

URBAN EMERGENCY MEDICAL RESPONSE VS. MINING EMERGENCY

MEDICAL RESPONSE: A COMPARATIVE STUDY

by

Christopher A. Enright

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Golden, Colorado

Date _____

Signed: _____
Christopher A. Enright

Signed: _____
Dr.-Ing. Jürgen F. Brune
Thesis Advisor

Golden, Colorado

Date _____

Signed: _____
Dr. Priscilla P. Nelson
Professor and
Department Head of Mining Engineering

ABSTRACT

Emergency medical response is one of the critical services provided to the citizens of the United States, and a certain standard of care exists for response in the urban environment today. This study seeks to evaluate and characterize whether this standard of care is met in both surface and underground mining in the United States. It will also provide recommendations on what can be changed to improve emergency medical care delivered to injured miners. Data from both the accident and injury database from the Mine Safety and Health Administration (MSHA), reports from the National Institute of Occupational Health and Safety (NIOSH), and publications and data on urban emergency medical care from various sources have been assessed to develop a comparison between the two operating environments. With the direct comparison of the data on care available and results, several critical shortcomings of the mining industry were identified, including a considerably lower standard of care and a pronounced travel time to definitive care. Considerable potential exists for the mining industry to improve care delivered, notably increasing training required for miners and mine emergency response professionals, collecting more comprehensive statistics and preparing for expedited transport to definitive care at an accredited trauma center.

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CHAPTER ONE: INTRODUCTION

The practice of mining engineering and research was first documented with the early works of Georg Bauer, a.k.a. Georgius Agricola, when focus was placed on the essential components of the location, extraction, and utilization of mineral resources. Since his early publication in 1556, mining and mineral engineering education and practice has advanced considerably, such that additional focus is placed (as time and technology advances) on more unconventional aspects of engineering, namely health, safety, sustainability, and social responsibility. While the prevention of illness, injury, and death at mines is a primary goal of engineering and mining as a whole, mine operators, and therefore engineers, bear responsibility to be prepared for illness, injury, or a fatality to occur at their site. This thesis presents a comparison between medical care provided in both the mining and urban environments, and notes considerable recommendations and possible changes for the mining industry to consider implementing.

Mining Prehospital Medical Care

The mining industry in the United States has maintained a proud and storied history of emergency response in a tradition similar to volunteer fire departments. Organized mine emergency response in the U.S. formally began during a series of mine disasters from 1900-1909, where a string of coal mine explosions killed 3,660 miners in 133 incidents (Mine Safety and Health Administration, 2016). As a consequence, in 1910 Congress passed the Organic Act (Public Law 179), establishing the U.S. Bureau of Mines (USBM). Initially, disaster responses were conducted by USBM engineers and mine safety researchers responding in rail-based ‘stations’ for the purpose of rescuing injured miners as well as investigating why and how accidents happened. Authorities and mine operators developed methods of responding to emergencies, treating injuries, and utilizing volunteers from the mine to search and rescue their fellow miners (Mine Safety and Health Administration, 2016). In the first five years of USBM responses, nearly 300,000 miners visited or met with these responders, with approximately 34,000 receiving first aid and rescue training.

The first demonstration of mine rescue techniques was done in 1911, along with the first technical conference discussing mine rescue techniques. Initial mine rescue competitions began in the same time frame: initially focused on first aid, then expanding into rescue tactics (Mine Safety and Health Administration, 2016). Since then, competitions between mine rescue teams have served as a metric for professional rescue team performance and preparedness in real-life scenarios. In the U.S., competitions have become the standard for training mine rescue teams.

Today, mine rescue competitions still set the standard for training mine emergency responders in the United States. National competitions for coal and metal/nonmetal mine rescue teams are held on an

annual basis, along with dozens of regional contests. The rules used in these competitions are the *de facto* training and operational standard for mine emergency response community; however, no research has investigated the efficacy of this training.

Little academic research has been done focusing specifically on the response to mining accidents, with research instead focusing on the prevention or investigation of incidents. Early medical and safety research in the mining industry by Cole et al. was released in 1988 and presented at the Mine Safety Education and Training Seminar, hosted by the U.S. Bureau of Mines. It contains observations on the state of first aid training for miners at the time, presented in the form of recommendations to an instructor. It includes brief study evaluating the care and the recommendations of some 77 experts. This report provided the U.S. with a preliminary baseline for the training of miners in first aid, predating the current certification system and regulatory requirements (Cole, Wasielewski, Haley, & Berger, 1988). Perhaps the most relevant publication comparing the two operating environments is “Emergency Medical Care in the Underground Environment”, presented by Kunkle two years prior (1986). While this paper lacks quantitative data on care provided or patient outcome, it does contain an analysis from a physician on the necessary difference in medical care for an underground mine. In a volume published in 1972, Lawrence and Wyndham discuss injury patterns of the time, noting common mechanisms and causes of injury to miners. In the same volume, Roantree (1972) discusses “Emergency Surgery” for physicians who respond to mine emergencies in a chapter of now-outdated trauma treatment methodology. Spencer (1972) discusses “Medical Aspects of Mines Rescue”, which targets the physiological effects and potential problems that rescue team members may encounter, but omits details on medical treatment or recommendations for preparation of mine emergency response.

Urban Prehospital Medical Care

Prehospital emergency medical care for the sick and injured has evolved considerably from first inception. In the early days of the Emergency Medical System (EMS), ambulances were staffed by persons with little training and equipment because emphasis was largely on the rapid transport of the injured person to a properly equipped hospital. Today’s modern prehospital care model was initially developed in military applications, where medics were responsible for some treatment on the battlefield in addition to rapid transport to the care of a physician.

In 1965, the National Academy of Sciences (NAS) and National Research Council Committees on Trauma and Shock published *Accidental Death and Disability: The Neglected Disease of Modern Society* (National Research Council Committees on Trauma and Shock, 1966). This white paper laid out the consequences of an insufficient EMS in the United States. According to this paper, in 1965, over 107,000 people were killed from accidental injury, with another 400,000 sustaining injuries with permanent

disabilities. The authors estimated that approximately 50% of ambulance services were provided by local morticians who were not capable of rendering basic or advanced life support. Based on experiences in the Vietnam War, seriously wounded soldiers had a better chance of survival in the battle field compared to traffic accident victims in the U.S. with similar traumatic injuries solely because the military was capable of providing simultaneous first aid and efficient transportation to emergency care facilities. The white paper states that death rates from battle injuries declined significantly from 8% in World War I to 2% in Vietnam.

This pivotal white paper is credited with the broad evolution and rapid advance of the urban EMS system after 1965. It eventually led to the creation of the National Highway Transportation Safety Administration (NHTSA) and the National Standard Curricula (NSC) for emergency medical care in 1985. Since then, training and required skill and knowledge for prehospital emergency care has continued to grow to reach the current standard in use for urban emergency medical response (Enright, Harman, & Brune, 2016).

CHAPTER TWO: RESEARCH OBJECTIVES AND METHODS

Research Objective and Specific Aims

The objective of this research is to compare and contrast emergency medical care at all U.S. mines with that in the urban environment, and to deliver actionable recommendations to guide policy and decision-making regarding the improvement of medical care at mines.

The specific aims of this study are the following:

1. Determine if a disparity is present between level of care provided at mines and in urban areas in the United States.
2. Investigate causes of any present disparity
3. Deliver recommendations for specific improvements that can be made to improve emergency medical care at mines and to address deficiencies identified.

This research project intends to address all of these issues, particularly providing cogent and actionable recommendations to both policymakers and mine emergency responders on potential improvements that can be made if deficiencies are identified.

Deliverables

Based on each of the specific objectives detailed above, the following deliverables are defined:

1. Tabular comparison of patterns of injury, standards of care, and other key performance metrics between the two specified environments.
2. Data comparison between injury causes and origins between the two specified environments
3. List of recommendations and guidance on how mines can improve care.

Research Methods

In order to provide actionable recommendations based on quantitative data, data collection and assessment will be the primary task in developing the conclusions needed for this thesis. A critical assessment of data will be conducted using standard library research techniques, as well as data analysis and collation, and testimony from professionals in the field of both urban and mining emergency medical care. The author will reference relevant texts on emergency medical care, particularly to determine recommended care for given injuries.

In the comparison of data between mining and urban emergency care systems, quantitative data will provide the most critical link to demonstrate the efficacy of medical care in the mining environment. By demonstrating that patient outcomes are or are not comparable to the urban setting, a need for

improvement in the mining sector is demonstrated. Specific guidance will be based on authoritative sources and texts, and will reflect the current state-of-the-art technologies.

Urban EMS metrics will be extracted from two targeted databases (NEMESIS and WISQARS™) and supplemented with publications on urban trauma and EMS care. Data regarding injuries to miners will be extracted from the MSHA Part 50 accident and injury database, a considerably more comprehensive database (Mine Safety and Health Administration, 2016). In order to facilitate the most accurate comparison between the urban and mining environments, the author will only utilize specific metrics from the mining MSHA Part 50 that have a direct counterpart in collected urban EMS data sets and publications, which tend to be more limited in both scope and breadth. Assessment will begin with the mining data, and will then be compared with the urban data in the appropriate manner. Analyses of the data will initially identify any obvious disparities. Only EMS data for adult trauma cases will be assessed, as these are the cases represented in the MSHA Part 50 data set and are relevant to this study. The majority of studies on trauma care outside of this thesis have followed the same selection or exclusion criteria, so data will require little confinement in this regard.

Recommendations will be based on both authoritative sources such as textbooks on trauma care and journal articles. The Author will use his professional judgment as both an urban Emergency Medical Technician (EMT), firefighter and a certified mine rescuer to determine what system changes would be relevant for improving outcomes.

CHAPTER THREE: EMERGENCY RESPONSE STANDARDS, 2016

Mine Emergency Response

U.S. federal regulations (30 CFR §56.18010 and §57.18010) applicable to surface and underground metal, nonmetal, and coal mines require first aid training for at least one person on each working shift. This “capable person” must be able to perform patient assessment and artificial respiration; control bleeding; and treat shock, wounds, burns, and musculoskeletal injuries. 30 CFR §75.1713 and §57.18014 require mine operators to arrange for emergency medical assistance and transportation for injured persons. U.S. mining regulations or MSHA program policy do not incorporate the qualifications required by the NHTSA EMS. MSHA inspectors are merely required to verify the scope of the qualified person’s training and the currency of their training (Mine Safety and Health Administration, 2014).

Mine rescuers and rescue operations default to the *de facto* standards set by of mine rescue competitions, and they are evaluated against such standards on an annual basis. No further or more specialized training for professional mine rescue personnel is mandated. This relationship is further substantiated in the mission statement printed in the 2016 Contest Rules for Metal and Non-Metal Mine Rescue: “This Contest Rule Book establishes procedures and rules that serve to guide the rescue teams in actual situations” (Mine Safety and Health Administration, 2016). With regards to first aid, the rule book references both *Emergency Medical Responder - First on the Scene* and the *AHA Heartsaver™ CPR Guidelines* (Mine Safety and Health Administration, 2016). The mine rescue contest rules do not require certification at the level of Emergency Medical Responder, and only reference certain chapters of the *Emergency Medical Responder* text. In addition, the referenced Heartsaver™ CPR training program published by the American Heart Association, is intended for the lay public, and not for persons expected to perform CPR as a professional rescuer. EMR certification requires certification in either Basic Life Support (BLS) or CPR for the Professional Rescuer, as certified by the American Heart Association or the American Red Cross (National Registry of Emergency Medical Technicians, 2016).

Urban Emergency Response and Levels of Certification

As of 2016, the United States maintains four levels of training and certification for prehospital medical care providers, with additional training opportunities for basic first aid without certification.

First aid trainings are available for the general public and can vary in scope, depth, and up-to-date content. First aid is also taught to new miners as part of 24- and 40-hour trainings under 30 CFR §48. First aid training generally includes basic cardiopulmonary resuscitation (CPR), splinting, and bandaging. Instruction programs are certified by a variety of non-governmental entities, including the American Red Cross, the National Safety Council, and the American Heart Association. Some variation exists in the

actual content of the training and there is little oversight in the content of training provided. Basic first aid trainings are not formally recognized as part of the general EMS system.

The entry level certification for the EMS system is Emergency Medical Responder (EMR), formerly known as First Responder. An Emergency Medical Responder is responsible for the basic assessment and treatment of traumatic injuries, recognition of medical emergencies and some limited treatment that includes oxygen administration and immobilization. EMRs are expected to have basic knowledge of anatomy and physiology, pathophysiology of shock, and basic medical conditions (NHTSA EMS Program, 2007). This is the minimum certification held by most firefighters. Mine rescue contest rules (Mine Safety and Health Administration, 2016) require this level of competency for members of mine rescue teams in both the metal/non-metal and coal industries.

