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BACK INJURIES IN UNDERGROUND COAL MINING

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16. Abstract (Limit: 200 words) The authors investigated the nature, cause and treatment of 224 back injuries which occurred in 156 different situations in underground coal mines. A detailed interview was conducted with each injured miner as 137 variables were explored to provide a complete picture of the injury scenario. The miners worked at 23 mines in six states. An important finding of the study was that sudden movement, which occurred in 52% of the injuries, is a more frequent factor than heavy lifting in causing back injuries. Along with sudden movement, other major injury causing factors were equipment seat design, lifting, cable handling, and slips/trips. No significant differences were found between the injury scenarios associated with lost time and non-lost time injuries; thus, both sets of scenarios should be used in developing back injury control strategies. Medical treatment and rehabilitation varied in content and quality. Dialogue between the medical, rehabilitation and mining communities is needed to develop an effective treatment strategy. Back injury control related training was found to be inadequate in most mines. Mine specific training for physical stress recognition and potential sudden force release should be added to the training currently given. Based on the information collected in this study, recommendations were made regarding equipment design, mechanical assists and procedures for material handling, training, etc., which, if implemented, will assist in reducing the frequency of back injuries in underground coal mining.				
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FORWARD

This report was prepared by the Industrial Engineering Department of West Virginia University, Morgantown, West Virginia. The research contract J0348044-05 was administered under the technical direction of the Pittsburgh Research Center with James Peay and Tom Bobick serving as Technical Project Officers. This report is a summary of the work recently completed for this agreement during the period July 31, 1984 to June 30, 1989.

In addition to the authors many individuals were involved in the research, planning and development of this report.

The participation of the management and workers of the 23 mining companies is greatly appreciated. The mine management at each facility was most supportive and generously shared their time and expertise to make this project a success. The miners who were interviewed in this study were very cooperative and freely shared their back injury experiences.

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CHAPTER 1

INTRODUCTION

The Bureau of Mines sponsored this research project to investigate back injuries which occur in the underground mining environment. Back injuries are a problem with a long history in both the industrial setting and in mining. The injured miner endures the pain and associated health problems which may result from a back injury while the mining industry supports the cost of these injuries through workers' compensation and medical payments. Neither position is a desirable one; thus, the Bureau sponsored the work reported in this document to gain greater insight into the back injury problem in underground coal mining and to develop concepts for intervention strategies.

Back injuries are the bane of the Safety Manager's existence. Costly, often undiagnosable, generally unresponsive to treatments other than time, and often unprovable with respect to cause or reality, back injuries remain a grey area of safety. Training, job redesign, and employee selection have been tried by various companies with varying degrees of reported progress, but when one examines the frequency and severity data for back injuries, one finds little evidence of overall success. This is true whether one examines general industry data or mining data -- back injuries typically account for 20 to 30 percent of all compensable injuries, and 25 to 40 percent of the compensable injury costs. Specific percentages vary with the data source, the coding scheme, the year, and the

nature of the work.

Any hope of solving the "back-injury problem" must begin with a basic understanding of back injuries and their relation to work activities. Consider first the injury itself. At least 19 anatomical structures in and around the back can produce back pain. Selective diagnosis as to pain source/cause is generally difficult or impossible since the potential pain sites produce inconsistent and overlapping pain descriptions. As a result doctors are generally unwilling to return the injured miner to work quickly. This can encourage malingering which may lead the safety department to address the problem apathetically. That is, they become convinced that there is little that can be done about the problem because people who choose to "have" a back injury will get their week off no matter what the company does.

The situation is complicated still further because back pain associated with age-induced degeneration of the back's anatomical structures is part of the normal aging process. Finally, we must consider the fact that people's backs are injured in an almost infinitely variable number of ways:

bending over, turning while shoveling, lifting light objects such as a tool, lifting heavy objects like timbers, rails, and bags of rockdust, etc. For every rule relating to back injuries, it seems there are numerous exceptions. For this reason, many safety professionals, lacking a sufficient technical, anatomical, physiological, and sociological background, simply give up and attribute the problem to malingerers or to the beginning of hunting and fishing seasons.

What does all of this mean? It means that we are dealing with a complex technical, medical, and sociological problem which probably cannot be solved by the traditional simplistic approaches, and certainly will not be solved by any single study.

Historically, the Bureau has conducted considerable research on the back injury problem. In addition, the Bureau has provided information on the problem to the mining industry through its Technology Transfer Symposia which are reported in Information Circulars 8948 and 9097.

A new approach was used in this investigation to study back injuries in an attempt to gain a deeper, more meaningful understanding of this complicated issue and to develop a series of recommendations to help control the problem.

Previous back injury studies have been based on workers' compensation injury reports. These injury reports simply do not contain sufficient detail or consistency from which to understand and to identify the factors which contribute to a back injury.

This research consisted of an injury by injury investigation using a structured interview as the basis of data collection. Detailed information was collected concerning a list of job/task variables; the how, what, when, where, why; posture before and during injury; production activities and demands; personal factors which might have influenced the injury; job history including non-mining and mining jobs; description of injury and treatment received; and the development of intervention strategies, where possible, which might reduce the frequency and severity of the back injury problem. The questionnaire is presented in Appendix A.

The back injuries studied occurred in twenty-three different underground coal mines in six states. Seventeen mines were in coal seams 70 inches or greater. Twelve of the coal mines used diesel power in one or more aspects of their underground operation. Eleven of the mines were unionized with an average workforce of 252 miners while the twelve nonunion operations averaged 84 miners each.

The chapters in this report present a literature review, research methodology, results, conclusions, and recommendations which are proposed based on the findings of this study.

CHAPTER 2

BACKGROUND

Injury is the principal preventable health problem in the United States. Injuries kill more Americans aged 1 to 44 years than all diseases combined. Each year more than 140,000 Americans lose their lives to injury, and many others suffer severe and often permanently disabling consequences of injury (1).

During 1986, occupation-related injuries in the United States occurred at a rate of 7.7 per 100 full-time workers (from approximately 5.5 million incidents of occupational injury) (2). Approximately half of these incidents resulted in lost workdays and approximately 47 million days were lost due to occupational injuries and illnesses. The overall average was 18 days lost per injury. Average lost workdays ranged from a low of 16 for the "wholesale and retail trade" to a high of 31 for "mining." The overall injury and illness fatality rate was 5.9 per 100,000 full-time workers in 1986, with the rates ranging from a low of 2.5 in "services" to a high of 28.2 in mining.

According to the National Safety Council's 1988 edition of Accident Facts, disabling work injuries in the entire nation totaled approximately 1,800,000 in 1987. Of these, 70,000 resulted in some permanent impairment and 11,000 were fatal. Throughout industry, the single most frequent type of disabling work injury involves overexertion, accounting for about 28 percent of all disabling work injuries and about 22 percent of disabling work injuries in mining. Overexertion injuries to the back occurred most frequently.

BACK INJURIES

Back pain is one of the oldest occupational health problems. The first recorded case of work-related low back pain is dated 2780 BC, when an Egyptian physician treating construction workers at the pyramid of Sakkara described a sprain of the spinal column (3). In 1700 Bernardino Ramazzini (considered the founder of occupational medicine) wrote about the back pain problems associated with numerous physical activities (4).

A study conducted by USA Today found that back ailments afflict an estimated 75 million Americans, have totally disabled about 2.5 million adults, lead to as many as 200,000 back surgeries each year, are a leading cause of absenteeism, are the second leading cause of hospitalization, are responsible for 18 million doctor visits a year, and cost about 93 million workdays

annually. The cost to general industry was estimated at \$14 billion per year (5).

The National Safety Council estimates that backaches are responsible for about 40 percent of all recorded absences from the workplace, and are second only to the common cold as the reason for missed work. They further estimate that occupational back injuries account for at least 20 percent of all occupational injury cases and that about 400,000 disabling back injuries occur at work each year. The average cost per back injury for workers' compensation cases closed in 1983 was estimated at \$4,489 in wage compensation and \$1,581 in medical payments.

Internationally, it has been estimated that in Canada back injuries represent a significant health problem among industrial workers accounting for 19-29 percent of all workers' compensation claims (6). The Australian Bureau of Statistics has reported that manual handling related accidents account for 25-40 percent of all occupational accidents and related sprain/strain injuries, and for 40-55 percent of all injuries. The predominant anatomical site of these injuries is the back (7). The Australian National Health and Medical Research Council has estimated that back pain is the greatest single cause of time loss attributed to work in Australia (8). Thus, it is not just a problem in the United States.

Traditionally, back injuries are the largest single category of lost-time accidents in the mining industry (9). For example, in 1981, of the 37,017 accidents in the mining industry, about 25 percent involved back injuries. Forty percent of the lost-time back injuries of underground coal miners resulted in the miner missing more than four weeks of work. The number of lost workdays per back injury incident was approximately six days more than other types of mining injuries.

During 1983, the 285 workers of a mine of the Youghiogheny and Ohio Coal Company incurred 33 lost-time injuries and 1,696 lost workdays. Of the 33 injuries, 15 were low back injuries which accounted for 833 lost workdays (10).

COSTS

Low back pain is believed to be the most expensive benign condition in the United States (11). A comprehensive estimate of annual back pain costs was conducted for the American Academy of Orthopaedic Surgeons (12). The primary sources of data were surveys conducted by the National Center for Health Statistics in 1977. The total annual costs were almost \$16 billion. Of this amount, 28 percent was for hospital inpatient services, 15 percent was for physician services, and 16 percent was wage earners' lost earnings. The other costs included were outpatient and emergency room

institutional services, outpatient diagnostic and therapeutic services, drugs, nursing home services, non-health sector goods and services, and homemakers' lost earnings.

A 1980 analysis conducted by the Mine Safety and Health Administration revealed the following information regarding low back injuries in industry: they comprise 26 percent of all occupational injuries, account for 30-40 percent of compensation costs, account for 60 percent of all industrial injury costs, accounted for 93,000,000 workdays lost in 1980, and result in \$5 billion in medical bills and \$12 million in legal fees per year (13).

THE NATURE OF BACK INJURIES IN GENERAL INDUSTRY

In general industry, research has shown that the major causes of back injury are materials handling, slips/trips, and pushing/pulling. In many cases causation may be difficult to determine because of a delay in the onset of symptoms. Historically, manual materials handling has been such a major problem that NIOSH (14) published the lengthy Work Practices Guide for Manual Lifting that summarized what was known about the problem and provided control recommendations. The guide reports, in essence, that people who lift too much too often experience overexertion and back injuries, and it provides a method for estimating relatively safe weights

to lift under ideal lifting conditions.

An extensive retrospective analysis of injuries among hourly employees of The Boeing Company evaluated 31,200 employees over a 15-month period and collected data on injuries, costs, and individual factors (15). There were 4,645 injury claims analyzed, which included 900 back injuries. Among the 900 back injuries, material handling was the cause of injury most commonly coded, followed by slips and falls.

During the period of July 1965 through December 1976, 5,584 Navy personnel were hospitalized for sprain and strain injuries sustained while on active duty. Approximately 56 percent of these injuries involved the back. The occupations demonstrating the highest hospitalization rates for back injuries were those that performed strenuous physical work involving heavy lifting tasks (16).

During a ten-year period in an Eastman Kodak plant, 45 percent of heavy handlers versus 34 percent of sedentary workers visited the medical departments for back pain. Truck drivers had the highest rate of compensable back injuries, with most of these injuries associated with loading and unloading trucks (3).

An examination of the reports of 2,437 accidents involving three or more lost workdays in the British construction industry noted that 22.4 percent of these

accidents involved back injuries and that 45.9 percent of these injuries occurred during material handling activities. Those construction workers whose jobs were defined as involving heavy manual work (repeated, frequent, high trunk stress inducing peak intra-abdominal pressures above 100mm Hg) had significantly higher rates than did workers with light jobs. Injury data from the British telecommunication industry (100,000 workers) were analyzed over a twelve month period: back injuries constituted 25 percent of all accidents and 66 percent of these back injuries involved material handling. Telecommunication jobs involving manual work performed outdoors, where work conditions are less controlled, were reported to have significantly higher rates of accidents, injuries, back injuries, and back injuries related to material handling. This study also examined the British nursing profession and estimated that nurses suffer approximately 20,000 incidents of back injury each year, and that lifting patients is implicated as the cause of up to 70 percent of all back injuries (17).

A study in Germany which compared workers in light and heavy work found that there was a clear difference between groups in spinal column discomfort and disorders. Back problems were most frequent among bus

drivers and least frequent among bank clerks (18).

An examination of the incidence of low back injuries associated with patient lifting in a major medical center revealed that the risk of back injury appears to be a function of the number of patient lifts performed. Nursing personnel in the frequent patient lifting group had more injuries as a result of the greater cumulative number of lifts they performed (19).

MATERIAL HANDLING RELATED BACK INJURIES

IN UNDERGROUND COAL MINING

Material handling is a major activity in underground coal mining. Loads handled are equal to or heavier than those handled in general industry. Typical "man-handled" loads are shown in Table 1 (20).

Table 1. - Materials Commonly Handled in Coal Mines

<u>Materials</u>	<u>Weights</u>
Roof bolts:	
5/8"x6', bundle of 10	55 lb
5/8"x10', bundle of 10	90 lb
Crossbar, oak, 4"x6"x16'	129 lb
Round post, oak, 6"x6'	57 lb
Concrete block, 8"x8"x16"	62 lb
Cement, 1 bag	80 lb
Rock dust, 1 bag	50 lb
Rail	300 lb

Most of the above materials exceed the recommended limits of the NIOSH work practices guide. Using the NIOSH action limit formula for lifting tasks, the calculation of lifting limits for a typical mine lifting task indicates that loads less than 16 pounds should not overly stress any worker, loads 16 to 50 pounds should be handled only by stronger workers, and loads above 50 pounds should not be lifted (21).

The NIOSH work practices guide recommendations apply to ideal lifting conditions. Lifting conditions in coal mining are seldom ideal: loads are bulky and do not have handles, and floor conditions vary from dry and uneven to wet, muddy, and slippery. Compared with most industrial environments, many underground coal mines have poorer lighting, wetter/slipperier/more uneven work floors, and severely restricted work spaces. Poor lighting and wet, slippery floors can result in back injuries from slipping and tripping. Underground miners who work in low-seam coal mines (less than 48 inch roof height) often lift heavy materials in severely restricted work postures (22). The two postures most often used during manual material handling activities in low-seam mines are stooping and kneeling. Each of these postures cause considerable stress to the spine, and may help explain the high incidence of low back pain in the mining industry. The stooped posture

causes the spine to be severely flexed and has been shown to substantially increase the spine's intradiscal pressure. This increased pressure may cause the disk to deform and the back of the disk to protrude and impinge upon the spinal nerves, resulting in low back pain. The kneeling posture causes the miner to use a twisting motion of the trunk to accomplish a lift due to the limited mobility afforded by this posture. The postures most often used to lift materials in the low-seam coal mine environment cause the miners to perform what are generally regarded as the two worst actions in terms of causing low back pain: bending and twisting. Task analyses were conducted at four underground low-seam coal mines to evaluate their supply handling systems (23). Analysis of videotapes revealed that miners handled materials while stooped a total of 37.8 percent of the time, 31.5 percent while on both knees, and 9.5 percent while kneeling on one knee.

In spite of this, however, a study of differential injury rates in low, medium, and high coal (20) showed that the back injury pattern is inconsistent with the reported loading of the back (Table 2).

Table 2. - Comparison of Back Injury Frequency Rates
by Mine Seam Height

<u>Mine Seam Height</u>	<u>Frequency rate per million manhours</u>
<48	7.51
48 to 60	10.87
60 to 78	4.90
>78	16.61

This may be due to a self selection process in which only people with strong healthy backs remain in this type of mine, or it may be due to a reduction in the amount of lifting done in these mines -- either more is done by equipment, or more materials are dragged, pushed, or pulled.

Table 3 describes the injury frequency and frequency rate for mining jobs with high back injury frequencies. This table is based on an analysis of job-related overexertion injury data for coal miners employed by a major coal company during the years 1977 to 1982 (20). The frequency provides a relative comparison of the magnitude of the problem per job, while frequency rate indicates the likelihood of getting hurt on a given job by adjusting the frequency for exposure hours. Exposure hours were tabulated on

a mine by mine basis using mine-specific activities rather than nominal job titles as the counting key.

Those jobs requiring considerable manual materials handling are the jobs with the highest rates. This is true even for the shuttle car operator since this company also used the shuttle car operator as a supply distribution person.

Table 3.- Frequency & Frequency Rates for Coal Mining Job

<u>Job Title</u>	<u>Frequency, number of injuries</u>	<u>Frequency, rate per 200,000 manhours</u>
Laborer	158	37.05
Trackman-helper	41	29.42
Brattice worker	18	18.30
Shuttle car operator	95	15.74
Mechanic-helper	129	13.22
Continuous miner/ operator-helper	54	10.73
Roof bolter-helper	67	10.29

In addition to looking at jobs, that study reviewed causes (activities at the time of injury) and agents (things handled or producing the injury). Materials handling dominated as the cause of injury (Table 4). Table 5 presents an overview of the agent involved at the time of injury.

Table 4. - High Frequency Causes of Back Injury
In Coal Mining

<u>Causes</u>	<u>Percent</u>
Lifting*.....	26
Lift-twist*.....	18
Slip-trip.....	18
Push-pull.....	15
Bend-lift*.....	7
Hit by object.....	7
Unload*.....	3
Operating machine.....	3
Other.....	4

*material handling

Table 5. - High Frequency Agents of Back Injury In
Coal Mining

<u>Agents</u>	<u>Percent</u>
General supplies.....	19
Planks, timbers.....	17
Riding in vehicle.....	17
Cables.....	15
Railroad related.....	13
Tools.....	10
Shovel, wheelbarrow.....	10

In a study of the accident data from 27 mines in 1973, a total of 269 materials handling accidents were identified (24). Materials handling functions were grouped according to the general purpose of the activities. "Production end use" involves activities such as rock dusting, roof bolting, and erecting timbers. "Production supply" includes transporting rock dust bags, transporting roof bolts, and transporting timbers. "Section move" involves moving haulage belts, transporting cables, and moving air lines and compressors. "Equipment maintenance" relates to the handling of materials from the surface yard to the point of use during maintenance of mine equipment. "Mine maintenance" includes erecting stoppings for ventilation, laying rail, and upgrading track. It was discovered that most accidents occurred during the production supply function (Table 6) and involved stationary actions of lifting, lowering, pushing, pulling, and holding.

Table 6.--Accident Frequencies for Different Handling Functions

Function	Percent
Production Supply.....	49
Equipment maintenance.....	16
Section move.....	13
Production end use.....	11
Mine maintenance.....	10

An analysis of Mine Safety and Health Administration back injury records for U.S. coal miners injured while working underground was conducted to identify the types of accident, types of objects associated with the injury, and conditions most frequently associated with the 2,492 reported cases of back sprain or strain during 1981 (25). The type of accident most frequently involved was overexertion in lifting things (Table 7).

Table 7.--Type Accident Associated With Back Injuries

<u>Accident type</u>	<u>Percent</u>
Overexertion.....	79
Falls.....	11
Jolts.....	7
Other.....	4

The types of things being lifted that were most frequently associated with back injuries were cables, broken rock and coal, timbers, and posts (Table 8). Pulling power cables was another common form of overexertion involving back injuries. Another activity associated with many back injuries was shoveling broken rock or coal. Although most back injuries were due to overexertion, a significant number were due to falls and jolts. The falls typically were the result of slipping

or tripping. The injuries due to jolts were typically the result of running over uneven places in the mining floor while riding in shuttle cars or underground transportation vehicles.

Table 8. - Types of Objects Associated With Underground Coal Miner Back Injuries

Object	Percent
Electric cables.....	11.9
Broken rock and coal.....	11.8
Timbers and posts.....	10.1
Misc. metal objects.....	8.0
Belt conveyor systems.....	5.1
Misc. wood objects.....	4.2
Steel rails.....	4.2
Bagged materials.....	4.2
Jacks.....	3.1
Mining machines.....	2.5
Roof bolts.....	2.5
Oil containers.....	2.5
Cement blocks.....	2.4
Buckets and cans.....	2.3
Metal covers and guards.....	2.1
Other.....	23.1

An analysis of Mine Safety and Health Administration data for underground coal mining accidents in 1983 and 1984 provided the following results regarding strain and sprain injuries. Strains and sprains accounted for 24.0 percent of all injuries in 1983 and 25.2 percent in 1984. The number of lost

workdays per strain and sprain injury was 19.0 in 1983 and 21.5 in 1984. During both years, back injuries dominated the strain and sprain injuries. For example, of the 2,475 strain and sprain injuries in 1983, 55 percent were back injuries and 54.3 percent of the 2,776 strain and sprain injuries in 1984 were back injuries; in contrast, knee injuries, the next largest category, accounted for only 11 percent each year. Most injuries involved material handling both years: 55.1 percent in 1983 and 51.8 percent in 1984; the next largest category involved slips/falls: 16.2 percent in 1983 and 18.5 percent in 1984 (26).

A radiologist at the Methodist Hospital in Pikeville, Kentucky conducted a study of the 306 underground mining accident victims admitted to the hospital emergency room during 1971 (27). This hospital is located in the center of Pike County in eastern Kentucky and mining is the main industry in that area. At the time of the study there were 408 underground coal mines in operation employing 5,649 miners. This hospital receives most of the victims of mine accidents in the county. "Acute back" was the third most common type of injury for hospitalized patients, accounting for 11 percent of the hospitalizations. (The two types of injuries that were more common than back injuries were classified

as "fractures/dislocations" and "contusions/abrasions.") The back injuries were attributed to lifting roof timbers, sand bags, pieces of rock and coal, and equipment, and to handling large electrical cables.

SUDDEN MOVEMENT

The epidemiological literature (28) (29) (30), has suggested that cognitive control of the neuromuscular system in a manual materials handler may mediate the risk of sustaining a low back injury, and that workers exerting sudden unexpected maximal efforts are particularly vulnerable to back injuries. Sudden unexpected loading appears to cause the neuromuscular system to respond in a manner which is significantly different from heavy but expected load handling. It is likely that sudden unexpected load handling causes the muscle control system of the trunk to over-respond and increase the risk of back injury. Because the trunk muscles are at a mechanical disadvantage compared to the external load due to the short moment arm between the muscles and the spine, very large trunk muscle forces are required to handle an external load. Under sudden unexpected loading it is believed that the trunk muscles exert even larger amounts of force which may overload the spine and cause a traumatic back injury. Furthermore, the unpredictability of the loading may result in inappropriate muscle

contraction(s) which may cause an injury.

