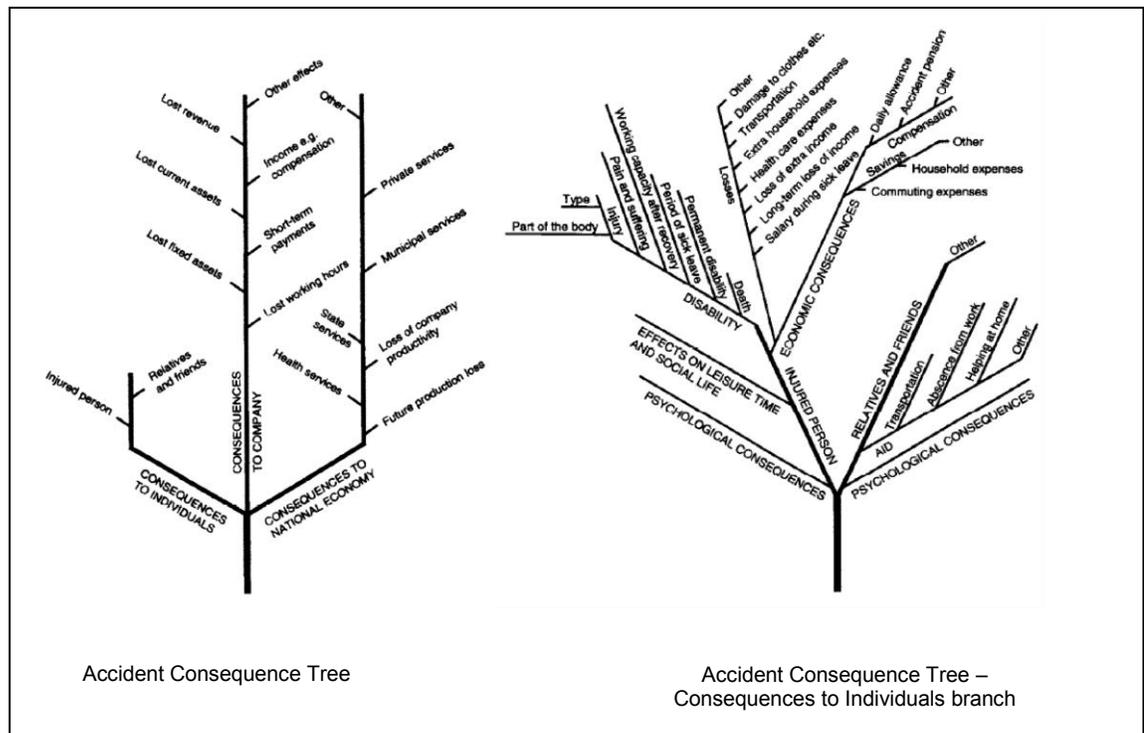
Figure 1.1.2: Accident Consequence Tree (Aaltonen, et al., 1996)

1.1.3 Injury pyramid. Research has established that incidents resulting in injury

occur in larger proportions than incidents resulting in severe injury or death (Heinrich,

Petersen & Roos, 1980; Christoffel & Gallagher, 2006; Bird, 1974). Bird (1974)

performed a study resulting in a ratio of 1 (serious or disabling injury): 10 (minor

injuries): 30 (property damage accidents): 600 (no damage or injury). Similarly, Heinrich,

Petersen & Roos (1980) estimate an accident frequency ratio of 1 major injury per every

29 minor injuries per 300 no-injury accidents. A 2001 surveillance of all injuries in the

US revealed a ratio of 1 (death): 10 (hospitalizations): 178 (treated and released)

(Vyrostek, Annest, & Ryan, 2004). These observations verify the importance of

understanding factors contributing to fatalities due to the large numbers of injuries which

also result from similar incidents (Figure 1.1.3).
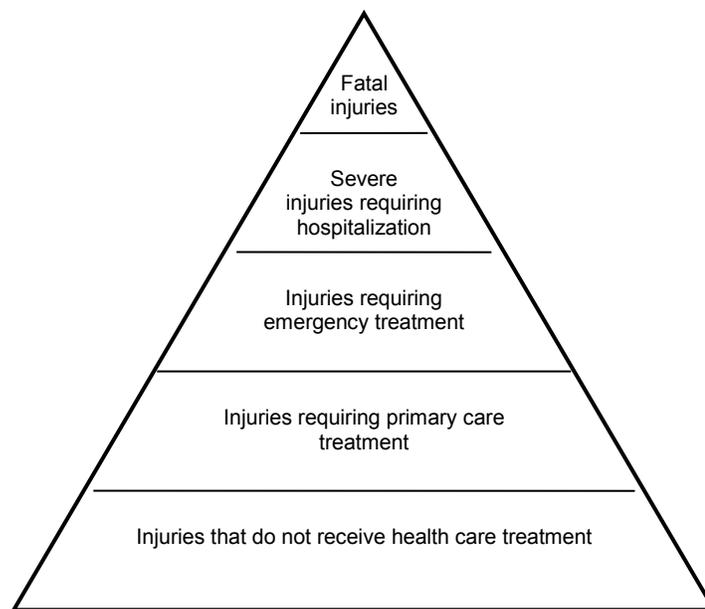
Figure 1.1.3: Injury Pyramid Example -Adapted from CDC Surveillance (Anderson & Conway, 2010)

1.1.4 Occupational fatalities in the US. Occupational fatalities in the US are tracked by the Census of Fatal Occupation Injuries (CFOI) and categorized by industry sector, occupation, and event type. According to CFOI, in 2008, 5,214 individuals lost their lives while on the job, averaging 3.7 deaths per every 100,000 workers. Construction and extraction occupations (977 deaths) were second only to transportation and warehousing sectors (1,376 deaths) in occupational deaths. By comparison, the third highest occupational sector for occupational deaths was managerial occupations with less than half as many fatalities as transportation/warehousing (553 deaths). The most common event type was transportation accidents with 2,130 fatalities; of these, over half identified as highway incidences (1,215 deaths) (USDL/BLS/CFOI, 2010).

1.1.5 Occupational fatalities in Wyoming. Wyoming worker injury rates are consistently higher than national rates, due in part to the fact that Wyoming employs a higher percentage of workers in high mortality risk occupations and industries than the national average. Additionally, Wyoming has consistently had one of the highest occupational fatality rates in the United States (Stinson, Mulloy, Boudreau, Newman, & Helkamp, 2010). Similar to national trends, industries that lead the state in occupational fatalities include mining (extraction) and transportation/warehousing (WYDOE, 2009). Highway transportation incidents are the leading event type in Wyoming occupational fatalities (Figure 1.1.5) (WYDOE, 2009).
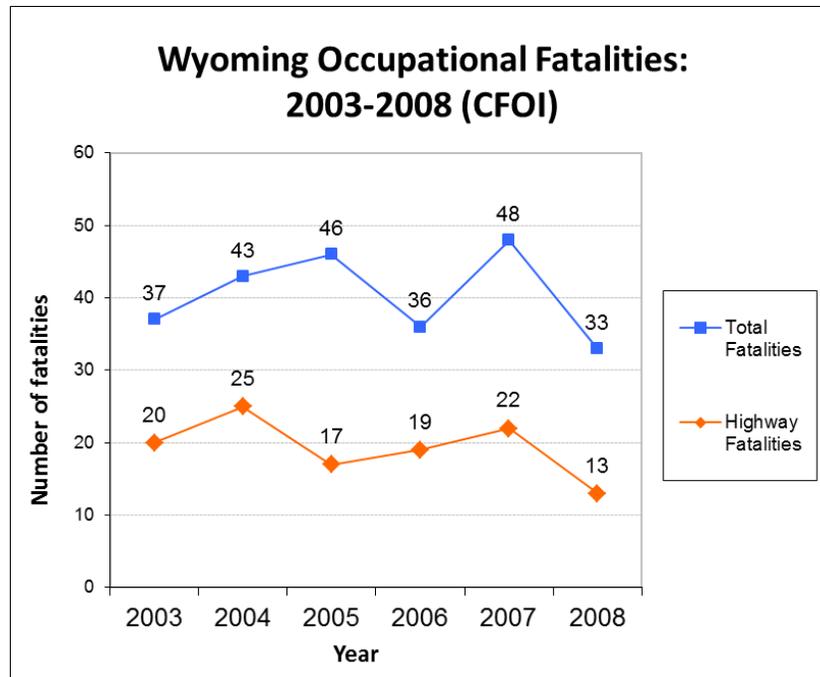
Figure 1.1.5: Wyoming Occupational Fatalities

1.1.6 Motor vehicle crashes. The National Highway Traffic Safety Administration (NHTSA) records the number and details of traffic accidents occurring in the US each year. According to the NHTSA, approximately 5.81 million motor vehicle crashes (MVC) occurred in the U.S. in 2008 (NHTSA, 2008 Traffic Safety, 2009). Of these crashes, an estimated 2.35 million people (occupants and non-occupants) were injured. Additionally, 37,423 lives were lost in 2008 and another 33,808 in 2009 due to MVCs (NHTSA – FARS, 2010). Fatality rates for 2008 were the lowest on record at 1.27 fatalities per 100 million vehicle miles traveled. The majority (4.15 million) of MVCs result in property damage only (NHTSA, 2008 Traffic Safety, 2009). The majority (2.07 million) of injury causing MVCs occurred in passenger vehicles (cars and light trucks). Large trucks, on the other hand, were the least common vehicle type involved in injury and fatality MVCs (23,000 & 677 respectively) (NHTSA, 2008 Traffic Safety, 2009).

1.1.7 Wyoming characteristics and immediate healthcare. With the exceptions of Cheyenne and Casper, Wyoming is classified as either rural or frontier. It is well documented that fatal motor vehicle crashes occur at significantly higher rates in rural areas than in urban (Zwerling, et al., 2004; Kmet, Brasher, & Macarthur, 2003; Gonzalez, Cummings, Phelan, Mulekar, & Rodning, 2008). In medicine, the "golden hour" is referred to in the immediate need for emergency medical treatment in trauma situations. The length of pre-hospital time in trauma treatment has been linked to patient survival (Gonzalez, et al., 2008; Gonzalez, et al., 2009).

With a population less than 550,000 and land area just over 97,000 square miles, the low population density (5.1; 2000 US Census) of Wyoming has yielded a total of 26 acute care hospitals in the state, 14 of which are designated as Critical Access Hospitals by the federal government (Wyoming Hospital Association, 2008). Critical Access Hospitals are rural hospitals with fewer than 25 acute care inpatient beds and are certified to receive reimbursement from Medicare (Rural Assistance Center, 2009).

Hospitals in Wyoming are also categorized according to the level of tertiary or specialized care they are able to provide. Only two hospitals in Wyoming, located in Cheyenne and Casper, are designated Regional Trauma Centers (RTC) and are equipped and staffed to provide advanced, specialized treatment (tertiary care) to trauma patients (Wyoming Trauma Program, 2008; WTP, 2009). Additionally, the Wyoming Medical Center in Casper is the only provider of air ambulance service in the state (Wyoming Medical Center, 2010). Eight more hospitals are designated Area Trauma Hospitals (ATH), which are staffed and equipped to treat the majority of trauma injuries, however a neurosurgeon is not required to be on staff and patients may be referred to an RTC for

additional treatment (WTP 2008; WTP, 2009). Over half of the hospitals in the state are designated either Community Trauma Hospitals (CTH) or Trauma Receiving Facilities (TRF), and are not equipped or fully staffed to provide advanced trauma care but are able to provide patient stabilization for referral to either ATH or RTC facilities (WTP, 2008; WTP, 2009). The transfer of trauma patients to adequately equipped and staffed trauma facilities increases the time frame from the event or exposure of injury to the provision of tertiary care.