The next skill level is the Emergency Medical Technician (EMT) certification. EMT certification requires 100-200 hours of classroom instruction and practice with approximately 24 hours in a clinical setting. It requires comprehensive knowledge of trauma treatment, assessment and treatment of medical emergencies, administration of certain medications, an understanding of pathophysiology with shock, and EMS operations (NHTSA EMS Program, 2007). Emergency Medical Technician is the fundamental level of skill for EMS operations. EMT is the standard for most firefighters and is the minimum skill level for an ambulance crew. For members of Mine Rescue Teams, EMT is considered a high level of care, where most corporate mine rescue teams have at least one EMT certified member. Larger mine operators typically have at least one EMT certified employee on each shift although this is not required by law.

Above the EMT is the Advanced EMT (AEMT) certification. AEMT was created to act as a bridge between the EMT and Paramedic levels. The scope of practice for the AEMT includes intravenous therapy, administration of nitroglycerine, dextrose, naloxone and epinephrine. AEMTs take additional hours of clinical education to gain an expanded depth and breadth of knowledge of emergency medical care. While AEMTs are rarely used at their scope of practice or as ALS providers in EMS systems (Mogg, 2015) some large corporate mine rescue teams employ AEMTs as senior medical staff members within their organization.

The Paramedic level of certification is the highest level of training for prehospital care in the United States. Paramedics have the broadest scope of practice and maximum training for EMS. They are permitted the broadest scope of practice in the pre-hospital environment, in some cases at a scope above that of a nurse and closer to that of a Physician's Assistant. Paramedics are permitted to administer a broad range of medications, including opiate analgesics, benzodiazepine sedatives, and are qualified to perform a broad set of emergency interventions for patient care. Paramedics are able to perform

intubation (oral and nasal), surgical percutaneous cricothyrotomies, transcutaneous pacing, cardioversion, manual defibrillation, and other advanced care procedures (McVaney, et al., 2015). Paramedics also maintain a comprehensive and broad scope of knowledge regarding medical care and trauma care, and a detailed knowledge of advanced medical conditions and their behavior. Paramedics routinely practice as the leading member on an ambulance crew, or in the hospital emergency department as an advanced care technician, and are permitted to work with minimal oversight from their physician medical director. To the knowledge of the author, no mine rescue teams use paramedics as routine team members, though some teams work with physicians and paramedics in a cooperative agreement.

CHAPTER FOUR: TRAUMA STATISTICS IN MINES VS. URBAN ENVIRONMENTS

U.S. Mines, 2010-2014

Federal regulation in the United States requires that mine operators and mining industry contractors annually submit data on production (coal only), employment, as well as submit reports of each fatal, disabling, lost time or otherwise reportable accident along with certain non-injury incidents. This data (Mine Safety and Health Administration, 2016) is then compiled in databases maintained and published by MSHA to be used as the primary source for mine injury statistics. This data, however, does not include injuries that are ‘not chargeable to the mining industry’: MSHA investigates all fatalities at mine sites, but deaths of “natural causes, homicides, suicides, and deaths of trespassers” (Mine Safety and Health Administration, 2016) are excluded from MSHA fatality statistics. Because of this exclusion of ‘nonchargeable’ deaths, these statistics likely fail to include mine deaths of a natural, perhaps pre-existing medical condition, as well as deaths that occur unrelated mining activities. Generally, these cases of natural causes of death are the hardest to treat and mitigate, meaning that a more advanced set of skills and training is required.

For the time period of 2010-2014, a total of 20,042 reportable injuries were recorded at U.S. mines. Of these incidents, 230 of them were fatal, with more than 50% of them (120) being attributed to multisystem trauma, as seen in Figure 4.1. Crushing, massive closed injuries, are the second largest cause of death from injuries at U.S. mines. Additionally, asphyxia and electrical injuries are a significant cause of death for miners, warranting evaluation as well. Nonfatal days-lost and fatal injuries account for 16,875 of the 20,042 injuries for the 2010-2014 timespan, as presented in Figure 4.2. With the addition of nonfatal injuries, the proportions of injuries change, with 61% of these injuries are musculoskeletal injuries like fractures, sprains, and strains. About 1,700 injuries were soft tissue wounds such as cuts, lacerations, and punctures. Another 1,800 injuries were associated with crushing, which would include crushing by machines, dropped objects and falling rocks.

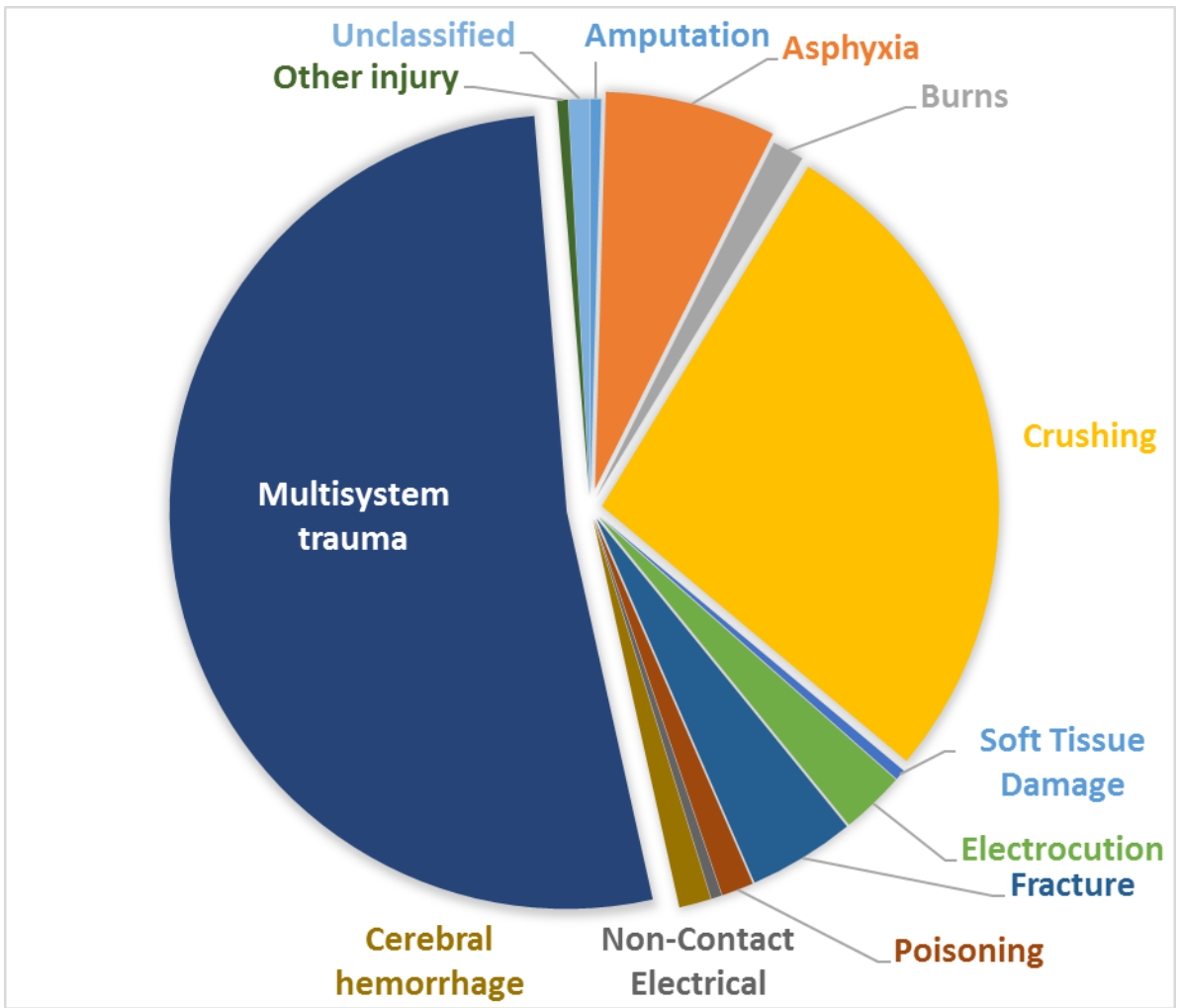


Figure 4.1: Fatal Injuries in U.S. Mines, 2010-2014, by nature of injury, modified from MSHA data, 2015

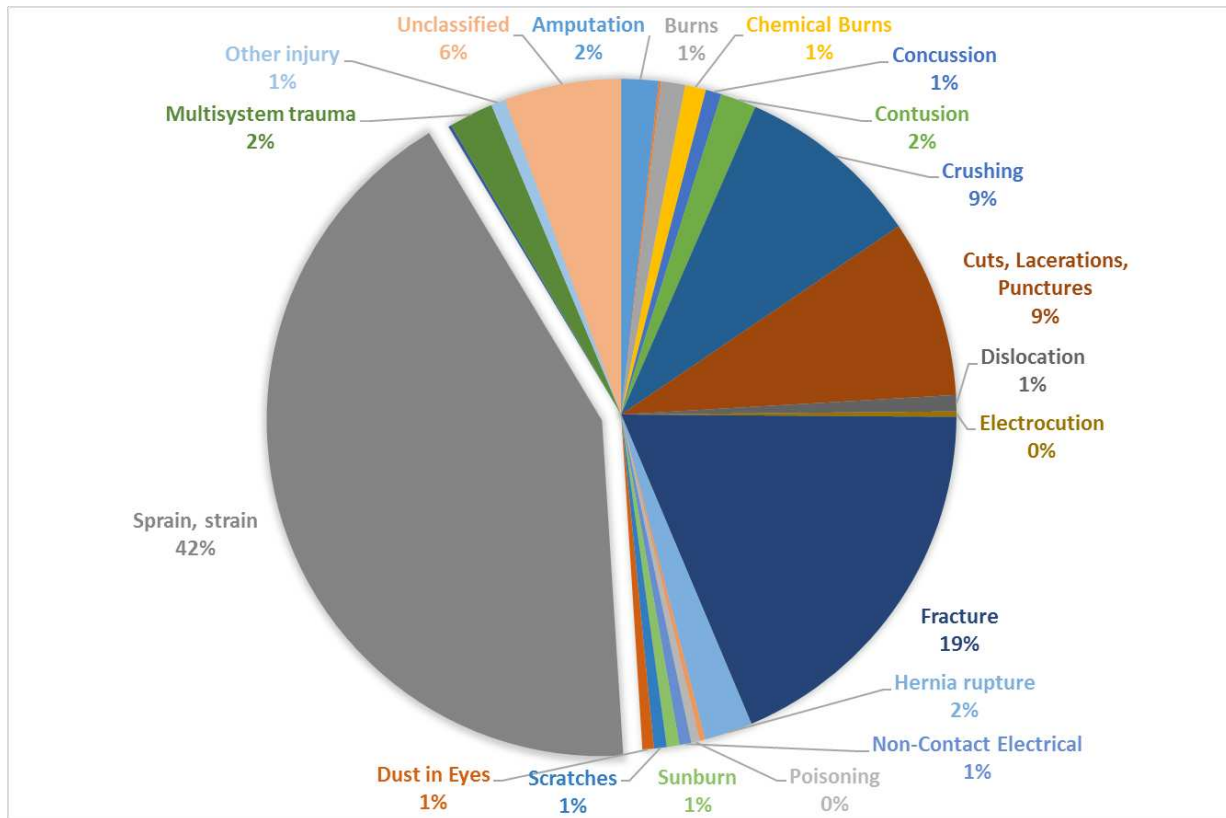


Figure 4.2: Fatal and Non-fatal days-lost injuries in the U.S. mining industry, by nature of injury, 2010 – 2014, modified from MSHA data, 2015

Natural causes of death are not examined or investigated in detail, as they are not chargeable to the mine as work related fatalities. The statistic shown in Figure 3 illustrate that more than twice as many people die at U.S. mines as reported in the workplace fatality statistics, where 354 natural deaths occurred and only 230 occupational fatalities. Most natural deaths are reported as heart attacks, with some irregular causes listed as well, such as lacerations and other soft-tissue injuries. With these fatalities not included in workplace statistics, the causes of these deaths may not be considered in the planning and mitigation efforts to eliminate mining related fatalities. To examine data similar to that of data from the urban environment, additional examination of injuries by accident, illness and injury classification from the MSHA 30 CFR Part 50 Database is required. Urban injury data from the WISQARS™ is centered around the cause of injury or death, not the specific injury itself. The Part 50 Database does have this information and can be evaluated in the same way as the urban data when the correct fields are assessed.

Fatal injuries tend to be most frequently caused by machinery and powered haulage, with these two categories making up 43% of the fatalities in the mining industry, as seen in Figure 4.4. Explosions and gas ignitions are the second most-significant cause of fatal injury, followed by falling rocks. This

significant proportion of explosions and ignitions is skewed by the Upper Big Branch Disaster in 2010, where 29 miners were killed in a methane and coal dust explosion.