A typical accident scenario is one in which either the person or the load shifts suddenly. In underground coal mining, this can happen while riding in a vehicle that hits a bump or collides with another vehicle, when walking through the mine and a miner slips but does not fall, or while carrying a load that shifts suddenly. In each case, the loading on the neuromuscular system occurs in a matter of milliseconds and either of two events results. First, the system cannot respond with the appropriate muscular contractions to provide protection for the body (when riding); second, in the case of the nonfalling slip, the body's natural reaction to prevent the fall causes the trunk muscles to overrespond or respond inappropriately, thus overloading the lower back. Numerous back injuries have been documented that have been caused by the nonfalling slipping or tripping accident. These can result in a variety of injuries: eccentric loading with muscle tears, muscle spasm, ligament damage, skeletal damage, or disk damage. Any of these may occur alone or in combination.

There are three studies which report data that is consistent with this description. Manning (31) reported that back injuries associated with slips, trips and falls (underfoot accidents) accounted for 70.5 percent of all back cases. Manning's data is summarized in Table 9.

Table 9. - First Event in Back Injury Accidents

<u>First Unforseen Event</u>	<u>Frequency</u>
Foot slipped.....	57
Tripped.....	7
Foot missed step or platform.....	5
Floor broke.....	3
Standing surface moved.....	3
Step or rung broke.....	2
Other loss of balance.....	9
Total underfoot accidents.....	86
Other.....	36
Total.....	122

Stobbe and Plummer (32) reported similar data for health care professionals, tire manufacturing plant workers, and coal miners. They noted however, that the injury patterns were different in each industry and that the sudden movement factors were generally only identifiable through an interview with the injured persons.

Jayson theorized that if a person attempts to lift an unexpectedly heavy weight or makes a sudden twist while carrying a heavy object, the muscles stabilizing the spine may fail to provide adequate support which may lead to damage of the back (33).

CONCLUSION

Injury is the principal preventable health problem in the United States, and back injuries account for about 20 percent of all occupational injury cases in general industry. The costs associated with these injuries are tremendous.

Material handling is a primary cause of back injuries, and material handling is more complicated and demanding in the underground coal mining environment.

Back injuries constitute the single largest category of mining injuries and also lead in the degree of severity as reflected in lost workdays. Back injuries represent a tremendous economic cost to coal companies, miners, their families, and to society.

SUMMARY OF SELECTED LITERATURE

Author	Date	Findings
CDC	1988	injuries kill more Americans aged 1 to 44 than all diseases combined. Each year more than 140,000 Americans lose their lives to injury.
U.S.BLS	1986	In 1986, injury rate was 7.7; 47 million days were lost due to occupational injuries and illnesses.
NSC	1988	There were 1,800,000 disabling work injuries in 1987; 70,000 resulted in a permanent impairment; 11,000 were fatal; overexertion involving the back is the most frequent type of disabling work injury.
Kelsey	1988	Back pain is one of the oldest occupational health problems. First recorded work-related low back pain is dated 2780 BC.
Snook	1983	In 1700, Bernardino Ramazzini wrote about back pain associated with physical activities.

Potter	1986	Back ailments afflict about 75 million; totally disable about 2.5 million adults; lead to about 200,00 back surgeries each year; are the leading cause of absenteeism; are the second leading cause of hospitalization; are responsible for 18 million doctor visits per year; cost about 93 million workdays annually; cost general industry about 14 billion per year.
Abenhaim	1987	Back injuries among Canadian industrial workers account for 19-29% of compensation claims.
Rawling	1986	Australian manual handling related accidents account for 25-40% of all occupational accidents and related injuries, and for 40-55% of all injuries.
NHMRS	1981	Back pain is the greatest single cause of time loss attributed to work in Australia.
BMIC 8948	1983	Back injuries are the largest cause of lost-time accidents in the mining industry.
Scopel/ Basich/ Raeder	1986	During 1983, the 285 workers of the Youghiogheny and Ohio Coal Company mine incurred 33 LT injuries and 1,696 lost workdays. Of the 33, 15 were low back injuries accounting for 833 lost workdays.

Mayer	1987	Low back pain is believed to be the most expensive benign condition in the U.S.
Holbrook	1984	The total annual back pain costs are almost \$16 billion including hospital inpatient services, physician services, wage earners' lost earnings, outpatient and emergency room institutional services, outpatient diagnostic and therapeutic services, drugs, nursing home services, non-health sector goods and services, and homemakers' lost earnings.
Taylor	1987	Low back injuries in industry comprise 26% of all occupational injuries, account for 30-40% of compensation costs, account for 60% of all industrial injury costs, accounted for 93,000,000 workdays lost in 1980, and result in \$5 billion in medical bills and \$12 million in legal fees per year.
Bigos	1986	A retrospective analysis of injuries among hourly employees of The Boeing Company evaluated 31,200 employees over a 15-month period: among the 900 back injuries, material handling was the cause of injury most commonly coded, followed by slips and falls.

- Marcinik 1986 During the period of July 1965 through December 1976, 5,584 Navy personnel were hospitalized for sprain and strain injuries sustained while on active duty; 56% of these injuries involved the back and strenuous physical work involving heavy lifting tasks.
- Kelsey 1988 During a 10-year period in an Eastman Kodak plant, 45% of heavy handlers versus 34% of sedentary workers visited the medical departments for back pain.
- Stubbs 1981 In the British construction industry, 22.4% of accidents of 3 or more lost workdays involved back injuries and 45.9% of these injuries occurred during material handling activities; jobs defined as involving heavy manual work had significantly higher rates than did workers with light jobs; in the British telecommunication industry, back injuries constituted 25% of all accidents and 66% of these back injuries involved material handling; in the British nursing profession, nurses suffer approximately 20,000 incidents of back injury each year, and lifting patients is implicated as the cause of up to 70% of all back injuries.

- Hettinger 1985 In a study in Germany, back problems were found most frequently among bus drivers and least frequently among bank clerks.
- Stobbe 1988 With patient lifting, the risk of back injury appears to be a function of the number of patient lifts performed. Nursing personnel in the frequent patient lifting group had more injuries.
- Stobbe/ 1983 Material handling is a major activity in
Plummer underground coal mining. Loads handled are equal to or heavier than those handled in general industry. Most lifts exceed the recommended lifts of the NIOSH work practices guide.
- Gallagher 1987 Lifting conditions in coal mining are seldom ideal: compared with most industrial environments, many underground coal mines have poorer lighting, wetter/slippier/more uneven work floors, and severely restricted work spaces; miners who work in low-seam coal mines lift heavy materials in severely restricted work postures.
- Bobick 1987 Task analyses conducted at underground low-seam coal mines revealed that miners handled materials while stooped a total of 37.8% of the time, 31.5% while on both knees, and 9.5% while kneeling on one knee.

- Stobbe 1983 A study of differential injury rates in low, medium, and high coal showed that the back injury pattern is inconsistent with the reported loading of the back and may be due to a self selection process in which only people with strong healthy backs remain in this type of mine, or it may be due to a reduction in the amount of lifting done in these mines.
- Stobbe/ 1983 An examination of the injury frequency
Plummer rates for mining jobs indicates that mining jobs requiring considerable manual materials handling are the jobs with the highest injury frequency rates: (frequency rates per two-hundred thousand manhours) laborer: 37.05, trackman-helper: 29.42, brattice worker: 18.30, shuttle car operator: 15.74, mechanic-helper: 13.22, continuous miner operator-helper: 10.73, roof bolter-helper: 10.29.
- Unger 1983 From accident data of 27 mines in 1973, a total of 269 materials handling accidents were identified; most accidents occurred during the production supply function and involved stationary actions of lifting, lowering, pushing, pulling, and holding.

Peters 1983 Of 2,492 reported cases of mining back sprain or strain during 1981, the type of accident most frequently involved was overexertion in lifting things; a significant number of injuries were due to falls and jolts.

Stobbe/ 1986 For underground coal mining accidents in
Bobick/ 1983 and 1984, strains and sprains
Plummer accounted for 24.0% of all injuries in 1983 and 25.2% in 1984; lost workdays per strain and sprain injury were 19.0 in 1983 and 21.5 in 1984; during both years, back injuries dominated the strain and sprain injuries; most injuries involved material handling both years; the next largest category involved slips/falls.

Zimmerman 1973 Of the 306 underground mining accident victims admitted to a hospital emergency room during 1971, "acute back" was the third most common type of injury for hospitalized patients, accounting for 11% of the hospitalizations; the back injuries were attributed to lifting roof timbers, sand bags, pieces of rock and coal, and equipment, and to handling large electrical cables.

- Magora 1973 Epidemiological literature has suggested that cognitive control of the neuromuscular system in a manual materials handler may mediate the risk of sustaining a low back injury, and that workers exerting sudden unexpected maximal efforts are particularly vulnerable to back injuries. Sudden unexpected loading appears to cause the neuromuscular system to respond in a manner which is significantly different from heavy but expected load handling. Under sudden unexpected loading it is believed that the trunk muscles exert even larger amounts of force, which may overload the spine and cause a traumatic back injury.
- Manning 1983 Back injuries associated with slips, trips and falls (underfoot accidents) accounted for 70.5% of all back cases.
- Stobbe/
Plummer 1988 Investigations into sudden-movement/
unexpected-loading related injuries of health care professionals, tire manufacturing plant workers, and coal miners showed that the injury patterns were different in each industry and that sudden movement factors were generally only identifiable through an interview with the injured persons.

Jayson 1987 If a person attempts to lift an
unexpectedly heavy weight or makes a sudden
twist while carrying a heavy object, the
muscles stabilizing the spine may fail to
provide adequate support which may lead to
damage of the back.

CHAPTER 3

METHODOLOGY

The goal of this project was to collect data on back injuries that had occurred in underground coal mines. The purpose of this unique data collection effort was to identify back injury related job factors that cannot be identified by the traditional "body count" approach to accident/injury recordkeeping. Examples of job factors that are not considered in the traditional approach include the impact of production constraints on the work procedures in use at the time of injury, the effect of "time pressures" on miner behavior, why the job was done the way it was done, how equipment design related to the injury scenario, etc.

Accomplishing this task required the development of a new approach to accident/injury related data collection. Prior to this research, the authors had conducted an in-depth analysis of coal mine back injury data using company accident reports and had found them sadly lacking in the type of detail necessary to understand the injury scenario (Stobbe, 1983). The authors decided the best approach was to investigate back injuries in a depth comparable to that used in a fatality investigation. In this research, we had a distinct information advantage -- the injured party was available to provide the accident-related details.

The collection of detailed information about an accident/injury event is best done via interview. After

some thought, a decision was made to develop a structured interview to ensure that a minimum information set was obtained on each accident/injury investigated. The format for this structured interview went through several iterations and tests before the minimum data set was defined. This was done to minimize the potential for missing data points -- some missing data was expected since not all of the injured persons would be willing to discuss all aspects of their injury (in actuality, this rarely happened).

The observation form used to record the information is presented in Appendix A. It consists of four general sections, one which describes the "5 w's" of the event, a second which investigates the biomechanical aspects of the lifting event if present, a third which describes the injury itself, along with its evaluation and treatment, and a fourth section which provides data on the injured person, and his/her work and injury history. Each section consisted of a series of questions designed to obtain the details necessary to determine the section's relevance to the injury.

MINE SELECTION

The proposal on which this research is based called for the investigation of two hundred back injury incidents which occurred in underground coal mining. Identifying two

hundred back injury events which could be investigated proved to be an extremely difficult logistical problem.

The first and most critical part of the problem was finding a group of underground coal mines which were willing to participate. The initial goal was to identify six mines that were reasonably close to the project's headquarters in Morgantown, WV. A working agreement was established with five mines within ninety minutes of Morgantown, and a sixth which was a five hour drive away.

It quickly became apparent that this group of six would be insufficient to complete two hundred interviews in any reasonable time frame. Furthermore, two of the mines closed, one had its workforce reduced by more than fifty percent, two were sold to new operators who chose not to cooperate in the research, and one had some recordkeeping problems which led to MSHA citations and reduced cooperation with the project. The result of this was a situation in which mines were entering and leaving the project throughout its life. Considerably more time was spent on mine recruiting than was originally planned, and the project took longer than planned. The mines which actually participated in the project were not selected based on their characteristics; rather, they were selected based on their willingness to cooperate in the research. There were eleven mines contacted which did not participate.

The mine population at which the investigations were done is summarized in Table 10. It shows diversity in those factors commonly used to characterize coal mining, such as mining type, location, and union affiliation. Ultimately, 23 mines belonging to 10 companies in six states participated. Half of the participating mines were unionized and half used diesel power in one or more aspects of their underground operation. All 23 mines operated one or more continuous mining sections, and nine of the twenty three (39%) operated at least one longwall. Mine size varied from twenty to four hundred underground personnel, with a mean size of 165. The nominal mine seam heights varied from 50 to over 100 inches, but three fourths of the mines were 70 inches or higher. Thus, the results of this study are biased toward higher mines in which most miners can walk upright.

Table 10. - DEMOGRAPHIC INFORMATION FOR MINES AT
WHICH INVESTIGATIONS WERE CONDUCTED

MINE #	STATE	MINING TYPE	UNIONIZED	DIESEL USED	APPROXIMATE SIZE
1	OH	L & C	Yes	No	400
2	WV	L & C	Yes	No	200
3	WV	L & C	Yes	No	300
4	WV	C	Yes	No	250
5	WV	C	Yes	No	230
6	KY	C	No	Yes	75
7	WV	L & C	Yes	No	180
8	WV	C	No	No	20
9	PA	L & C	Yes	No	350
10	IL	C	No	Yes	300
11	IL	C	No	Yes	150
12	IL	L & C	Yes	No	170
13	IL	L & C	Yes	No	190
14	IL	L & C	Yes	No	200
15	CO	L & C	Yes	Yes	300
16	KY	C	No	Yes	80
17	KY	C	No	Yes	40
18	KY	C	No	Yes	60
19	KY	C	No	Yes	70
20	KY	C	No	Yes	50
21	KY	C	No	Yes	60
22	KY	C	No	Yes	60
23	KY	C	No	Yes	45

Key: OH = Ohio
WV = West Virginia
PA = Pennsylvania
IL = Illinois
CO = Colorado
KY = Kentucky

L = Longwall
C = Continuous Mining

INJURED MINER SELECTION

The injured persons who participated in the study were selected randomly, with the criterion being that they had recently reported a back injury. The injured miners were identified by the mines, each of which had a working agreement with the research team in which the team was periodically notified about the status of back injuries at the mine.

The actual interviews were conducted by one or two members of the research team. Approximately seventy percent of the interviews were conducted by two persons. All but three of the interviews were conducted at the mine site, with the majority of them being conducted underground at the miner's work site. This arrangement created an interview environment which while comfortable for the miner, resulted in a considerable waste of research team time waiting for transportation, waiting for the injured miner to become available, etc. The three off-site interviews were with miners who were off work for an extended period. The interviews varied in length, with thirty to forty minutes being typical. Extremely simple accident events were evaluated in fifteen to twenty minutes, while complex lifting accident events sometimes took more than an hour to complete.

In addition to the injured person, we interviewed other persons as appropriate and available. Typically, this

included the mine's safety engineer, and sometimes the injured miner's supervisor.

A major problem which almost prevented completing the project was data confidentiality. Many of the individual miners, most of the union representatives, and all of the mine managers, were concerned that someone else would find out what they had said, or how they were operating. Individuals were concerned about company reprisal; management was concerned with MSHA and/or union reprisal. As a result of these concerns, great care was taken to "sterilize" the data collected so that no one, including the members of the research team, could identify individual persons or mines once the data had been entered into the data base.

CONTROL MEASURE IDENTIFICATION

This proposal outlined an approach to be used in collecting control measure information. This phase of the project was conducted as a separate effort in parallel with the back injury investigations. It is discussed in Chapter 8.

DATA ANALYSIS

All of the data analyzed in the project was collected either by interview, or by measurement in the mine. As a result, all of the critical data was in narrative form.

With two hundred twenty-four injuries in the data base, the direct analysis of a set of narratives was prohibitive. Thus, the questions in the structured interview were reduced to one or more variables which could be coded. Ultimately, there were 137 variables in the data base, with two to 156 values per variable.

The interview and measurement data was converted from narrative to numeric code by the research team. Several variables were left in narrative form and placed in the data base. These narratives provided additional insights as they describe the accident event and the injury in detail. Where mixed source data from injured miners, safety personnel, and supervisors existed, it was pooled during the coding process.

The codes were developed as the project progressed. This was a conscious decision based on the fact that at the outset, we could not anticipate all of the codes necessary to describe the collected data. The project goal was to investigate back injury events in as much detail as possible, and we chose to carry over the detail into the coding process. From prior experience, we knew it is much easier to use the computer to combine codes during the analysis process than it is to get additional detail on an event once it has been coded.

The actual data coding was done by the principal

investigators. Any data that was ambiguous with respect to code was discussed by the investigators prior to code assignment. When the coding was complete, the data was entered into a statistics/data base management program and verified. The data was then checked for within case cross-variable coding consistency. A commercial software package (Prodas^R produced by Conceptual Software of Houston, Texas) was used for data base management and for basic statistical analysis. SAS^R was used for the higher level statistics.

There were three types of analysis performed: simple frequency counts, multiple crossed variable frequency counts (for example lost time, sudden movement, job, and overall task,) where the focus was on the number of times each combination of the four variables occurred, and stepwise regression analysis. The frequency counts are useful in providing an overall view of the data, and the crossed variable counts are useful in identifying specific situations that are associated with injuries. A stepwise regression analysis was performed to provide a statistical estimate of the occurrence frequencies to determine whether the rates exceeded their expected value. However, the results of the regression analysis were not conclusive.

CHAPTER 4

RESULTS

The results section of this report begins with this chapter and continues with chapters 5 through 11. This chapter begins with a summary of the personal data about the injured miners. This includes general personal data such as age, height, weight, as well as job related data such as job title, job working when injured, task specific experience and mining experience. The evaluation continues with a descriptive summary of the most significant data blocks collected during the interviews. The analysis proceeds from the general to the specific, beginning with broad summaries of the mining activities in progress when back injuries occurred and ending with a detailed presentation of the specific activities being done by a miner when the miner was injured.

The activity/task summary is followed by a summary of the when-where-why aspects of the injuries and an evaluation of alternate work methods that could have been used. This is followed by a summary of the relevance of training, job safety analysis, routine versus unusual tasks, and the contributions of other miners and equipment to the injuries.

The general data summaries were included to provide a context in which the more specific multi-variable analysis which follows them could be understood. The multi-variable analyses explore the data in more depth, for example, comparing the details associated with maintenance and production related back injuries to determine whether they are different in nature, type, or cause -- thus leading to similar or different corrective measures.

PERSONAL DATA

The following section contains personal data about the 224 underground coal miners who experienced a back injury. Table 11 shows the frequency distribution for age. The mean age of this population was 37.7 years with a standard deviation of 7.7 years. The distribution of age ranged from a low of 21 years to a high of 64 years. The median age is 37 and the mode is 30. Seventy-five percent of the back injuries occurred to miners 41 years of age or less while less than eight percent of the back injuries happened to miners 50 years of age or older. Figure 2 presents the distribution of back injuries versus age.

The mean height of the miners who participated in the study was 70.4 inches with a standard deviation of 2.94 inches. Table 12 presents the frequency distribution of miner height. The mode for height for this group of miners was 72 inches. Figure 2 presents the frequency histogram.

Height ranged from 5'1" to 6'6". Seventy-seven percent of this population is six feet or less in height.

The mean weight of this study population was 189.50 pounds with a standard deviation of 30.44 pounds. The weights ranged from 125 to 325 pounds. The median was 182 pounds while 72% of the miners weighed 209 pounds or less as shown in Table 13. Figure 3 presents the frequency histogram for weight of this population.