Greater Level of Tertiary Care   Lower Level of Tertiary Care

RTC   >   ATH   >   CTH   >   TRF

1.2 Problem Statement

In epidemiology, illness and injuries are viewed as the result of interactions between agent, host and environment as illustrated in the epidemiological triad (Figure 1.2) (Runyan, 1998; Barnett, et al., 2005; Espitia-Hardeman & Paulozzi, 2005; Anderson, 2010). In the epidemiological triad, the host is defined as the person or persons at risk of injury or illness. The agent is the vector or delivery mechanism of the injury or illness. Environment includes both the physical setting of the incident occurrence as well as the sociocultural aspects of the community the event takes place in including policy, procedures and societal norms. The cycle or epidemic of the injury or illness is broken through the interruption of the interactions between these three factors (Runyan, 1998; Barnett, et al., 2005; Espitia-Hardeman & Paulozzi, 2005). Such intervention can occur at three discrete time intervals: pre-event, event, and post-event. Haddon combined
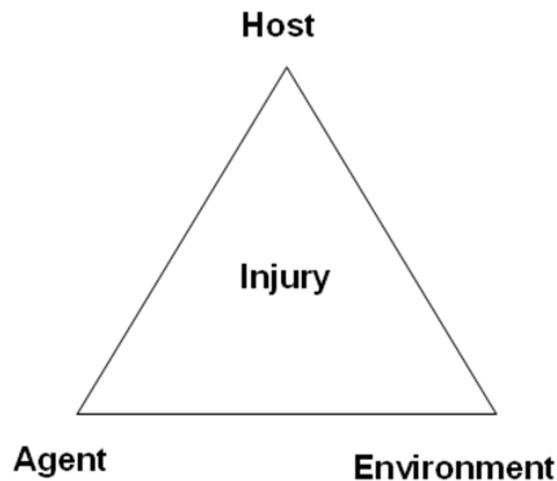
Figure 1.2: Epidemiological Triad (Runyan, 1998; Barnett, et al., 2005; Espitia-Hardeman & Paulozzi, 2005)

the factors of the epidemiological triad with the three time phases to create the Haddon matrix, a diagram used to breakdown the complexities of injury and illness occurrence in an effort to gain a better understanding of the injury/illness cycle, determine specific areas for intervention, and brainstorm plausible intervention methods (Runyan, 1998; Barnett, et al., 2005; Espitia-Hardeman & Paulozzi, 2005).

A recent surveillance study on Wyoming's occupational fatalities presented by Dr. Paul Anderson (2010) (while working with CDC-NIOSH, Anchorage, Alaska) at the College of Health Sciences 2010 Grand Rounds Research Day used this method to highlight key factors in motor vehicle crashes – the leading cause of occupational fatalities in the state (Anderson & Conway, 2010). The proposed study addresses the post-event, environmental factor of time to rescue in addition to distances traveled (Table 1.2).

Table 1.2: Haddon Matrix - Motor Vehicle Crashes (Anderson & Conway, 2010)			
	Human	**Agent**	**Environment**
Pre-Event	-Alcohol -Fatigue -Speeding -Distraction	-Vehicle Type -Configuration	-Road Alignment/ Surface -Weather/Lighting -Traffic Pattern -Visibility
Event	-Safety equipment -Corrective maneuvers	-Rollover protection -Ejection	-Roadside objects -Wildlife strikes
Post-Event	-CPR training -Dial 911 -Scene safety	-Post crash fire -Entrapment	-Time to rescue -Visibility

The rurality of Wyoming may pose an additional challenge in the delivery of emergency services for traumatic injuries resulting from motor vehicle crashes. Greater distances between crash site and EMS origin increases prehospital time. In addition, the lack of specialized care available in the majority of Wyoming's hospitals requires a system of referral for advanced trauma injuries. This socioenvironmental characteristic may be an influential factor in the high rate of occupational fatalities in Wyoming. Longer prehospital times and delays in tertiary care due to referral may decrease patient survival.

1.3 Purpose of the Project

The purpose of this study is to examine the influences of emergency service travel distances and pre-hospital times on occupational motor vehicle fatalities in the state of Wyoming. Additionally, this study will provide valuable insight into current healthcare resources, potential gaps in healthcare resources, and healthcare needs in the rural state of Wyoming.

The specific aims of this project are a) to identify police and EMS response times in relation to event outcome (death on site/ transport via coroner or transport by EMS to treating facility); and b) to identify EMS travel distances correlated with victim survival length for transport to a medical facility (versus death on site). If a relationship exists, a map will be produced highlighting areas in Wyoming outside of favorable EMS travel distances.

Overall, this project will explore occupational fatalities in Wyoming in relation to healthcare parameters including the following:

➢ Total elapsed time from estimated time of accident to EMS and police notification.

➢ Total elapsed time from EMS and police notification and EMS and police arrival.

➢ Total elapsed time from estimated time of accident to EMS and police arrival.

➢ Distance of accident site to nearest hospital.

➢ Facility trauma designation (RTC, ATH, CTH, TRF).

These factors will be analyzed both spatially using a geographic information system as well as statistically to determine significance. Results will provide another piece to the puzzle of Wyoming's occupational fatalities by addressing a post-event, environmental condition generated in a Haddon time-phase matrix established through state occupational fatality surveillance (Anderson & Conway, 2010). In a broader sense, the proposed study will provide insight and a methodology for community healthcare planning in the state of Wyoming as well as in similar rural and frontier communities. Additional areas for future study are also expected to result from this investigation.

Lastly, this project supports a larger study being conducted by the research group of Drs. Suzanne Clark, Pam Clarke, Kem Krueger, Carol Kobulnicky, and David Hunt.

This larger study is an investigation of injury treatment types and rates in addition to education and training needs in first responders and first receivers in mining and extraction impacted communities. As transportation events span all industry and occupational categories in the state of Wyoming, results will provide insight into mining and extraction fatalities as well.

1.4 Implication for Social Work Practice and Health Provider Community

The proposed study addresses two areas of macro level social work – community development and public policy. Addressing community organization and development requires an accounting of community needs and resources; healthcare provision is an example of both. The inability for healthcare facilities to effectively provide services in response to community need would indicate inadequacy in healthcare provision (Homan, 1999). Provision of services in a community or within a service providing facility is guided by policy (Popple & Leighninger, 2008). Through examination of a public service (EMS) in relation to a community need (motor vehicle crash rescue), the proposed study is linked to policy in service provision and community development. Furthermore, use of a GIS provides a readily interpretable format for information display in addition to a common frame of reference when addressing policy issues across disciplines.

The theoretical basis for this study is rooted in systems perspective and the public health model. This study emphasizes systems perspective through the examination of the interactions and relationships between motor vehicle crash victims and emergency medical response. EMS and trauma services, two vital components of motor vehicle crash injury treatment, are a part of larger healthcare systems including individual hospitals as well as overall state healthcare resources. The referral system of Wyoming hospitals is an

example of component interaction within the larger healthcare system. Additionally, the epidemiological triad and Haddon matrix exemplify the complex system of host, agent, and environmental factors in addition to time associated with injury and illness, in this case the complexities of motor vehicle crashes.

The system of host, agent and environment are also associated with the public health model. The public health model is designed to identify specific areas in an illness/injury process for intervention. In addition to the triad, the public health model also outlines levels of prevention. Primary prevention is targeted at preventing the incident occurrence and includes discovering predispositions, environmental factors, causes, and vectors. By identifying these factors, communities can become empowered to address and reduce incident occurrence. If EMS response times or travel distances to treating facilities is found to be a contributing factor to MVC occupational fatalities, hospitals and first responders can intervene at the primary step. Secondary prevention is the discovery and treatment of the condition in early stages and includes education, outreach and adequate treatment. Tertiary prevention occurs once the incident has occurred and is focused on delaying or minimizing the consequences (Welu & Cam, 1972).

CHAPTER TWO

Literature Review

2.1 The Alaska Model

During the 1980's, Alaska had the highest rate of occupational fatalities in the US. In response, the newly established NIOSH Alaska Field Station designed a comprehensive injury surveillance system titled the Alaska Occupational Injury Surveillance System (AOISS). A set of four principles provide the foundation for the AOISS model: a) problem definition including risk factors through surveillance and data collection, b) building of community relationships in addition to interagency collaboration, c) prioritizing prevention methods through development of hierarchies including use of Haddon's matrices, and d) creating action plans shaped to the individual community being addressed. Following these principles, Alaska significantly reduced the state's occupational fatality rate over the 1990's. Likewise, individual case studies using the Alaska model in helicopter logging and commercial fishing demonstrated significant decreases in occupational fatalities (Conway, Lincoln, Husberg, Manwaring, Klatt, & Thomas, 1999).

2.2 Motor Vehicle Crash Fatalities

2.2.1 Fatal highway accidents and EMS accessibility in rural Texas. A study by Brodsky and Hakkert (1983) explored the connection between fatal highway accidents in rural Texas and Emergency Medical Service accessibility in the years 1975-1978. The study area consisted of the 62 rural counties (based on 1970 Census) in Texas additionally excluding accidents which occurred within town limits. EMS and ambulance locations were obtained from 1979 Texas Department of Health information. Hospital

information was gathered from the 1974 Public Health Service and 1978 American Hospital Association Guide. Variability in EMS locations led to three groupings for the study: access, mixed, and remote. Access was defined as a county containing a hospital and at least two separate ambulance service locations. Remote counties contained no hospital and no more than one ambulance service. The mixed category had more services than remote but less than access counties (Brodsky & Hakkert, 1983).

Consistency tests performed by Brodsky & Hakkert (1983) included a) mean percent of highway within five miles of ambulance service, b) highway miles per ambulance, c) highway miles per emergency medical technician (EMT) and d) distance to nearest metropolitan center. All four tests verified access areas demonstrated greater accessibility. Log linear analysis was performed in a four step process: a) relevant variables included in the accident files were tested for association with accident severity and EMS response; b) associated variables were included in the model; c) factors found significant in the model were retained; d) model parameters were expressed as natural logs of odds ratios (logits).

Factors demonstrating significant association with severity (dependent variable) and EMS response (independent variable) included the type of accident (overturned, multivehicle, fixed object) and the number of persons involved in the accident. Alignment of road interacted with type of accident. Time of day of the accident was not significantly related to EMS response but was associated with type of accident and number of persons involved. No significant differences were found between EMS regions. Logit analysis revealed highest % severity (66.4% fatality) in a multivehicle accident involving more than 2 persons, in a remote region, in the evening, on a curve.

2.2.2 Hospital proximity and fatalities in motor vehicle crashes in 15-24 year olds. Bentham (1986) conducted a study on the relationship of motor vehicle crash fatalities and hospital proximity in England and Wales (excluding the Isles of Scilly and the City of London) for the years 1979-1983. Data on fatal crashes was obtained from the Office of Population Censuses and Surveys. Mortality rates were based on place of residence not location of accident. Class composition, car ownership, and journeys to work in car or motorcycle variables (expressed as percentages) were included in analysis as reflections of geographical variation and dependence on private transport. Analysis of variance found mortality rates were significantly greater ($p<0.001$) in rural areas and growth areas than urban areas. Class composition, car ownership and proximity of Accident and Emergency Department were all found to be statistically significant under multiple regression analysis. The journey to work variable was not significant and was removed from the model. Class composition results showed higher mortality in lower classes (social class IV and V). Speculation on this relationship includes social, economic, cultural and behavioral factors. Household car ownership was used to reflect area dependence on private transportation and was demonstrated in higher percentages in rural areas. Proximity to a hospital with an Accident and Emergency Department remained significant when both class composition and car ownership were controlled for indicating a possible relationship between motor vehicle crash outcome mortality and access to emergency care (Bentham, 1986).