Non-Fatal Days Lost (NFDL) injuries, as seen in Figure 4.5, are most frequently caused by materials handling. Nearly 10,000 injuries during the surveyed time span were caused in this way. Slips or falls of a person from standing are the second most frequent cause of days lost injuries, followed by machinery and powered haulage related injuries in third place.

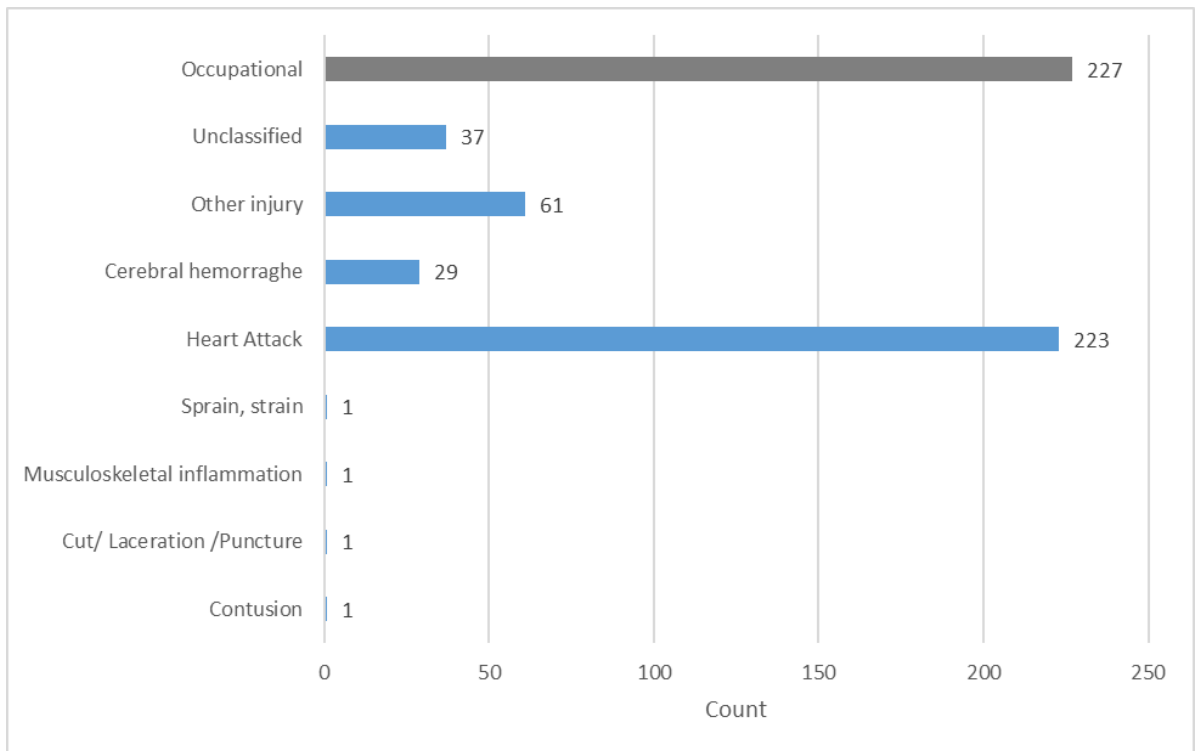


Figure 4.3: Natural or non-chargeable deaths at U.S. Mines, 2010-2014, modified from MSHA data, 2015

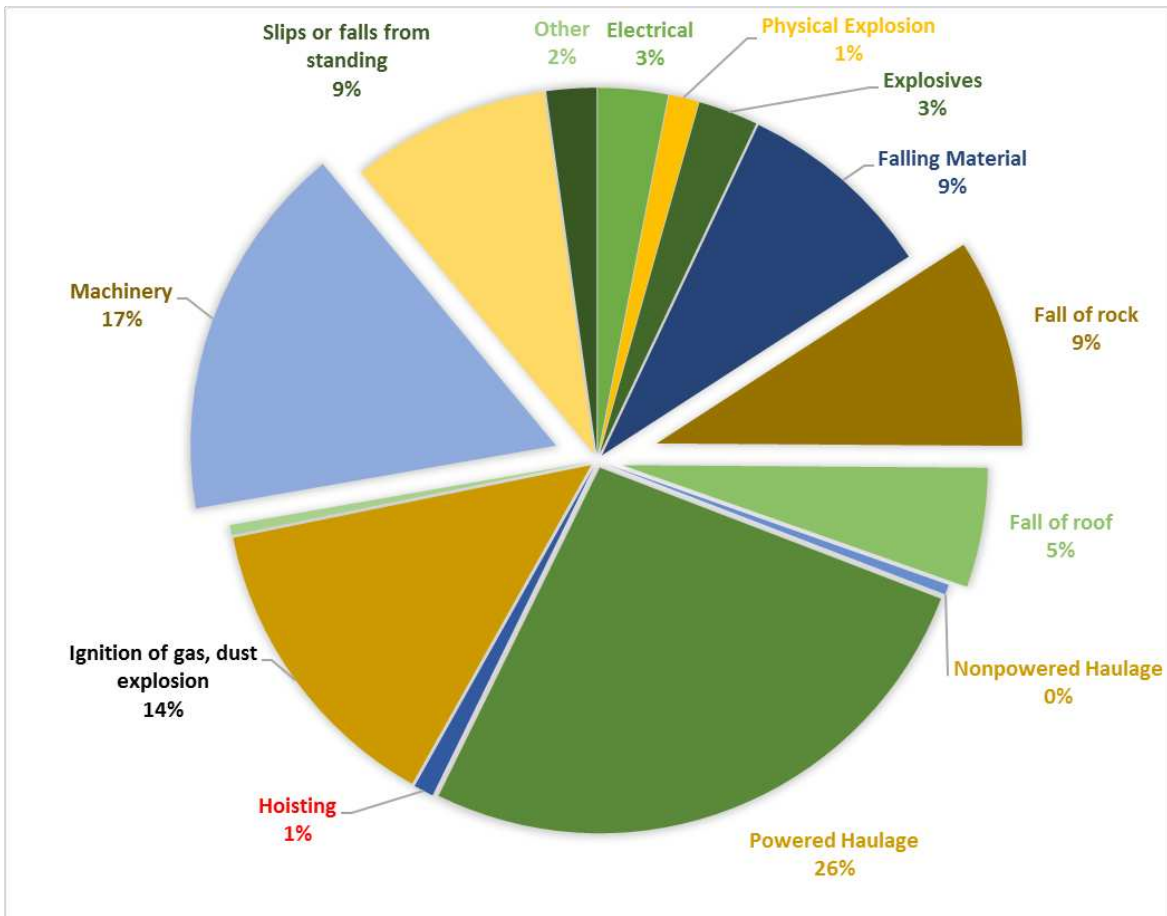


Figure 4.4: Causes of fatalities in U.S. mines, excluding natural causes, 2010-2014, n=227, modified from MSHA data, 2015

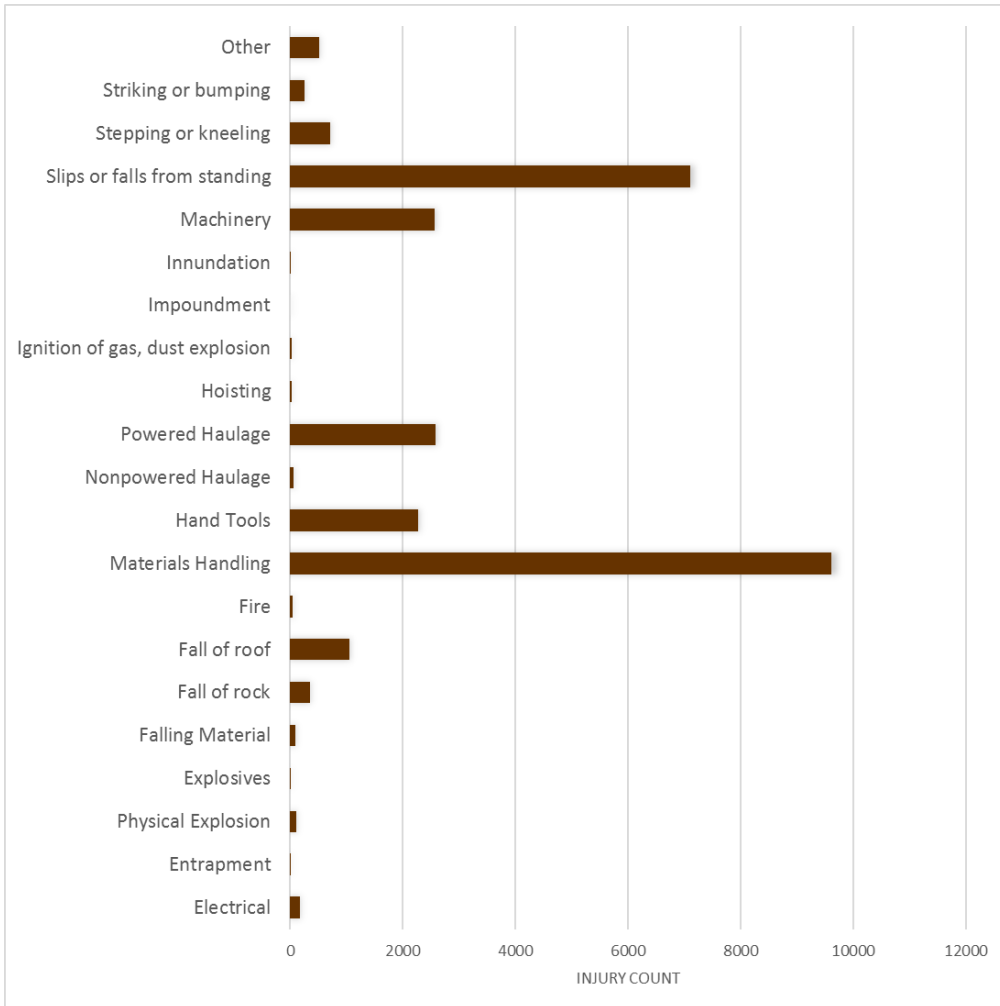


Figure 4.5: Causes of Non-Fatal Days Lost Injuries, 2010-2014, modified from MSHA data, 2015

Traumatic Injuries in the Urban United States

Urban trauma care statistics are less consolidated than those of the mining industry. Data is extracted from reports and studies done on emergency medical services and trauma care.

The first source of data is the Web-based Injury Statistics Query and Reporting System (WISQARS™). For this data set, analysis will be restricted to only ages 18-70, as miners cannot be under 18 in the United States, and it can be assumed that a majority of miners are retired by age 70. This data set is presented in Figure 4.6Figure 4.7, showing that falls of persons are the leading cause of non-fatal injuries in the U.S. between 2001-2014, with nearly 60 million injuries documented for the surveyed population and time frame, followed by overexertion, general struck-by or struck against, and vehicle accidents, with about 30 million injuries each. This is different than causes of NFDL injuries in the mining industry, where a majority of injuries stem from materials handling, and falls are only the second

largest cause of NFDL injuries. In contrast to nonfatal injuries, Figure 4.7 shows the leading cause of fatal injuries is traffic accidents. For the same sampled time period, 430,000 Americans were killed in motor vehicle accidents, with poisoning and falls following. These statistics are somewhat consistent with the causes of injury for the mining industry, where powered haulage incidents are comparable, in some ways, to traffic accidents. Poisoning or injuries from chemicals represent a much smaller percentage of fatalities in the mining industry than in the urban environment.

Additional urban data comes from a variety of sources, the first of which is a study by Newgard et al. on prehospital care, evaluating the relationship between patient outcome and transport time. This study included an analysis of 3,600 critical injuries across a variety of EMS systems around the United States, and presented data both in outcome in relation to time as well as other key characteristics.