Table 11. - Frequency Distribution of Miner Age

Age of Injured Person	Frequency	Cummulative Frequency	Cummulative Percent
21	1	1	0.45
24	1	2	0.89
25	1	3	1.34
27	4	7	3.13
28	11	18	8.04
29	10	28	12.50
30	17	45	20.09
31	12	57	25.45
32	13	70	31.25
33	10	80	35.71
34	5	85	37.95
35	10	95	42.41
36	10	105	46.88
37	15	120	53.57
38	14	134	59.82
39	8	142	63.39
40	14	156	69.64
41	12	168	75.00
42	3	171	76.34
43	7	178	79.46
44	7	185	82.59
45	7	192	85.71
46	3	195	87.05
47	3	198	88.39
48	4	202	90.18
49	5	207	92.41
50	3	210	93.75
52	2	212	94.64
53	4	216	96.43
54	2	218	97.32
55	1	219	97.77
57	1	220	98.21
61	2	222	99.11
63	1	223	99.55
64	1	224	100.00

n = 224 Mean Age - 37.66
Standard Deviation = 7.73 years

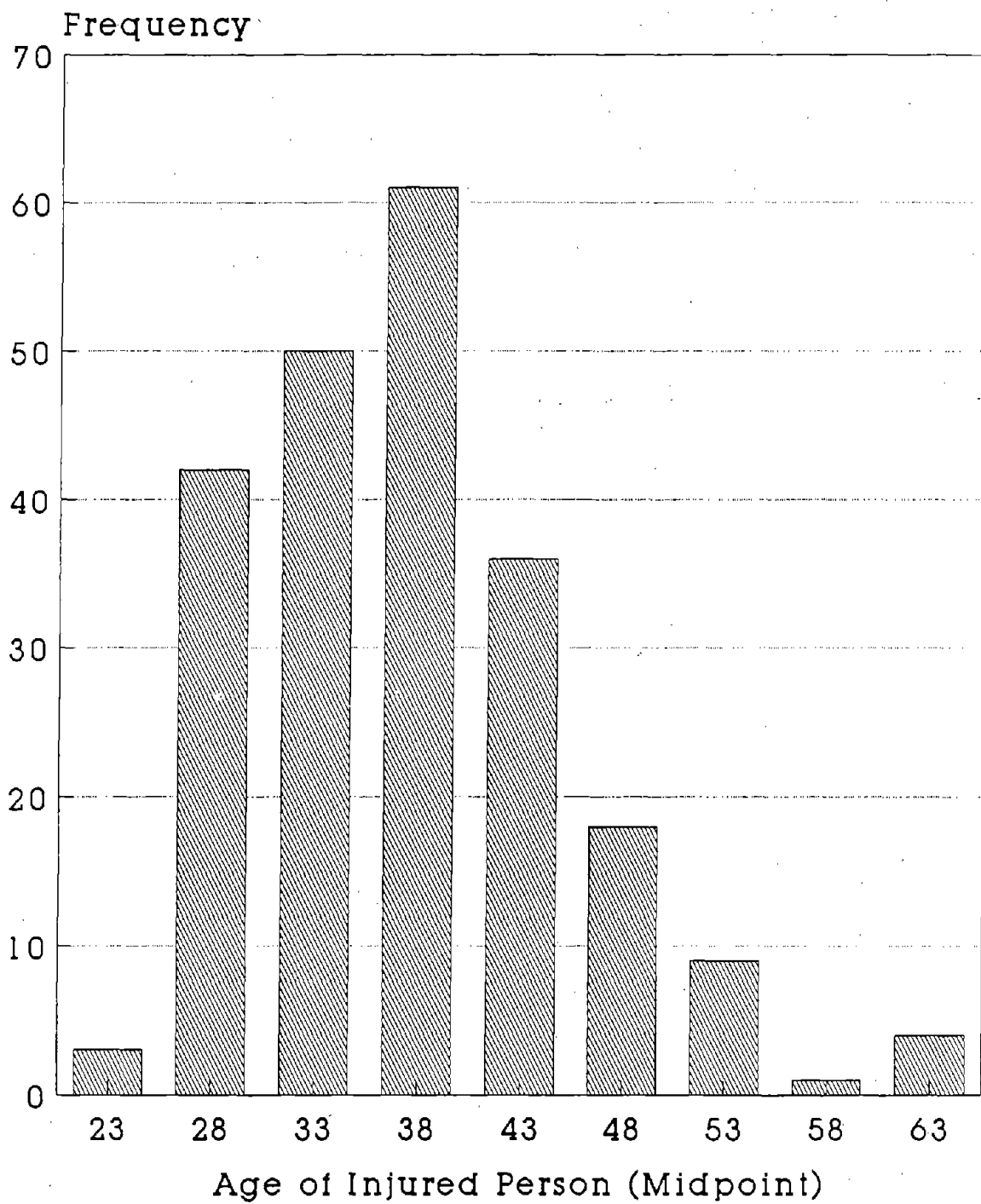


Figure 1. - Age

Table 12. - Frequency Distribution of Miner Height

Height of Injured Person	Frequency	Cummulative Frequency	Cummulative Percent
61	1	1	0.45
62	1	2	0.89
63	2	4	1.79
64	3	7	3.13
65	6	13	5.80
66	8	21	9.38
67	14	35	15.63
68	21	56	25.00
69	23	79	35.27
70	28	107	47.77
71	27	134	59.82
72	40	174	77.68
73	17	191	85.27
74	20	211	94.20
75	5	216	96.43
76	7	223	99.55
78	1	224	100.00

n = 224 Mean Height = 70.42 inches
Standard Deviation = 2.94 inches

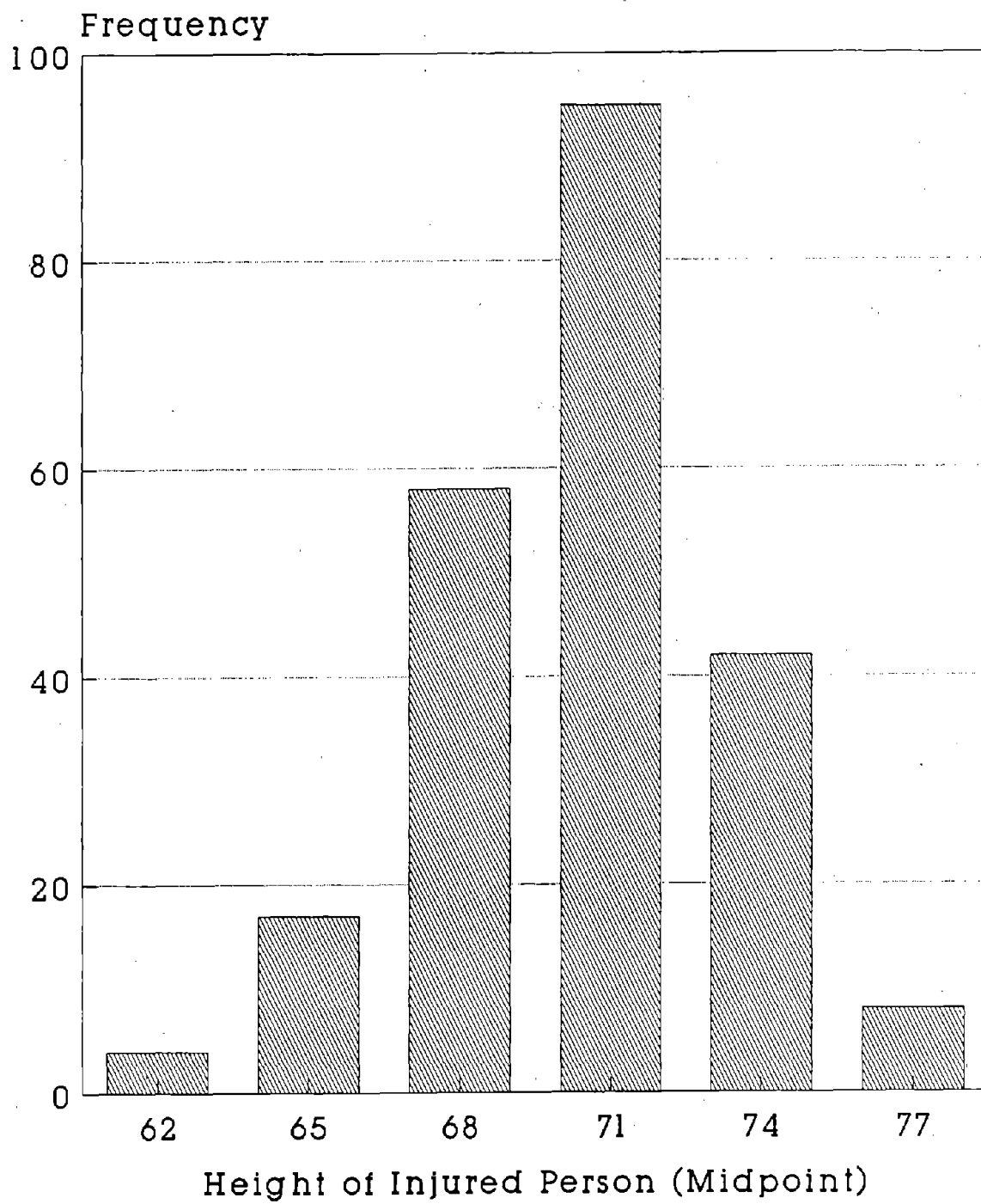


Figure 2. - Height

Table 13. - Frequency Distribution of Miner Weight

Weight of Injured Person	Frequency	Cummulative Frequency	Cummulative Percent
125	1	1	0.45
135	3	4	1.79
140	5	9	4.02
145	3	12	5.36
150	9	21	9.38
152	2	23	10.27
155	5	28	12.50
160	4	32	14.29
163	1	33	14.73
164	2	35	15.63
165	10	45	20.09
168	1	46	20.54
170	11	57	25.45
171	1	58	25.89
173	2	60	26.79
175	19	79	35.27
176	1	80	35.71
177	1	81	36.16
178	2	83	37.05
180	27	110	49.11
182	2	112	50.00
184	1	113	50.45
185	14	127	56.70
186	2	129	57.59
190	14	143	63.84
192	1	144	64.29
195	8	152	67.86
199	1	153	68.30
200	5	158	70.54
204	1	159	70.98
205	2	161	71.88
207	1	162	72.32
209	1	163	72.77
210	13	176	78.57
211	1	177	79.02
212	2	179	79.91
215	6	185	82.59
218	1	186	83.04
220	6	192	85.71
225	5	197	87.95
227	1	198	88.39
228	1	199	88.84
230	8	207	92.41
238	1	208	92.86
240	5	213	95.09
245	2	215	95.98

Table 13. - Weight of Injured Miner (Cont'd)

Weight of Injured Person	Frequency	Cummulative Frequency	Cummulative Percent
248	1	216	96.43
250	4	220	98.21
280	2	222	99.11
300	1	223	99.55
325	1	224	100.00

n = 224 Mean weight = 89.50 pounds
Standard Deviation = 30.44 pounds

Table 14 presents the frequency of lost work days for the 116 LT injuries in this study. The number of lost days ranged from 1 to 132. The mean for lost days was 19.73 and the standard deviation was 30.02. Fifty percent of the LT injuries had six or fewer lost days.

The longest LT injury (132 days) involved a CM operator who was working with a CM move. He was attaching the tongue of a low boy to a motor. The 100 pound tongue was between the miner's knees and he was supporting it. The miner was in this stooped posture supporting the load for thirty seconds as he was having difficulty getting the tongue attached to the motor. The mine height was 78 inches and there were no obstructions to his movement or movement of the tongue. He initially experienced a sharp pain in the center of his lower back at the beltline. He

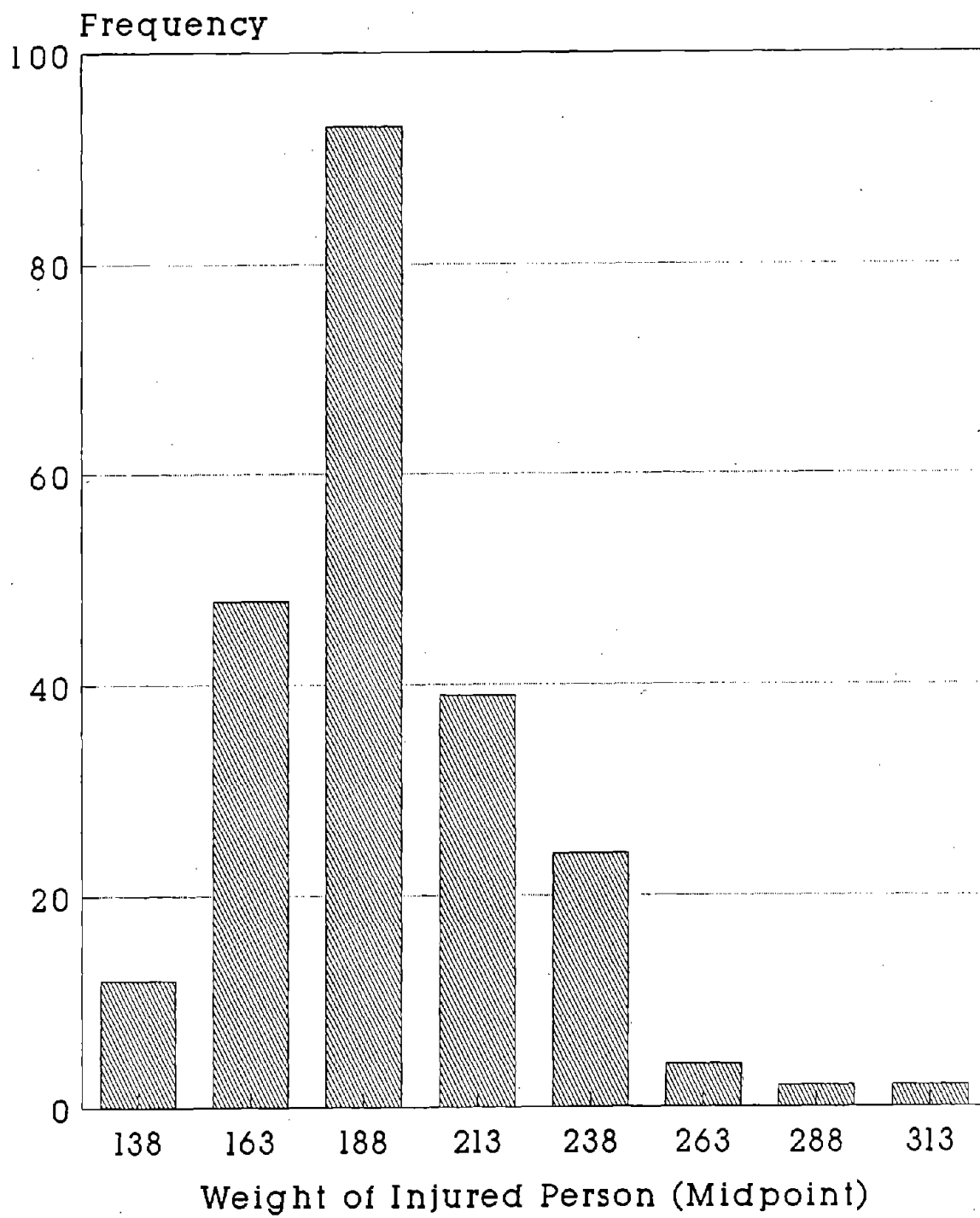


Figure 3. - Weight

was examined and the injury was diagnosed as a muscle spasm. He received physical therapy and medication for treatment. It is not clear why he lost 132 days for a muscle spasm while other diagnostically more severe injuries resulted in less lost time.

In reviewing the 224 injuries contained in this study, it appears that the scenarios for LT and NLT injuries are often quite similar both in terms of their source activity and the injured miner's body dynamics. Thus, it is difficult to determine why one injury results in LT while another does not. For example, an accident similar to that just describes occurred when another miner suffered a NLT injury as a result of transporting a 35 pound gear while walking 600 feet in a similar posture. This miner was expediting the work since his normal job title was foreman. He had a small item to carry in one hand. The gear was too large and heavy to carry in the other hand, so he decided to position the gear on his lower back and steady it with one hand. Since the mine height was 50 inches, he had to walk in a stooped position with his knees bent. This miner's injury was diagnosed as a spinal misalignment and he received treatment from his chiropractor.

In both instances, the miner was bent over at the waist with a significant load. They each remained in this posture for an extended period of time. These two injuries involved the same general activity, same posture, same

environmental conditions, similar biomechanical forces, and neither person slipped or tripped. Why does one become a long-term LT injury and the other a short, non-disabling incident of pain?

The second most severe injury in terms of lost days (120) involved a general laborer who was pulling a RB cable with the plug end over his shoulder as he walked forward slightly stooped. He had unplugged the cable from the power center and pulled the cable for 135 feet. Mine height (96 inches) was not a constraint, nor were there any obstructions in his path. The bottom was normal and posed no problems with slipping. The miner experienced a sharp, burning pain in his lower back. His doctor diagnosed the injury as a muscle strain. Treatment prescribed for the injury included heat, physical therapy and ultrasound. Biomechanically, this injury was much less stressful, yet he lost 120 days.

In comparison, a miner was pulling several sections of rock dust hose into the returns. The bottom area was dry, there were no obstructions, and the mine height was over seven feet. One end of the rock dust hose was over his shoulder as he was pulling it in a slightly stooped posture while walking forward. Both injuries contained the same general activity, a similar posture, similar environmental conditions, approximately the same resistive forces, and neither person slipped or tripped. Again, why does one

become a long term LT injury and the other a short, non-disabling incident of pain?

It is the authors' belief that, from an injury prevention viewpoint, LT and NLT injuries are equally important to study, since the injury scenarios are quite similar and other factors, such as employee attitudes, management attitudes, medical diagnosis, medical treatment, and individual pain tolerance have an important bearing on whether the injury becomes LT, and how much time is lost.

Table 14. - Frequency Listing of Lost Work Days

LOST DAYS	FREQUENCY	PERCENT	CUMULATIVE FREQUENCY	CUMULATIVE PERCENT
1	9	7.8	9	7.8
2	13	11.2	22	19.0
3	13	11.2	35	30.2
4	10	8.6	45	38.8
5	9	7.8	54	46.6
6	5	4.3	59	50.9
7	6	5.2	65	56.0
8	3	2.6	68	58.6
9	2	1.7	70	60.3
10	6	5.2	76	65.5
11	1	0.9	77	66.4
12	2	1.7	79	68.1
13	1	0.9	80	69.0
14	2	1.7	82	70.7
15	2	1.7	84	72.4
17	3	2.6	87	75.0
21	2	1.7	89	76.7
23	1	0.9	90	77.6
25	1	0.9	91	78.4
28	1	0.9	92	79.3
30	1	0.9	93	80.2
31	1	0.9	94	81.0
36	1	0.9	95	81.9
37	1	0.9	96	82.8
41	1	0.9	97	83.6
42	1	0.9	98	84.5
45	4	3.4	102	87.9
48	1	0.9	103	88.8
49	1	0.9	104	89.7
66	1	0.9	105	90.5
80	1	0.9	106	91.4
88	1	0.9	107	92.2
90	2	1.7	109	94.0
100	3	2.6	112	96.6
110	1	0.9	113	97.4
111	1	0.9	114	98.3
120	1	0.9	115	99.1
132	1	0.9	116	100.0
116			100.0	

MEAN LOST DAYS = 19.73

STANDARD DEVIATION = 30.02

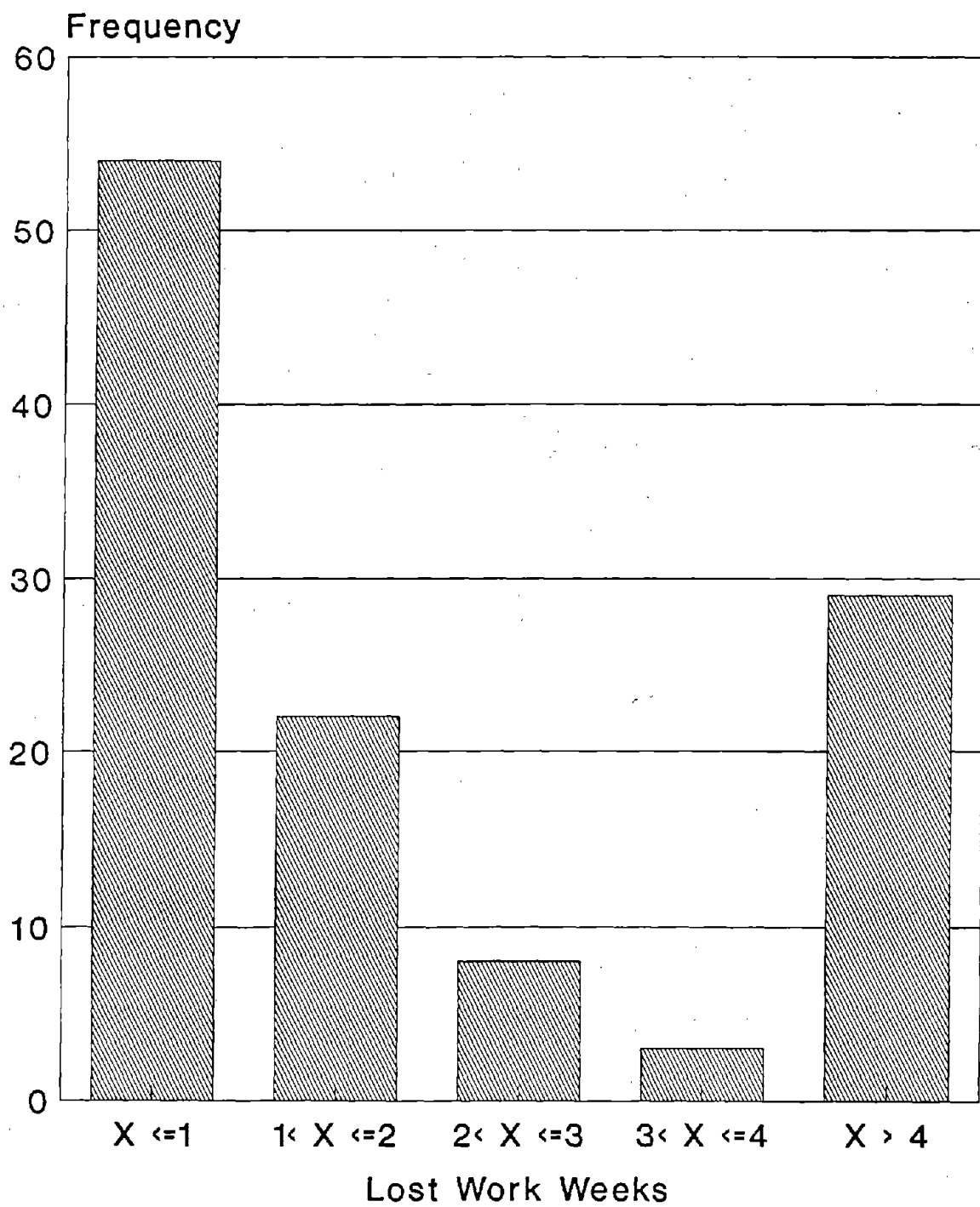


Figure 4. - Lost Work Weeks

RESTRICTED WORK

There were only seven cases in which the injured miner was returned to work with a medical restriction. In all seven cases the restriction was that the injured miner was to be on "light duty" for a period of time which ranged from one day to "until medical approval is obtained." Two of the cases were NLT and five were LT. None of the mines involved in the study had an organized light duty program -- including those in which light duty was assigned by the medical authority. The light duty work to which the injured were assigned ranged from surface work such as painting, getting parts, answering the phone, and cleaning the bathhouse to being sent back to their regular sections with the understanding they would not be assigned any high physical stress work (this director was not generally followed upon the section). Administrative personnel at all of the mines felt that while it was desirable to bring the miners back to work as soon as possible, there just was not enough light duty work available to make it practical at a mine.

Table 15 presents the mining job classification history for the miners in this study. Each miner interviewed was asked his mining work history, and up to four jobs were recorded.

As might be expected, the job classification of General Laborer (GL) appeared most frequently in the miners work histories. This means that somewhere in each miner's work

history, there is a period of exposure to the physical stresses that are a routine part of the GL's work.

There were 124 miners with experience as a general laborer, 70 with experience as a roof bolter, 67 with shuttle car experience, and 58 with continuous miner experience.

Table 15. - Mining Job Classification History

<u>Job Classifications</u>	<u>Lost Time</u>		<u>TOTAL</u>
	<u>NO</u>	<u>YES</u>	
Roof bolter	34	36	70
General Laborer	54	70	124
Shuttle car operator	32	35	67
Continuous miner operator	26	32	58
Beltman	12	12	24
Bratticeman	3	6	9
Maintenance	30	14	44
Scoop operator	16	10	26
Surveyor - rodman	4	0	4
Electrician	4	10	14
Safety inspector	2	1	3
Office job	1	0	1
Foreman	14	10	24
LW shield person	2	1	3
Motor operator	2	4	6
Construction	7	4	11
Mine examiner	4	2	6
Shearer operator	4	6	10
Welder	1	2	3
Ventilation person	2	4	6
Stoper or jackleg operator	0	3	3
Trackman	3	2	5
Prop man	2	3	5
Contract miner	1	1	2
Head gate operator	2	1	3
Others	17	27	44

Experience on the task being performed had a mean of 7.15 years and a standard deviation of 5.07 as presented. The mode for task experience was one year with a frequency of 27, however, four, five, eight, and ten years each exceeded a frequency of 20. Table 16 shows that 80% of the injured miners had ten or less years on task being performed.