2.2.3 EMS accessibility and outcome in Norfolk County, England. Jones and Bentham (1995) studied the effect of EMS response time on road traffic accident outcome in Norfolk between the years 1987-1991. Data on road traffic fatalities was

collected from Stats 19 Police Reports, Norfolk Death Register, and local newspapers. GIS was used to estimate EMS travel time and distances for each accident. Logistic regression was used to determine significance of associated road traffic accident variables. Variables not found significant were removed from the model. Analysis showed age, speed limit, road user type (bicyclist, motorcyclist, or other – pedestrian not included), and number of casualties involved to be significant. Variables found to not be significant and subsequently removed from the model included the year of the accident, time of day, day of the week, and the number of vehicles involved. Additionally, the following factors were not found significant when confounding factors were controlled for: a) ambulance travel time to the scene of the accident, b) travel time from accident site to Accident and Emergency Department, and c) total ambulance journey time (Jones & Bentham, 1995).

2.2.4 Contributing factors in rural motor vehicle crash fatalities. Zwerling, Peek-Asa, Whitten, Choi, Sprince and Jones (2004) performed a decomposition analysis on the contributing factors of fatal motor vehicle crashes in rural and urban areas. National data was obtained from the 2001 Fatality Analysis Reporting System under the National Highway Traffic and Safety Administration and the National Automotive Sampling System's General Estimates System. Fatal crash incidence density, defined as the total number of fatal crashes divided by the number of miles traveled, was decomposed into three factors: a) injury fatality rate, b) crash injury rate, and c) crash incidence density (Figure 2.2.4). The authors found the injury fatality rate to be three times higher in rural areas, weighing the most on crash incidence density suggesting

Fatal crash incidence density (A)		Injury fatality rate (B)		Crash injury rate (C)		Crash incidence density (D)
$\dfrac{\text{\# fatal crashes}}{\text{\# vehicle miles traveled}}$	=	$\dfrac{\text{\# fatal crashes}}{\text{\# crashes with injuries}}$	x	$\dfrac{\text{\# crashes with injuries}}{\text{\# all crashes}}$	x	$\dfrac{\text{\# all crashes}}{\text{\# vehicle miles traveled}}$

Figure 2.2.4: Zwerling, et al., p.25 "Disaggregation of the fatal crash incidence density into component parts."

factors of the crash as well as after the crash are greater determinants than exposure. Survival of a crash with injury was lower in rural than urban areas. Older drivers also had higher crash fatality incidence density than younger drivers. The authors suggest intervention strategies targeted at reducing injury severity and consequences, including emergency medical service improvements (Zwerling, et al., 2004).

2.2.5 Data linkage analysis of prehospital factors in motor vehicle crash fatalities. Gonzalez, Cummings, Phelan, Mulekar, and Rodning (2006) performed a data linkage analysis of prehospital factors influencing mortality in motor vehicle crashes in search of contributors to higher rural fatality rates in seven southwestern Alabama counties. Data was collected and entries were linked from the State of Alabama Police Accident Reports (PARs) and EMS Patient Care Reports (PCRs). Additionally, entries were transformed and projected for mapping using Geographic Information Systems allowing for crash site identification and rural/urban differentiation. Statistical analyses were then performed on 4,694 linked cases including 164 mortalities. Results found rural fatalities nearly twice the rate of urban. Significantly more patients were found dead on scene (DOS) in rural settings than urban however mortality rates for patients who met Trauma Alert Criteria (TAC) were similar in rural and urban settings. This finding suggests that lower injury severities contribute to higher rural mortality rates. Response times were significantly greater in rural than urban settings as well as longer within rural

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settings in cases with mortalities than without mortalities. Additionally time on scene and

transport time was significantly greater in rural cases. Overall, results indicated a

correlation between prehospital length of care and patient mortality (Gonzalez,

Cummings, Phelan, Mulekar, and Rodning, 2006).

Another study by Gonzalez, Cummings, Phelan, Mulekar, and Rodning (2009)

examined the effects of prehospital time on patient mortality in rural motor vehicle

crashes in a statewide analysis of Alabama motor vehicle crashes. Data was collected

from the State of Alabama PARs and EMS-PCRs covering a two year time frame (2001-

2002) yielding 714 cases for analysis. Data were differentiated between urban and rural

using a GIS. Categories selected for statistical analysis were EMS response time, EMS

scene time, EMS transport time, overall EMS prehospital time, EMS distance to crash

site, number of motor vehicle crashes, patent trauma alert criteria (TAC), and mortalities.

Similar to their smaller scale study, results revealed significantly longer response times in

rural versus urban settings in both cases with and without mortalities, including

significantly longer scene times. In fatality cases, the total prehospital time was also

significantly longer in rural areas including significantly greater response times and mean

travel distances. Within rural settings, EMS response time was significantly greater in

cases with mortality than without suggesting patient survival is negatively influenced by

greater EMS response time. DOS rates within urban and rural settings were similar at

rates of 52% and 53%; however, DOS rates in comparison were significantly greater in

rural versus urban implying similar injury severity in urban and rural crashes however

lower injury severities may contribute to rural mortalities. This finding additionally

suggests that lower injury severities may be influenced by prehospital EMS treatment (Gonzalez, Cummings, Phelan, Mulekar, & Rodning, 2009).

Kmet, Brasher, and Macarthur (2003) performed a cross-sectional study of motor vehicle crash fatalities in five regions of Alberta, Canada occurring between the years 1995-1997. Study objectives were to determine crash fatality rates, assess rate variations, and explore area-level predictors in relation to the rate variations. Results showed male fatality rates more than double the rate of females with the highest crash rate occurring in 15-24 year old age category. Crash fatality rates were nearly five times greater in rural areas versus urban. Study of area-level predictors suggested rural location and increased impaired driving rates were linked with higher crash fatality rates. Possible rural factors suggested by the authors that may contribute to the increase in rural fatality rate included exposure, driving habits (i.e., alcohol, safety precautions), road conditions and accessibility to trauma care (Kmet, Brasher, & Macarthur, 2003).

2.3 Geographic Information Systems (GIS)

GIS is a technological tool designed to combine geographic locations with associated aspatial information. The system functionality of GIS allows for management of large amounts of information readily projected into maps and analyzed. GIS also allows for the simultaneous presentation of data across disciplines, united by spatial reference. Visual display of spatially referenced data has the advantage of providing a common language, a different perspective, as well as the means to present large amounts of information in a readily recognized format (O'Looney, 1997). In medicine and social services, GIS can be used to map available healthcare resources as well as identify unmet health needs. Furthermore, the establishment of a standardized GIS public health

surveillance method allows for tracking of healthcare resources, use, and needs over time which leads not only to better public health response and intervention, but can improve prediction and prevention measures as well (World Health Organization, 2007). In 1990, the World Health Organization (WHO) launched the Public Health Mapping and GIS Program in efforts to better coordinate and standardize disease and health surveillance and improve healthcare delivery worldwide. Health mapping can be used to monitor disease outbreaks, healthcare service availability and accessibility, and the distribution of medical supplies such as medication, as well as quickly determine resource locations in emergency situations (WHO, 2007).

Rafalski and Zun (2004) performed a GIS study on emergency department (ED) use by the Chicago Fire Department (CFD) in trauma cases at the Mount Sinai Hospital in Chicago. Locations of Chicago fire companies were obtained from the Bureau of Medical Services and Mount Sinai Hospital's data warehouse was data-mined for ED cases. While located in western Chicago, Mount Sinai is the assigned trauma center for the Chicago South EMS System, therefore the majority of CFD admissions should originate from the southern district. GIS analysis revealed the majority of cases admitted to Mount Sinai by the CFD originated from the Chicago Central EMS System. The authors note how such a misrepresentation can have detrimental effects on emergency preparedness in the city, especially in disaster cases, resulting in unequal caseloads in the area hospitals. Significant increases in patients leaving without treatment resulted when patient volume reached nine or more. As a result of this discovery, a surge protocol was established in which physician assistants were deployed to counter high ED patient numbers (Rafalski & Zun, 2004).

In a meeting abstract, Kvam (2009) briefly described the use of GIS in Emergency Medical coordination centers and EMS out of the Buskerud Hospital in Drammen, Norway. The project objective was to present data valuable in redesigning of emergency service and ambulance plans. Geospatial coordinates were collected from each emergency vehicle along with patient and injury characteristics and EMS response times. Data were analyzed using ArcMap (ESRI) for spatial cluster identification. Results revealed weak-links in three areas: a) areas with both seasonal and permanent clusters of differing emergency need, b) areas with poor coverage and long response times, and c) areas with low positive cardiac arrest outcomes (Kvam, 2009).

GIS can also aide in the evaluation of current public services and determine need and placement for additional resources. In 2002, Denver, Colorado began assessing the Denver Fire Department's (DFD) services and performance for development of a Fire Facilities Master Plan (Genzer & Luhan, 2009). Data from 2001 service calls were provided to GIS analysts by the DFD and geocoded for map projection yielding a call density layer over the city. Distances from firehouses to call areas were calculated and joined to the density layer, accentuating areas of the city outside of the DFD four-minute response criteria. Through observation of the underserved areas, GIS analysts were able to recommend various solutions to the city officials and planning board including construction of additional fire stations, relocation of existing fire stations, and expanding existing stations. Using the GIS analysis, the city of Denver was able to cooperate with the neighboring city of Glendale to provide improved service to bordering areas as well as choose favorable sites for the addition of several new fire stations (Genzer & Luhan, 2009).

2.4 State of the Knowledge

The Alaska Occupational Injury Surveillance System provides a foundation for addressing Wyoming's high occupational fatality rate. The decline of occupational fatalities in Alaska's workforce seen since the implementation of AOISS suggests the feasibility of successfully identifying and dissipating Wyoming's current trend (Conway, Lincoln, Husberg, Manwaring, Klatt, & Thomas, 1999). Surveillance work already performed by Dr. Paul Anderson (2010) through NIOSH utilizing the AOISS model has identified potential contributing factors in need of further exploration including EMS response time in motor vehicle crashes which is to be analyzed in the proposed study.

Findings by Zwerling, Peek-Asa, Whitten, Choi, Sprince and Jones (2004) on the contribution of event and post-event factors on fatal crash incidence density along with their suggestion for reducing the consequences of crashes further supports the decision explore a post-event environmental factor of Wyoming's occupational transportation event fatalities. The literature also consistently revealed higher rates of motor vehicle crash fatalities in rural settings in conjunction with increased EMS response times, indicating the importance of EMS delivery for patient survival (Zwerling, et al., 2004; Gonzalez, Cummings, Phelan, Mulekar, and Rodning, 2006; Gonzalez, Cummings, Phelan, Mulekar, & Rodning, 2009; Kmet, Brasher, & Macarthur, 2003). As a rural state, Wyoming crash victims may be at an increased risk for mortality if EMS response times are insufficient in delivering timely tertiary care.

Use of GIS in community resource planning provides a method to combine data from differing sectors to accurately study geographically related information. Literature shows how GIS can be used to determine community need in service planning (Genzer &

Luhan, 2009; Kvem, 2009; Rafalski & Zun, 2004). GIS can also provide a common frame of reference readily interpretable to audiences and can be influential in community development and policy planning (Genzer & Luhan, 2009). As a statewide motor vehicle crash study, the proposed study will benefit from a GIS approach in both analysis as well as presentation to concerned Wyoming officials as well as other rural regions facing similar situations.

CHAPTER THREE

Research Design

This study was a secondary analysis of a database previously compiled by Dr. Paul Anderson (2010) in CDC-NIOSH surveillance of Wyoming's occupational fatalities between the years 2003-2007.

3.1 Research Questions

This study spatially and statistically analyzed Wyoming occupational fatalities involving motor vehicle crash events in relation to the following:

➢ Total elapsed time from estimated time of accident to EMS and police notification.

➢ Total elapsed time from EMS and police notification and EMS and police arrival.

➢ Total elapsed time from estimated time of accident to EMS and police arrival.

➢ Distance of accident site to closest healthcare facility.

➢ Facility trauma designation (RTC, ATH, CTH, TRF).