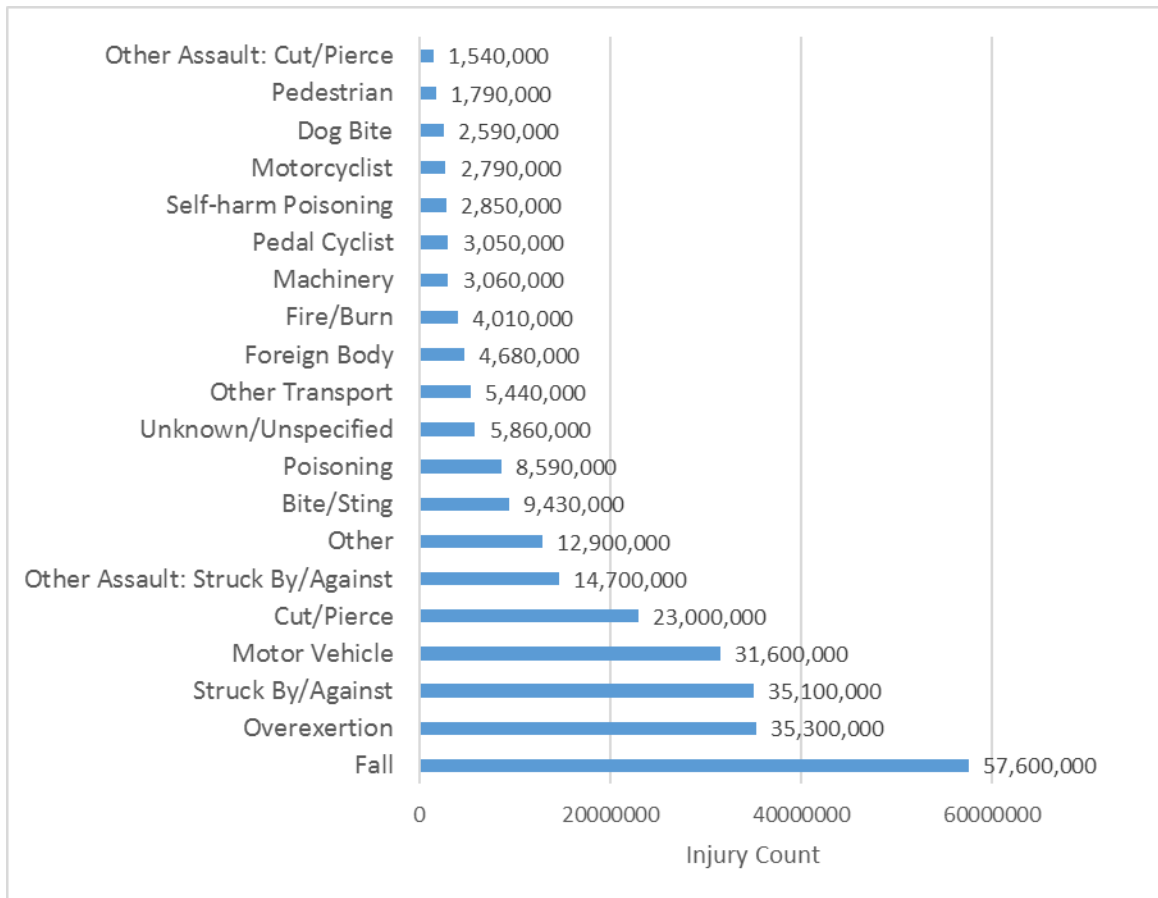


Figure 4.6: Causes of Urban, Nonfatal Injuries, 2001-2014, Ages 18-70, Rounded (Centers for Disease Control, National Center for Injury Prevention and Control, 2016)

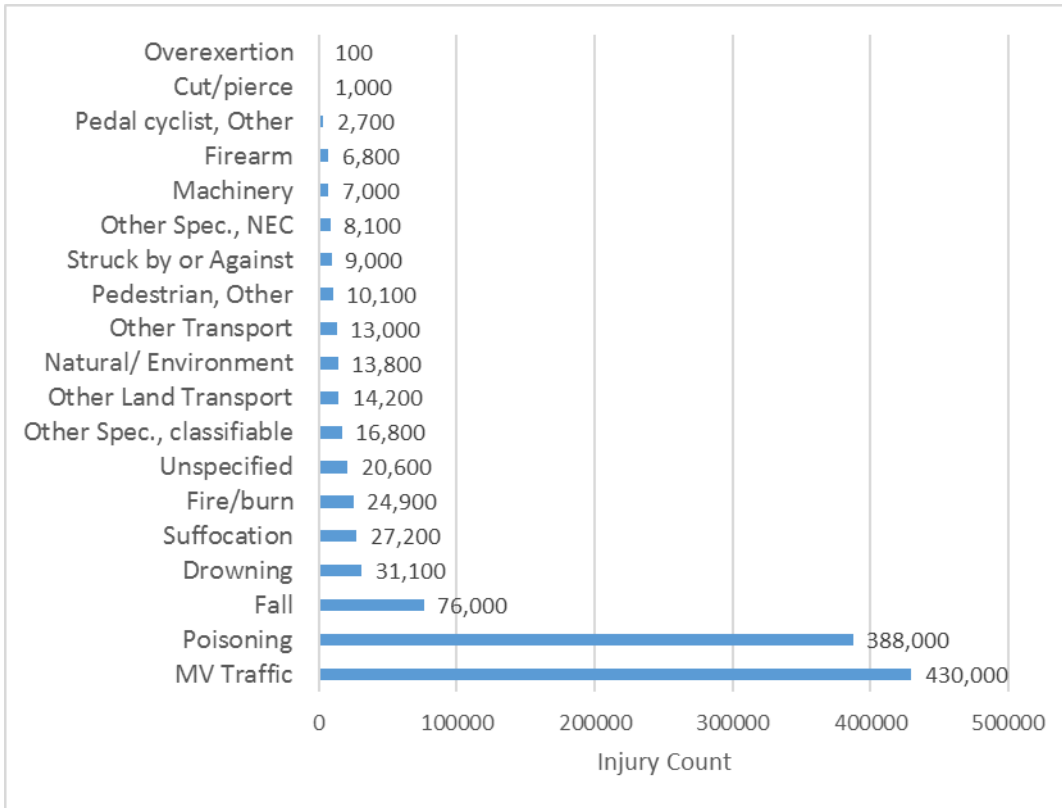


Figure 4.7: Cause of Urban Traumatic Deaths, 2001-2014, Ages 18-70, Rounded to Three Significant Figures (Centers for Disease Control, National Center for Injury Prevention and Control, 2016)

Data by Newgard et al., (2010), as presented in Figure 4.8 and Figure 4.9, is nonspecific on severity of injury or loss of life, but does provide broad statistics on how severe injuries may happen. Only patients that were unstable, severely injured or required advanced care in the field were included this study population. This data set is also correlated with mortality and transport time, although the authors of the paper were unable to demonstrate statistical significance in this correlation.

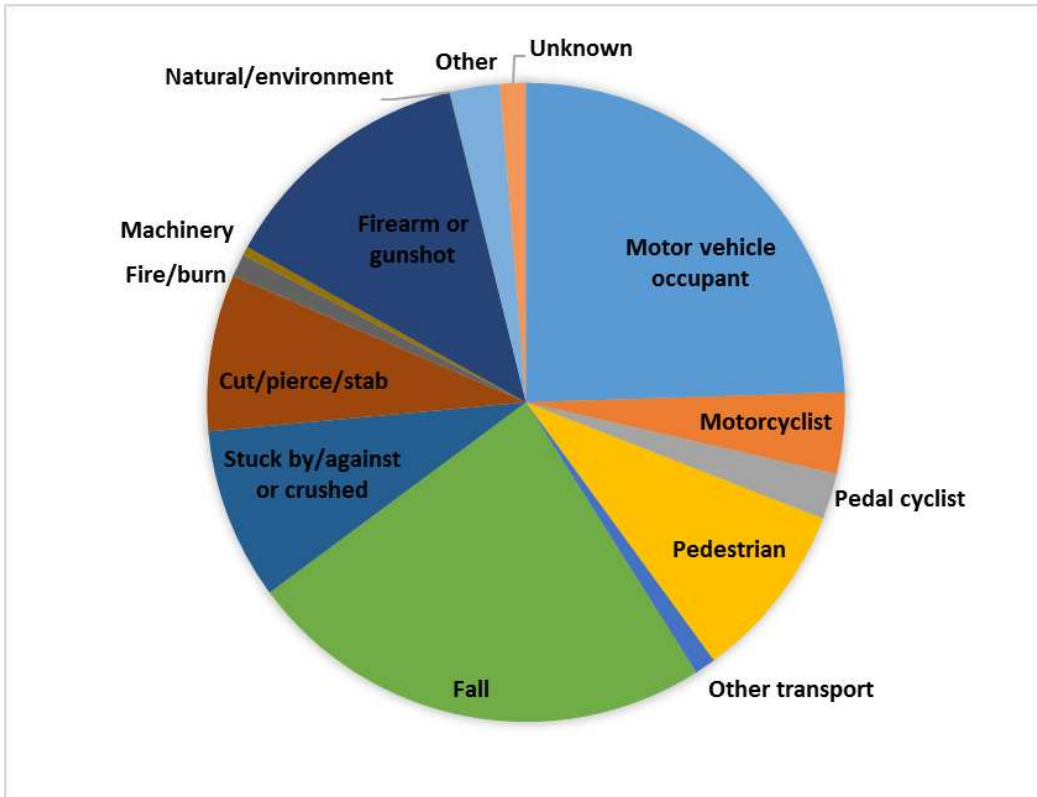


Figure 4.8: Causes of Injury for Study Group (Newgard, et al., 2010)

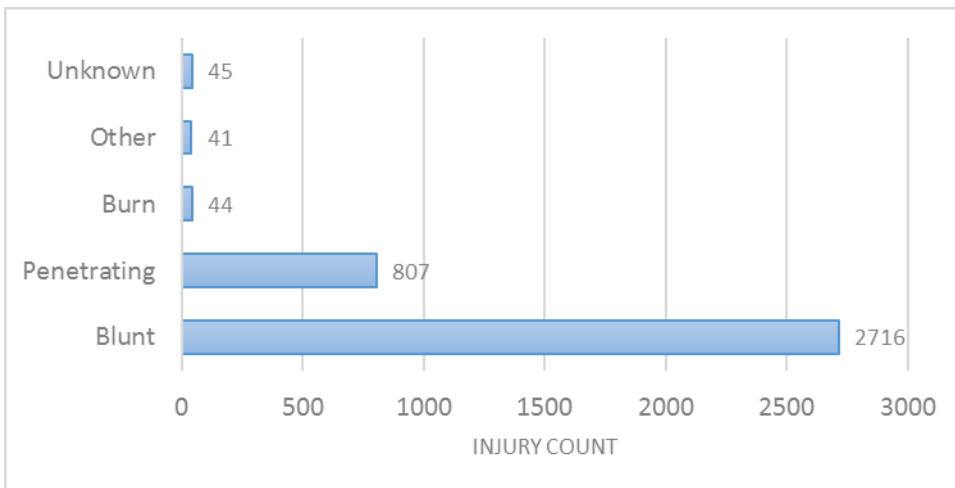


Figure 4.9: Type of injury for study group (Newgard, et al., 2010)

CHAPTER FIVE: TRAUMA CENTER ACCESS

To examine the perspective of access to trauma centers by injured persons at mine sites, the 25 mine ID numbers with the largest employment in the year 2015 in the U.S. will be analyzed for their travel times to definitive care. For the study of these mines, distance and time to the nearest accredited trauma center was evaluated. Trauma centers were the only medical facilities considered, as they contain the facilities and specialization needed to provide the care to stabilize critically ill or injured patients. Employment numbers, mine names, and controlling company is from the MSHA Part 50 Database for employment and production, and the addresses of record from these data were used in conjunction with maps and aerial photos to determine the location of the mine office location. The nearest trauma center was determined using addresses and data from each state's Department of Health or the American College of Surgeons or American Trauma Society. From the address of the nearest trauma center and the location of the mine office, ground travel times and distances were determined using Google Maps. If the nearest trauma center is a level III or below, additional research was done to find the nearest level I or II facility. For the purpose of this study, all travel times are simply ground travel times from the mine parking lot to the hospital. This data does not include travel time from the point of injury to the mine parking lot, so these times are the bare minimum time for travel of the patient to the hospital. Times for travel to the surface from an underground mine can exceed an hour depending on method of transport, location in the mine and potential shaft wait times.

Trauma Center Background Information

To clarify and provide background on trauma centers and what each level of care means, some functional background is provided on the definition of each trauma center level. These descriptions are based on the descriptions from the American Trauma Society (American Trauma Society, 2016).

Level I Trauma Center: The most advanced receiving hospitals available. Capable of receiving any patient with any severity of injury without the need to transfer the patient to a more advanced facility. They are a facility intended to receive patients from a broad region and providing care from initial injury through rehabilitation. They are required to maintain 24-hour in-house surgeons, cardiac catheterization, anesthesia, and other specialized disciplines. They maintain education and research capabilities for trauma care in the field and in-hospital, as well as receive a minimum number of critical patients on an annual basis. These facilities generally include aeromedical evacuation receiving capability, as well as are required to accept all incoming patients.

Level II Trauma Center: Capable of initiating and delivering care to all injured patients. A level II facility maintains 24-hour presence of general surgeons and emergency physicians, as well as typically

maintaining on-call response from specialized surgeons. These facilities often transfer advanced or tertiary care needs to a level I facility.

Level III Trauma Center: Capable of stabilizing and fundamental critical care to injured patients. These facilities can care for a majority of patients, where critical patients are transferred to a level I or II facility. They maintain 24-hour coverage by only emergency physicians, with coverage by surgeons and anesthesia on an on-call basis. These facilities often maintain agreements to back up level IV and community hospitals.