Table 16. - Experience on Task Being Performed

Experience On Task(years)	Frequency	Cumulative Frequency	Cumulative Percent
1	27	27	12.05
2	13	40	17.86
3	19	59	26.34
4	22	81	36.16
5	22	103	45.98
6	6	109	48.66
7	15	124	55.36
8	23	147	65.63
9	12	159	70.98
10	23	182	81.25
11	10	192	85.71
12	6	198	88.39
13	5	203	90.63
14	6	209	93.30
15	2	211	94.20
16	2	213	94.09
18	2	215	95.98
19	1	216	96.43
20	3	219	97.77
21	2	221	98.66
22	1	222	99.11
29	2	224	100.00

n = 224 Mean = 7.15 years
Standard Deviation = 5.07 years

The study participants were asked to describe their non-mining job history. Thirty-six or 16% of the 224 miners did not have any significant (more than six months) non-mining history. For the remaining 188 or 84% of the miners, jobs such as construction laborer, factory worker, truck driver, and mechanic were mentioned frequently. Table 17 summarizes their last and next to last significant non-mining work experiences before becoming a miner.

An important reason for collecting the non-mining job history was to obtain an overview of the types of physically demanding jobs the typical miner experienced prior to entering the mines. Jobs known to be physically demanding such as construction laborer, factory worker, truck driver and mechanic were part of the work history of 55 percent of the miners in this sample. These jobs, plus others in the table contain tasks which expose miners to significant back loading.

When the mining and non-mining work histories are pooled, it becomes clear that almost all of the injured miners had been previously exposed to significant low-back biomechanical stress on one or more jobs.

In a review of the leisure time activities which this population enjoyed it was evident that they participated in physically active pursuits. Their recreational activities involved fishing, hunting, motorcycles and off road vehicles, basketball, baseball or softball, farming,

mechanic and other sports such as golf, swimming. These kinds of activities while appearing normal for this type of population would add to the cumulative loading of the back experienced by this population of individuals.

Table 17. - Non-Mining Job History

<u>Non-Mining Jobs</u>	<u>Lost Time</u>		<u>TOTAL</u>
	<u>NO</u>	<u>YES</u>	
N/A	101	99	200
Construction laborer	32	23	55
Press operator	1	0	1
Truck driver	12	12	24
Maintenance foreman	2	1	3
Saw mill operator	4	1	5
Auto plant	3	2	5
Military - communicator	2	0	2
Foundry worker	2	0	2
Factory worker	13	18	31
Crane operator	1	0	1
School teacher	1	1	2
Mechanic	5	12	17
Timbering	2	2	4
Roustabout, oil & gas	2	1	3
Railroad laborer	1	1	2
Parts sales	1	2	3
Gas station attendant	1	3	4
Police officer	2	0	2
Farmer	1	4	5
DOH Employee	1	0	1
Maintenance	1	5	6
Salesman	2	1	3
Navy - flight deck	1	0	1
Welder	1	3	4
Loading trucks	2	1	3
Military	2	9	11
Production supervisor	2	1	3
Phone installer	1	2	3
Carpenter, painter, etc.	2	4	6
Heavy equipment operator	2	4	6
Office Worker	4	0	4
Boat building	1	0	1
Fireman	1	1	2
Refrigeration	1	2	3
Jet mechanic	0	2	2
Meatcutter	1	1	2
Chemical plant worker	0	2	2
Mining surveying crew	0	1	1
Marine gunner	0	2	2
Cabinet maker	0	1	1
Forklift operator	0	1	1
Professional wrestling	0	1	1
Plumbing	0	2	2
Postman	0	1	1
Lead smelter laborer	0	1	1
Secretary	0	1	1
Restaurant worker	2	0	2
TOTALS	216	232	448

JOB-TASK ACTIVITY ANALYSIS

Table 18 describes the overall task in progress when the miner was injured. Table 18 presents broad task categories like maintenance and production to group the data while Table 19 uses more specific activities like operating a continuous miner or lifting cables to provide task details. For example, one overall production task is cable handling, which is further divided into lifting, lowering, dragging, pulling, and carrying cables in Table 19.

Table 18, Overall Task Summary, leads to the following observations. First, at this gross level, there does not appear to be any difference between the sources of lost time (LT) and non-lost time injuries (NLT). Second, there is no one mining activity that is responsible for back injuries. Maintenance, Production, and Safety and Health related activities account for about the same number of injuries, while together they account for 67% of the injuries. This observation is important because it indicates no one approach will be the long sought "panacea" to stop back injuries. Furthermore, our favorite target -- material handling-- (restricted to its pure form) accounts for less injuries than haulage and transportation. Thus, while improving the section supply operation will help, it

will not end the problem. Finally, the reader should note that the task categories of beltline and construction collectively account for eight and one-half percent of the back injuries.

The point must be made that not all LT and NLT back injuries which occurred at the participating mines were included in the study and task exposure data were not available.

TABLE 18. - SUMMARY OF OVERALL TASK at the TIME OF INJURY

Task Category	Lost Time		TOTAL
	Yes	No	
Maintenance	28	25	53
Safety & Health	28	24	52
Production	20	25	45
Haulage & Transportation	9	13	22
Material Handling	9	7	16
Beltline	9	4	13
Construction	4	2	6
Other	<u>9</u>	<u>8</u>	<u>17</u>
TOTALS	116	108	224

Note: Maintenance includes all preventive and breakdown maintenance activities including welding and tool handling. Safety & Health includes tasks performed primarily for safety and health reasons such as roof bolting, ventilation, cribbing, rock dusting, and scaling top, etc. Production includes operating and moving the CM, cable handling, and tasks related to longwall operation. Haulage includes SC and Scoop operations, track haulage, and personnel transportation. Material Handling includes "pure" material handling such as section resupply and bolter stocking. Beltline includes shoveling along the beltline, clearing the belt, extending the belt, and feeder alignment. Construction includes tasks in which permanent structures such as rails, stoppings, overcasts, and beltline are built.

Table 19 presents the activity which the injured miner was performing at the time of injury and whether this resulted in a LT or NLT injury. This study contains a total of 224 back injuries (116 LT and 108 NLT) which are attributed to 156 different types of activities or tasks on which underground coal miners hurt their backs.

The activities associated with material handling have long been identified as a major cause of back injuries. In Table 18 material handling was strictly defined as involving section resupply and bolter restocking. As the list of activities presented in Table 19 is reviewed it is possible to shift activities away from other categories and place them into the material handling category based on different definitions of material handling. In chapter 5 of this report material handling is viewed from a different perspective and the back injuries are studied in detail. Typically miners were handling such items as bags of rock dust, timbers, I-beams, mandoor, etc. Most of these represent one individual lifting alone, but a number involved several miners lifting an object together.

Table 19 indicates that the most common activity was cable (waterline) moving, pulling, or hanging. Twenty-five miners were injured while moving, pulling, and hanging miner cable and/or water line with five similar injuries attributed to lifting and dragging RB cable and/or water line. Ten of the twenty-five injuries involved lost time. This clearly indicates that cable handling is a hazardous

activity which frequently results in a back injury.

The activity of walking was found to be responsible for 27 back injuries. Seven injuries occurred while walking downhill, and seven when the miner stepped in a hole. Other walking injuries included striking their head against the top, walking backwards, and tripping over an object or slipping. For the walking activity the injuries were 14 LT and 13 NLT injuries.

Twenty-seven injuries were associated with operating a piece of equipment, riding in a mantrip, or exiting equipment. Eleven of these injuries resulted in lost time. The shuttle car (SC) was involved in 11 of the 27 back injuries and 7 of the 11 were LT injuries. In eight cases the SC hit a bump which jarred and injured the operator. The three remaining SC injuries were caused by collisions. Similarly, two scoop operators were jarred by rough bottom, and four continuous miner operators were jarred while cutting or tramming the machine. The design of the operators compartment in general and the seat/suspension system in particular is inadequate.

When Tables 18 and 19 are reviewed, it is apparent that the types of activities which result in back injuries are quite varied -- far too varied to be solved by any one approach.

Table 19. - Activity at Time of Back Injury Including
Lost Time and Non-Lost Time

<u>Activity</u>	<u>Lost Time</u>	<u>Non-Lost Time</u>	<u>Total</u>
1. Climbing off machine	2	0	2
2. Shoveling	6	4	10
3. Dragging piece of wet curtain	2	1	3
4. Dragging hose	1	1	2
5. Walking backwards	0	1	1
6. Reaching for 5 ft plastic pipe	0	1	1
7. Walking downhill	4	4	8
8. Moving miner cable and/or water line	6	10	16
9. Building cribs	0	1	1
10. Bending roof bolt in ceiling	1	1	2
11. Restocking bolter	1	0	1
12. Repairing teletram differential	1	0	1
13. Rolling 4' spool of miner cable	0	1	1
14. Hit feeder-conveyor with SC	0	1	1
15. Moving bolter cable and water line	0	1	1
16. Prying on gathering motor on RB	0	1	1
17. Teletram operator hit CM	0	1	1
18. Driving SC - hit bump	3	5	8
19. Drilling hole with RB-slate fell	1	1	2
20. Removing drill steel	0	1	1
21. SC steering failed and hit rib	1	0	1
22. Driving spads into low roof	0	1	1
23. Reached over side of scoop/ lift motor cover	0	1	1
24. Turning over box of 6 SCSR	0	1	1
25. Pry bar to hold bracket in place	0	1	1
26. Pushing dust box out of scoop bucket	1	0	1
27. Lifting 4"x8"x18' header	1	1	2
28. Picking up 2 bags rock dust	0	1	1
29. Walking - stepped in hole	3	3	6
30. Operating CM cutting bottom-jolt	1	2	3
31. Loading tool box onto bucket of scoop	1	0	1
32. Picking up fallen top-new piece fell	0	1	1
33. Pushing rock duster into scoop bucket	0	1	1
34. Lifting oxygen cylinder	1	0	1
35. Lift/hand sheave	1	0	1
36. 6 miners flipping railcar stop with plate	2	0	2
37. Lifting timbers and pulling thru mandoor	1	0	1

38. Lifting SC or CM panel cover	2	0	2
39. Transferring tool box between low boxes	0	1	1
40. Loading elevator with box of metal	0	1	1
41. Handling 6" x 16' long I-beams	1	1	2
42. Carrying gear	0	1	1
43. Reloading RB w/ rock dust	1	0	1
44. Lifting wooden and metal tie off bottom	1	0	1
45. Standing and lifting 7200V cable	0	1	1
46. Standing on drill head holding RB + wrench	1	0	1
47. Bending over and stood up	0	1	1
48. Using pry bar to move LW jack	1	0	1
49. Prying refrax plate - 150 lbs.	0	1	1
50. Removing slate top with pry bar	0	1	1
51. Walking across supply car	0	1	1
52. Carrying 5 gal. jug of water	0	1	1
53. Moving crib blocks	1	2	3
54. Fell off roof bolter in high top	1	0	1
55. Standing on RB head using torque wrench	1	0	1
56. Inspecting top and/or rib	1	0	1
57. Lifting steel bar	1	0	1
58. Roof bolting-rock fell hit hard hat	1	0	1
59. Switching hands--carrying transit	0	1	1
60. Lifting mandoor	0	1	1
61. Exiting vehicle - mantrip, forklift	2	0	2
62. Carrying two five gallon cans of oil	1	0	1
63. Pulling cable, jerked	2	0	2
64. Walked into RB plate in low top	3	0	3
65. Bent over to read CM meter	1	0	1
66. Install push blocks on LW	1	0	1
67. Tying cable at ceiling height	0	1	1
68. Maintenance on LW stage loader	0	1	1
69. Driving into/from work area	0	2	2
70. Adjusting tilted LW shield	0	1	1
71. Walking/tripped on cable	1	0	1
72. Stopping rotating shaft with belt	1	0	1
73. Picking up section of chain	0	2	2
74. Lifting air pressure tank from RAM car	1	0	1
75. Carrying beltline roller	1	0	1
76. Operating CM, checking position	0	1	1
77. Carrying Props	0	1	1
78. Operating feeder controls	0	1	1
79. Lift/drag section of belt	0	1	1
80. Lifting pallet out of mud	1	0	1
81. Lifting DA ram (LW)	1	1	2

82. Using pry bar to lift frozen roller	1	0	1
83. Lifting stretcher	1	0	1
84. Lifting grout pump	0	1	1
85. Lifting vent. tube	1	0	1
86. Picking up a cap wedge	1	0	1
87. Dumping mop bucket	1	0	1
88. Lifting/jerking on waterpipe	0	1	1
89. Lifting timber & tossing to side	1	0	1
90. Walking & slipped on wet board	0	1	1
91. Running away from failed pressure line	0	1	1
92. Assembling panline	1	0	1
93. Lift & carry timbers	1	0	1
94. Carrying 5 gal. of oil	1	0	1
95. Repair LW shield flipper	0	1	1
96. Position roller on belt structure	1	0	1
97. Climbing onto beltline	1	0	1
98. Swinging 5 gal. oil pail among shields	1	0	1
99. Lifting belt starter	1	0	1
100. Driving bobcat on surface	1	0	1
101. Welding in prep plant	1	0	1
102. Climbing down ladder to exit vehicle	0	1	1
103. Prybar to lift heavy load	1	0	1
104. Using wrench to tighten bolt	0	1	1
105. Pounding nails into boards	1	0	1
106. Repairing slam door	1	0	1
107. Using jack leg drill	0	1	1
108. Walking panline	1	0	1
109. Maintenance on CM	1	1	2
110. Putting up cable hooks	1	0	1
111. Carrying 20 lb/ft rail	0	1	1
112. Woke up with muscle spasm after building overcast	1	0	1
113. Unroll new section belt material	1	0	1
114. Emptying vehicle	0	1	1
115. Operating RB controls	1	0	1
116. Lifting and carrying panel cover for loader	0	1	1
117. Bent over trying to attach low boy tongue to motor	1	0	1
118. Picked up crib block and threw it	1	0	1
119. Placing crib under axle of railcar to change wheels	1	0	1
120. Throwing resin onto RB	0	1	1
121. Riding on mantrip	0	1	1
122. Handling hydraulic pipe on LW	1	0	1
123. OJT on roofbolter	1	0	1
124. Cutting metal	1	0	1
125. Removing fittings from LW haulage box	0	1	1

126.Lifting 40 lb metal sheet off low cart	1	0	1
127.Lifting and carrying 75 lb modules for power center	0	1	1
128.Using wrench to loosen bolts	2	0	2
129.Two miners carrying 200 lb. steel sheet when one dropped it	0	1	1
130.Repositioning forks on fork lift	0	1	1
131.Bend over and picked up piece of metal	0	1	1
132.Making water spray boom bracket	0	1	1
133.Lifted and dragged RB cable	1	1	2
134.Stepping off bus	0	1	1
135.Throwing scrap into scrap bin	0	1	1
136.Lifting 8" I-beam to 30" high saw table	0	1	1
137.Driving scoop	1	1	2
138.Supporting 18" dia. vent tube overhead	1	0	1
139.Attempting to restart main belt	1	0	1
140.Cutting tailgate using LW shear	1	0	1
141.Pulling RB cable while walking backwards	0	1	1
142.Pushing broken gofer out of haulageway	0	1	1
143.Walking to face & tripped on RB	0	1	1
144.Lifted & threw CM cable	1	0	1
145.Picked up rotation drill motor & put in gofer	1	0	1
146.Was helping to pull track idler to CM	1	0	1
147.Tightening truss bolt with small ratchet	1	0	1
148.Lifting rock out of way	1	0	1
149.Trying to move a coil of power cable	1	0	1
150.Walking backward sweeping belt line	0	1	1
151.Removing stone from between shields	0	1	1
152.Lifting mandoor and stepping through	0	1	1
153.Moving CM between cuts	1	0	1
154.Washing out wheelbar with a rag	0	1	1
155.Loading rock duster into lowboy when it tripped	1	0	1
156.Lifting rerailer off track and twisted	0	1	1
TOTALS	116	108	224

Table 20. - Was Task Routine?

<u>Task Status</u>	<u>Lost Time</u>		<u>TOTAL</u>
	<u>NO</u>	<u>YES</u>	
Routine -- yes	95	98	193
Routine -- no	10	15	25
NR -- bad top	1	2	3
NR - cutting rock	1	0	1
NR - moving 600 of cable	1	0	1
NR - beltline very high	<u>0</u>	<u>1</u>	<u>1</u>
TOTAL	108	116	224

Table 20 addresses a common fallacy -- that back injuries only occur during non-routine activities. In fact, 86% of the back injuries occurred while the injured was doing a task which was routine for the miner.

Table 21 addresses the same question which was asked in Table 20, but from a different perspective, by asking why the injured miner was performing the task/activity that caused the injury. Here we see the same pattern -- 84% of the injuries occurred while doing something that was a normal part of the injured miner's job resulting in 188 injuries with 97 being LT; another 9% occurred while the injured miner was helping another miner to perform a task, or performing a task for another miner. The remaining 7% break down as follows: miners assigned to other jobs while the section was down (3%), production emergencies (1%), doing a job someone else failed to do (1%), being the only one available to do the task (1%), and training another person and working out of job on overtime (1/2% each).

In total, only 3 1/2% of the injuries occurred while a person was assigned to work outside his/her normal job.

Table 21. - Reason Injured Was Doing the Task?

<u>Reason</u>	<u>Lost Time</u>		<u>TOTAL</u>
	<u>NO</u>	<u>YES</u>	
Normal part of job	92	97	188
Helping out	7	12	19
Reassigned, section down	4	2	6
Reassigned, on OT	1	0	1
No one else available	1	1	2
Someone else did not do	1	1	2
Emergency	1	2	3
Training/being trailed	<u>1</u>	<u>1</u>	<u>2</u>
TOTAL	108	116	224

One of the unique features of this research project was its focus on the reason the injury producing task/activity was being done the way it was being done, whether there was an alternate method(s) for doing the task, and the reason(s) the alternate was not being used. Table 22 focuses specifically on the availability of alternate methods. This Table shows that in 77% of the cases, one or more reasonable alternative methods were available.

Table 22. - Were Alternate Methods Available for Performing Task?

<u>Available</u>	<u>Lost Time</u>		<u>TOTAL</u>
	<u>NO</u>	<u>YES</u>	
Yes	84	89	173
No	24	27	51

WORK METHODS/PROCEDURES ANALYSIS

At some mines there is a serious attempt made to develop written work procedures or to write job safety analyses (JSA) which cover the work done. All of the participating mines had some written work procedure guidance, but it generally was not specific enough to serve as guidance in avoiding back injuries. During each interview, the injured miner was asked about the written procedures or JSAs that applied to the injury producing task or activity. Table 23 summarizes the data obtained.

Table 23: Did Written Work Procedures Exist for Task

<u>Did Written Work Procedures Exist?</u>	<u>Lost Time</u>		<u>TOTAL</u>
	<u>NO</u>	<u>YES</u>	
Yes	29	27	56
No	67	61	128
Using Normal Procedure	22	18	40

Table 23 shows that written procedures existed for only 25% of the tasks/activities, and that in another 18% of the cases, the injured miner was following the "accepted practice" at the mine. In the remaining 57% of the cases, either no written materials existed, or the nature of the incident made written materials irrelevant -- for example, slipping while walking, or walking into a section of low top.

Table 24 addresses the question of whether there was a difference between the activity at time of injury and the standard method established for performing the activity. In 125 situations or 56% there was no standard method. In 61 or 27% of the cases there was no difference between the way the activity was performed and the standard method. However, in 34 instances the standard method was not followed and resulted in 14 LT and 20 NLT injuries. Four cases went in the maybe category as it was not clear whether the standard method was followed or not.

Table 25 presents the reasons given for not following the standard method. In 19 of the 36 cases (includes two maybe cases from Table 10) the person(s) failed to follow the rules even though the rules were realistic. In six cases the rules were not followed because for the particular situation the rules were felt to be unrealistic. In four cases the rules may not have been followed, and this includes two of the maybe cases. In two injuries the circumstances prevented the use of normal procedures and in five cases the proper equipment was not used.

An additional question was asked for the 36 cases identified in Table 25: Would the standard method have helped? In all cases it was agreed the standard method would have improved the situation. In summary, the standard method was followed in 61 of the 99 cases where

there was a standard method. In 36 of the remaining 38 situations following the standard method may have had a positive impact on the situation.

Table 24. - Was There a Difference Between the Activity at Time of Injury and the Standard Method Established for Performing the Activity?

<u>Difference</u>	<u>Lost Time</u>		<u>Totals</u>
	<u>NO</u>	<u>YES</u>	
Not applicable (means no standard method)	58	67	125
No	28	33	61
Yes	20	14	34
Maybe	<u>2</u>	<u>2</u>	<u>4</u>
TOTALS	108	116	224

Table 25. - Reason Given for Not Applying Standard Method

<u>Activity at Time of Injury: Is there Standard Method</u>	<u>Lost Time</u>		<u>TOTAL</u>
	<u>NO</u>	<u>YES</u>	
Failed to follow rules, unrealistic	2	4	6
Failed to follow rules, realistic	12	7	19
May not have followed the rules	3	1	4
Circumstances prevented normal procedure	1	1	2
Proper equipment not available	1	1	2
Foreman failed to use proper equipment	1	0	1
Failed to use correct equipment	<u>0</u>	<u>2</u>	<u>2</u>
TOTALS	20	16	36

In this research, an alternate method was defined as a method of doing the task other than the method that was used. This includes behavioral changes like getting close to the object lifted or lifting less, procedural changes such as scaling top before working in an area, equipment modifications such as using vehicle seats with shock and vibration isolation, and work practice changes such as using a mechanical device to lift or drag equipment or tools. There were 85 different alternate methods identified. The most frequently suggested alternate methods are described in Table 26.

TABLE 26. - Commonly Proposed Alternate Methods

<u>METHOD</u>	<u>FREQUENCY</u>
Use an additional person	22
Use mechanical means to move objects	20
Wear seat belt in vehicle	7
House keeping improvement	6
Redesign seat to absorb shock & vibration	5
Reposition body to improve leverage	5
Use scoop ram to move items	5
Use appropriate shovel	4
Squat lift	4
Move feet instead of twisting	4

No significant differences were observed between LT and NLT injuries in the alternate methods proposed to avoid the injury.