Research questions included:

➢ Do prehospital times and response intervals affect accident outcome (transport via coroner vs. EMS) in Wyoming occupational motor vehicle crashes?

➢ Does the trauma designation of the nearest hospital affect Wyoming occupational motor vehicle crash outcome (transport via coroner vs. EMS)?

➢ Does distance from scene of event to nearest hospital affect Wyoming occupational motor vehicle crash outcome (transport via coroner or EMS to nearest hospital)?

3.2 Population

Two hundred and ten occupational deaths were reported in Wyoming between the years 2003 – 2007. Of these, 103 were highway motor vehicle crashes. Wyoming

occupational fatality surveillance identified 81 (78.6%) of these cases via Wyoming

Department of Transportation (WYDOT) crash report search and matching with death

certificates and worker's compensation claims (Anderson & Conway, 2010).

The study population consisted of 81 occupational highway accident victims.

Upon approval from WYDOT (Tom Carpenter, personal communication, 20 July 2010),

WYDOT crash report files were received from the CDC-NIOSH Alaska Regional Office.

A list of crash report numbers was provided by Dr. Paul Anderson identifying reports

pertaining to occupational fatalities. In crash reports containing more than one death, the

occupational death was determined by vehicle type, ownership, and occupation of the

victim/s as reported on the crash report. Worker's compensation claims and death

certificates were not used in this study.

Names of deceased individuals were not included in database creation.

Demographics collected included age, gender, and state of residence of the deceased. IRB

approval was not required as all subjects are deceased as confirmed by Tara Nelson,

Associate General Counsel, University of Wyoming (Appendix A).

3.3 Data Analysis

Spatial analysis was conducted using ESRI's ArcGIS v.10. The data set was

created in Microsoft Excel using data collected from the WYDOT crash reports.

Locations of motor vehicle crash fatalities were determined from crash report accident

location fields. Latitude and longitude for each accident site were obtained using Google

Earth and the WYDOT GIS Map Viewer (http://gis.wyoroad.info/PublicViewer/

process?cmd=viewer). Additional data for GIS analysis and geographic referencing and

their sources include hospital/treatment facility location (ESRI: ArcGIS Online, State of

Wyoming); Wyoming state, county and city boundaries (Wyoming GeoLibrary); Wyoming major roadways, rivers and other geographical features for providing frame of reference for display purposes (ArcIMS Image Service; Wyoming GeoLibrary). Staff and faculty of the Wyoming Geographic Information Science Center (WYGISC) were consulted to verify GIS design and accuracy of results.

SAS and PASW were used to statistically analyze the data. Descriptive statistics including frequencies, means, medians, modes, and standard deviations were performed for each variable. Additionally, ANOVAs were run to determine significance of EMS and police response time intervals, and distances from crash site to nearest hospital. Chi-square analysis or Fisher's Exact Test was also used to analyze the relationship between outcome and driver status, ejection status, vehicle type, and residence. Residence was divided into three categories: a) local – Wyoming, b) regional – Colorado, Nebraska, South Dakota, Montana, Idaho and Utah; and c) non-regional – all states excluded from local and regional categories. To relax the data assumptions required for ANOVA, the response time intervals were collapsed into categories and Chi-Square analysis was used to analyze the relationship between response intervals and outcomes.

CHAPTER FOUR

Results

This chapter presents the results of the study including tables, charts, and GIS images. A discussion of the results will follow in Chapter Five.

4.1 Data Analysis

Seventy-seven of the 81 crash reports were used for the study. Four cases (200316113, 200412496, 200312752, and 200721087) either did not have confirmed deaths on the crash report or had multiple deaths and the occupational fatality could not be confirmed. Additionally, the location of case # 200614517 could not be verified and was omitted from the spatial analysis. The number of event outcomes/destinations reported totaled 56 (69.1%). Individual cases varied in fields completed on the crash reports resulting in further variation in subjects between statistical tests.

4.1.1 Population demographics. The number of victims transported to morgues or mortuaries via coroner equaled 34 (60.7%, n=56). The remaining 22 victims were transported by EMS to hospitals. Seventy-one of the 77 victims were male (92.2%). Accident victims' ages ranged from 16 to 73, with a mean age of 42.91 (n=76). As shown in table 4.1.1a, 75.3% (n=58) of victims were reported as drivers of the vehicle, which was not significant in relation to event outcome (n=55, x^2=1.36, p=0.244).

Table 4.1.1a: Chi-Square Tests : Event Outcome * Driver

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	1.360[a]	1	.244		
Continuity Correction[b]	.709	1	.400		
Likelihood Ratio	1.339	1	.247		
Fisher's Exact Test				.334	.199
Linear-by-Linear Association	1.335	1	.248		
N of Valid Cases	55				

a. 0 cells (.0%) have expected count less than 5. The minimum expected count is 5.20

b. Computed only for a 2x2 table

Fifty-six cases had state of residence reported on the crash reports. Residence was

determined from recorded state on the crash report presumably copied from the victim's

driver's license. Cases with no reported death on the crash report which did include state

of residence were included as all cases were previously identified as occupational deaths.

A total of 21 different states were represented by the accident victims. Results

shown in Table 4.1.1b show nearly half of the fatalities were residents of the State of

Wyoming (38, 49.4%). The remaining accidents were nearly equally divided between

regional and non-regional residences (18, 23.4% and 21, 27.3%, respectively, see Figure

4.1.1a). There were no significant correlations between event outcome (transport by

coroner to morgue versus transport by EMS to hospital) and local, regional or non-

regional residency as shown in Table 4.1.1c (n=56; x^2=2.04, p=0.728).

Table 4.1.1b: STATE OF RESIDENCE

State	Frequency	Percent
AR	1	1.3
AZ	2	2.6
CA	1	1.3
CO	7	9.1
DE	1	1.3
FL	5	6.5
GA	1	1.3
ID	3	3.9
KY	1	1.3
MN	1	1.3
MT	4	5.2
NC	1	1.3
NV	1	1.3
NY	1	1.3
SD	2	2.6
TX	2	2.6
TN	1	1.3
UT	2	2.6
VA	1	1.3
WA	1	1.3
WY	38	49.4
Total	77	100.0
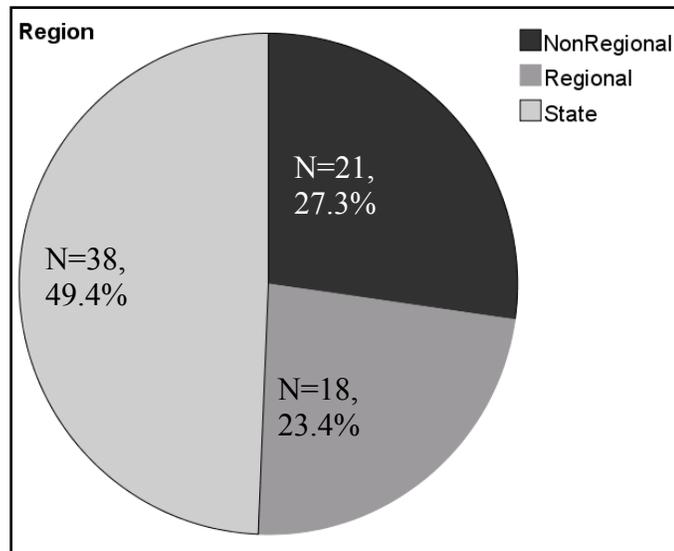
Figure 4.1.1a: Residence of accident victim

Table 4.1.1c: Chi-Square Tests: Region of Residence * Event Outcome

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	2.042[a]	4	.728
Likelihood Ratio	2.390	4	.664
N of Valid Cases	56		

a. 4 cells (44.4%) have expected count less than 5. The minimum expected count is .46

Figure 4.1.1b shows that of the 77 fatalities, 28 (36.84%) remained in their vehicles, 10 (13.16%) were partially ejected, 23 (30.26%) were totally ejected and 15 (19.74%) were trapped requiring extraction. When cross tabulated with event outcome, ejection (partial and total), non-ejection, and entrapment were not significantly related to outcome as seen in Table 4.1.1d (n=56, p=0.813).

Table 4.1.1d: Chi-Square Test, Event Outcome * Ejection/No Ejection/Entrapment

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	.951[a]	3	.813
Likelihood Ratio	.969	3	.809
Linear-by-Linear Association	.000	1	.987
N of Valid Cases	56		

a. 3 cells (37.5%) have expected count less than 5. The minimum expected count is 1.57
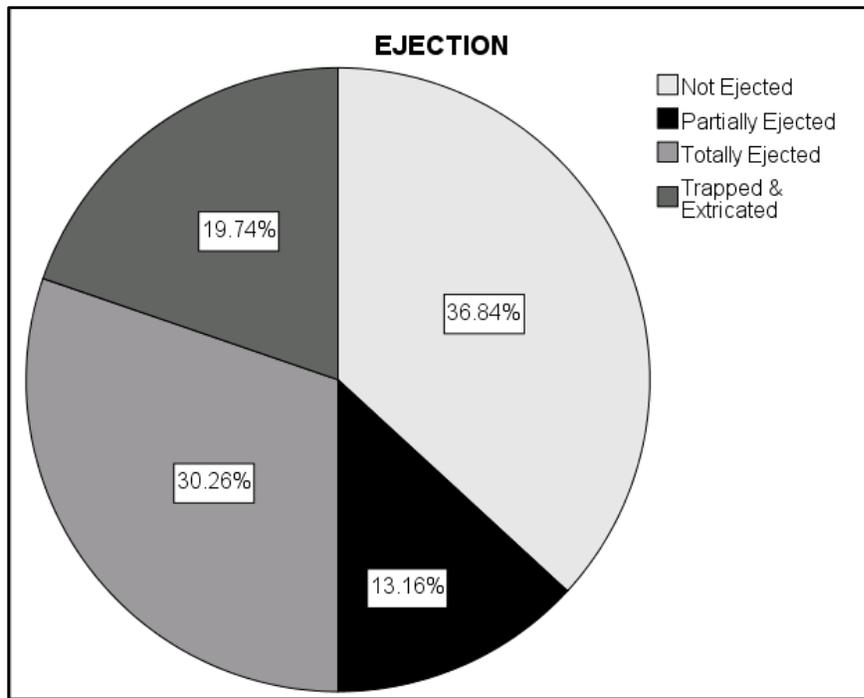
Figure 4.1.1b: Ejection or entrapment percentages of accident victims