Level IV Trauma Center: Capable of stabilizing patients and initiating advanced trauma life support care before transferring care to a higher-level facility. They are capable of providing basic evaluation, stabilization, laboratory services, and diagnostics of sick or injured patients. Their facilities maintain availability of trauma physicians on an on-call basis, and may maintain surgery or critical-care facilities on site (but are not required). They maintain agreements for rapid critical care transport of patients to Level I or II facilities.

This data indicates that 12 of the 25 largest U.S. mining operations have a ground transport time greater than one hour to definitive care. Several mines have ground travel times of two to three hours to reach a designated trauma center, most notably the gold fields in northern Nevada. From a perspective of closest facility, 32% of mines have a level I trauma center as the nearest receiving facility, with another 36% with a level II facility as closest, as shown in Figure 5.2. When distances are plotted as a histogram (Figure 5.1), 15 of the 25 mines are within 61 miles of a trauma center. This is largely due to eastern coal mines, which are generally much closer to cities and medical care as opposed to western mines. In the cluster between 230 and 286 miles from a hospital are the gold mines in northern Nevada, namely Newmont's South Area as well as Barrick's Cortez and Meikle Mines, where the nearest trauma centers are in Reno or Salt Lake City. Between 90 and 200 miles are the Arizona open-pit copper mines and one or two other commodities.

Distribution of ground travel times can be grouped in three sets; under one hour, between one and two hours and over two hours. Several of the short travel times can be attributed to having community hospitals in the towns nearby. Travel times over one hour can potentially endanger patient lives. Travel above two hours to three hours present a significant risk to the patient (Salomone, et al., 2014). The mines in northern Nevada fall into this category. For patient with an ischemic stroke, a blood clot in the brain, transportation time to a trauma center alone would likely worsen the situation to a point where the patient might not recover (McVaney et al., 2015).

This disparity of distance and transport time presents challenges from a regulatory perspective. Mines within an hour of a trauma center are lower risk and better match the access to trauma centers in the urban U.S., while some mines are far more remote and would therefore necessitate advanced care and transport much sooner, potentially at the site itself, delivered by the operator. Additional challenges are provided by the nature of the mining industry itself and the types of mines in question. A surface mine may simply have the ambulance respond directly to the scene of the accident or a helicopter can land on a bench or haul road near the scene. Underground operations always require intermediate transportation from the scene to the surface. This can potentially add up to an additional hour or more before the patient can be loaded into an ambulance or helicopter

Trauma Center Access for Urban U.S. Population

To compare distances between mines and trauma centers to the urban access of injured persons to a trauma center, two key performance metrics were assessed. First, the simple count of accredited trauma centers was evaluated. This data was gathered from an inventory of trauma centers in the US, which assessed counts, types and distributions of trauma centers across the U.S. (MacKenzie, et al., 2003). The distribution of trauma centers by type is presented in Figure 5.4, with only 16% of trauma centers accredited as Level I. Estimates done in a separate study by Branas et al. in 2005 indicate that 69-84% of U.S. residents have access to a Level I or II trauma center within 60 minutes. Once Level III trauma centers are included, 89% of the U.S. population is within 60 minutes of a trauma center (Branas, et al., 2005), in contrast to the mining industry, where only 60% of the 25 largest mines have level I, II or III trauma centers as closest access. The geographic distribution of trauma centers is presented in Figure 5.5 (Branas, et al. 2005). When the regions within one hour of level I or II trauma centers are compared with the location of the chargeable mine fatalities in 2014 (as shown in Figure 5.5), a disparity becomes apparent. Few fatalities are actually within the regions where care is available within one hour, implying that many of the fatalities in 2014 would not have had appropriate access to definitive care in reasonable time.

Table 5.1: Location and Transportation Distances for Largest 25 Mine Sites, 2015, using MSHA data, 2015

Rank	Mine or Plant Name	Company	Type and Commodity	Employees	Nearest Hospital (miles)	Ground Travel Time to Hospital (min)
1	Morenci	Freeport-McMoRan	Surface Copper	3115	56	70
2	Black Thunder	Arch Thunder Basin Coal	Surface Coal	1628	109	114
3	North Antelope Rochelle	Peabody Energy	Surface Coal	1418	119	123
4	Green Valley	Freeport-McMoRan	Surface Copper	1279	33	42
5	Chino	Freeport-McMoRan	Surface Copper	969	83	119
6	Bingham Canyon	Rio Tinto Kennecott	Surface Copper	960	10	20
7	Marshall County	Murray Energy	Underground Coal	954	22	39
8	Cortez	Barrick Gold	Surface and Underground Gold	932	286	250
9	Minnitac	U.S. Steel	Surface Iron	905	5	17
10	Stillwater	Stillwater Mining	Underground Platinum-group	873	85	102
11	Bagdad	Freeport-McMoRan	Surface Copper	869	125	125
12	Smoky Valley Common Ops	Round Mountain Gold (Kinross)	Surface Gold	866	238	228
13	Westvaco	Tronox Alkali	Underground Trona	851	158	160
14	South Area	Newmont	Surface Gold	842	264	224
15	No. 7	Warrior Met Coal	Underground Coal	811	16	25
16	Bailey	Consol Energy	Underground Coal	726	28	43
17	Bayer Alumina Plant	Alcoa World Alumina	Aluminum Milling/Processing	720	7	11
18	Hibbing Taconite	Hibbing Taconite	Surface Iron	718	10	13
19	Boron Operations	U.S. Borax (Rio Tinto)	Surface Boron	717	55	52
20	Safford	Freeport-McMoRan	Surface Copper	714	11	20
21	Ray	Asarco	Surface Copper	712	81	90

Table 5.1, continued

22	Cumberland	Cumberland (Alpha Natural Resources)	Underground Coal	696	21	28
23	Tilden	Cleveland Cliffs and US Steel	Surface Iron	670	19	31
24	Fort Knox	Fairbanks Gold (Kinross)	Surface Gold	662	27	42
25	Meikle	Barrick Gold	Underground Gold	637	284	253