The obvious next question is: why were the alternate methods not used? This is addressed in Table 27.

TABLE 27. - Reason for Not Using Alternate Method

<u>REASON</u>	<u>FREQUENCY</u>
Inconvenient to use	52
Not available at mine	30
Miner in too much of a hurry	25
Miner failed to size up job	22
Never given consideration at mine	14
Work area short one miner	11
Proper equipment not conveniently available	8
Supervisor would not allow	4
Other	7

The striking thing about Table 27 is that in 85 of the 224 cases investigated (38%), the injury producing event apparently occurred because the miner was in a hurry, or it was inconvenient to use a "safer" approach or proper equipment. In another 10% of the cases the miner failed to "size up job" -- that is, the miner did not evaluate the job-related-stresses/ potential-energy-releases before starting the task. This means that in almost half the cases the miner could have avoided the injury producing event by choosing a different approach to the task. This is not to say that the injuries are a "miner's problem." Rather, it is to say that in spite of equipment designs which incorporate unsafe features, poor mine operation, and

planning which is lacking, in almost half of the cases, the injury may have been prevented.

EQUIPMENT DESIGN

Another approach to evaluating the use and availability of alternate methods is to determine whether management planning could have changed equipment, procedures, or work practices to avoid the incident. Table 28 presents 65 cases (29%) where this was true. The authors applied their knowledge of the accident scenario and operation mine to make their judgment.

The need for improved equipment designs from equipment manufacturers and planning on the part of mine management is evident in the following areas:

- I) Improved equipment design
 - A) operator cab for shuttle car, continuous miner, teletram, scoop, roofbolter and mantrip vehicles
 - 1) seat design -- suspension system to reduce the impacts of bumps, jolts and vibrations on the operator
 - 2) operator restraint system for shuttle cars, teletrams and mantrip vehicles -- reduce operator impact against canopy due to bumps and keep operator in seat in case of collisions

Table 28: Type of Outside Mine Planning

<u>Type of Outside Mine Planning</u>	<u>Lost Time</u>		<u>TOTAL</u>
	<u>NO</u>	<u>YES</u>	
Non-skid on slippery surfaces	1	0	1
Position the SCSR's on perimeter of sled	1	0	1
Supply correct equipment to section	1	2	3
Provide mechanical handling aids	2	4	6
Proper storage	1	0	1
Improve equipment design	6	10	16
Plan section layout to avoid crush points	1	0	1
Keep bottom smoother	2	0	2
Better housekeeping	2	0	2
Improve seat design	1	1	2
Use proper method for situations	1	1	2
Person shouldn't shovel continuously	1	0	1
Bolt ribs	1	1	2
Mandoors which open sideways	2	0	2
Use scoop to handle timbers	0	2	2
Supply 6' sections of roller conveyor	0	2	2
More efficient loading of supply cars	0	3	3
Design special jack for changing tires	0	1	1
Package materials in smaller weights	0	3	3
Plan maintenance where accessible	0	1	1
Emphasize covering holes	0	1	1
Better design of coupler for low boy	0	1	1
Emphasize no horseplay	0	1	1
Change type of roofbolt	0	1	1
Ensure adequate training on new equipment	0	1	1
Training on surface	0	1	1
Better housekeeping	0	1	1
Provide larger tools or air tools	0	2	2
Provide a pole to support vent tube in high top	0	1	1
Improve cab design	<u>0</u>	<u>1</u>	<u>1</u>
TOTALS	23	42	65

- 3) maximize effective canopy height -- permits better operator posture and vision
- 4) identify control functions -- label, shape and/or location code of controls by function
- 5) apply ergonomics when selecting equipment, particularly in the cab design -- consider operator vision, seat comfort, operator posture, control layout, function, labelling and shape coding of controls by function.

B) Roofbolters(RB)

- 1) canopies on ATRS systems on roofbolters should be sized to cover the RB operator during all phases of the bolting procedure. Openings in canopies should be sized to allow vision while still preventing rocks large enough to produce injuries from falling through.
- 2) RB supplies should be stored within easy reach of the roofbolter -- this reduces lifts, reaches and the amount of walking done in the face area.
- 3) in mines where extra long RBs that must be bent before insertion are used provide a fixture on the roofbolter so the bolt can be easily bent.

C) Mechanical equipment aids to assist in the handling of timbers, I-beams, tires, motors, LW jacks, LW props, etc.

- 1) multi-purpose boom hoist which attaches to scoop and portable boom hoist
- 2) jack device to aid in the changing of tires and wheels
- 3) come-along devices which can attach to flipper on shield, roof bolt in ceiling or rib, etc., which can assist in lifting, moving, holding and positioning heavy roof support, rail, repair parts, etc.

D) Supplies

- 1) coordinate the preloading of supply cars on the surface considering the jobs and sequence of use of the supplies underground
- 2) place heaviest items securely on perimeter of the supply cars to minimize lifting while reaching
- 3) purchase prepackaged materials and supplies in manageable weight bundles and bags, and purchase bags with handles whenever possible

E) Panel covers and manddoors

- 1) hinge on side instead of top -- easier to open and less chance of getting body part pinched or smashed

- 2) hinge panel covers on side instead of bolting -- reduces lifting and carrying and saves time
- 3) if panel cover must be removed make it out of lighter material -- thinner steel or perhaps a lighter material

E) Job Procedures

- 1) when equipment changes are made take the time to explain the purpose and procedures to all mine supervisors and employees.

For each injury the following question was asked of the injured and then discussed by the researcher: "How could this situation be avoided?" Tables 29 and 30 contain the responses to this question. Table 29 records what was judged the most effective response and Table 30 records the second best suggestion. An answer of N/A was recorded if an effective response was not found. The following are some of the most frequently mentioned suggestions from Table 29.

- 1) size up the task before performing the task (21 cases, 12 LT)
- 2) use mechanical lifting and handling aids (19 cases, 9 LT)
- 3) get additional miner (17 cases, 8 LT)
- 4) redesign seat and provide a restraint system (14 cases, 4 LT)

- 5) position self properly to lift (12 cases, 7 LT)
- 6) lift less weight (10 cases, 4 LT)
- 7) redesign roof bolter (7 cases, 5 LT)

The preceding seven categories account for 100, or 45%, of the back injuries, of which 49 were lost time. The most frequent recommendation was to size up or think about a safer, easier way to do the task. The "macho" approach, where one or more persons simply tries to manhandle items was all too frequently the approach which was employed. This leads directly into the second, third and sixth most frequent categories, which recommend the use of mechanical lifting and handling aids, get an additional miner and lift less weight. More design time and effort needs to be expended on the development of devices and procedures to aid in the handling and lifting of I-beams, timbers, heavy and awkward repair parts, equipment tires and wheels, LW props., cable and water lines, etc.

All too often miners were injured while attempting to handle heavy, clumsy items, often with poor bottom conditions and in restricted spaces and postures. These four categories include 67 (30%) of the injuries described in Table 29, with 33 being LT injuries.

The fourth and seventh categories address the issues of seat and restraint system design. The cab design on mining equipment is cramped and space is limited. However, this undesirable situation is aggravated by seats which are rigidly attached directly to the equipment frame. This

transmits machine vibration and road bumps and jolts directly to the operator. This is made more severe since the equipment possesses little or no suspension system for damping or absorbing vibration and/or bumps. A seat designed to isolate the operator from these abuses is urgently needed. When bottom conditions result in a rough road surface the use of an operator restraint system would prove beneficial. The recommendation is to design a seat and restraint system together which complement each other.

The fifth and sixth categories are directed at the person performing the lift: to position themselves properly and not to lift heavy items. This means to get as close as possible to the load avoiding extended arms and upper torso. Also, they should not be twisting or turning while lifting. They must have a good coupling to the load, such as good hand holds or handles. The surface on which they are standing should not be slippery or cluttered to avoid slipping and tripping. While this seems obvious, numerous injury scenarios included slippery or cluttered walking surfaces. An effective training program which instructs the workers in techniques to assess a task's physical difficulty, along with basic lifting biomechanics, and the use of mechanical lifting and handling aids should reduce injury risk.

RB design change suggestions include a larger canopy and control labeling. Control standardation by label, shape, and location coding across RB manufacturers would reduce

the inadvertent activation of the wrong control. This is increased greatly when operators change from one bolter to another. Similar coding standardization would be helpful for other equipment as well.

Table 29. - How Could Situation be Avoided? - First Choice

<u>How Could Situation be Avoided?</u>	<u>Lost Time</u>		<u>TOTAL</u>
	<u>NO</u>	<u>YES</u>	
N/A	8	4	12
Redesign bolter	2	5	7
Size up task before doing it	9	12	21
Use scoop to clean floor	1	1	2
Sign slippery spots	1	0	1
Use vehicle to drag cable	2	1	3
Scale roof	2	2	4
Non-skid on change/shower floor	1	0	1
Use wheelbarrow in place of shovel	1	0	1
Lift less weight	6	4	10
Provide alignment aids to help			
scoop to feeder	1	0	1
Redesign cable hooks	1	0	1
Raise canopy to improve vision	1	0	1
Use mechanical lifting and			
handling aids	10	9	19
Do not manhandle things	1	2	3
Redesign seat and restraint system	10	4	14
Check roof area	3	1	4
Position self properly to lift	5	7	12
Position heavy items on sled			
perimeter	1	0	1
Take tension off cable before lifting	2	0	2
Get additional miner	9	8	17
Check roadway for holes and			
roughness	1	3	4
Use ram in scoop to move rock duster	1	0	1
Use backpack to carry small, heavy			
items	1	0	1
Don't twist trunk while lifting	3	2	5
Move supplies on supply car closer			
to point of use	1	2	3
Moving slowly	1	0	1
Avoid overhead hazards	1	2	3
Watch out for slick spots in path	3	2	5
Watch foot placement	2	2	4
Use tool to reach unsupported spots	1	0	1
Don't put feeder in cross-cut	1	0	1
Use chain to drag heavy objects to			
access point	1	1	2
Pretest equipment on surface	1	0	1
Stay under LW shield	1	0	1
Lift drill before pulling out steel	1	0	1
Change pipe fitting	1	0	1
Use pry bar	1	0	1
Housekeeping	3	0	3

Table 29. - How Could Situation be Avoided? - First Choice
(Cont'd)

<u>How Could Situation be Avoided?</u>	<u>Lost Time</u>		<u>TOTAL</u>
	<u>NO</u>	<u>YES</u>	
Have person loosen muscles	2	0	2
Bolt rib and have larger block	1	0	1
Redesign mandoor to open sideways	1	0	1
Use different posture	1	0	1
Install permanent rerailer	1	0	1
Don't shovel overhead	0	3	3
Proper maintenance	0	2	2
Wear seat belt	0	1	1
Use scoop to move timbers	0	2	2
Use equipment to drag cables			
long distances	0	1	1
Design new jack	0	1	1
Reposition low meter	0	1	1
Lower cutter head	0	1	1
Hang cable out of way	0	1	1
Add a mechanical brake to stop fan	0	1	1
Pull shorter length of hose	0	1	1
Use cable covers on ground	0	1	1
Provide lifting handle or tool	0	2	2
Use expanded metal on LW toes	0	1	1
Position equipment for easy			
maintenance access	0	1	1
Check ground before using heavy			
equipment	0	1	1
Take periodic rests during long			
periods of heavy exertions	0	5	5
Use dipped steel plate in bottom			
of SC bucket	0	1	1
Cover hole	0	1	1
Support tongue with block	0	1	1
Do not throw heavy objects	0	1	1
No horseplay	0	1	1
Use resin or combination roof bolt	0	1	1
Better training on new equipment	0	2	2
Use two additional miners	0	1	1
Eliminate restricted work area	0	1	1
Use air impact tool	0	3	3
On LW do not cut into soft bottom	0	1	1
Do not stand on tailgate motor	0	1	1
Adequate cab area	<u>0</u>	<u>1</u>	<u>1</u>
TOTALS	108	116	224

Table 30 which summarized the way in which a situation could be avoided reinforced the findings of Table 29. The common suggestion were the use of more persons in certain lifting situations, eliminating attempts to manhandle heavy objects by using mechanical lifting aids, applying better planning before undertaking the task, and better seat design.

Table 30. - How Could Situation be Avoided? - Second Choice

<u>How Could Situation be Avoided?</u>	<u>Lost Time</u>		<u>TOTAL</u>
	<u>NO</u>	<u>YES</u>	
N/A	57	49	106
Design special tool	1	2	3
Redesign tool shovel	1	3	4
Use more people	8	13	21
Gravel slippery spot	2	2	4
Do not shovel overhead	1	0	1
Relieve cable and water line tension	4	0	4
Change teletram operator behavior	1	0	1
Enlarge RB canopy	1	3	4
Reposition handle and/or make motor door lighter	1	0	1
Don't manhandle--use mechanical means	8	8	16
Position body to eliminate twisting	1	4	5
Check roadway for holes and debris	2	2	4
Better planning	2	5	7
Bend at knees instead of waist	1	3	4
Keep walkway clear of obstacles	2	1	3
Better seat design	5	1	6
Rest more often or rotate task	2	3	5
Move item out of way before lifting	2	1	3
Safer cab interior	1	2	3
Redesign entry/exit ladder	1	0	1
Design equipment for easy maintenance access	1	0	1
Take apart hose before handling	1	0	1
Design equipment for easy transfer	1	1	2
Redesign rerailer for easy handling in tight spot	1	0	1
Use roller conveyor	0	1	1
Proper maintenance	0	1	1
Check for overhead hazard	0	4	4
Eliminate mop dump lip	0	1	1
Prepare equipment for use on surface	0	1	1
Move supplies as close as possible on supply car	0	1	1
Use simulators for training	0	1	1
Use wrench with longer handle	0	3	3
TOTALS	108	116	224

Table 31A shows that equipment was involved in 65% of the back injury cases (73 LT and 73 NLT). The roof bolter was involved most often (14), continuous miner (CM) and roofbolter cable handling was second (13), followed by shuttle car (10), continuous miner (8), hand shovel (7) and scoop (7). In addition to these six, access panels on equipment, belt, jack leg drill, long-wall shield, panline, supply car, transportation vehicle, and ventilation fan, were involved. In all, 70 different equipment items were involved in the scenarios in which miners were injured. These examples show the diversity of equipment items that miners were handling, operating, riding, maintaining, etc. when they suffered a back injury. They also indicate that the problem cuts across the entire range of equipment used in mining.

Table 31A. - What Type of Equipment Was Involved in
the Injury?

<u>What Type Equipment</u>	<u>Lost Time</u>		<u>TOTAL</u>
	<u>NO</u>	<u>YES</u>	
N/A	35	43	78
Roof Bolter	5	9	14
Shovel	2	5	7
Mandoseal or rockduster	3	1	4
Sole of shoe	2	1	3
Miner cable	8	5	13
Belt	3	1	4
Shuttle Car	5	5	10
Scoop	5	2	7
Teletram	1	0	1
Pry bar	3	1	4
Access panel on scoop	1	0	1
Feeder at end of belt	2	1	3
Continuous Miner	4	4	8
Tool box	1	1	2
Transit and tripod	1	0	1
Mandoor	2	0	2
Wheelbarrow	1	0	1
Prop	3	0	3
LW Shield	1	1	2
Jack leg drill	1	0	1
Transportation vehicle	3	1	4
Grout pump	1	0	1
Pipe	1	1	2
Pressure hose couple	1	0	1
LW shield	1	0	1
Ladder on end loader	1	0	1
20 lb/ft overcast rail	1	0	1
Loader	1	0	1
Socket wrench and cheater pipe	1	1	2
Power center module	1	0	1
Power center cover	1	0	1
Lift truck	1	0	1
Water spray bracket	1	0	1
Saw table	1	0	1
Gofer	1	0	1
Sections of chain	1	0	1
Rerailer	1	0	1
Dust box in bucket of scoop	0	1	1
SC access panel	0	1	1
Sheave block	0	1	1
3 ft. Torque wrench	0	1	1
Motor - locomotive	0	1	1
Beltline roller	0	2	2
Ventilation fan	0	1	1

Table 31A. - What Type of Equipment Was Involved in the Injury? (Cont'd)

<u>What Type Equipment</u>	<u>Lost Time</u>		<u>TOTAL</u>
	<u>NO</u>	<u>YES</u>	
LW push block	0	1	1
Hydraulic cable	0	1	1
Air tank on ramcar	0	1	1
Transfer chute	0	1	1
Stretcher	0	1	1
Vent tube	0	2	2
Mop bucket	0	1	1
Toe of LW shield	0	1	1
Panline	0	1	1
5 gal container	0	1	1
Bobcat	0	1	1
Sledge hammer	0	1	1
Derailer	0	1	1
Tongue of low boy	0	1	1
Supply car	0	1	1
7' roof bolt	0	1	1
Low cart (4" above floor)			
hauls steel	0	1	1
LW head drive	0	1	1
LW tailgate motor	0	1	1
Rotation drill motor for RB	0	1	1
Track idler for CM	0	1	1
Racket wrench	0	1	1
Beltline power cable	0	1	1
Track-pod rock duster	<u>0</u>	<u>1</u>	<u>1</u>
TOTALS	108	116	224

Equipment involvement is further explored in Table 31B which describes how the equipment was involved in the injury? Some of the most frequently observed situations were:

- load too heavy and awkward (33 cases, 17 LT);
- lack of seat suspension (15 cases, 6 LT);
- performing equipment maintenance (9 cases, 4 LT);
- continuous miner had to be moved (7 cases, 2 LT);

- person overloaded shovel (5 cases, 4 LT);
- canopy on RB too small (4 cases, 3 LT);
- equipment failure (4 cases, 2 LT);
- too much force required to operate wrench (3 cases, 2 LT);
- better sole design may improve traction (3 cases, 1 LT).

These situations provide a sampling of the most frequent ways in which equipment was involved in the injuries. The first situation, which identifies loads as being too heavy and awkward, points to the need for mechanical handling aids and improved task procedures to reduce these loads. The second item points to the need for improved seat design to reduce the operator's exposure to bumps and jolts. Presently most seats are attached directly to the frame of the equipment and lack any shock absorbing features. This transmits the impact directly to the operator and subjects the back to sudden loadings which can result in injury.

The RB canopy is often too small, and RB operators are injured by falling coal and rock. If a grating is used, the size of the openings in the grating should be as small as possible so large rocks and coal cannot fall through the openings.

In several situations a large amount of force was required to use a wrench. In two, a cheater bar was added to the wrench, and in a third the tool broke. For these difficult nut loosening tasks the use of penetrating oil and/or a power tool would reduce the risk of injury.

Table 31B. - How Was the Equipment Involved?

<u>How Was Equipment Involved?</u>	<u>Lost Time</u>		<u>TOTAL</u>
	<u>NO</u>	<u>YES</u>	
N/A	35	43	78
Person overloaded shovel	1	4	5
Too heavy and awkward	16	17	33
No storage location on RB	2	0	2
Better sole design may improve traction	2	1	3
Beltline too high	1	0	1
SC hit feeder	1	0	1
Bucket of scoop suddenly tilted	1	0	1
Teletram hit CM	1	0	1
Slate bar used to lift gathering motor	1	0	1
Canopy on RB too small	1	3	4
Lack of seat suspension	9	6	15
Equipment failure	2	2	4
Supply car loaded incorrectly	1	0	1
CM had to be moved	5	2	7
Equipment maintenance	5	4	9
Trying to move rock duster into scoop	1	0	1
Trying to move refrax plates with prybar	1	0	1
Too much force to operate wrench	1	2	3
Using slate bar on well anchored top	1	0	1
Trying to switch hands--transit	1	0	1
Equipment was unstable	1	0	1
Lack of visibility	1	0	1
Equipment anchors created space problems	1	0	1
Limited area to handle pump	1	0	1
Entry/exit ladder poorly designed	1	0	1
No easy way to handle cable	1	0	1
Hit canopy	2	0	2
Too much at one time	1	0	1
Had to be moved	1	0	1
Fork on lift truck was struck	1	0	1
Being lifted	2	1	3
Dragging cable	2	0	2
Stepping off bus	1	0	1
Shoveling to panline	1	1	2
Opening mandoor from bottom up	1	1	2
Being cleaned	1	0	1
Person standing on RB	0	3	3
Dust box moved out of scoop bucket	0	1	1
Moving LW jack cylinder	0	1	1
Egress path not visible	0	1	1

Table 31B. - How Was the Equipment Involved?(Cont'd)

<u>How Was Equipment Involved?</u>	<u>Lost Time</u>		<u>TOTAL</u>
	<u>NO</u>	<u>YES</u>	
Meter in poor location	0	1	1
Person jumped off equipment	0	1	1
Equipment in walkway	0	2	2
Design caused jams	0	1	1
Had to be lifted to empty	0	1	1
Lack of well placed handles	0	2	2
Overturned	0	1	1
Wrong tool for task	0	1	1
No easy way to handle cable	0	1	1
No tool available to grab belt	0	1	1
Slipped in bucket of scoop	0	1	1
Derailler was cleaned	0	1	1
Person lifting up 16' header to place on RB	0	1	1
Trying to attach tongue to motor	0	1	1
Changing rail wheels	0	1	1
Operator was involved in horseplay	0	1	1
Trying to bend roof bolt	0	1	1
RB controls not familiar	0	1	1
Used to transport metal sheets	0	1	1
Miner stood on LW tailgate motor	0	1	1
Being transferred from track to lowboy	<u>0</u>	<u>1</u>	<u>1</u>
TOTALS	108	116	224

Design factors in equipment which played an important role in the injury of each miner are presented in Table 32. Equipment design factors were identified in 106 (47%) of the cases. The following represent the most frequently identified design factors:

- 1) weight (19 cases, 8 LT);
- 2) poor seat design (13 cases, 4 LT);

- 3) continuous miner cable had to be moved (6 cases, 1 LT);
- 4) shovel blade too large (5 cases, 4 LT);
- 5) canopy of roof bolter too small (4 cases, 3 LT);
- 6) cab restraint system (4 cases, 2 LT);
- 7) work platform access problem (4 cases, 4 LT);
- 8) no way to grab item, need handles (4 cases, 4 LT).

The design factors listed in Table 32 lead to the same conclusions as those drawn from Table 31B. In addition, several design problems were also identified. They include handles on pieces of equipment, easier access to work platforms, and the need to provide shovels with a range of blades sizes which would permit miners to shovel weight appropriate to conditions.