Semi-trucks with trailers were the most common vehicles involved in fatal crashes (n=31, 40.3%, see Figure 4.1.1c). Pickups were the second most common vehicle reported at 24 (31.2%). Vehicle types were segregated into four groups: a) passenger cars, b) trucks and pickups, c) semi-trucks and semi-trucks with trailers, and d) other (other, van/mini-bus, and emergency vehicle). Chi-square analysis revealed no significant correlations between vehicle type and event outcome (n=56, x^2=3.36, p=0.339, see Table 4.1.1e).
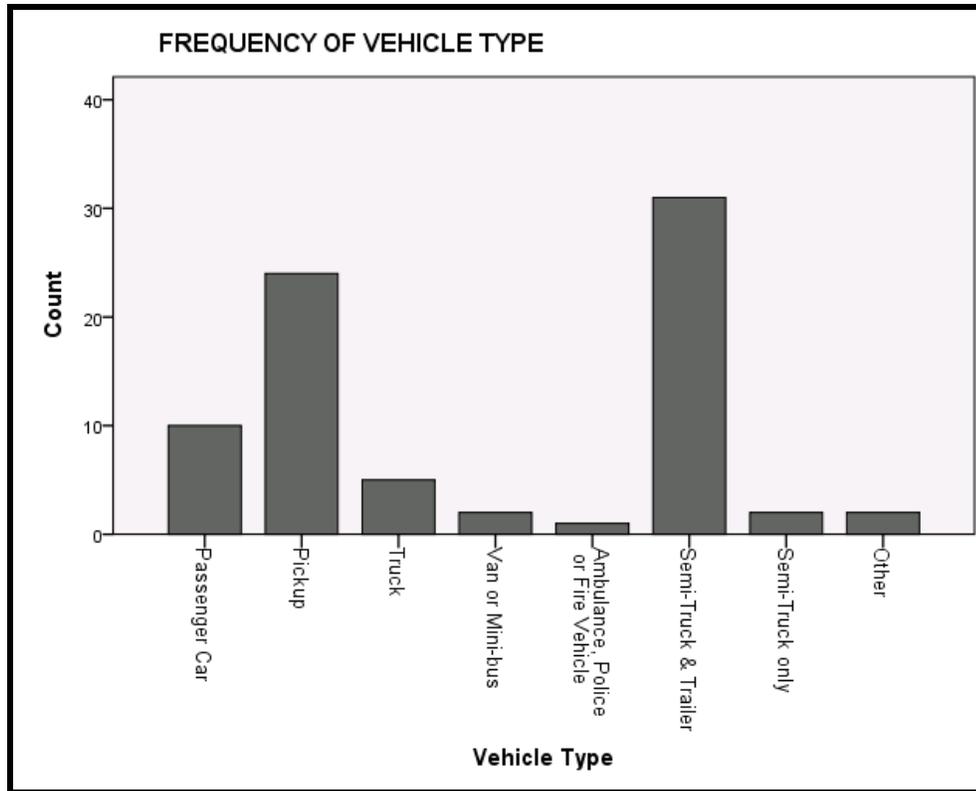
Figure 4.1.1c: Frequencies of vehicle type

Table 4.1.1e: Chi-Square Tests, Vehicle Type * Event Outcome

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	3.360[a]	3	.339
Likelihood Ratio	3.475	3	.324
Linear-by-Linear Association	3.273	1	.070
N of Valid Cases	56		

 a. 3 cells (37.5%) have expected count less than 5. The minimum expected count is 1.18
4

4.1.2 Police response times. Seventy-seven cases were analyzed to determine

significance of police notification times after estimated time of incident in relation to

event outcome. The mean time from accident to police notification was 11.20779 minutes

with a range of 0 – 115 minutes. The mode was four minutes with a median time of seven

minutes.

Seventy-seven cases were analyzed to determine significance of police on scene

arrival time after notification in relation to event outcome. The mean response time after

notification to scene of incident was 24.7013 minutes. Times ranged from 0 to 96 with a

mode of 96 and median of 19. Response times were coded for Chi-Square analysis as

follows: a) 0 = less than 30 minutes, b) 1 = 31 to 60 minutes, and c) 2 = greater than 60

minutes. Chi-Square analysis revealed no correlation between event outcome and police

response times from time of notification to scene arrival (n=56, x^2=.375, p = .829, see

Table 4.1.2a).

Table 4.1.2a: Chi-Square Tests, Event Outcome * Police Response (Notification-Arrival)

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	.375[a]	2	.829
Likelihood Ratio	.397	2	.820
Linear-by-Linear Association	.127	1	.721
N of Valid Cases	56		

a. 2 cells (33.3%) have expected count less than 5. The minimum expected count is 1.57

Analysis of variance confirmed no significance between response times after notification

until scene arrival and event outcome (n=56, p = .837, see Table 4.1.2b).

Table 4.1.2b: ANOVA, Event Outcome * Police Response (Notification – Arrival)

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.089	2	.045	.179	.837
Within Groups	13.268	53	.250		
Total	13.357	55			

Seventy-seven cases were analyzed to determine significance of total police response time since estimated time of accident to arrival on scene. The mean total response time was 34.2987 minutes with a range of 1 to 130 minutes. The median time was 29 minutes and mode was 111 minutes. Response times were coded as before and tested for correlation with event outcome. Chi-Square analysis showed no correlation (n=56, x^2=0.428, p = 0.428, see Table 4.1.2c) and confirmed by ANOVA (n=56, p = 0.442, see Table 4.1.2d).

Table 4.1.2c: Chi-Square Tests, Event Outcome * Police Total Response Time

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	1.697[a]	2	.428
Likelihood Ratio	1.727	2	.422
Linear-by-Linear Association	.041	1	.839
N of Valid Cases	56		

a. 2 cells (33.3%) have expected count less than 5. The minimum expected count is 3.14

Table 4.1.2d: ANOVA, Event Outcome * Police Total Response Time

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.405	2	.202	.828	.442
Within Groups	12.952	53	.244		
Total	13.357	55			

4.1.3 EMS response times. Seventy-seven cases were analyzed to determine significance of EMS notification times after estimated time of incident in relation to event outcome. The mean time from accident to EMS notification was 17.1299 minutes

35

with a range of 0 to 91 minutes. The mode was two minutes with a median time of five minutes.

Seventy-seven cases were analyzed to determine significance of EMS on scene arrival time after notification in relation to event outcome. The mean response time after notification to scene of incident was 18.6104 minutes. Times ranged from 0 to 60 with a mode of 13 and median of 15. Response times were coded for Chi-Square analysis as follows: a) 0 = less than 30 minutes, b) 1 = 31 to 60 minutes, and c) 2 = greater than 60 minutes. Chi-Square analysis showed significant correlation between event outcome and EMS response times from time of notification to scene arrival (n=53, x^2=4.126, p = 0.042, p<0.1, see Table 4.1.3a).

Table 4.1.3a: Chi-Square Tests, Event Outcome * EMS Response (Notification – Arrival)

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	4.126[a]	1	.042		
Continuity Correction[b]	2.756	1	.097		
Likelihood Ratio	4.753	1	.029		
Fisher's Exact Test				.064	.044
Linear-by-Linear Association	4.048	1	.044		
N of Valid Cases	53				

a. 1 cell (25.0%) have expected count less than 5. The minimum expected count is 3.74
b. Computed only for a 2x2 table

Analysis of variance of EMS arrival times after notification in relation to event outcome also showed significance (n=52, p=0.043, p<0.1, see Table 4.1.3b).

Table 4.1.3b: ANOVA, Event Outcome * EMS Response (Notification – Arrival)

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	1.002	1	1.002	4.306	.043
Within Groups	11.866	51	.233		
Total	12.868	52			

Seventy-seven cases were analyzed to determine significance of total EMS response time since estimated time of accident to arrival on scene. The mean total response time was 34.5325 minutes with a range of 2 to 104 minutes. The median time was 28 minutes and mode was 104 minutes. Response times were coded as before and tested for correlation with event outcome. Chi-Square analysis showed no correlation (n=53, p = 0.458, see Table 4.1.3c) and confirmed by ANOVA (n=53, p = 0.474, see Table 4.1.3d).

Table 4.1.3c: Chi-Square Tests, Event Outcome * Total EMS Response Time

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	1.561[a]	2	.458
Likelihood Ratio	2.286	2	.319
Linear-by-Linear Association	.889	1	.346
N of Valid Cases	53		

a.2 cells (33.3%) have expected count less than 5. The minimum expected count is .83

Table 4.1.3d: ANOVA, Event Outcome * Total EMS Response Time

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.379	2	.190	.759	.474
Within Groups	12.489	50	.250		
Total	12.868	52			

4.2 Spatial Analysis

Spatial analysis consisted of identifying hospitals nearest the incident site and their corresponding trauma designations. Additionally, distances from crash sites to the nearest hospital as well as the closest Regional Trauma Center were calculated using ArcGIS software. Locations were interpreted from crash reports for 75 crash sites and plotted on a map of Wyoming using WyLam projection. US hospitals were obtained from USGS-Geographical Names Information System, ESRI and clipped to the state of Wyoming. Two hospitals, Ivinson Memorial Hospital in Laramie, Wyoming, and Wyoming Medical Center in Casper, Wyoming were not included in the US hospital database. Latitudes and longitudes provided by Google Earth were used for the locations of the two hospitals which were then merged with the hospital file. A road network was used to find incident to facility distances. All crash sites were located on major highways except for four cases. These four cases were individually measured on the GIS to the nearest major road or crash site. The two distances were then added together to obtain the best available distance estimate.

Wyoming Transportation Event Occupational Fatalities and EMS Accessibility, 2003-2007
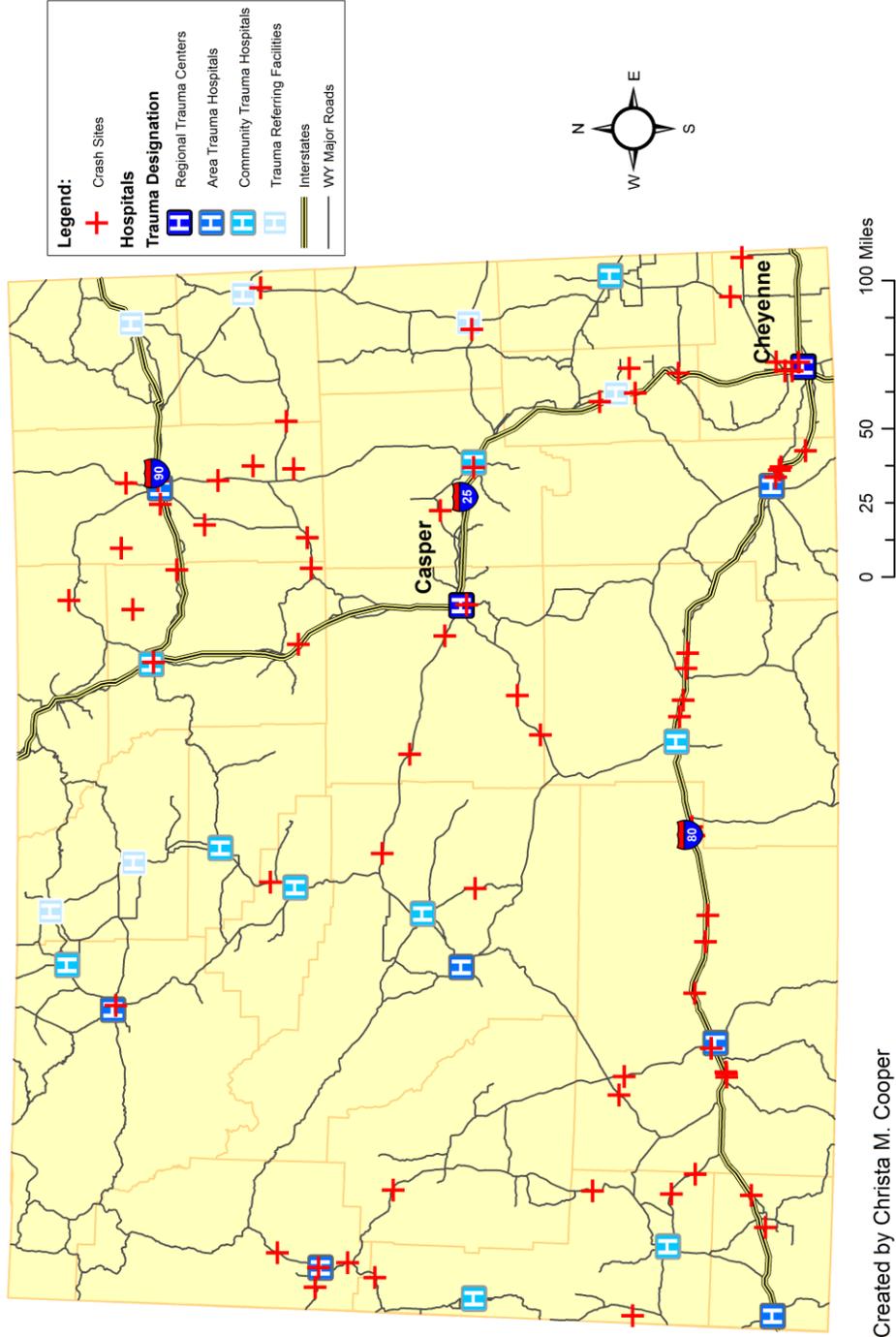
Created by Christa M. Cooper