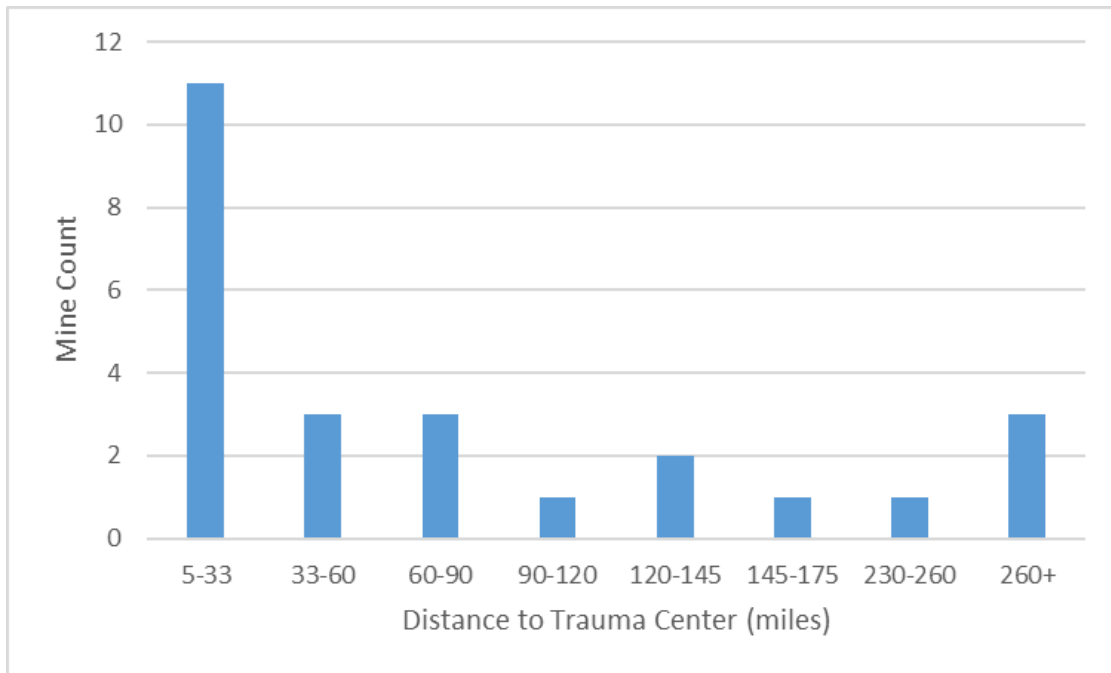


Figure 5.1: Histogram of distances from top 25 mines to trauma centers

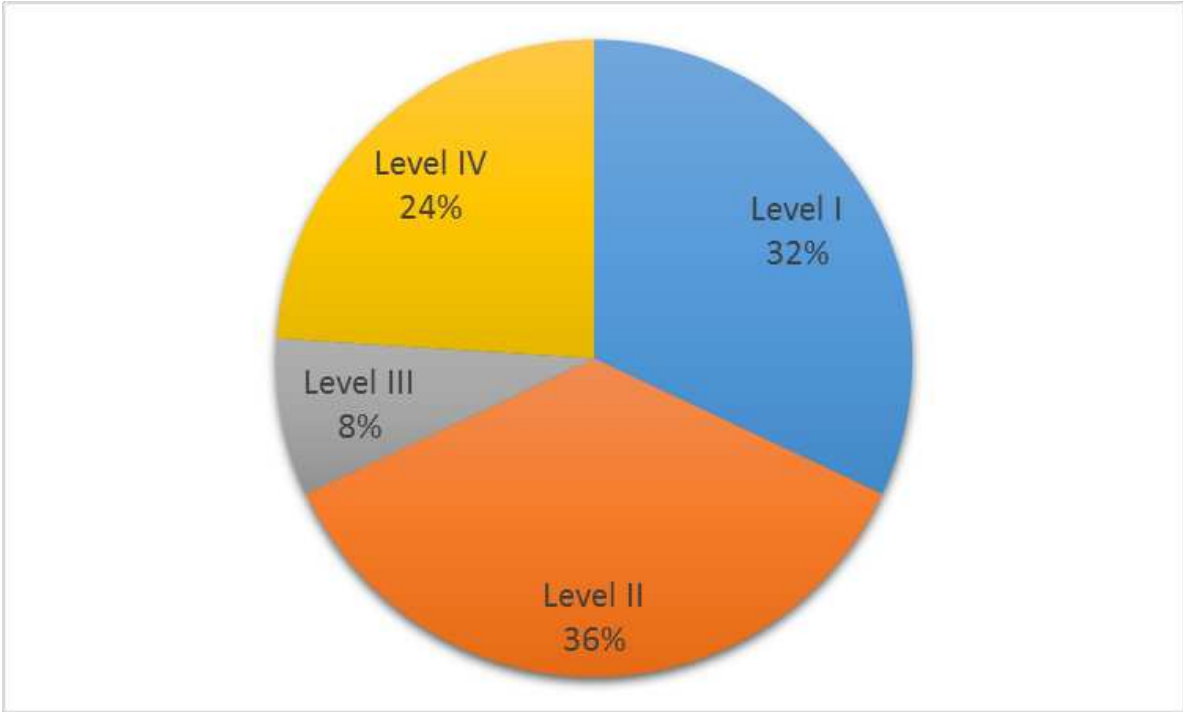


Figure 5.2: Trauma center levels closest to top 25 mines

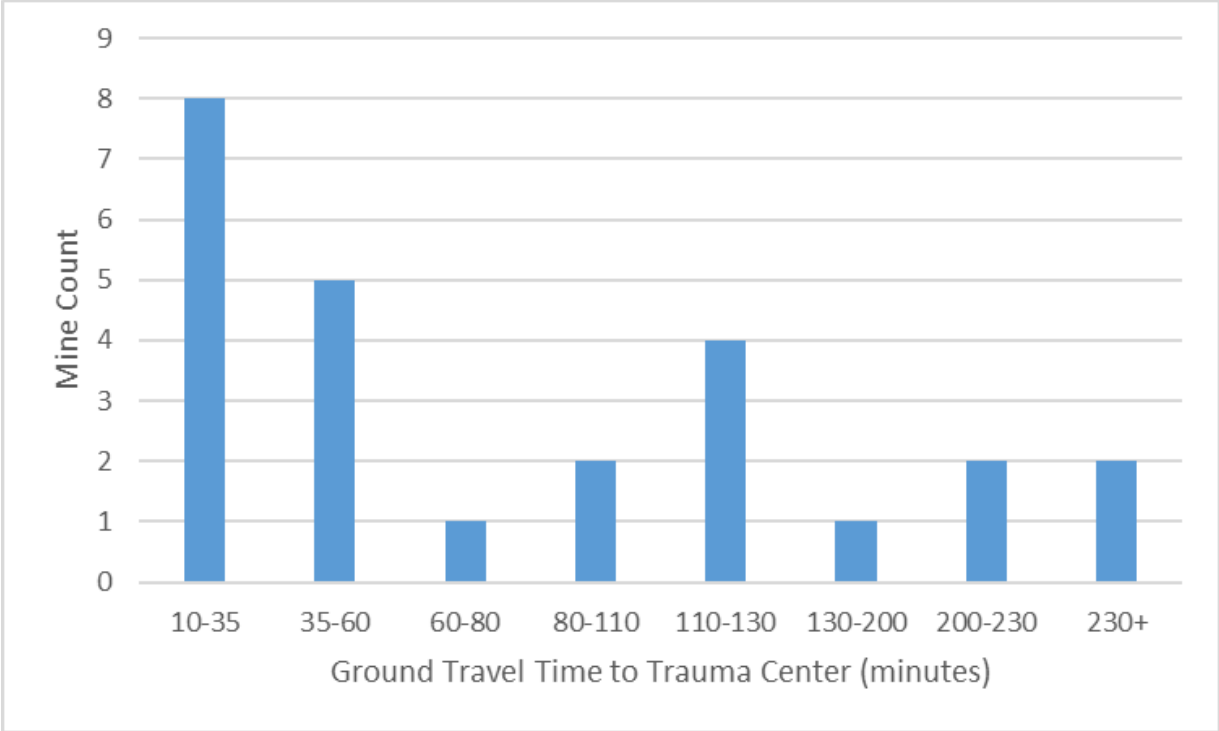


Figure 5.3: Histogram of ground travel times from top 25 mines to trauma center

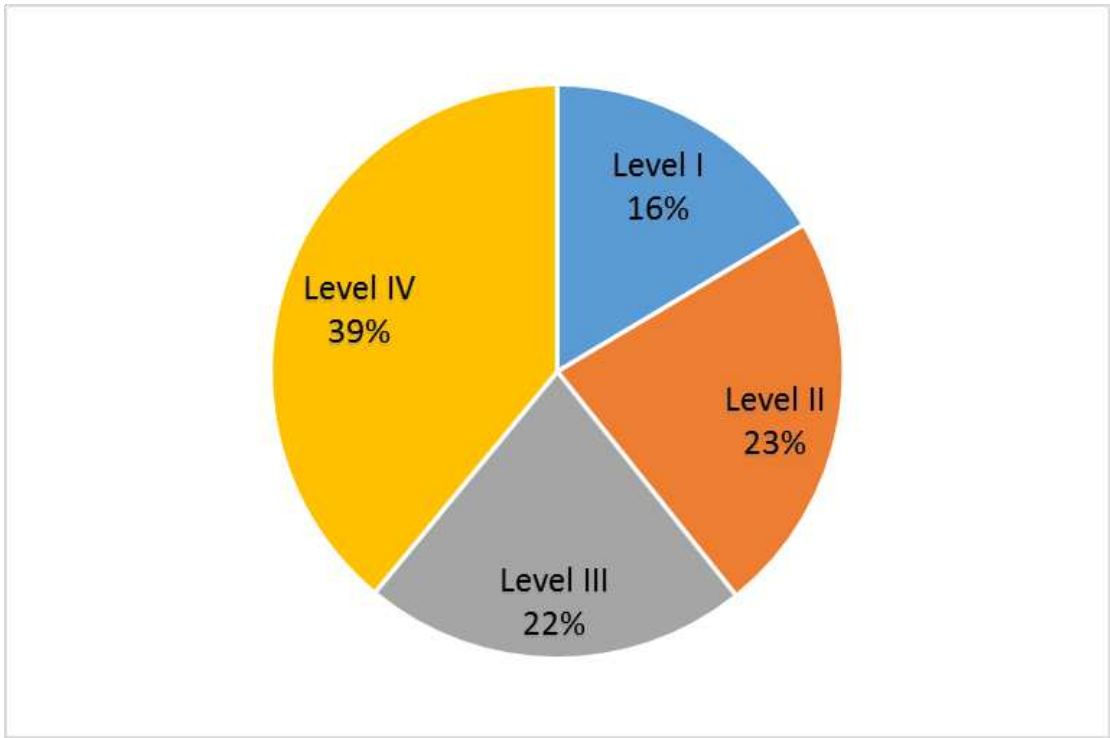


Figure 5.4: Distribution of U.S. trauma center levels (MacKenzie, et al., 2003)

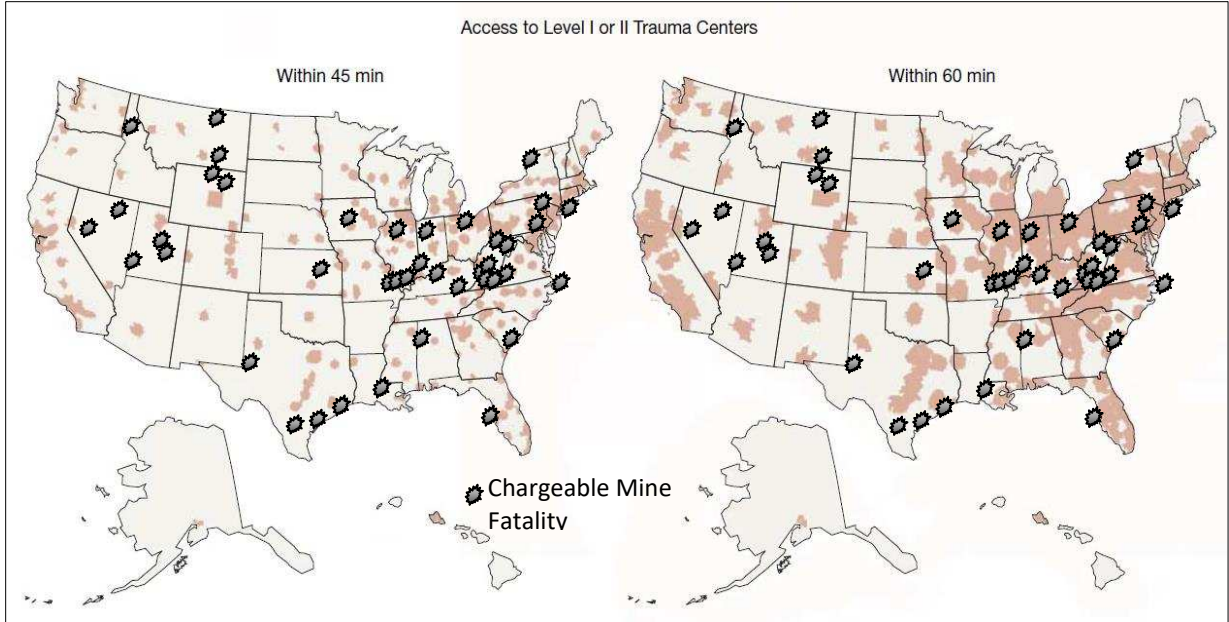


Figure 5.5: Maps showing travel times to Level I or II trauma centers (Branas, et al., 2005) with Locations of Chargeable U.S. Mine Fatalities, 2014 Overlaid (National Institutes of Occupational Safety and Health, 2016)

CHAPTER SIX: INJURY TREATMENT

The following injuries and conditions were evaluated and appropriate treatment indicated as follows:

1. Multisystem Trauma
2. Crushing
3. Amputation
4. Asphyxia
5. Musculoskeletal injuries (sprains, strains, fractures)
6. Electrocution
7. Myocardial infarction
8. Lacerations, Abrasions, Punctures
9. Burns
10. Head injuries

Prehospital emergency medical care is centered on ensuring basic life functions continue, fundamentally leading to the circulation of oxygenated blood containing essential nutrients to the tissues of the body. High priority (life support) medical care includes:

- Control of hemorrhage
- Management of airway, often including endotracheal intubation
- Artificial respiration
- Cardiopulmonary resuscitation, including the administration of cardiac medications and manual defibrillation
- Intravenous fluid resuscitation to boost circulatory system function

Secondary to this basic life-support process, medical care is focused on the comfort and long-term recovery of the patient. While not as time-critical, these interventions lead to better long term outcomes when coupled to life support care. Supporting care includes:

- Pain management, often using opioids
- Splinting of fractured and sprained limbs
- Wound cleaning and bandaging, key to preventing infection

The scope of practice required to deliver the most effective treatment for a traumatically injured patient is based on the specific treatments provided. Basic life support providers (EMT and AEMT) can administer some of the care required, including hemorrhage control, limited airway management, splinting and wound management, and AEMTs may begin fluid resuscitation (NHTSA EMS Program,

2007). The maximum scope of treatment in the prehospital environment is limited to Paramedics, particularly administration of any medication, and invasive treatments. In the urban setting, most 911 calls are answered by an ambulance crewed by at least one paramedic, with EMTs or AEMTs responding with the Fire Department. Some systems use a program called “Emergency Medical Dispatching” (EMD) to determine the severity of the incident and assign resources to match; meaning less critical patients only requiring EMT care have an EMT crew dispatched, where high-priority patients have a paramedic and EMT crew dispatched.

Based on the national education standard and the accepted national scope of practice from the NHTSA EMS program, Enright et al. 2016 evaluated treatments and the minimum scope of practice to provide effective intervention to the medical emergency. This is summarized in Table 6.1.

Table 6.1: Recommended scope of practice and time sensitivity for different types of injuries (Enright, Harman, & Brune, 2016)

<i>Injury</i>	<i>Recommended Scope</i>	<i>Time Sensitivity</i>
Multisystem Trauma	AEMT	High
Crushing	Paramedic	High
Amputation	AEMT	High
Asphyxia	Paramedic	High
Musculoskeletal injuries (sprains, strains, fractures)	EMT	Moderate
Electrocution	Paramedic	Moderate
Myocardial infarction	Paramedic	High
Lacerations, Abrasions, Punctures	AEMT	Low
Burns	AEMT	Moderate
Head injury	AEMT	Moderate

CHAPTER SEVEN: ANALYSIS

In analysis and comparison of both travel distances and injury rates and causes, the need for earlier and advanced medical care for injuries in the mining industry is apparent. Serious injuries that may lead to death require advanced care for the effective stabilization and treatment of the patient. Improvements in the available level of pre-hospital care and a decrease in time to definitive care is expected to lead to a decrease in injury severity and fatality.

In the urban environment, advanced emergency medical services generally arrive within 10 minutes. This rapid response time directly correlates with a higher survival rate for traumatically injured patients, as demonstrated in a clinical study conducted in North Carolina (Blackwell & Kaufman, 2002). Blackwell and Kaufman recommend that EMS first response times should not exceed five minutes. Their study noted that, of those patients whose response time exceeded 5 minutes, 64 or 1.6% of 4,043 died. Among 1,381 patients who received initial care in under 5 minutes, only 7 or 0.5% died. This study was done in a 911 system where calls were prioritized, so that critical patients received a faster response time. Physicians involved in this study also noted a select set of calls where it was apparent to them that a sub-five-minute response would have made a definitive improvement in patient outcome. An additional study conducted by Feero et al. (1995) in Portland OR, demonstrated that shorter times to ALS care and transportation to a hospital would improve survival rates in selected patients. The Feero study looked at so-called ‘unexpected survivors’, where the average time until ALS contact was 3.5 minutes. In contrast, ‘unexpected deaths’ had an average ALS first contact time of 5.9 minutes. The unexpected survivors also averaged a total time out-of-hospital of 20.8 minutes while the unexpected deaths averaged 29.3 minutes. Out-of-hospital time in this context is defined as the time between injury and arrival at the definitive care hospital.

In contrast, Newgard et al. (2010) were unable to determine a correlation between out-of-hospital time and patient survival. Their study assessed 146 EMS systems transporting to 51 trauma centers with a total of 3,656 patients meeting criteria as “critical” for the study. Newgard et al. found no statistically significant relationship between out-of-hospital time and patient survival, questioning the so-called “Golden Hour” axiom often used to justify rapid patient transport. Galvagno et al. (2012) studied data from 2007-2009 correlating critically injured trauma patient outcomes with the use of helicopter transportation. This study found, with high statistical confidence, that helicopter travel did improve patient outcomes where helicopter transport resulted in a 1.5% increase in patient survival.

Twelve of the largest 25 mines have a travel time of longer than an hour to reach definitive medical care. This does not include transportation from the injury site to the point where ambulance care is

delivered, so particularly for underground mines, these times are likely to exceed one or more hours. Even though the “Golden Hour” was questioned in one study, it seems obvious that a shorter time-out-of-hospital is a clear benefit for patient outcome. For example, in the author’s experience for managing EMS incidents in suburban Colorado, the first 911 call is generally placed within 1-2 minutes of the incident. Law enforcement, fire and EMS responders are dispatched within 2-3 minutes after the call is placed, with the average arrival of the first medical personnel within about seven minutes of dispatch or less than ten minutes after the injury. EMS personnel often spend 5-20 minutes on scene with the patient, and take 5-20 minutes to transport the patient to a hospital, resulting in a total incident to hospital time of as little as 20 minutes to one hour, as illustrated in Figure 7.1. In urban settings, advanced life support providers with advanced medical equipment make contact and begin life-saving interventions within 10-15 minutes of the initial incident. These life-saving interventions within the first few minutes include controlling bleeding, advanced cardiac life support and defibrillation. Such interventions are not offered at underground or most surface mine accidents. Lack of advanced initial care cannot be compensated by rapid transport. As Figure 7.2 illustrates, ALS contact for an underground mine accident can take 55 minutes or more. Adding the time to hospital of 100 or more minutes may result in two to three hours of out-of-hospital time. Delays in discovery and notification of responders add a delay to this time, and in the event that disentanglement or extrication is required, this time extends further. At a surface mine, some advantages exist where ambulance or helicopter response can directly reach the point of injury, eliminating intermediate transport by on-site emergency responders. This shortened time is illustrated in Figure 7.3. Figure 7.4 illustrates additional time savings that can be achieved by using a helicopter. It can be safely assumed that helicopter transport can be made available for seriously injured patients.