Table 32. - Primary Equipment Design Factors

<u>Design Factors</u>	<u>Lost Time</u>		<u>TOTAL</u>
	<u>NO</u>	<u>YES</u>	
N/A	58	60	118
Shovel blade too large	1	4	5
Weight	11	8	19
No place to lay transfer pipe	1	0	1
Design of sole of boot	2	1	3
Beltline too high	1	0	1
Canopy too low and restricted vision	2	1	3
Canopy on RB too small	1	3	4
Poor seat design	9	4	13
Restraint system	2	2	4
Layout of first aid sled improper	1	0	1
Continuous miner cable had to be moved	5	1	6
Lower cable hook on CM	1	0	1
Redesign cable reel on RB	1	0	1
Improve handle design for tool boxes	1	1	2
More stable jacks	1	0	1
Anchors not located correctly	1	0	1
No way to grab item-handle needed	2	4	6
Access for maintenance difficult	1	0	1
Ladder rungs not self cleaning	1	0	1
No easy way to handle cable	2	1	3
Use air wrench	1	0	1
Had to reach thru canopy to store supply	1	0	1
Mandoor opens from bottom	1	0	1
Work platform access problem	0	4	4
Longer handle on wrench	0	2	2
Motor - locomotive - poor visibility	0	1	1
Reposition the low meter	0	2	2
Rust on equipment	0	1	1
Tank relocated on newer models	0	1	1
Hinge access panels for maintenance access	0	1	1
No way to grab item, need handle	0	4	4
Chute design was poor	0	1	1
Mop dump station too high	0	1	1
Toes of shield are slick	0	1	1
Access for maintenance difficult	0	1	1
Cab design not suited to rollover	0	1	1
Bucket of SC is slick if wet	0	1	1
Flange welded to tongue, poor design	0	1	1
Use scoop to move cable	0	1	1
Roofbolt longer than seam is high	0	1	1
Cart is very low (4" high)	0	1	1
Stronger wrench	0	1	1
RB controls not familiar	0	2	2
Unstable	0	1	1
TOTALS	108	116	224

For some injuries, multiple equipment features were a factor in the injuries. Table 33 summarizes the secondary equipment design factors for 38 cases. The more frequently identified secondary design factors are presented below:

- 1) need restraint system for operators of CM, SC, etc. (9 cases, 5 lost time);
- 2) need special tool for the task (5 cases, 3 lost time);
- 3) inappropriate handle length for shovel (4 cases, 3 lost time).

Table 33. - Secondary Equipment Design Factors

<u>Secondary Design Factors</u>	<u>Lost Time</u>		<u>TOTAL</u>
	<u>NO</u>	<u>YES</u>	
N/A	86	100	186
Inappropriate handle length for shovel	1	3	4
Mandoseal mixer requires extra lifting	1	0	1
Shovel blade too large	1	0	1
Feeder	1	1	2
Continuous miner	2	0	2
Foam filled tires are solid	1	1	2
Poor seat	4	0	4
Restraint system needed	4	5	9
Handle location on motor compartment	1	1	2
Need special tool for the task	2	3	5
No clearance due to LW hoses	2	0	2
Need longer handle for greater leverage	1	0	1
Too hard to take hose apart	1	0	1
Need a mechanical means to assist with rail wheel changes	0	1	1
Limited vision	<u>0</u>	<u>1</u>	<u>1</u>
TOTALS	108	116	224

There were only two cases in which the event that injured the miner also resulted in property damage. In one case, a shuttle car collided with a continuous miner, knocking the operator out of the miner and causing \$100 damage to the equipment. In the other case, the operator of a Bobcat drove over some soft ground and rolled over causing \$1500 damage to the Bobcat. While this data is often collected as part of the accident/injury report, it appears that equipment damage has little to do with back injuries in underground coal mining.

NUMBER OF MINERS REQUIRED FOR JOB

The number of persons required to do a task is sometimes an issue in back injuries. Table 34 presents the number of miners normally used on the tasks on which the injuries occurred. Most (163 or 73%) were single person tasks, while the remaining are multiple person tasks requiring two to six persons.

Table 35 presents the number of miners actually performing the task at the time of injury. Most (183 or 82%) were single person tasks, thus 20 of the multiple person tasks were performed alone. Nineteen of these were two person tasks and one was a three person task. In addition, two of the five person tasks were actually performed by just four persons.

Table 36 presents the reasons why the tasks were performed using fewer miners than normal. In 10 cases the reason was that they were in a hurry and did not bother to

ask for additional help. In two other cases the extra miner was assigned elsewhere and in seven situations no-one else was around. The need for planning ahead is evident. In these cases advanced planning may have permitted the arrangement for an additional miner to be available or even more desirably it may have permitted the use of a mechanical means to assist in the lift.

Two responses which seem more difficult to solve were the two instances when there just was not sufficient room for the extra miner to get hold of the object and one instance when the second miner was sick that day.

Multiple person lifting and handling is difficult to perform successfully since it requires all members of the group to lift evenly and constantly. Multiple person lifts are tough to perform under the best of environmental conditions, but most mining conditions complicate the situation. When situations require multiple person lifts to handle a heavy object, then a mechanical means of performing this activity is strongly recommended.

Table 34. - How Many Miners Normally Perform This Task?

<u>How Many Normally do Task?</u>	<u>Lost Time</u>		<u>Totals</u>
	<u>NO</u>	<u>YES</u>	
1	83	80	163
2	19	26	45
3	2	4	6
4	2	2	4
5	2	2	4
6	<u>0</u>	<u>2</u>	<u>2</u>
TOTAL	108	116	224

Table 35. - How Many Performed Task This Time?

<u>How Many Performed Task this Time?</u>	<u>Lost Time</u>		<u>Totals</u>
	<u>NO</u>	<u>YES</u>	
1	91	92	183
2	12	14	26
3	1	4	5
4	4	2	6
5	0	2	2
6	<u>0</u>	<u>2</u>	<u>2</u>
TOTAL	108	116	224

Table 36. - Why Was the Number of People Different
This Time?

<u>Why # People Differ This Time?</u>	<u>Lost Time</u>		<u>Totals</u>
	<u>NO</u>	<u>YES</u>	
N/A	95	107	202
Extra Miner was assigned elsewhere	2	0	2
Just no one else around	4	3	7
In hurry and did not bother to ask	6	4	10
No room for second miner	1	1	2
2nd person was sick	<u>0</u>	<u>1</u>	<u>1</u>
TOTAL	108	116	224

The question was posed, "Were other miners a factor in the injury?" In only eight injuries were other miners thought to be a factor as defined by the injured party. Five of these cases were NLT and three were LT. The reasons why other miners were a factor for the NLT injuries were:

- 1) scoop operator tilted the bucket unexpectedly (1 case);

- 2) someone else failed to do the job correctly (3 cases);
- 3) injured person was holding part for the welder (1 case).

For the three LT injuries there were three different reasons why other miners were thought to be a factor:

- 1) someone else failed to do the job correctly;
- 2) position of co-worker required twisting of the body;
- 3) they failed to size up the job.

Another question which was asked of the study participants was "Were communications a factor in your back injury?" The interview responses to this question indicated that in only six instances were communications thought to be a contributing factor to the accident. Four of these cases were LT injuries.

Training was thought by the injured to be a factor in 26 situations. For the 13 NLT cases the comment that training may have covered the activity was made in 11 cases while in the two remaining cases the injured thought that employees should be trained to keep the area clean (better housekeeping). For the 13 LT situations 12 stated training may have covered the activity and one suggested the training of the LW operators should include not to cut into soft bottom.

Of these 26 comments, 23 of the injured miners were uncertain as to whether the activity was covered in the injured's training. One implication of this is to suggest that the foreman frequently reinforce employee training by reminding employees of hazardous conditions of the task.

Table 37 shows the responses of the injured to the question "Do special hazards exist when performing this task?" For 98 of the 224 or 44% of the cases the injured party failed to identify a special hazard. For the 126 cases where a special hazard was identified the most frequently identified hazard in 19 cases was the object being too heavy. Bad top was denoted as a special hazard in 16 situations. In 13 instances the injured stated that the weight was heavy and awkward to handle. For 11 cases a rough roadway was described as the special hazard. A slippery walking surface was mentioned in 9 cases as the problem. Other hazards which were frequently mentioned were high frequency of lifting a moderate load, excessive push/pull force, awkward position and multiple floor obstacles. Other special hazards which were mentioned three or fewer times are also contained in Table 37.

The injured miners in 126 cases recognized that there was a special hazard associated with the activity they were performing. The remaining 98 injured personnel did not think there was a special hazard associated with the

activity they were doing. In a previous unpublished study performed by the authors where underground coal miners were asked to rate the relative level of hazardousness between mining equipment and tasks the authors found that miners were not particularly adapt at evaluating the relative hazardousness of situations. Perhaps training should focus more on aiding the miner to build a hazard knowledge base so he/she can more accurately identify the hazards associated with a given set of circumstances.

Table 37. - When Performing the Activity
Do Special Hazards Exist?

<u>Special Hazards</u>	<u>Lost Time</u>		<u>Totals</u>
	<u>NO</u>	<u>YES</u>	
No	51	47	98
Bolter operator couldn't reach hole	1	1	2
High frequency moderate lifting	2	4	6
Slippery walking surface	4	5	9
Bad top	7	9	16
Shoveling too high belt	1	0	1
Object too heavy	9	10	19
Bar could slip	2	1	3
Rough roadway	6	5	11
CM was jolting operator while cutting bottom	2	0	2
Lifting posture--didn't bend knees	2	1	3
Deenergize line before working on it	1	0	1
I-beams heavy and awkward	2	1	3
Trying to carry too many items at once	1	0	1
Excessive push/pull force	2	4	6
Deep water/unseen objects	1	0	1
Limited cab area and vision	1	2	3
Multiple floor obstacles	1	3	4
Heavy weight, awkward position	5	8	13
Awkward position	1	5	6
Two persons carrying heavy load	1	0	1
Cluttered floor	1	0	1
Shoveling to panline	2	1	3
Shoveling all shift	1	0	1
Opening mandoor from bottom up against high velocity air	1	0	1
Low seam height causes awkward position	0	3	3
Snag and sudden jerk	0	2	2
High frequency, low weight lifting	0	1	1
Heavy timbers	0	1	1
Excessive sitting & jarring vibrations	<u>0</u>	<u>2</u>	<u>2</u>
TOTALS	108	116	224

ACCIDENT ENVIRONMENT

The site of the injury is recorded in Table 38. As might be expected, most accidents occurred in the face area, which is normally where the highest concentration of miners is working for a continuous mining section. Of the 73 injuries in the face area 42 were LT while 31 were NLT for a ratio of LT to NLT injuries of 1.35 as compared to the ratio of 1.07 for the total study. This indicates that the back injuries which happened in the face area were generally more severe, since these resulted more frequently in LT injuries. These 42 LT injuries averaged 24 lost work days per injury. Six of these cases involved lost workdays which equaled or exceeded 90 days per case, with the highest being 120 days lost. The second most frequent area of the mine where back injuries were found to occur was a tie between the haulageway with 29 total injuries of which 12 were LT, and the underground areas away from active face having 29 total injuries with 15 being LT. The haulageway had fewer LT injuries than the study's ratio average for LT to NLT while the underground areas of the mines away from the active face were equal to the study's ratio.

For the twelve haulageway LT injuries the number of lost workdays averaged 21.5 days per injury. The two worst LT cases required 88 and 90 days off the job. For the category of underground area away from the active face there were 15 LT injuries, which averaged 11.1 lost

workdays per injury. One injury required 48 days off work while all others were under thirty days.

The longwall (LW) shield area resulted in 15 total injuries, with 11 being LT. The ratio of LT to NLT injuries is 2.75, which means 2.75 LT injuries for each NLT injury. This points to the LW shield area as a high potential area for LT back injuries. The eleven LT incidents in the LW shield area averaged 21 days off per injury with the most severe requiring 111 days off. Another area where a significant number of back injuries occurred is in the surface shop. A total of 15 injuries were recorded here, of which 5 were LT. The ratio of LT to NLT injuries was .5, which indicates that two NLT injuries were happening for each LT injury.

Table 38. - Injury Site Location

<u>Injury Site Location</u>	<u>Lost Time</u>		<u>TOTAL</u>
	<u>NO</u>	<u>YES</u>	
Longwall shield	4	11	15
Face area	31	42	73
Haulageway	17	12	29
Beltline	12	14	26
Surface--office area	6	2	8
Underground away from active face	14	15	29
Underground Maintenance shop	1	1	2
Track heading	1	3	4
Elevator	1	0	1
Returns	4	2	6
Travelway	3	1	4
Surface, heavy equipment	1	4	5
Longwall, T-gate, H-gate areas	1	2	3
Surface shop	10	5	15
Dump car loading area	1	0	1
Surface storage	1	0	1
Bathouse	0	1	1
Prep. plant	0	1	1
TOTALS	108	116	224

Table 39 presents mine height classification versus LT and NLT back injuries. Since the majority of mines in this study had mine heights greater than 72 inches and exposure hour data was not available it is inappropriate to try to draw conclusions concerning the importance of mine height versus frequency of back injuries. Rather this data is presented as factual information to demonstrate that over 77% of the back injuries studied occurred in mines with ceiling heights over 72 inches while 22% occurred in mines 42 to 72 inches in height and just two back injuries occurred in mines less than 42 inches. This should not be interpreted that fewer back injuries occur in the low mine height group since a very small number of participants in the study worked under this condition.

Table 39. - Mine Height Classification Versus Lost Time and Non-Lost Time Back Injuries

Mine Height Classification	Lost Time		Total
	Yes	No	
Crawling, duck-walking (<42 inches)	2	0	2
Bent to some degree (42 to 72 inches)	23	26	49
Walking (> 72 inches)	<u>91</u>	<u>82</u>	<u>173</u>
	116	108	224

Table 40 relates bottom conditions with the job being performed when injured and presents the frequency of LT injuries and the total lost work days. The general laborer classification experienced 16 LT injuries where bottom conditions were applicable and which resulted in an average of 27.8 days lost per injury. One of the more serious injuries resulted in 111 lost work days for a general laborer involved in walking over to fix the LW stage loader and catching his foot on a coil of cable. The bottom was slushy and muddy and in an effort to keep from falling he jerked his leg. The injured miner felt that poor footing and the sudden jerk and twist were the cause of his injury.

Sixteen miners suffered LT back injuries while performing the roof bolting task where bottom conditions were a factor. Their average stay off the job was 24 days, with the longest being 110 days.

The job of longwall jack/prop man experienced seventeen LT back injuries in which bottom conditions played a part. This resulted in an average of 20.8 lost workdays per injury. The most serious LT injury for this job classification resulted in 100 days lost. The injured was pulling a cable which stopped moving so he gave the cable a strong jerk which hurt his back. The bottom was in average condition.

Table 40. - Lost Time Injuries Per Bottom Condition
for Selected Job Working Classification

	Job Working When Injured					
	Jack/Prop Man		General Laborer		Roof Bolter	
Bottom Conditions	Lost Time Freq. Days		Lost Time Freq. Days		Lost Time Freq. Days	
Loose Rock & Coal	--	--	2	27	6	173
Average Conditions	4	154	5	151	4	100
Wet & Slippery	1	10	3	16	1	4
Dry	5	108	1	80	3	14
Rough & Rutted	1	4	1	6	1	5
Cluttered	--	--	1	10	1	88
Obstructed	3	42	--	--	--	--
Slushy & Muddy	3	36	3	154	--	--
	17*	354	16*	444	16*	384
Average Days Lost	20.8		27.8		24.0	

* Bottom condition did not apply to all LT injuries for each job classification.

Freq. = Frequency

Environmental conditions shown in Table 41 played a role in just nine of the 224 back injuries. Three of the nine back injuries were LT with two being the result of muddy and wet conditions and for the other injury cold was thought to be a contributing factor. For the six NLT injuries cold and muddy/wet conditions were a factor in two cases each while excessive water and cluttered floor were a factor in one injury each. The two muddy/wet cases plus the one cluttered case were responsible for slip and trip type of injuries.

Table 41. - Environmental Conditions as a Factor
in Back Injuries

<u>Condition</u>	<u>Lost Time</u>		<u>Total</u>
	<u>YES</u>	<u>NO</u>	
Cold	1	2	3
Excessive Water	0	1	1
Muddy/Wet	2	2	4
Cluttered Floor	0	1	1
Not Applicable	113	102	<u>215</u>
			224

DATE/TIME OF INJURY

Table 42 presents the shift being worked when injured and includes a breakdown of LT versus NLT back injuries. On day shift 119 or 53% of the back injuries occurred with 64 or 54% being LT injuries versus 55 of 46% NLT injuries. Second or swing shift experienced 67 or 30% of the injuries with 36 being LT. On midnight shift 38 or 17% of the back injuries happened with 16 being LT injuries. This investigation did not collect hourly exposure data by shift so it is not reasonable to compare the number of injuries between shifts to draw any inferences.

TABLE 42. - Shift Worked Lost Time Versus Non-Lost
Time Back Injuries

<u>SHIFT BEING WORKED</u>	<u>LOST TIME (frequency)</u>	<u>NON-LOST TIME (frequency)</u>	<u>Totals</u>
Day	64	55	119
2nd or Swing	36	31	67
Night/Midnight	<u>16</u>	<u>22</u>	<u>38</u>
TOTALS	116	108	224

As presented in Table 43, 11 of the 224 back injuries occurred while the miner was working overtime. Five of the 11 were LT. For two of the LT injuries the miner had performed the job of mechanic during their regular 8-hour shift. For the six NLT injuries which occurred on overtime the miner had performed a variety of jobs during the regular shift. These jobs consisted of mason work, mechanic, section foreman, roofbolter, and general inside laborer including shoveling.

Table 43. - Did Injury Occur on Overtime?

<u>On Overtime?</u>	<u>Lost Time</u>		<u>Total</u>
	<u>YES</u>	<u>NO</u>	
No	111	102	213
Yes	<u>5</u>	<u>6</u>	<u>11</u>
TOTALS	116	108	224

Table 44. - If Date of Injury Reported Was Different, Why?

<u>Reason</u>	<u>Lost Time</u>		<u>Totals</u>
	<u>Yes</u>	<u>No</u>	
Same Date -- injury reported on same day as it occurred	94	93	187
Unknown-- may have been reported on same date, but records were incomplete	13	8	21
Miner not immediately concerned	3	6	9
Pain did not start till later	2	0	2
No company policy on reporting injuries on the same day	<u>4</u>	<u>1</u>	<u>5</u>
TOTALS	116	108	224

Table 44 shows information concerning the timeliness of reporting the back injury. Just 16 of the 224, or just over 7%, were reported a day or more after the injury had occurred. In the early stages of the study one mine did not have a strict policy regarding the reporting of injuries on the same day of occurrence. This accounts for the "company having no policy" category. Later in the study this mine changed their policy and after that all mines had the requirement to report any injury on the same day it occurred. As the data shows this rule was followed except in eleven cases where the miners were not immediately concerned or the pain did not start till later.

TRAINING

The type of training each of the injured received and whether it was related to the task being performed when injured is presented in Table 45. In 31 cases the injured miner had not been trained while in 17 other instances the training given was not applicable to the situation which resulted in the injury. Therefore, in 48, or 21% of the cases the miner had received no useful training and 28 or 58% of these cases were LT injuries. In 74 or 33% of the cases the miner had received on the job training (OJT) which was the most popular form of training. General laborer (GL) task training was the second highest category as 42 or 19% of the interviewees had been instructed with GL training. Since this is usually the entry level job in the mine and the types of tasks performed by GLs vary

widely this is not a suprising result. As presented in Table 45 the job classifications of roof bolter, shuttle car operator, mechanic, continuous miner operator and face boss were listed as the type of training received by 7, 9, 10 and 17, respectively, of the injured.

Another question which was asked of the interviewees was whether they had been instructed in general lifting techniques. Table 46 indicates that 142 or 63% had been given some type of general lifting training with 73 of the miners in the LT group and 69 in the NLT group. In 67 or 31% of the cases no general lifting training had been received. The majority of the mines had provided some type of general lifting instruction to their employees.

This raises questions of "How effective is the training the miners are given and how relevant is it to reducing back injuries? Does general lifting training enable the miners to avoid back injuries in terms of frequency of occurrence and severity?" Can training by itself significantly impact the back injury problem? This study was not designed to answer these valid questions, however, it can be stated that 176 or 79% of the injured had received at least some training which applied to the situation.

Table 45. - Type of Training Received Versus Lost Time and Non-Lost Time Back Injuries

<u>Type of Training Received</u>	<u>Lost Time</u>		<u>Total</u>
	<u>No</u>	<u>Yes</u>	
None	14	17	31
Training not applicable to situation	6	11	17
General Labor Task training	25	17	42
On job training	36	38	74
Roof Bolter task training	7	10	17
SC task training	4	5	9
Mechanic task training	7	3	10
CM operator task training	3	6	9
Face boss, had all available training	3	4	7
Learned elsewhere	3	1	4
General task training for trackman	0	1	1
Motor operator training	0	1	1
Injured was trainer	0	1	1
Injured was being trained	<u>0</u>	<u>1</u>	<u>1</u>
TOTALS	108	116	224

Table 46. - General Lifting Training versus Lost Time and Non-Lost Time

<u>Did Miner receive General Lifting Instruction?</u>	<u>Lost Time</u>		<u>TOTALS</u>
	<u>NO</u>	<u>YES</u>	
Not applicable	9	6	15
No	30	37	67
Yes	<u>69</u>	<u>73</u>	<u>142</u>
Totals	108	116	224

SUPERVISION/INJURED MINER AGREEMENT

It is sometimes stated that there are major differences between supervision's opinion of an accident, and the injured person's view. In each case, we queried the mine administration with respect to the injury as reported, and found administrative hesitation in only 8 of the 224 (4%) cases. It should be noted however, that we did not interview injured miners when the mine management felt a legal issue was likely to develop over the injury because we did not want to complicate the legal situation. This happened in nine cases, so the rate of contention over the reality of the injuries may be higher.

In the eight cases we identified, we found four in which supervision felt that the injured miner was taking advantage of the situation to get time off, one in which supervision felt the injury happened off the job, and two in which the injury was blamed on labor-management difficulties -- the man was assigned to a job he did not like because of union activity, so the man claimed an injury.

Generally, however, this study found that there was good agreement between supervision's view of an injury's cause and the injured miner's opinion.