4.2.1 Hospitals. Of the 26 acute care hospitals in Wyoming, 17 were identified as the nearest hospital to accident sites. Campbell County Memorial Hospital in Gillette, Wyoming, was nearest the most accident sites at 12 (16%). Memorial Hospital of Sweetwater County in Rock Springs, Wyoming was second with 10 (13.3%) nearby crash sites. Three hospitals were marked only once as the nearest facility (See Figure 4.2.1 and Table 4.2.1).
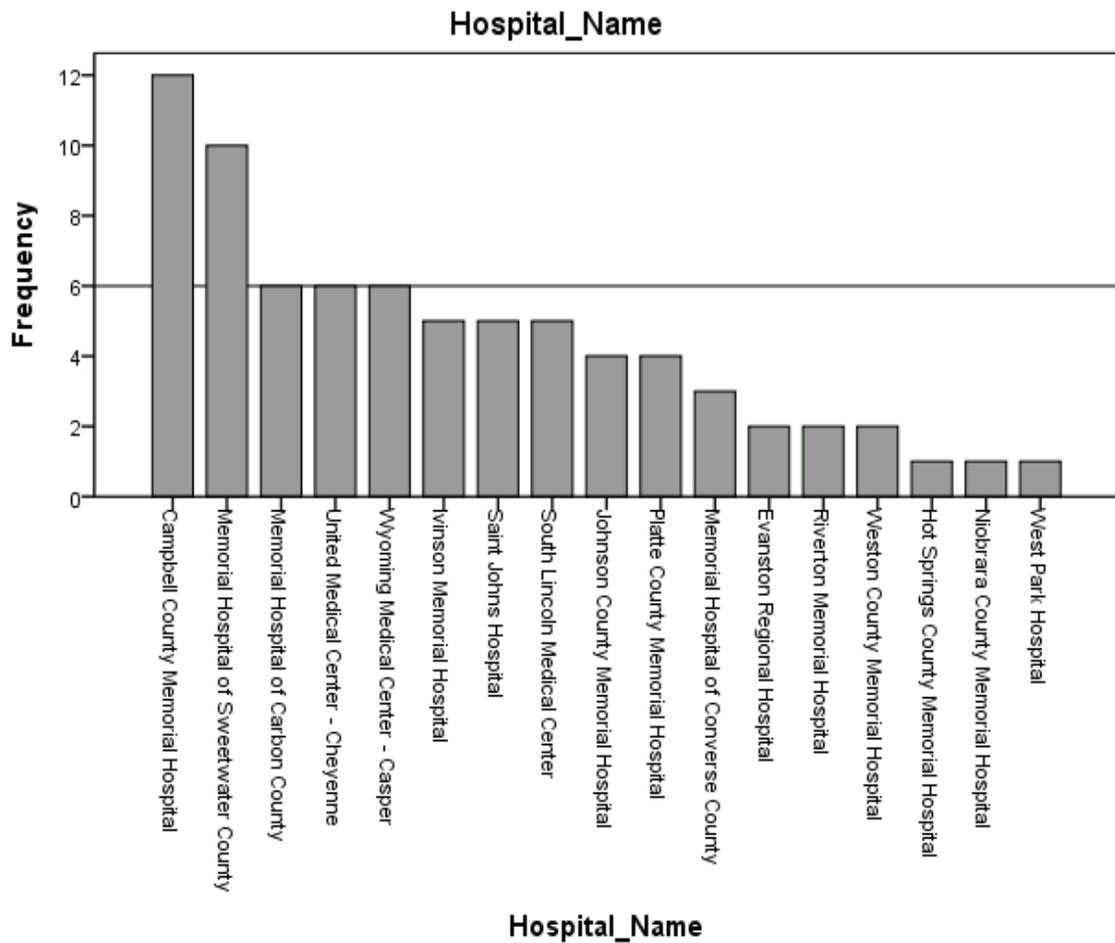
Figure 4.2.1: Name of hospital nearest crash sites

Table 4.2.1: Hospital Name and Frequency

	Frequency	Percent
Campbell County Memorial Hospital	12	16.0
Memorial Hospital of Sweetwater County	10	13.3
Memorial Hospital of Carbon County	6	8.0
United Medical Center - Cheyenne	6	8.0
Wyoming Medical Center – Casper	6	8.0
Ivinson Memorial Hospital	5	6.7
Saint John's Hospital	5	6.7
South Lincoln Medical Center	5	6.7
Johnson County Memorial Hospital	4	5.3
Platte County Memorial Hospital	4	5.3
Memorial Hospital of Converse County	3	4.0
Evanston Regional Hospital	2	2.7
Riverton Memorial Hospital	2	2.7
Weston County Memorial Hospital	2	2.7
Hot Springs County Memorial Hospital	1	1.3
Niobrara County Memorial Hospital	1	1.3
West Park Hospital	1	1.3
Total	75	100.0

4.2.2 Trauma designations. The trauma designations of the 17 identified

hospitals were analyzed for frequency and relationship with event outcome of the 75

cases. Area Trauma Hospitals had the greatest frequency at 35 (46.7%). Trauma

Referring Facilities had the lowest frequency at 7 (9.3%). The two Regional Trauma

Centers in the state, located in Casper and Cheyenne, were third at a frequency of 12

(16%) (Table 4.2.2a & Figure 4.2.2).

Table 4.2.2a: Trauma designation

	Frequency	Percent	Valid Percent	Cumulative Percent
ATH	35	46.7	46.7	46.7
CTH	21	28.0	28.0	74.7
RTC	12	16.0	16.0	90.7
TRF	7	9.3	9.3	100.0
Total	75	100.0	100.0	
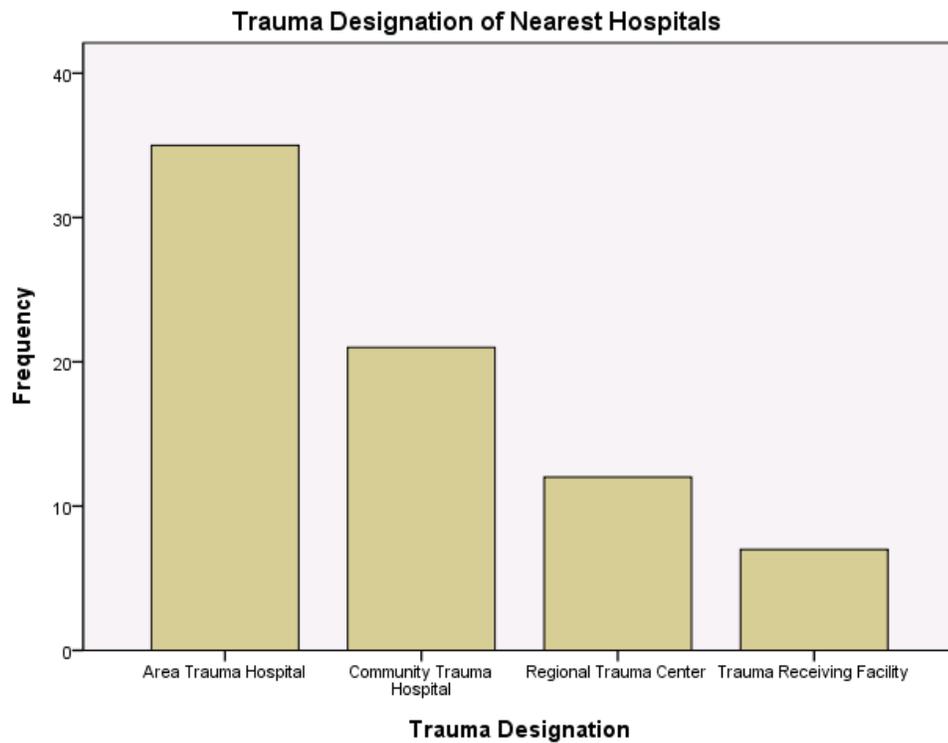
Figure 4.2.2: Trauma designation of hospitals nearest to crash sites

Chi-Squares were run for each of the four trauma designations to determine

correlation with event outcome. Trauma Receiving Facility designation was not

significantly correlated with event outcome (n=55, x^2=2.21, p=0.137, see Table 4.2.2b).

Community Trauma Hospital designation was also not significantly correlated with event

outcome (n=55, x^2=1.528, p=0.216, see Table 4.2.2c). Area Trauma Hospital designation

was not significantly correlated with event outcome (n=55, x^2=1.222, p=0.269, see Table

4.2.2d). Regional Trauma Center Designation, however, was significantly correlated with

event outcome (n=55, x^2=2.95, p=0.086, p<0.1, see Table 4.2.2e).

Table 4.2.2b: Chi-Square Tests, Trauma Receiving Facility * Event Outcome

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	2.210[a]	1	.137		
Continuity Correction[b]	1.153	1	.283		
Likelihood Ratio	2.499	1	.114		
Fisher's Exact Test				.223	.141
Linear-by-Linear Association	2.170	1	.141		
N of Valid Cases	55				

a. 2 cells (50.0%) have expected count less than 5. The minimum expected count is 2.80
b. Computed only for a 2x2 table

Table 4.2.2c: Chi-Square Tests, Community Trauma Hospital * Event Outcome

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	1.528[a]	1	.216		
Continuity Correction[b]	.859	1	.354		
Likelihood Ratio	1.508	1	.219		
Fisher's Exact Test				.235	.177
Linear-by-Linear Association	1.500	1	.221		
N of Valid Cases	55				

a. 0 cells (.0%) have expected count less than 5. The minimum expected count is 6.00
b. Computed only for a 2x2 table

Table 4.2.2d: Chi-Square Tests, Area Trauma Hospital * Event Outcome

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	1.222[a]	1	.269		
Continuity Correction[b]	.688	1	.407		
Likelihood Ratio	1.223	1	.269		
Fisher's Exact Test				.286	.204
Linear-by-Linear Association	1.200	1	.273		
N of Valid Cases	55				

a. 0 cells (.0%) have expected count less than 5. The minimum expected count is 10.00.
b. Computed only for a 2x2 table

Table 4.2.2e Chi-Square Tests, Regional Trauma Center * Event Outcome

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	2.950[a]	1	.086		
Continuity Correction[b]	1.761	1	.184		
Likelihood Ratio	3.380	1	.066		
Fisher's Exact Test				.126	.089
Linear-by-Linear Association	2.896	1	.089		
N of Valid Cases	55				

a. 2 cells (50.0%) have expected count less than 5. The minimum expected count is 3.20.
b. Computed only for a 2x2 table

Overall cross tabulation between event outcome and hospital trauma designation was near significant levels (n=55, x^2=6.227, p=0.101, p<0.1, see Table 4.2.2f and Table 4.2.2g).

Table 4.2.2f: Cross tabulation, Event Outcome * Trauma Designation

		Trauma designation				
		ATH	CTH	RTC	TRF	Total
Dead	0	13	7	7	6	33
Alive	1	12	8	1	1	22
Total		25	15	8	7	55

Table 4.2.2g: Chi-Square Tests, Trauma Designation * Event Outcome

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	6.227[a]	3	.101
Likelihood Ratio	6.916	3	.075
N of Valid Cases	55		

a. 4 cells (50.0%) have expected count less than 5. The minimum expected count is 2.80

4.2.3 Distances to nearest hospitals. The mean distance from incident site to nearest hospital was 24.7993 miles. Distances ranged from 1.2863 to 59.0862 miles. Distances were categorized into six categories for statistical analysis: a) less than 10 miles, b) 11-20 miles, c) 21-30 miles, d) 31-40 miles, e) 41-50 miles, and f) 51-60 miles. Analysis of variance showed no significant differences for the following categories (n=55): a) less than 10 miles (p=0.261, Table 4.2.3a), b) 11-20 miles (p=0.358, Table 4.2.3b), c) 41-50 miles (p=0.872, Table 4.2.3e), and d) 51-60 miles (p=0.224, Table 4.2.3f). Significant relationships between distance and event outcome were found in distances 21-30 miles (p=0.077, p<0.1, Table 4.2.3c) and 31-40 miles (p=0.057, p<0.1, Table 4.2.3d).