No coherent records or database exist for organized use of mine emergency response resources, making research into their effectiveness and outcomes difficult. While the MSHA database does record the reported time of accident, it does not provide a timeline for first response, transportation, arrival at the hospital etc. In contrast, the US Fire Administration develops and collects data based on the National Fire Incident Reporting System (NFIRS). The NFIRS database is used by both researchers and fire departments to analyze how fire departments are used, and to guide decisions on training, equipment and overall incident preparedness. Accident data like this are used and essential for urban emergency planning, training and equipment selection. The same approach could be easily applied to emergency response in the mining industry if sufficient data were available. In the absence of suitable data on how mine emergency response resources are used, mine emergency planning is lacking.

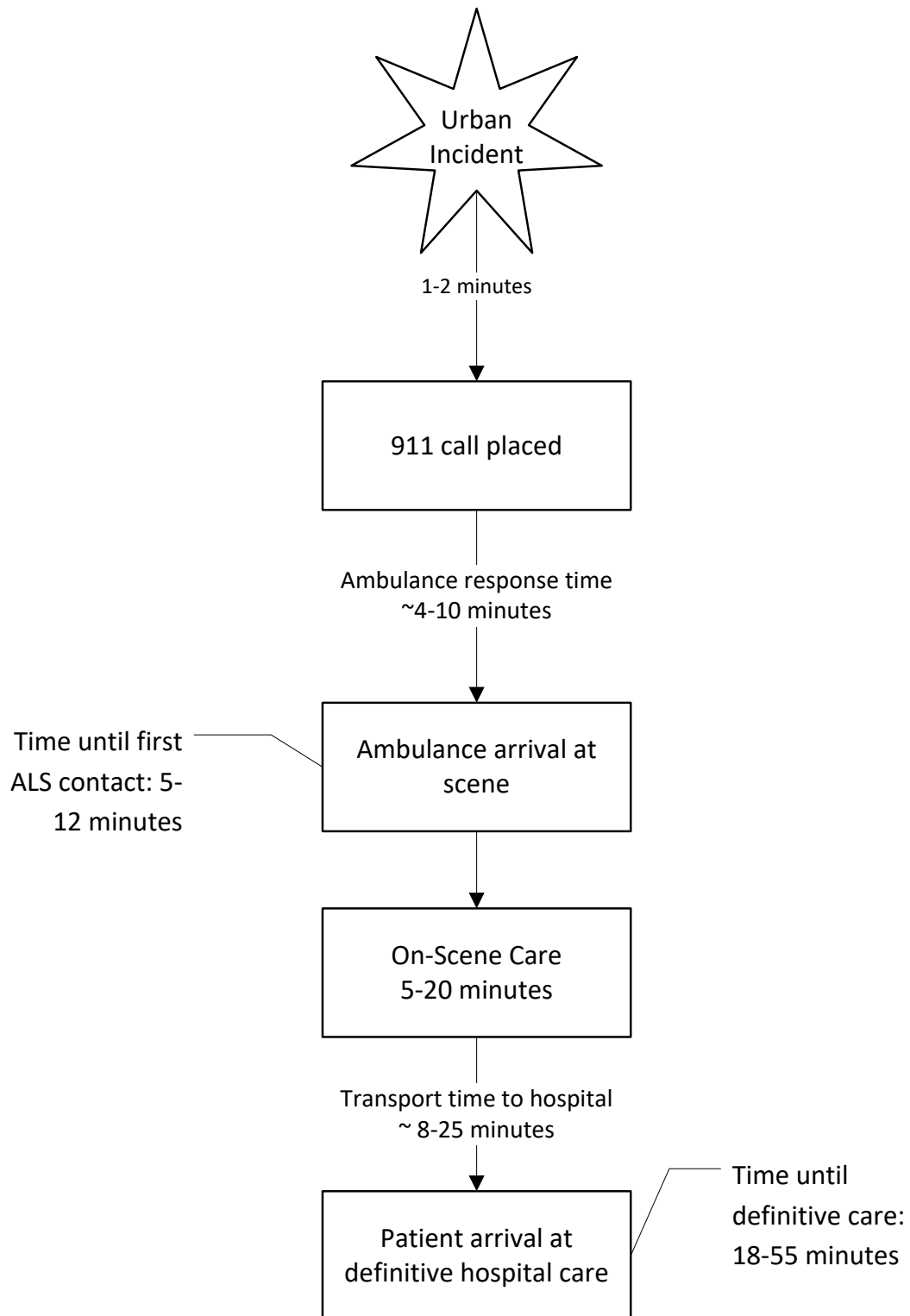


Figure 7.1: Conceptual timing for medical care for an urban emergency



Figure 7.2: Conceptual timing for medical care for an underground mine accident. Times are assumed based on experience and data collected on transport times from mines to hospitals.

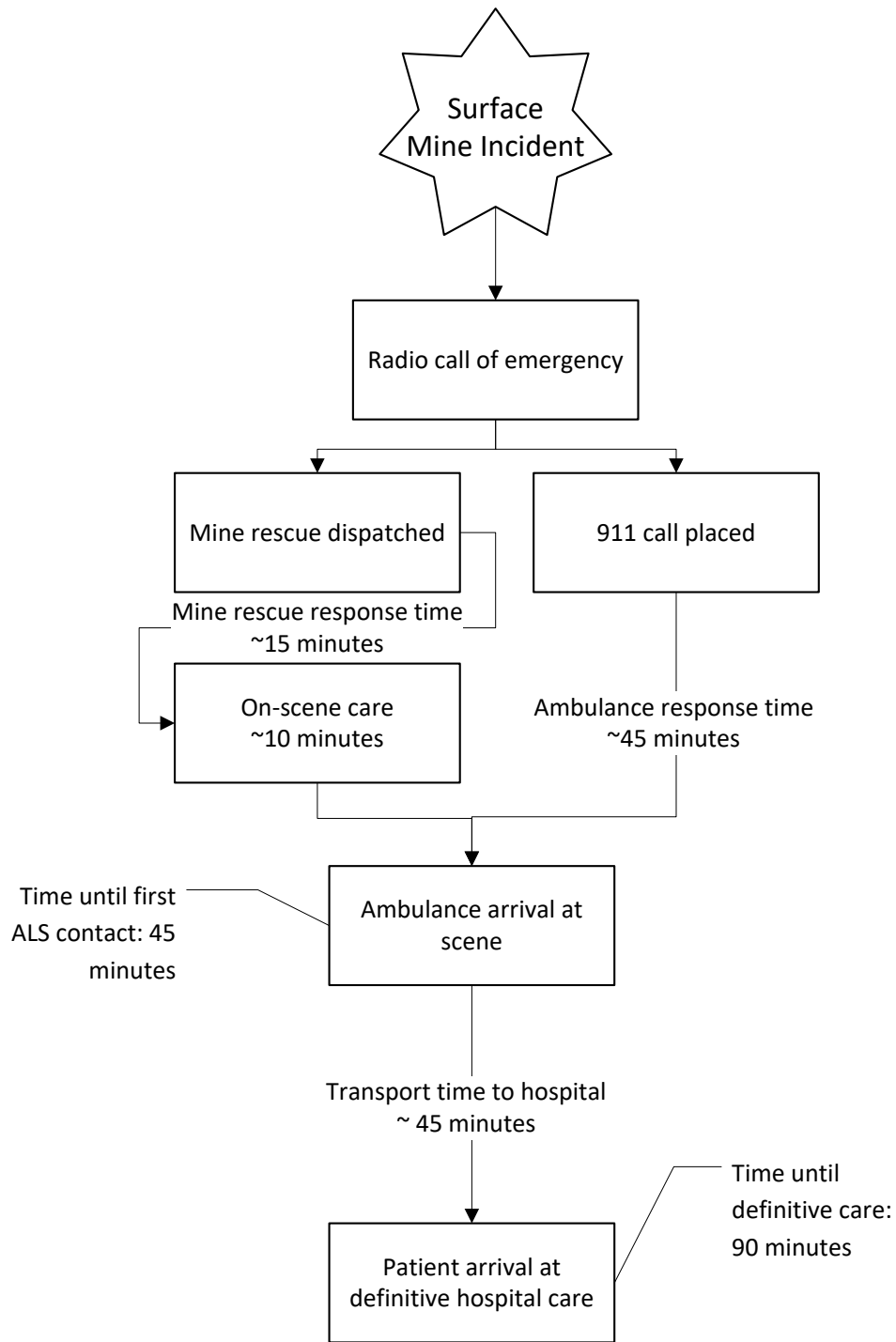


Figure 7.3: Conceptual timing for medical care for a surface mine accident, ground travel only. Assuming ambulance can travel directly to the scene.

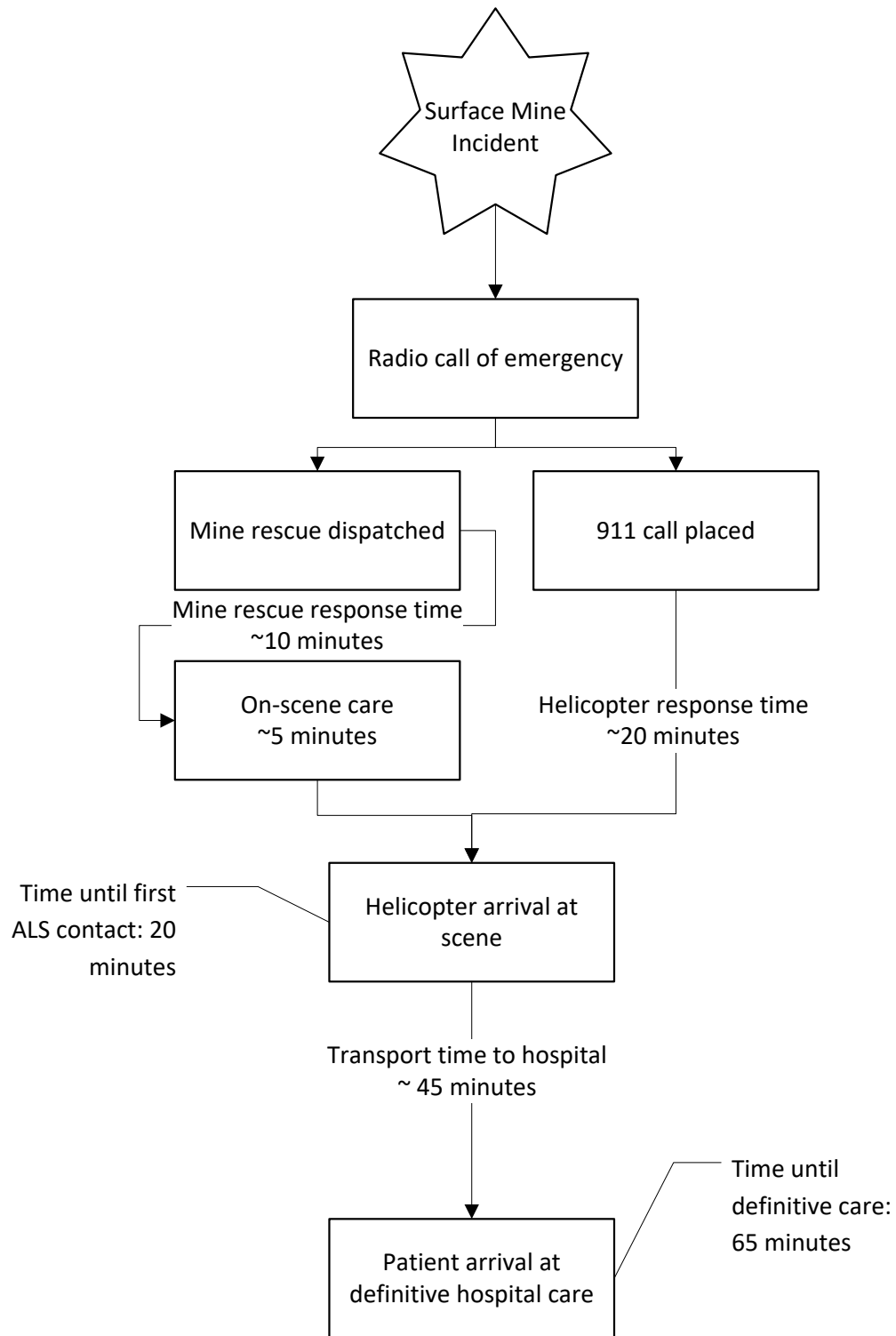


Figure 7.4: Conceptual timing for medical care for a surface mine accident, helicopter evacuation

CHAPTER EIGHT:SHORTCOMINGS TO ADVANCED PRE-HOSPITAL CARE IN THE MINING SECTOR

Training and Level of Care Among Emergency Responders in Mines

The scope of practice or level of care by emergency responders in the mining industry lags behind training and best practices as seen in the urban environment. For a similar pattern of injuries and fatalities between the two environments, the urban environment largely uses paramedics and EMTs to deliver care, while the mining environment relies on at best EMTs, but largely on EMRs. With transport times often exceeding an hour to definitive care at a trauma center, this level of care is a significant shortcoming for the mining industry. The requirements provided by 30 CFR §56.18010 and §57.18010 for medical care required at mine sites is inadequate to provide extended care to even traumatically injured patients as the regulation appears to intend. When non-chargeable or natural cause incidents are involved, the required capabilities fail to provide the care needed to save lives in the event of heart attacks, strokes or other natural causes of death.