Of the 224 back injuries only two injuries were perhaps not work related. This was based on the authors' interviews and observations, company records and

discussions with company personnel. However, it is important to mention that the research team did not investigate every back injury that happened at each participating mine. In several instances employees had workman's compensation actions underway and did not care to discuss their injuries while in other cases the safety director suggested we skip an individual for reasons such as miner was on vacation, sick leave, miner did not care to discuss his/her injury, etc. The authors were most impressed by the cooperation they received when they interviewed the injured miners and the company personnel. Each one wanted to contribute and share his/her experiences and ideas.

CHAPTER 5

MATERIAL HANDLING ACTIVITIES

This chapter on material handling presents a series of summaries of the data collected with respect to lifting accidents. This includes postures, locations, mine variables, etc. This is followed by an evaluation of 45 material handling injuries.

LOAD HANDLING METHOD

Table 47 summarizes various ways in which loads were handled in 152, or 68% of the 224 injury cases. The most frequent category was lifting for which 42 injuries occurred; 19 of these were LT. The category of pull and lift contained 23 injuries, with 13 being LT injuries. Combining all categories which involved some element of lifting resulted in 107 injuries covering lifting, pull and lift, push, pull and lift, lift and twist, lift and carry, lift/twist and throw, push and lift, lift lying down and lifted and started to turn. Of these 107 injuries, 59 were LT versus 48 NLT. This represents a ratio of 1.23 LT to NLT back injuries, higher than the 1.07 ratio for the entire study. However, if the pure lift category is removed from this data, the other eight categories which include lifting plus another activity such as pull, push, twist, etc., resulted in a ratio of 40 LT to 25 NLT injuries or 1.6. This shows more LT back injuries than would be expected. Therefore, this would indicate that the combination of lift plus pull, carry, twist, throw, and/or

push is a potentially risky activity with respect to back injuries.

The next category was pull, with 18 injuries which were divided equally between LT and NLT back injuries. The shoveling activity contained 8 injuries which were equally divided between LT and NLT injuries. The push category showed 7 injuries of which just 2 were LT.

Table 47. - Handling of Loads: Push--Pull--Lift

<u>Push - Pull - Lift</u>	<u>Lost Time</u>		<u>TOTAL</u>
	<u>NO</u>	<u>YES</u>	
N/A	35	37	72
Push	5	2	7
Pull	9	9	18
Lift*	23	19	42
Pull and lift*	10	13	23
Push or pull	2	1	3
Push, pull, lift*	2	4	6
Lift and twist	3	5	8
Lowering load	1	0	1
Shoveling	4	4	8
Carry	3	3	6
Hold	1	0	1
Lift and carry*	6	5	11
Lift/twist and throw*	4	6	10
Push and lift*	0	5	5
Lifting lying down*	0	1	1
Swing sledge	0	1	1
Lifted and started to turn	<u>0</u>	<u>1</u>	<u>1</u>
TOTALS	108	116	224

* Combined to give a picture of all cases which contained an element of lifting.

LOAD/AGENT OF INJURY ANALYSIS

The loads/agents involved in the injury are presented in Table 48. In 150, or 67%, of the cases a load/agent was a

factor in the injury. The following is a list of the most frequent loads/agents.

1. Cable (19 cases, 8 LT)
2. Coal and rock (8 cases, 5 LT)
3. Cable and water line (7 cases, 4 LT)
4. Timbers and headers (7 cases, 5 LT)
5. Crib block(s) (6 cases, 4 LT)
6. Rock (4 cases, 2 LT)

Categories one and three involve cable and/or water line handling and account for 26 cases, of which 15 cases are LT. The handling of cable and/or water line has been identified by several variables as an important factor in back injuries. Some of these variables are activity at time of injury (Table 19), type of equipment in the injury (Table 31A), and primary equipment design factor (Table 32). These analyses point to the need for less strenuous methods for handling and hanging cable and/or water line. Later in the report there is a special cable handling section which addresses this problem.

Categories two and six include coal and/or rock which was load/agent in 12 cases, of which seven were LT injuries. Coal and/or rock were involved in the injury as the injured was either shoveling, lifting, or carrying it, or it fell and hit the injured party.

While performing the shoveling activity the injured were often twisting and/or lifting the loaded shovel and depositing the load on a conveyor belt which was above

shoulder height, or overstressing the body by trying to shovel too heavy a load or attempting to reach too far with the shovel. In several cases the injured tried to lift or carry too large a piece of rock instead of using a sledge hammer to break it into smaller pieces. The falling coal and/or rock scenario may have been a random event or a failure to check the condition of the top or rib.

Categories 4 and 5 include handling timbers, headers and crib blocks, which were the load/agent in 13 cases of which 6 resulted in LT injuries. Another heavy item which fits this category and was a factor in two additional injuries was I-beams. The handling of timbers, headers and I-beams usually involves multiple person handling due to their size and weight. Mechanical means of assisting the miners in handling these objects is needed to reduce the amount of lifting, carrying and holding during the positioning of the object.

Table 48 also shows that the handling of sheet steel, including access panels and doors on equipment, was responsible for 12 back injuries, with 4 of those being LT. In several cases the sheet steel was heavy and awkward and the worker should have had available and have used a mechanical means to assist in the handling of these heavy items. The access panels and doors are often made from 1/2 inch sheet steel, which makes them heavy and difficult to handle. Perhaps a lighter gauge of steel or a lighter material would be adequate.

Another generic group of items includes larger repair items such as rotation drill motor, track idlers for CM, LW push blocks, etc. This group resulted in 6 injury cases, 4 of which were LT injuries. Again, these objects, due to weight and/or size, require mechanical means to assist the miner in handling.

Table 48. - Load/Agent Involved in the Injury

<u>Load/Agent</u>	<u>Lost Time</u>		<u>TOTAL</u>
	<u>NO</u>	<u>YES</u>	
N/A	37	37	74
Rock	2	2	4
Coal and Rock	3	5	8
Curtain	1	2	3
Mandoseal or rockdust hose	2	1	3
Transfer pipe	1	0	1
Cable	11	8	19
Roof bolt and endcap	1	1	2
Spool of cable	1	0	1
Cable and waterline	3	4	7
Gathering head motor	1	0	1
5 ft. drill steel	1	0	1
Portable drill - 6 lbs.	1	0	1
Cover -- door over motor	2	1	3
Six self-contained rescuers	1	0	1
Pry bar - 18"	1	0	1
Bags of rock dust	1	0	1
Timbers and headers	2	5	7
Tool box	1	1	2
Rock duster	1	1	2
I-beam	1	1	2
Gear - 35 lbs.	1	0	1
Box of metal - 10 lb.	1	0	1
7200V power center cable	1	0	1
Refrax plate	1	0	1
Slate bar in well anchored top	1	0	1
5 gallon bucket of water	1	2	3
Crib blocks	2	4	6
Mandoor	1	0	1
Transit and tripod	1	0	1
Section of belt	1	1	2
Chain	2	0	2
Jack leg drill assembly	1	0	1
Prop	2	0	2
Grout pump	1	0	1
Pipe	1	1	2
Concrete block	1	0	1
Wrench	1	2	3
20 lb/ft rail	1	0	1
Box of resin	1	0	1
2 ft. socket wrench with 4 ft. cheater	1	1	2
Power center module--75 lbs	1	0	1
Power center panel--200 lbs.	1	0	1
24 x 18 x 0.5 inch metal--80 lbs.	1	0	1

Table 48. - Load/Agent Involved in the Injury(Cont'd)

<u>Load/Agent</u>	<u>Lost Time</u>		<u>TOTAL</u>
	<u>NO</u>	<u>YES</u>	
50 lb water spray bracket	1	0	1
Pieces of scrap metal	1	1	2
90 lb I-beam	1	0	1
Gofer	1	0	1
Mandoor which opened from bottom	1	0	1
Wash rag	1	0	1
Rerailer	1	0	1
Bundle of roof bolts	0	2	2
Rock dust box for RB	0	2	2
5 gallon bucket of shear bits	0	1	1
SC Access panel	0	1	1
Oxygen cylinder	0	1	1
Sheave block	0	1	1
Wooden tie with metal tie attached	0	1	1
Pry bar under 800 lb cylinder	0	1	1
12 foot roof bolt and wrench	0	1	1
Checking torque with torque wrench	0	1	1
Steel bar 12 ft long	0	1	1
2-5 gallon of oil	0	1	1
Light Item not otherwise specified	0	1	1
Beltline roller	0	2	2
Air pressure tank	0	1	1
Tongue on Low Boy	0	1	1
LW push blocks	0	1	1
DA ram	0	1	1
Pallet	0	1	1
Stretcher	0	1	1
Vent tube	0	2	2
Mop bucket	0	1	1
8 lbs. hand tool	0	1	1
Power center plug & cable	0	1	1
4' pry bar	0	1	1
Sledge hammer	0	1	1
Roof bolt	0	1	1
10 inch wide by 8 ft. 40 lbs. steel sheet	0	1	1
Rotation drill motor	0	1	1
Track idler for CM	<u>0</u>	<u>1</u>	<u>1</u>
TOTALS	108	116	224

LOAD CHARACTERISTICS ANALYSIS

Table 49 presents a summary of the loads which were judged to be bulky in terms of size, mass or volume. Of the 224 cases in the study, 131 did not involve loads or the loads were not rated as bulky. This leaves 93, or 42% of the cases where the load was described as being bulky. Loads which were in this category were cable and/or water hose, mandoseal hose (25 cases, 8 LT), I-beam (3 cases, 2 LT), LW cylinder (3 cases, 2 LT), timber (5 cases, 4 LT), etc.

Unstable or slippery loads were noted in 53, or 24% of the cases, as shown in Table 50. Mandoseal hose, cable and/or water hose and I-beam were the most frequent loads in the unstable or slippery category.

Table 49. - Bulkiness of Load Involved in the Injury

<u>Load - Bulky</u>	<u>Lost Time</u>		<u>TOTAL</u>
	<u>NO</u>	<u>YES</u>	
N/A	57	74	131
Yes	16	13	29
Cable, waterhose, mandoseal hose	17	8	25
200 lb. gathering motor for bolter	1	0	1
Bags of rock dust	1	1	2
Rock duster	1	0	1
I-Beam -- 350 lbs.	1	2	3
Refrax plate	1	0	1
LW cylinder	1	2	3
Mandoor	1	0	1
20 ft. of chain	1	0	1
LW prop -- 10 lbs.	1	0	1
Section of belt	1	1	2
Round timber	1	4	5
30 ft. long rail	1	0	1
2'x 4' x 0.25" steel panel	1	0	1
200 lb. power center	1	0	1
Scrap metal	1	0	1
90 lb I-beam	1	0	1
Broken down gofer	1	0	1
Rerailer	1	0	1
Tool box	0	1	1
Large oxygen cylinder	0	1	1
Wooden tie with metal tie	0	1	1
2-5 gallon of oil	0	1	1
130 lb. vent tube	0	1	1
Beltline roller structure	0	1	1
Crib block 36" x 6" x 8"	0	1	1
7' roof bolt	0	1	1
18" dia. by 20 ft. vent tube	0	1	1
Rotation drill motor	0	1	1
Track idler for CM	0	1	1
TOTALS	108	116	224

Table 50. - Unstable or Slippery Load Involved in the Injury

<u>Load - Unstable/Slip</u>	<u>Lost Time</u>		<u>TOTAL</u>
	<u>NO</u>	<u>YES</u>	
N/A	78	93	171
Yes	10	9	19
Mandoseal hose will whip	1	1	2
Cable, water hose	14	7	21
I-beam, 350 lb.	1	1	2
Mandoor	1	0	1
Jack leg drill	1	0	1
200 lb. power center	1	0	1
90 lb. I-beam	1	0	1
800 lb. LW cylinder	0	1	1
Mop bucket full of water	0	1	1
Tongue on low boy	0	1	1
Bending roof bolt	0	1	1
Track idler for CM	0	1	1
TOTALS	108	116	224

Table 51 presents a summary of loads where the shape of the load contributed to the injury. Once again cables and/or water hose and mandoseal hose were the most frequent types of loads, involved in 29 injuries, of which 12 were LT. Headers and timbers in the (4"x8"x14' range) led to five injuries, of which four were LT. Handling of crib blocks contributed to five injuries, of which three were LT. Shoveling was cited as the activity in five cases, with three resulting in LT injuries.

In summary, the handling of bulky loads, unstable or slippery loads and/or loads where shape was a factor point to a similar conclusion: that for most of these types of loads mechanical aids or improved procedures should be available to assist the miner in lifting, carrying, holding, positioning, etc., of the loads.

Table 51. - Shape of Load Contributed to Injury

<u>Load - Shape</u>	<u>Lost Time</u>		<u>TOTAL</u>
	<u>NO</u>	<u>YES</u>	
N/A	42	51	93
Cable, water hose, mandoseal hose	17	12	29
Five foot plastic pipe	1	0	1
12 ft. roof bolt plus end cap	1	1	2
4 ft. spool of cable	1	0	1
200 lb. gathering motor	1	0	1
5 ft. drill steel	1	0	1
Less than 10 lbs.	1	0	1
Steel - 52 lbs. and 50" L x 13"W x 5"H	1	0	1
50 lb. Rock dust bags	1	1	2
4"x8"x14', headers and timbers	1	4	5
Rock - 200 lb.	1	0	1
Rock duster - 150 lb.	1	0	1
Tool box -- 140 lbs., 48" long	1	1	2
5 Gallon bucket of shear bits	1	1	2
Muddy curtain 7' x 70'	1	1	2
Five foot long cylinder	1	1	2
Gear -- 35 lbs.	1	0	1
Box of metal -- 10 lbs.	1	0	1
Refrax plate -- 150 lbs.	1	0	1
Slate bar -- 25 lbs.	1	1	2
Torque wrench	1	1	2
Crib block 36" x 6" x 8"	2	3	5
Mandoor	1	0	1
Transmit and tripod	1	0	1
20 ft. of log chain -- 100 lbs.	1	0	1
130 lb. DA ram	1	1	2
6" x 8" x 6' prop	1	1	2
Belt section	1	2	3
Shoveling	2	3	5
Grout pump	1	0	1
20 ft. of pipe	1	1	2
Jack leg drill	1	0	1
30 ft. long rail	1	0	1
8" x 8" x 10' timber	1	0	1
2' x 4' x 0.25" panel door	1	0	1
Box of resin	1	0	1
2 ft. socket wrench pipe	1	0	1
Power Center module	1	0	1
5 ft. square steel	1	0	1
24 x 18 x 0.5 inch metal sheet	1	0	1
50 lb. water spray bracket	1	0	1
Pieces of scrap metal	1	0	1
3 ft. I-beam	1	0	1
Gofer	1	0	1
Rock -- 20 to 30 lbs.	1	0	1
Pulling up to open a vertical mandoor	1	0	1

Table 51. - Shape of Load Contributed to Injury(Cont'd)

<u>Load - Shape</u>	<u>Lost Time</u>		<u>TOTAL</u>
	<u>NO</u>	<u>YES</u>	
Rag	1	0	1
Rerailer	1	0	1
400 lb. dust box for RB	0	1	1
550 lbs. piece of steel	0	1	1
Scoop panel - 1/2" x 48" x 30"			
10 ton jack	0	1	1
350 lbs. of I-beam	0	1	1
Wooden tie and metal tie - 75 lbs.	0	1	1
LW Cylinder - 800 lbs.	0	1	1
5 ft. RB w/plate	0	1	1
5 gallon container	0	2	2
12' - 3" diameter steel bar	0	1	1
2-5 gallon cans of oil	0	1	1
150 lb. LW push block	0	1	1
50 lb. air pressure tank	0	1	1
50 lb., 4 ft. belt roller	0	1	1
Vent tube 2 ft. diameter x			
15 ft. long	0	1	1
Box of bolting glue	0	1	1
Bundle of roof bolts	0	1	1
42" roller structure	0	1	1
Power center plug & cable	0	1	1
Tongue on low boy	0	1	1
7' roof bolt	0	1	1
Piece of sheet metal			
(.5" x 10" x 12")	0	1	1
2 ft. socket wrench plus 4 ft.			
cheater	0	1	1
10" by 8 ft. long steel sheet	0	1	1
Wrench	0	2	2
20 ft. by 18" vent tube	0	1	1
Rotation motor for RB	0	1	1
Track idler for CM	0	1	1
Blocks and Rails	<u>0</u>	<u>1</u>	<u>1</u>
TOTALS	108	116	224

Table 52 presents data on whether the load possessed handles or was grippable. In 74, or 33% of the cases this was not relevant, since these cases did not involve handling a load. Of the remaining 150, or 67% of the cases, which involved handling a load, in two thirds of these cases the load possessed handles or was judged to be grippable. In the remaining 50 cases the load did not contain handles nor was it grippable, resulting in 22 LT and 28 NLT injuries.

Table 52. - Loads with Handles/Grippable

<u>Load - Handles/Grippable</u>	<u>Lost Time</u>		<u>TOTAL</u>
	<u>NO</u>	<u>YES</u>	
N/A	37	37	74
No	28	22	50
Yes	43	57	100

LIFTING BEHAVIOR ANALYSIS

Table 53 presents how the load was grasped in terms of symmetry in the sagittal plane, hand positions, and whether the object possessed handles or was grippable. This was a relevant question in 146, or 65% of the 224 cases. In 52, or 23% of the cases the injuries involved a symmetric loading of the body about the sagittal plane, while in 94, or 42% of the injuries, the scenario resulted in an asymmetric loading of the body which resulted in an imbalance of physical loading on the body about the

sagittal plane. This imbalance in body loading requires a more complex set of responses of the neuromusculoskeletal system than a symmetric lift.

For symmetric handling of load cases, 24 resulted in NLT injuries and 28 resulted in LT injuries for a total of 52 back injuries. The breakdown for asymmetric lifts was 44 NLT and 50 LT cases for a total of 94 cases. Asymmetric handling of loads was responsible for 1.8 times more back injuries in this study than symmetric handling. This indicates that asymmetric handling when compared to symmetric handling may significantly increase the risk of a back injury. Therefore, when handling loads, asymmetric lifting should be avoided whenever possible.

The scenario of how the load was grasped which resulted in the most (34) back injuries, was an asymmetric lift without handles and the hands underneath the object. The second most frequent description, which resulted in 23 injuries, was a symmetric lift possessing the same characteristics: no handles and the hands underneath the object. The third most frequent scenario, causing 17 back injuries, was an asymmetric handling situation in which two hands were grasping a load over one shoulder. This was observed in the handling of power cables and/or water hose. This situation resulted in 11 LT incidents as compared to 6 NLT injuries. This represents a high ratio of LT to NLT injuries of 1.8 times as many LT injuries as

NLT injuries. The fourth and fifth most frequent scenarios involved the same conditions of no handles on the object with hands on the sides of the object for asymmetric (14 injuries) and symmetric (13 injuries) handling.

In summary, asymmetric handling appears more risky than symmetric; 1.8 times more injuries involved asymmetric handling. However, there appears to be no difference in the ratio of LT versus NLT injuries between the asymmetric and symmetric handling.

Table 53. - How Was the Load Grasped?

<u>How Was Load Grasped?</u>	<u>Lost Time</u>		<u>TOTAL</u>
	<u>NO</u>	<u>YES</u>	
Sym* lift with handles	1	4	5
Sym w/o handles, hands on sides	6	7	13
Sym w/o handles, hands underneath	10	13	23
Asym** with handles	4	7	11
Asym w/o handles, hands on side	8	6	14
Asym w/o handles, hands underneath	16	18	34
Sym w/o handles, arms extended, push	1	1	2
Asym one hand	6	2	8
Sym, one in each hand, with handle	1	0	1
Asym, two hands over shoulder	6	11	17
Sym, grippable, hands on top	1	2	3
Sym, 2 hand grasp behind back, grippable	1	1	2
Asym, two hands in front	1	1	2
Sym, extended reach, using tool	2	0	2
Sym, w/o handles, hands on top	1	0	1
Asym, one hand under--one behind	1	0	1
Asym, one hand on top	2	0	2
Asym grippable, not lifted	0	3	3
Asym, 1 item in each hand - shoulder level	0	1	1
Asym, one hand, handle	<u>0</u>	<u>1</u>	<u>1</u>
TOTALS	68	78	146

* Sym = Symmetric

** Asym = Asymmetric

Table 54 presents the action of reaching which was involved in 106, or 47% of the injury cases, of which 51 were LT. The asymmetric categories of reaching forward while lifting (17 injuries, 7 LT), reaching forward while pushing (9 injuries, 4 LT), reaching overhead (8 injuries, 3 LT), and reaching forward while pushing, lifting, and pulling (10 injuries, 6 LT) combined for 44 of the 106 back injuries in this summary, with 20 being LT injuries. Asymmetric reaching resulted in over 41% of the injuries in this table, while 39% of the LT injuries were attributed to asymmetric reaching.

Table 54. - Position of Arms During Activity

<u>Arm Position</u>	<u>Lost Time</u>		<u>TOTAL</u>
	<u>NO</u>	<u>YES</u>	
N/A	53	65	118
Reaching, asym* throwing twist	5	8	13
Bending, asym reach to one side	10	4	14
Asym reaching forward while lifting	10	7	17
Asym reaching forward while pushing	5	4	9
Asym reaching overhead,	5	3	8
Bending forward -- sym**	4	6	10
Arms extended forward -- pulling & backing up	2	6	8
Walking, kyphosis, arms behind back	1	0	1
Asym reaching forward while push, lift, pull	4	6	10
Lifting & pulling across body with twist motion	5	2	7
Leaning sideways to drop object	2	0	2
2 persons carrying panel asym load on right hand	1	0	1
Asym reach, stoop, washing movement	1	0	1
Hold curtain w/ hands behind body	0	1	1
Reaching overhead, sym	0	2	2
Reaching sideways lying down	0	1	1
Standing and turning with arms	<u>0</u>	<u>1</u>	<u>1</u>
TOTALS	108	116	224

* asym = asymmetric

**sym = symmetric

Table 55 presents the frequency of handling the agent involved in the injury. An interesting result of this table shows that items rarely handled (less than one per shift) resulted in 30 back injuries and the ratio of LT to NLT was 2.0 versus the ratio of 1.07 for all injuries in the study. This may indicate there is a need for better

task procedures, refresher training and/or handling equipment when moving loads which are rarely handled.