Table 4.2.3a: ANOVA, Event Outcome * less than 10 miles

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.314	1	.314	1.293	.261
Within Groups	12.886	53	.243		
Total	13.200	54			

Table 4.2.3b: ANOVA, Event Outcome * 11-20 Miles

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.211	1	.211	.859	.358
Within Groups	12.989	53	.245		
Total	13.200	54			

Table 4.2.3c: ANOVA, Event Outcome * 21-30 Miles

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.765	1	.765	3.262	.077
Within Groups	12.435	53	.235		
Total	13.200	54			

Table 4.2.3d: ANOVA, Event Outcome * 31-40 Miles

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.880	1	.880	3.786	.057
Within Groups	12.320	53	.232		
Total	13.200	54			

Table 4.2.3e: ANOVA, Event Outcome * 41-50 Miles

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.007	1	.007	.026	.872
Within Groups	13.193	53	.249		
Total	13.200	54			

Table 4.2.3f: ANOVA, Event Outcome * 51-60 Miles

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.367	1	.367	1.514	.224
Within Groups	12.833	53	.242		
Total	13.200	54			

Wyoming Transportation Event Occupational Fatalities and EMS Accessibility: 2003-2007 Routes to Nearest Hospitals
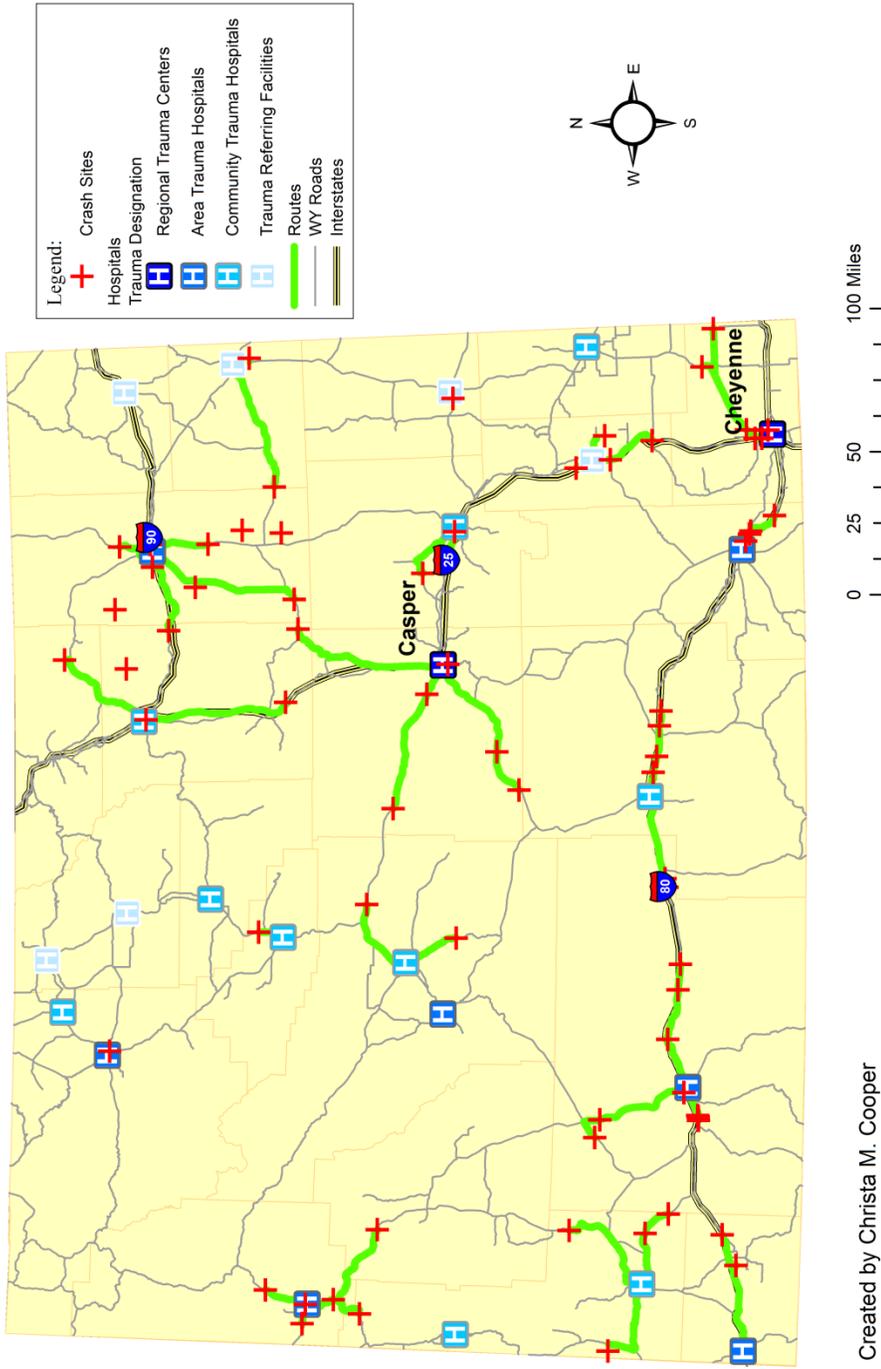
Created by Christa M. Cooper

CHAPTER 5

Discussion

Chapter five discusses the results of the study including demographics as well as results in relation to the research questions outlined in chapter three. Limitations, future directions and concluding remarks will follow in chapter six and seven.

5.1 Demographics

In this study, all cases ended in fatalities. This provided ease of accessing information needed to complete the study in the given timeframe. Of the fatalities, over half (60.7%) were found dead on scene and were taken by coroner to morgues. This statistic is important in demonstrating the fact that over half of the victims never received any emergency care beyond what occurred on site. This knowledge highlights the importance of EMS, especially in rural and frontier regions.

The variability in state of residence was expected. While approximately half of the fatalities were Wyoming residents, the other half was closely split between neighboring states and other states. Three interstates bisect Wyoming: a) I-90, b) I-25, and c) I-80. Interstate 80 is a major east-west thoroughfare with heavy transporter traffic. Semi-trucks with trailers were the number one vehicle involved in fatal occupational motor vehicle crashes with I-80 experiencing the highest number of accidents in the study. This information can provide public health agents with a target population for addressing host and environmental factors in fatal occupational injuries.

The proportions of victims ejected or partially ejected in comparison to those remaining in the vehicle or trapped were unexpected. Wyoming does not have a primary seat belt enforcement law which might presumably result in higher numbers of ejections

in motor vehicle crashes. In 2010, it was estimated that only a third (32.5%) of victims of fatal crashes in Wyoming were wearing seat belts (Lucero, 2011). In this study, over a third of victims remained in the vehicle and not trapped. Previous surveillance of this dataset found 58% (n=47) of victims were not wearing safety belts (Anderson, 2010). The remaining 42% could account for those not ejected; however, this study did not investigate this avenue. Similarly, since this study explored fatalities only, the effectiveness of safety belts in injury or fatality prevention cannot be verified (see chapter six for more detail).

5.2 Police Response Times and Accident Outcome

The first part of the study was to determine if elapses in police response times were significant contributors to event outcome. Statistical analysis revealed police response times at all intervals (time of accident to notification, notification to on scene arrival, and total time since accident to scene arrival) do not contribute to accident outcome. Police mean response times were shorter than EMS response times providing evidence that police are often the first emergency worker on scene after an accident. Due to the minimal medical training provided to police officers, however, influence on event outcome is expected to be minimal in cases involving serious life-threatening injuries.

5.3 EMS Response Times and Accident Outcome

The response time of EMS to the scene of an accident would be predicted to have an impact on victim survival due to the provision of medical treatment by trained professionals. Statistical tests revealed a correlation between EMS response times from time of notification to scene arrival; however, overall response time since time of accident was not significant.

The lack of significance of total EMS response time aligns with findings by Jones & Bentham (1995) in traffic accidents. The results also indicate that the timely presence of EMS does not affect whether accident victims are pronounced dead on scene and taken by coroner or are alive to receive emergency treatment prior to death. In Wyoming, Emergency Medical Technicians - Basics are not permitted to intubate patients which may prevent life-prolonging interventions in rural accidents (Wyoming Department of Health, 2008). This restriction could potentially explain the lack of significance in overall EMS response times. Despite these findings, the significant response time from the time of notification to arrval highlights the importance of timely EMS care.

5.4 Trauma Designations of Nearest Hospitals to Accident Sites

Only 17 of the 26 acute care hospitals in the state of Wyoming were nearest in vicinity to the traffic accidents. Nearly half (46.7%) of the hospitals were Area Trauma Hospitals which are second to Regional Trauma Centers in trauma treatment designation and capabilities. The Regional Trauma Centers, which are most prepared to provide tertiary care for treating trauma injuries, were nearest to only 12 of the crash sites. Campbell County Memorial Hospital and Memorial Hospital of Sweetwater County were nearest 22 (combined) of the crash sites and are both rated as Area Trauma Hospitals. Unlike Regional Trauma Centers, one of the limitations of Area Trauma Hospitals is that neurosurgeons are not required to be on staff limiting tertiary care services. The results indicated a nearly significant (p=0.101) correlation between trauma designation and event outcome, signifying the level of treatment capabilities of the nearest hospital to react to the accident may have a role in the outcome. When divided between the four trauma designations, the Regional Trauma Centers were indeed the only trauma level designation

significantly correlated (p=0.086) with the event outcome. This suggests that Regional

Trauma Center EMS arriving on scene to accidents involving life threatening injuries

may be able to provide better care and stabilization to trauma victims despite the inability

to ultimately save their life. If this is the case, upgrading trauma services at additional

hospitals, especially those most frequently used, could potentially save additional lives.

5.5 Distances of Nearest Hospitals to Accident Sites

The results of the spatial analysis showed no significance between event outcome

and distance with the exception of the range 21 to 40 miles (21-30, p=0.077; 31-40,

p=0.057). This suggests that distances of sites closest to hospitals (20 miles or less) do

not influence event outcome. The same surmise can be made for crash sites at farther

distances (greater than 40 miles) from hospitals. This may be due to the fact that sites

closest to hospitals are able to receive treatment sooner and incidents farther away have a

longer delay. The significant correlation between distance and event outcome between

the two extremes may signify a transition point in which the event outcome can be

influenced. This possibility is of importance especially in rural regions in which many

areas lie within or outside of a 21-40 mile radius of a hospital. This find can potentially

assist policy-makers in determining where additional hospitals may need to be built in

order to provide adequate emergency care in the state. The following map provides buffer

areas surrounding hospitals at a radius of 21 and 40 miles to illustrate potentially

underserved areas in Wyoming. Such a map can readily be produced for other regions

and states using simple GIS techniques.