Initial training for miners under 30 CFR §48 requires a training component on first aid. This initial training lacks specific guidance in the regulations, and approved training plans don't necessarily follow an organized training program or certification program for medical care. Initial new miner training usually includes an abbreviated version of hands-only CPR and the Tactical Emergency Combat Care guidelines (Butler & Giebner, 2016) for trauma treatment, instructing new miners how to take care of critically injured miners until advanced medical care arrives. While the basic level of training given to all miners is helpful to some degree, this level of care is not sufficient. Some mines maintain advanced medical equipment, notably Automated External Defibrillators (AEDs), large medical kits, a level of care comparable to urban environments is not available in mines. Urban ALS providers, particularly paramedics, supported with a full complement of medical equipment and supplies, often make the difference that saves a life.

Emergency Planning and Preparedness

Early and effective planning is used in the urban environment for determining how emergency response resources are distributed. For the mining industry such preparation is also lacking. Federal regulations only stipulate that "Each operator shall make arrangements in advance for obtaining emergency medical assistance and transportation for injured persons." (30 CFR § 75.1713). MSHA program policy does not provide guidance to either inspectors or mine operators on how to comply with this regulation, leaving this preparedness step simply to interpretation by each operator.

As a cooperative effort of the mining industry led by the National Mining Association, the CORESafety program (National Mining Association, 2016) presented a sample Underground Emergency Response Plan, as well as other supporting resources and documentation for emergency management at mines. This plan was provided to be applied, perhaps with minor modifications, to any underground operation, and are provided for the planning efforts of the mining industry, and is supplemented with planning aid documents to help in the process of building an emergency management plan for a site. CORE Safety appears to be primarily geared toward managing corporate risk and liability. It is limited as a preplan both for specific resources or as a protocol for recommended actions. Figure 8.1 and Figure 8.2 present snapshots of the section for medical emergencies from the CORESafety underground mine emergency response plan (National Mining Association, 2016). The author finds the plan provided by CORESafety to be inadequate as a guideline to provide effective care to injured persons. It is difficult to follow and fails to provide necessary, specific guidance. In comparison with standard operating procedures for response to emergencies used by urban EMS organizations, the CORESafety provides little detail on what courses of action should be prearranged or what decisions would be advisable under given circumstances. It does not specify levels of care, resources and equipment that should be made available at mine sites. A mine operator would not be able to use CORESafety resources effectively to create a well-equipped and functioning emergency medical service for the mine. In particular, CORESafety does not specify or recommend a level of care and medical training for first responders, mine rescue personnel or individual miners.

Neither CORESafety nor MSHA address natural or non-work-related causes of injury and death. This makes effective planning and preparedness for these medical emergencies difficult. Including natural causes of death in the MSHA records would provide a more realistic picture on emergencies occurring at mines, and would likely lead to improved health outcomes in all mine-related injuries.

MEDICAL EMERGENCIES / ACCIDENTS:

EMERGENCY LEVEL LOW

- Minor injuries (first aid level) during routine operations with safety policies and practices fully implemented.

EMERGENCY LEVEL MEDIUM

- Single serious injury.

EMERGENCY LEVEL HIGH

- Multiple serious injuries or at least one fatality.

In the event of a serious injury or illness, the first priority is the prevention of any additional injuries. All personnel responding to the scene should take precautions to prevent injury to themselves and others prior to commencing a rescue. Move the victim only if they are in grave danger.

Trained first aid personnel are scheduled on each shift and should be contacted as soon as possible to render aid and transport the injured.

Assess the accident scene:

- Secure the scene before entering
- Identify the mechanism of injury
- Assess the victim with care
- Treat / Stabilize life-threatening injuries

Notify the Area Supervisor, if unavailable then Mine Dispatch, by radio, telephone, or mine phone. If by radio or phone state the following to clear the airway:

“Emergency, Emergency, Emergency, I have a Medical Emergency”

Figure 8.1: Page One of CORESafety Underground ERP for Medical Emergency

Give the following information:

- 1 Your name
- 2 Location
- 3 Nature of injuries and number of injured persons (do not give names)
- 4 Type of help needed, i.e., gear, transportation, and personnel
- 5 # of emergency personnel already on scene
- 6 Make sure help is on the way
- 7 Do not hang up until told to do so.

The Area Supervisor is responsible for:

- Calling for the response of all emergency personnel needed, and requesting radio silence when necessary.
- Requesting no phone calls offsite, via telephone or cell phone.
- Providing unobstructed access to and from the scene for emergency personnel and equipment.
- Providing any additional support requested by emergency personnel.
- Notifying Mine Dispatch, HSLP and Management
- Radio silence must be maintained during the emergency, when requested.
- During all emergencies no phone calls are to made offsite to non-company personnel.

Do Not Call Local Media, Families or Government Agencies.

Mine Dispatch will notify the emergency response personnel and fill out the Emergency Activity Log

- The Mine Dispatcher will dispatch the Emergency Response Team. Be available to assist emergency response personnel if required.
- Fill out witness statement, first aid report or incident report as needed.
- All accidents / incidents will be investigated in accordance with North America Procedures.
- All attempts should be made to prevent injured or ill persons from leaving the property unless accompanied by at least one other individual. If the company rescue vehicle is used, a minimum of two people must accompany the injured - An EMT or first responder to render aid and one other to drive.
- If a medical emergency or accident occurs that requires patient transport to the hospital, will call Sheriff Dispatch (911) and request a rendezvous with ambulance or Access Air. The First Responder / EMT and supervisor shall make the determination as to who to call.

Figure 8.2: Page Two of CORESafety Underground ERP for Medical Emergencies

CHAPTER NINE: RECOMMENDATIONS

Mines represent a unique set of hazards, where serious injury and illness can occur in remote and austere locations. Delivery of the best possible patient care, with the intent to minimize morbidity and mortality from accidents or illnesses in the mining industry should be a key focus of safety and emergency response planning at mines. Based on mining accidents and injuries 2010 to 2014, the required level of care for typical injury types in mining accidents was evaluated to devise recommendations. Medical research and experience in wars has led to providing rapid, high-level paramedic care for patients injured in urban settings. Highly qualified medical professionals and well-equipped ambulance services have significantly improved survival rates since the 1970s. The “Golden Hour” is considered a standard for the maximum out-of-hospital time to best patient outcomes.

In mines, distances of 200 or more miles to the nearest accredited trauma center and transport times of two to three hours are common. This makes it difficult to provide a level of patient care at mines that is comparable to urban settings. Still, significant improvements can be made to the care that injured or ill miners receive. Following are specific recommendations to improve medical emergency response at mines:

Recommended Training for Miners and First Responders

1. All miners should be trained in CPR and AED usage, and certification should be required for employment.
2. Mines within a <30-minute response time from an EMS agency and within one hour ground transport time from a level II trauma center should maintain at least one EMR on duty with each shift.
3. Mines within one hour of EMS arrival and within two hours of a level II trauma center should maintain at least one EMT on each shift.
4. Mines with greater than one hour EMS response time should keep a Paramedic and an EMT on site on each shift, along with appropriate medical equipment.
5. Mine rescue teams should maintain a Paramedic as their team medic. All team members should be certified as EMTs.
6. Mine rescue training should be improved to focus more on providing advanced levels of pre-hospital care for injured miners.

Recommendations in Emergency Planning

7. Mines with greater than one hour transport time to a level II trauma center should establish and maintain an agreement with helicopter aeromedical evacuation for rapid transport of patients.
8. Mines with longer than three hours' transport time to a level III trauma center should their own develop ground or air ambulance transportation capability for patients, with a Paramedic and EMT on site covering each shift.

Recommendations in Patient Outcome Recordkeeping

9. All injuries or fatalities at mines should be cataloged as part of the Part 50 database, with a separate field indicating chargeability or potential culpability to the mine operator.
10. Similar to the National Fire Incident Reporting System, the mining industry or MSHA should maintain a database of use and capabilities of mine emergency response resources. This database allows for both the tracking of outcomes of mine emergency responses as well as to identify how teams are used so that gaps in training can be identified.

In addition to improved training and skills of miners and emergency responders at mine sites, additional preparatory work is needed for the mining industry as a whole. Regulations lack requirements on how mines must prepare for the transport and care of the sick and injured, leaving decisions to the mine operators alone. As mines are in more remote locations further away from trauma centers and emergency medical services, mines must be independent and be prepared to ensure that miners can get to the definitive care required when seriously injured. Many larger mine sites have installed or constructed helipads to hasten or simplify aeromedical evacuation in the event of serious injury. Few mines, notably some of the large mining complexes in Nevada, have developed their own ground transport ambulance capability. This level of care and capability can provide considerable benefit to the injured or sick person if transport time exceeds several hours, particularly if travel of EMS resources to the site takes more than an hour.

From a more systemic perspective, the data collected and statistics presented by the mining industry are lacking behind urban emergency medical care. Mine data is only collected on occupational injuries and illnesses, discounting incidents not directly related to the work performed. While these statistics should differentiate between occupational and non-work-related cases, including non-occupational cases will likely improve overall patient outcomes in mines.

A secondary systemic concern is that data is not available on mine emergency response resource availability and utilization. This absence of data is in stark contrast to the urban fire and emergency

medical services, where data is collected for every single emergency response. It is therefore difficult to provide accurate detail on what medical response capabilities should be reasonable available in the mining industry. Lack of effective federal regulations or corporate consensus perhaps may characterize the mining industry as antiquated or less concerned with the health and welfare of miners. With the implementation of a suitable data collection system similar to what is present for urban EMS, efforts to improve miner health and survival can be better calibrated.

CHAPTER TEN: SUMMARY AND CONCLUSIONS

Ongoing and concerted efforts by health and safety professionals, engineers and regulators have helped the mining industry achieve a net downward trend in mine fatalities, but work remains to be done. The mining industry is at a turning point, and similar to US urban emergency medical care in the 1960s, improvements in the quality and speed of care delivered can save lives. While the mining industry does indeed lag behind at the moment, changes can be made to render the quality of care delivered to better match that in the urban areas of the United States.

The first and most critical change recommended is the combination of the rapid delivery of ALS care and rapid transport to definitive care at a trauma center. This change will likely make a strong improvement the number of mine fatalities, chargeable or otherwise, and is therefore strongly recommended for potential regulatory change or voluntary adoption as leading practice for the mining industry.

This change in care delivered can be coupled with a systemic change in planning and preparedness considerations, where the mining industry and MSHA will need to shift their perspective on fatalities and injuries at mine sites to include non-occupational and therefore non-chargeable deaths. As these are not considered in the general statistics of injury and fatality, operators, researchers, emergency planners and responders may fail to consider significant causes of death that can likely be mitigated with changes in focus. Mine operators are very likely not attempting to be negligent in the preparedness for and response to emergencies at their mines, but simply may lack the guidance and information to take effective action. With specific recommendations on how to make improvements to patient care and be better prepared for an injury or illness, mine operators can reduce resultant mortality in the event of an incident. Federal regulators as well are likely not malicious or particularly negligent in this matter either, they may simply fail to understand that changing their perspective to see that non-chargeable fatalities are preventable as well.

The mining industry in the United States can certainly achieve further reduction in the number of fatalities and the severity of injuries, but only with changes and buy-in from both MSHA and the mine operators themselves. With aggressive action to implement improvements in both planning, preparedness, training and data collection for mine site emergency response will likely result in a decrease in the number of fatalities and a decrease in end morbidity of victims of mine accidents. While not all deaths can be prevented, the implementation of advanced and aggressive care and transport, coupled with effective planning can certainly save the life of at least one miner.

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