Wyoming Transportation Event Occupational Fatalities and EMS Accessibility - 21 and 40 Mile Hospital Buffers

Legend:
Hospitals
Trauma Designation
- Regional Trauma Centers
- Area Trauma Hospitals
- Community Trauma Hospitals
- Trauma Referring Facilities

- Interstates
- WY Major Roads
- 21 Mile Radius
- 40 Mile Radius

Casper

Cheyenne

0   25   50   100 Miles
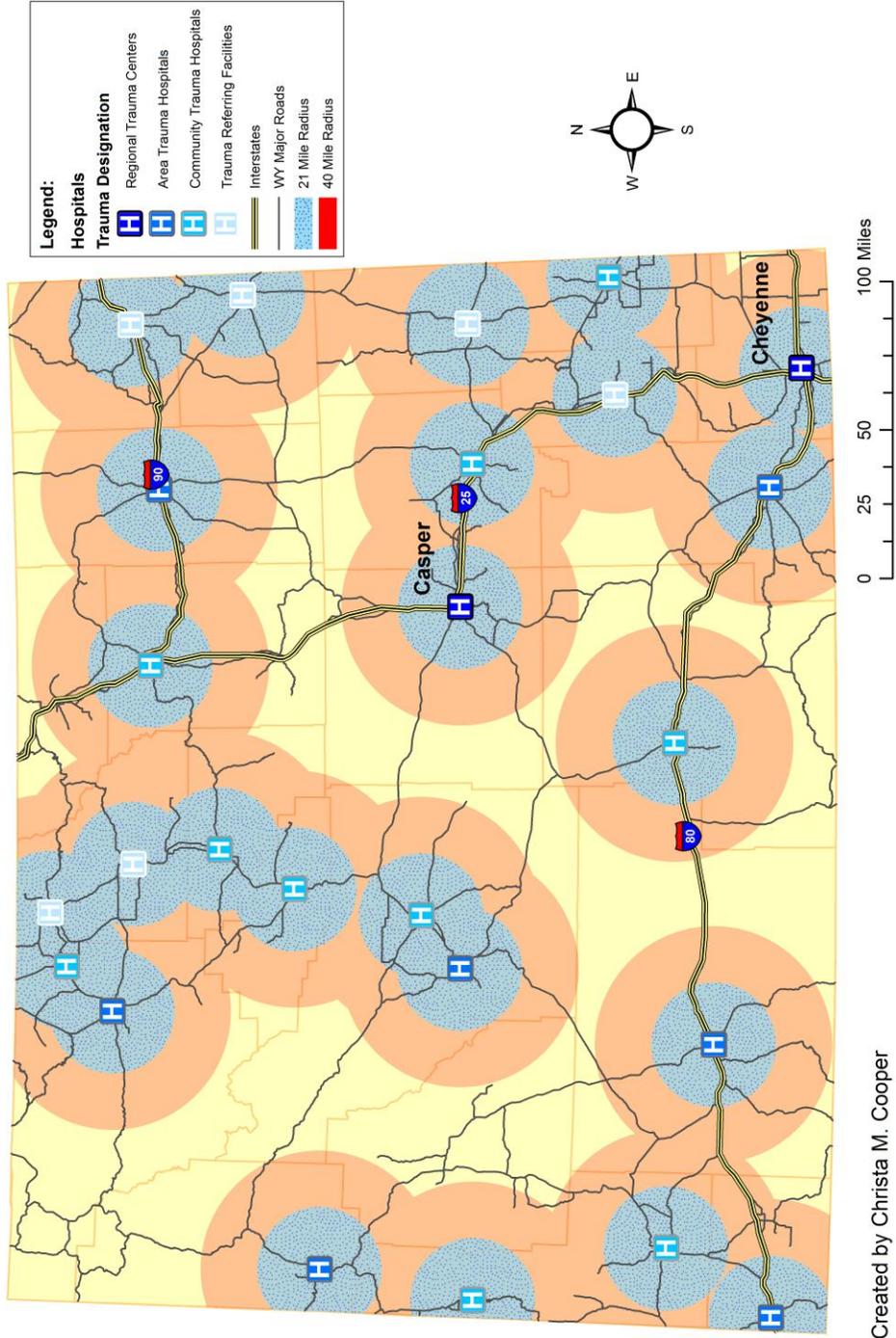
Created by Christa M. Cooper

CHAPTER SIX

Limitations, Future Research, and Application

6.1 Limitations

One of the main limitations of this study is the fact that only occupational

fatalities were examined. As a result, conclusions based on the results can only be made

which refer to treatment prior to death for crash victims. Regardless of the differences in

response times, nearby hospitals trauma designation and travel distances, the outcome of

the events remains the same. Despite this fact, the numerous studies which have

developed into the injury pyramid (see chapter one) suggest that numerous injuries in

survivors result from similar accidents (Heinrich, Petersen & Roos, 1980; Christoffel &

Gallagher, 2006; Bird, 1974). Those accidents studied here which resulted in fatalities are

only the most extreme cases represented by the pyramid's tip.

A similar limitation is the omission of death certificates and hospital records in

the study. Death certificates were referred to in the initial verification of the occupational

deaths in Wyoming occupational fatality surveillance, however were not obtained for this

study (Anderson, 2010). Death certificates would provide date, time, and place of death

for victims who were not found dead on site but were transported via EMS to nearby

hospitals. By reviewing death certificates, these transported victims could be further

sorted to those who were found dead on arrival, received tertiary treatment, were

transferred to a different hospital where death occurred, and how long victims survived

overall after the accident. Hospital records would also be able to provide injury severities

for victims received, treatments provided, patient transfers, and date and time of death.

Another limitation of the study is the dependence on the reliability of data recorded on crash reports. While all the crash reports consisted of the same form, they were completed by different police officers. As such, variances in interpretations due to individual viewpoints likely existed. Additionally, not all of the crash reports were complete leaving gaps in the study database which led to fewer cases for analysis. Lastly, the forms were hand written in the field and then scanned into computer files instead of being typed, leading to accurate reading of various handwriting.

Another limitation of the study was found in the GIS analysis. The analysis used examined distances only from crash sites to hospitals. Since response times were explored separately, this may have been less of a limitation than if GIS alone was used. As it was, the road network did not take into account geographical features such as terrain and slower speeds for turns, town roads, and weather conditions. Additionally, the buffers created around the hospitals show a general 21-40 mile radius that does not take into account the presence of roads. Without accounting for the presence of roads, sites within the buffer zone may actually be at a greater distance due to backtracking and road changes.

6.2 Areas for Future Research

As highlighted under limitations, survivors and injuries were not included in this study. One key area for future research should be the inclusion of survivors and injuries resulting from occupational motor vehicle crashes. Inclusion of survivors and those injured from such accidents would provide a comparison to better explore which factors not only prolong survival to receive emergency treatment, but also leads to overall victim survival.

Incorporating information from death certificates and hospital records would provide additional information for comparison and analysis. Information regarding patient transfers for victims initially transported to local hospitals would provide valuable information regarding hospital needs for tertiary care resources. Injury severities could be used to control for confounding factors in the data. For victims who survived longer than others, potential differences in care could be explored. By specifically identifying needs and gaps in EMS and tertiary care services, better policy decisions can be made to address the issue.

Another option for future research is expansion of the dataset. Since this study was a secondary analysis of a database containing information for 2003-2007, newer information is available to update the dataset. Additionally, the opportunity to go further back in records to provide a larger sample exists. The larger the case number, the more powerful the study becomes.

Future research could also explore the relationship between cell phone coverage in the state with response times. As a rural and frontier state, cell phone coverage is not entire and dead zones are common (dependent on carrier). As a result, differences between time of accident and initial emergency phone calls may affect police and EMS response times. Such a potential gap could negatively influence police and EMS response times as analyzed in this study. Cell phone coverage impact on emergency care delivery would be readily identifiable and potentially addressed for improved service.

Another area for future study would be to compare similar fatality (and injury) rates and factors with similar rural or frontier states. Such interstate comparison can reveal differences in policies and resources that may not come to light in intrastate only

analysis. For example, regarding EMT-B's ability to intubate, a restrictive state such as Wyoming could compare fatality and survival rates with less restrictive states that permit intubation.

6.3 Application

In addition to study findings and areas for future research, this project illustrated several areas regarding practical application which can be addressed in the present. One of these areas is the need for a primary seatbelt law in the state of Wyoming. As results showed, over a third of the victims were ejected or partially ejected from their vehicles at the time of the accident (see Figure 4.1.1b). In their surveillance study, Anderson and Conway (2010) found 58% (n=81) of crash victims were not wearing their seatbelts. Current Wyoming legislation permits ticketing of the failure to wear a seatbelt only as a secondary act following initial citation of a primary law breakage (e.g. speeding) (Wyoming Legislative Services, 2010). This law prevents enforcement of seatbelt wearing separate from other offenses. The adoption of a primary law would allow officers to enforce seatbelt use independently, increasing seatbelt use in the state. The NHTSA estimated Wyoming seatbelt use rate at 68.6%, the second lowest rate in the US (NHTSA, Seat Belt Use, 2009). Increasing the use of seatbelts would likely reduce the number of injuries and fatalities due to motor vehicle crashes.

This study also opens the door for employers to address safety needs through their business policies. Individual businesses have the ability to set safety standards as a form of prevention. These standards can include mandatory safety trainings, rules and regulations, as well as assessments. Compliance with such policies can be reinforced with positive incentives such as bonuses as well as negative consequences such as suspension

or termination if safety policies are not followed. While a company policy may not ensure that every driver is wearing their seatbelt at all times, setting the standard and expectancy of follow through from the time of the initial interview may increase safety actions in the employee.

Another area for consideration is consistency in crash documentation. Crash reports used in this study varied in completeness as well as consistency. Consistency is further weakened due to the variability in reporter's perceptions. One way to address this issue would be to hire a single individual responsible for overseeing form completeness and thoroughness. Review by one individual would provide a means to increase consistency between reports. Crash report forms can also be updated to include additional relevant information including GPS coordinates and injury type and severity ratings.

This study also presents the feasibility of using GIS in the fields of Social Work and Public Health. A field of study rich in history, social work should be readily adaptable to new technologies which may increase positive societal interventions. GIS is a valuable tool which can be used not only for environmental queries but in any field where geographical features such as population distribution may be a factor. In rural regions such as Wyoming, geography is of specific concern as community resources such as healthcare is spread over large distances. As this study has shown, gaps and underserved areas can be revealed using GIS. Once these areas and needs are identified, plans for action and policy changes can be devised and implemented to provide adequate resources.

This study also exemplified the role social work can play in addressing a state wide safety issue. The need for policy change and community awareness and intervention

evidenced in this study can readily be assisted by social workers. The complexities of the

interactions occurring before, during and after vehicle accidents including response times,

distances, and hospital trauma designation exemplify systems theory and the public

health model. In such a complex system, multiple changes may need to be made to have a

measurable effect on accident outcome. As the AOISS demonstrates, once contributing

factors are discovered, interventions need to occur at the community level with the

methods of invention designed with the inclusion of affected community members

(Conway, Lincoln, Husberg, Manwaring, Klatt, & Thomas. 1999).

CHAPTER SEVEN

Conclusions

Wyoming has consistently had one of the highest occupational fatality rates in the nation. As a rural and frontier state, delivery of emergency services to remote locations is a potential environmental factor contributing to this high rate. This study examined 77 cases of occupational motor vehicle fatality cases to determine the influence of police and EMS response times as well as travel distances from incident site to nearest hospital. While response times did not show a strong correlation between victims' survival to receive emergency treatment versus transport by coroner to the local morgue, a ring 20 miles in length surrounding hospitals showed some correlation to event outcome. This suggests an opportunity for intervention may exist to change event outcome in severe motor vehicle crashes. Such intervention may include faster response times, higher standards of training for responders, or placement of emergency call boxes in cellular 'dead zones' to increase notification times of accidents.

Additionally, Regional Trauma Center hospital designation was also significantly associated with event outcome. This suggests that increasing training and resources to additional hospitals to Regional Trauma Center status could decrease deaths on site and increase victims' chances to receive emergency trauma treatment. While the accidents in this study all ended in fatality, the ratios of fatality to injury implies interventions will assist greater numbers of those injured as well as reduce potentially mortal injuries. While prevention of such severe accidents is preferred, traffic accidents resulting in severe injury and death will always exist. Information on how to provide better post-incident care will increase survival rates.

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RE: IRB question

Tara Nelson

Sent: Monday, May 17, 2010 11:55 AM

To: Alice P. Miller; Christa M. Cooper

Christa:

Research about people who are deceased does not meet the definition of research with human subject. Therefore, you do not need to submit an IRB proposal.

Call or email with questions.

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