Table 55. - Handling Frequency of Agent Involved in Injury

<u>Handling Frequency</u>	<u>Lost Time</u>		<u>TOTAL</u>
	<u>NO</u>	<u>YES</u>	
Frequent, more than 3 per hour	15	16	31
One to three per hour	28	16	44
Infrequent, less than 1 per hour	14	19	33
Rare, less than 1 per shift	10	20	30
Full shift continuous shoveling	2	4	6
30 Minutes continuous shoveling	<u>3</u>	<u>2</u>	<u>5</u>
TOTALS	72	77	149

Tables 56 and 57 present information concerning the obstructions to movement of the load and the lifter's body. In 42, or nineteen percent of the cases there were obstructions to the movement of the load; 28 of these incidents resulted in LT back injuries while 14 were NLT back injuries. This demonstrates a ratio of two LT back injuries for every NLT back injury which is a high ratio compared to the fact that there were 116 LT versus 108 NLT injuries in the study which is a ratio of 1.07.

The problem of limited vertical and horizontal clearance made it more difficult to move the load in 20 cases, of which 13 resulted in LT back injuries. The second major problem was equipment in the movement path which

contributed to 13 injuries, of which 11 were LT. Therefore, based on this information it appears that when obstructions to the movement of a load are present the risk of a LT back injury is greater. This is due to the person modifying his/her posture to accommodate the circumstances, frequently resulting in an awkward asymmetric posture. Therefore, when obstructions to movement of the load are present, alternatives to manual handling of the load should be considered. If equipment is in the way move the equipment before moving the object. Also, consider using a mechanical device to move the load.

In Table 57 a summary is shown concerning the obstructions to movement of the injured employee's body and how this relates to LT and NLT injuries. A total of 45, or 20% of the cases contained a problem with restricted movement of the lifter's body, with 22 incidents resulting in LT injuries.

Table 56. - Obstructions to Movement of the Load

<u>Obstructions</u>	Lost Time		<u>TOTAL</u>
	<u>NO</u>	<u>YES</u>	
Limited vertical + horizontal clearance	7	13	20
Equipment in movement path	2	11	13
Limited ceiling height (less than 55")	3	0	3
Item wedged between timbers	1	0	1
Drill stuck in hole	1	0	1
Floor cluttered (cribs & blocks)	0	1	1
Had to lift over edge	0	1	1
Pinned against rib	0	1	1
Floor cluttered with pieces of metal	0	1	1
TOTALS	14	28	42

In 17 cases the cause for restricted movement of the lifter's body was limited ceiling height, while in 11 cases there was equipment in the path of the worker which limited body movement. The third most frequent cause (7 cases) was that the lifter could not get close enough to lift the load. The fourth most frequent cause was tight clearance between equipment.

For this variable of restricted movement of the injured person's body there did not appear to be any difference in the frequency of LT versus NLT injuries as the ratio was 22 to 23, or nearly one. However, in 17 cases equipment was the reason for the obstruction and in most cases it could have been moved before the object was lifted, thus removing the obstruction.

Table 57. - Obstructions to Movement of the Injured Employee's Body

<u>Obstructions</u>	Lost Time		<u>TOTAL</u>
	<u>NO</u>	<u>YES</u>	
Tight clearance between equipment	4	2	6
Couldn't get close enough to lift	4	3	7
Limited ceiling height	8	9	17
Equipment in path	5	6	11
Couldn't get close enough to apply force	1	1	2
Stuff in walkway	1	0	1
Body twisted due to obstruction	<u>0</u>	<u>1</u>	<u>1</u>
TOTALS	23	22	45

One of the most variable environmental conditions in underground coal mining is the condition of the bottom. Table 58 presents the bottom conditions for applicable incidents in this study.

In 189 cases where this question was applicable the most frequent bottom condition (45 cases) was described as dry, while in 39 incidents the bottom was judged to be average, which might have included coal and/or rock dust and some dampness. The conditions of loose rock and coal and wet and slippery described the conditions in 27 cases each, for a total of 54. Bottom conditions were slushy/muddy for 17 incidents, while rough and rutted described conditions in 16 cases.

In the comparison of NLT to LT injuries, dry conditions resulted in 26 NLT and 19 LT incidents. This may indicate that miners were hurt less seriously when handling loads on dry surfaces as compared to 18 NLT and 21 LT injuries for the scenario of average conditions where some coal and/or rock dust and dampness were present; 14 NLT and 13 LT injuries for the scenario of loose rock and coal; 8 NLT and 8 LT injuries for the scenario of rough and rutted bottom; 13 NLT and 14 LT injuries for the scenario of wet and slippery; and 7 NLT and 10 LT injuries for the scenario of slushy/muddy.

Bottom areas which were very obstructed or cluttered with cribs were the scene of 4 NLT and 11 LT injuries. This is 2.75 times more LT injuries as compared to NLT injuries for these bottom conditions.

This data emphasizes the importance of a good coupling of the person performing the lift and the bottom or floor area. It also suggests that this coupling or footing may be a good variable in determining the severity of back injury as indicated by the categories of NLT versus LT injuries.

The ratio of LT to NLT injuries for dry conditions was .73 as compared to 1.17 for average conditions, .93 for loose rock and coal, 1.0 for rough and rutted, 1.08 for wet and slippery and 1.43 for slushy/muddy. Therefore, slushy/muddy conditions appear to contain the greatest risk for a LT injury.

Table 58. -Condition of Bottom Area Where Injury Occurred

<u>Bottom Condition</u>	<u>Lost Time</u>		<u>TOTAL</u>
	<u>NO</u>	<u>YES</u>	
Loose rock and coal	14	13	27
Average floor conditions	18	21	39
Wet and slippery	13	14	27
Dry	26	19	45
Rough and rutted bottom	8	8	16
Very obstructed area	4	7	11
Slushy/muddy	7	10	17
Cluttered with cribs	0	4	4
On top of equipment	0	2	2
Wet scoop bucket	<u>0</u>	<u>1</u>	<u>1</u>
TOTALS	90	99	189

CHAPTER 6

EVALUATION OF MATERIAL HANDLING INJURIES

This section provides a review of 45 material handling back injuries. These injuries were selected based on a definition of material handling that includes activities associated with production end use, production supply, section move, and mine maintenance, but excluding activities such as cable handling equipment maintenance and shoveling. This breakdown is generally consistent with that used by Unger (1986).

In order to have a clearer understanding of the injuries included in this grouping of material handling injuries the following terms are defined:

- A) Production end use is the handling of items during their end use at the working face, such as rock dusting, roof bolting and erecting temporary ventilation curtains.
- B) Production supply is the handling of materials from the surface storage areas to locations near the working face, but excluding the actual end use handling.
- C) Section move includes the handling of materials as mining proceeds from one production section to another, such as hauling belts, tearing up or laying rails or moving longwall face supports, etc.

D) Mine maintenance involves handling of supplies for maintenance of the mine and includes erecting permanent ventilation stoppings, cribbing for roof support, etc.

Excluded from this material handling accident summary were shoveling and cable, curtain and hose handling activities as these are discussed in chapter 8 of this report. The handling of equipment maintenance items was also not included.

The forty-five material handling back injuries included twenty-two LT injuries with an average of 13.8 lost days per LT injury, 15 sudden movement injuries of which eight were LT, 16 cases where sudden movement may have occurred, and four injuries in which employee posture was a factor. Eight back injuries happened during production end use activities, nine during production supply, nine during section move and nineteen during mine maintenance. The range for lost days ranged from 1 to 90. The material handling activities were subdivided into the five following categories:

- 1) Lift and carry (21 injuries/11 LT);
- 2) Jerk and/or twist (10 injuries/3 LT);
- 3) Throw objects (5 injuries/3 LT);
- 4) Lift pull and/or push (5 injuries/4 LT); and
- 5) Lift and reach (4 injuries/1 LT).

LIFTING AND CARRYING INJURIES

The first category of material handling injuries contains those activities where miners were lifting and carrying timbers, I-beams, cribs, blocks, props., etc. The statistics are as follows for this category of lifting and carrying:

- . Twenty-one back injuries;
- . Eleven LT injuries;
- . Three sudden movement related injuries;
- . Ten questionable sudden movement related injuries;
- . One posture related injury;
- . Two injuries which occurred during production end use activities;
- . Four injuries that happened during production supply activities;
- . Five injuries which were associated with section move activities; and
- . Ten injuries which happened during mine maintenance activities.

The following are some briefly stated scenarios from among the 21 cases in this category.

- A miner moved fifty timbers (6"x8"x14') during shift for a longwall move. The timbers were lifted from ground level, carried to and put through a mandoor and carried to a scoop on the other side of the mandoor. The employee lost four days.

- A miner carried 45 cribs 30 feet while building cribs during half the shift. Near the end of this activity he felt pain. This was a NLT injury.
- During the shift the miner was building an overcast, which included lifting and carrying I-beams, timber, blocks, etc. This employee lost 21 days.
- Most of the shift was spent carrying props around a longwall shield area. The injured man and another miner were carrying a DA cylinder through the shield area when he was injured. This was a LT injury and the employee missed seven days.
- A mechanic went to get a rotation drill motor for a roof bolt at the underground shop. He lifted and carried the drill motor over to and placed it in the gofer. He lost three days due to the injury.

In 62%, or 13 cases the miner(s) involved should or could have used a mechanical means of assisting him/her in handling the load. In five cases the mechanical means was not available in the mine. Equipment and methods are needed to replace manual handling of timbers, I-beams and other heavy, bulky items. In four incidents the injured stated that the mechanical means was available, but inconvenient to obtain; in three cases miners were in too much of a hurry. In one instance the supervisor would not allow the use of a chain connected to a scoop to move a DA cylinder down the shield line. The longwall shield area is

usually a difficult area due to limited vertical and horizontal clearances in which to handle replacement parts, five gallon cans of fluids, props, etc. The material handling in this area needs to be studied and mechanical aids and procedures developed to reduce the amount of manual effort presently required.

Other alternative ways of preventing the injury may have been the addition of another person to assist with the task or to lift less weight. However, the same responses surfaced: inconvenient, in a hurry, failed to size up the job, etc. In general, the normal solution to performing a material handling task seems to be some form of manual handling of the situation. This attitude needs to be changed by providing the workforce with several options involving straightforward mechanical aids plus procedures to assist the miners in material handling.

JERKING AND TWISTING INJURIES

The second category of material handling injuries includes activities in which miners were jerking and/or twisting during lifting of the load. A summary of the statistics for this category of material handling is as follows:

- . Ten back injuries;
- . Three LT injuries;
- . Eight sudden movement related injuries;
- . Two questionable sudden movement related injuries;
- . Three posture related injuries;

- . Three injuries which occurred during production end use activities;
- . Three injuries which happened during production supply activities;
- . One injury that resulted from section move activities; and
- . Three injuries that involved mine maintenance activities.

Several of the case scenarios are cited to provide an overview of why and how each injury occurred.

- A miner picking up and moving crib block out of the way to set a ventilation fan. He was twisting the upper part of his body during this process and lost two days of work.
- A miner was carrying a five gallon jug of water and his hard hat hit a cable and was falling off. He jerked his head to the side, attempting to keep his hard hat from coming off his head, and twisted his back. This was a NLT injury.
- A miner was squatting while lifting a wooden tie fastened to a metal tie. The bottom was muddy and the ties were stuck in the mud. As he applied more lifting force they suddenly started to move resulting in a sudden movement of his body, which jerked as he tried to keep his balance. This resulted in thirty lost days.

-- Two miners were carrying a five-foot-square piece of steel weighing 200 pounds when one miner dropped his end, jerking the other miner and injuring his back. This was NLT injury.

-- An employee was removing 8"x8"x10' timbers from a scoop bucket. They were wedged tight so he had to jerk on several to get them loose. This was a NLT injury.

In summary, the training of miners should include an emphasis on positioning the body to eliminate or minimize twisting of the body and to avoid jerking on loads. If the object cannot be lifted or moved with a steady application of force, one should use a pry bar or mechanical means to lift or move the load. In 40% of the cases, the response was given that it was inconvenient; in 20% of the cases miners were in a hurry; and in 30% of the cases they failed to size up the task. In nine of the ten cases there was an alternative approach available which was a "potentially" safer method. In the remaining case the shift was short one miner that day. As in the lifting and carrying category, the prevalent attitude is one of manual material handling instead of using the mechanical aids which are available or developing improved aids and procedures.

THROWING OBJECT INJURIES

The third category includes cases where the injured was throwing an object during the lifting process. The breakdown of these injuries is as follows:

- . Five back injuries;
- . Three LT injuries;
- . Two sudden movement related;
- . Three questionable sudden movement related;
- . One injury which occurred during production end use activities;
- . One injury which resulted from section move activities; and
- . Three injuries that happened during mine maintenance.

The following injury scenarios provide insight as to the types of tasks which were being performed in the throwing category:

- A miner was working on the beltline when he bent over, picked up a crib block and threw it in an awkward position. He felt pain in his back. This was a LT injury which lasted fifteen days.
- The crew was involved in retreat mining and the injured miner was pulling eight foot round timbers and tossing them onto the CM. As he was throwing one he felt a pain in his back. He also had to pull and jerk on some of the timbers and he was in a hurry.
- A piece of metal weighing about 40 pounds was on a low cart. The injured was in an awkward position as he lifted one end, pulled and threw the piece to the side. He was injured and lost 49 days from work.

In these five cases the most frequent scenario was lifting and throwing a heavy object from an awkward position. Again, the reasons given for performing these tasks in the way they were performed were that the injured was in a hurry or it was convenient to do it the way it was done. In the retreat mining case injury the reason of being in a hurry is understandable, but is manually jerking on timbers to loosen them and then manually carrying and tossing the timbers onto the CM the best way?

LIFTING AND PUSHING OR PULLING INJURIES

The fourth category of material handling includes those injuries which resulted from activities which involved lift, pull and/or push. The following provides an overview of these injuries:

- . Five back injuries;
- . Four LT injuries;
- . One sudden movement related injury;
- . One questionable sudden movement related injury;
- . Two injuries not related to sudden movement;
- . One injury related to posture;
- . Two injuries which happened during production end use activities;
- . Two injuries which resulted from section move activities; and
- . One injury that occurred during mine maintenance.

The following injury scenarios describe cases where the load/agent was being lifted, pulled and/or pushed.

- Three miners were lifting a six inch by sixteen foot I-beam. It was on the ground and the miners needed to place it on a support which was 36 inches high. They were pulling and pushing on the I-beam while lifting it. One of the three miners was injured on this task and he lost one day of work.
- The injured was pulling 48 inch belt off of a roll during a belt move. He felt pain in his back and lost four days.
- The injured was crouching on top of a CM supporting a ventilation tube while attempting to extend it to the face. He was pushing and pulling while in an awkward position. This resulted in a LT injury of three days.

The scenario where three miners were attempting to lift a 350 pound I-beam from the bottom of the mine to a 36 inch high support is an excellent example of the need for a mechanical aid. It is difficult to perform multiple person lifts without sudden load shifts or overloading of one or more of the participants. Therefore, when more than one person is required due to the weight of the load, a mechanical aid is a good alternative. In two instances the injured party would have used a second person, but the shift was short one miner.

LIFTING AND REACHING INJURIES

The fifth category involved lifting and reaching activities. These injuries are described as follows:

- . Four back injuries in this category;

- . One LT injury;
- . One sudden movement related injury;
- . Two posture related injuries;
- . One was not sudden movement related;
- . Two injuries which resulted from production supply activities; and
- . Two injuries that occurred during mine maintenance tasks.

The following descriptions relate the characteristics of several injuries in the lift and reach category.

- A miner carried a bundle of ten roofbolts at knee height. When he approached the roof bolter, he lifted and reached out to put them on the roof bolter. He felt a pain in his back. This resulted in a LT injury of ten days.
- The injured bent over to pick up a heavy piece of 1/2 inch thick steel sheet. He had to extend his reach to get the steel due to obstructions. This was a NLT injury.
- Two employees were building an overcast. They had been lifting blocks and other supplies over and under the beltline. The two were carrying a mandoor around the beltline requiring the injured to extend his reach while lifting. This was a NLT injury.

In this lift and reach category the injured were handling heavy objects with their arms extended forward of the

body. This means the center of mass of the object had a longer lever arm with respect to the body. Therefore, the back muscles had to exert a greater force to balance the forces created by the load. In three of the cases the injured was physically prevented from getting closer to the load due to some obstruction. One should either move the obstruction allowing proper positioning of the body or use a mechanical handling aid. In the case of the roof bolts, the miner was handling a bundle of tin which is a bulky, heavy load. A smaller bundle of five bolts would be more manageable.

In summary the material handling injury section points accusingly toward the attitude "to get things done." While this is commendable, this attitude frequently leads to the manhandling of loads which could be more safely handled using mechanical aids. A mechanical means is quite often available, but is viewed as not being very effective so the task is undertaken applying manual means.

Mechanical handling assists are particularly needed in the movement of parts and supplies on the longwall sections. Also techniques for handling timbers, I-beams, rail, etc. need to be developed to reduce the component of manual effort required to accomplish these tasks. The coordination in the providing of supplies to the mine sections is often not well organized. This results in multiple manual handling of supplies and frequently wasted supplies. Both add cost to the production of coal.

CHAPTER 7

INJURY DETAIL AND MEDICAL TREATMENT

Medical care is a critical, but often overlooked, part of a company's back injury management and cost control program. This is easily put in perspective when one considers the fact that once a back injury happens the amount of time lost from work due to the injury is completely determined by the injured miner and the attending doctor -- and most miners are quite willing to accept a doctor's offer of time off from work to let the injury heal. Thus, in reality, unless a mine or mining company remains in very close contact with the doctors its miners visit, they are "at the mercy" of the doctors when it comes to controlling LT. (One could argue that it is injury severity that determines the amount of LT, but this really only applies when surgery is necessary. In the other cases, the diagnosis is often an "educated guess." Without a good diagnosis it is hard to select the correct treatment and there are numerous conflicting schools of thought as to the correct treatment for a given injury.)

Given the criticality of medical treatment and the relative remoteness of most mines from medical treatment, data was collected about the medical care received by the miners after being injured. This data was collected from both the miners and the records held by the safety departments. The medical care received was broad in scope and quality -- in general, however, both mines and miners

were dissatisfied. Medical issues are summarized in the following tables: 1) individual summary tables; and 2) comparison of different aspects of treatment.

INJURY LOCATION

Table 59 summarizes the injury site by LT and NLT injury. Many injuries involved more than one site, and data was collected on the two dominant sites. Thus, there are more than 224 data entries in this table. The table shows that the location of LT back injuries is evenly divided between sides of the body, whereas the center of the back is the more frequent site for NLT injuries. The vertical location most likely to be injured is around the beltline (anatomically, this is along the top of the iliac crests from the left to the right side of the back) for both LT (40.9%) and NLT (43.8%) injuries. The second most common location is in the soft tissue between the base of the ribs and the top of the iliac crest (LT = 16.7%, NLT = 24.9%).

PAIN DESCRIPTION

Table 60 summarizes the descriptions of the pain. Many people used more than one adjective to describe their pain, so this table also has more than 224 entries. The most common description for both LT and NLT injuries was a sharp or stabbing pain. The next most common were a burning sensation and a dull ache. Together they accounted for 76% of the described pain.

DIAGNOSIS

Table 61 summarizes the diagnoses received by the injured miners. Here again the total exceeds 224 entries due to multiple diagnoses. The most common diagnoses were muscle strain/sprain (49.5%), disc damage (13.7%), and pulled muscle (12.1%). Together they accounted for 75% of the diagnoses.

Table 59. - Part of Back Injured

<u>Back Location</u>	<u>Lost Time</u>		<u>TOTAL</u>
	<u>NO</u>	<u>YES</u>	
Back-neck	9	14	23
Left cervical	2	0	2
Left thoracic	4	2	6
Left soft tissue	13	6	19
Left beltline	9	24	33
Left hip, buttock	5	7	12
Left leg	4	7	11
Center cervical	0	3	3
Center thoracic	5	6	11
Center soft tissue	11	12	23
Center beltline	32	25	57
Center hip, buttock	8	5	13
Right cervical	1	2	3
Right thoracic	0	2	2
Right soft tissue	9	9	18
Right beltline	16	15	31
Right hip, buttock	3	14	17
Right leg	0	6	6
Beltline all across	1	2	3

Table 60. - Description of Pain

<u>Description</u>	<u>Lost Time</u>		<u>TOTAL</u>
	<u>NO</u>	<u>YES</u>	
Sharp	56	70	126
Dull ache	20	12	32
Burning sensation	17	16	33
Numbness or tingling	7	6	13
Tightness	4	6	10
Pulling sensation	3	6	9
Tearing sensation	1	3	4
Like muscle spasm	3	6	9
Pinch or sting	0	5	5
Other	5	4	9

Table 61. - Back Injury Diagnosis

<u>Description</u>	<u>Lost Time</u>		<u>TOTAL</u>
	<u>NO</u>	<u>YES</u>	
Muscle sprain/strain	34	60	94
Pinched nerve	3	9	12
Pulled muscle	9	14	23
Bruise	7	4	11
Disc damage	10	16	26
Spinal misalignment	3	4	7
Muscle spasm	1	3	4
Fracture	1	2	3
Facet joint sprain	0	3	3
Genetic defect	1	1	2
Torn ligament	3	2	5
None	39	10	49

A detailed comparative analysis of the three variables revealed there was no consistent pattern among them -- that is, sharp pains, dull aches, etc., appeared in most anatomical locations, and were associated with all of the diagnoses. Furthermore, no particular pain description was associated with any given diagnosis. Even the most straightforward diagnoses like bruise and fracture were associated with a number of pain descriptions.

EXAMINATION PROCEDURE

The next table summarizes the examination procedures that were used. The number used on any given miner varied from zero to six, thus the total entries in Table 62 exceed 224. The first fact to note in this table is the difference in medical visit rates between LT and NLT injuries. Miners who suffered LT injuries were examined by a doctor in 91.4% of the cases, while miners who did not lose any time were examined in only 50.9% of the cases. It is interesting to speculate whether the pain intensity or other discomfort forced the miners to seek medical care, or whether they received medical care (by being taken from the mine to the hospital) and as a result of being seen by a doctor they were given time off from work. Indeed, there were a number of older miners who stated during the interview that they had been told to take a few days off to rest and had declined the time off because they knew it to be unnecessary.

Table 62. - Examination Procedures Used by Doctors
(Percent of the Time a Procedure Was Used)

<u>Procedure</u>	Lost Time	
	<u>NO</u>	<u>YES</u>
Palpation	72.7	72.6
X-ray	63.6	75.5
Range of motion tests	58.2	69.8
Straight-leg raise	30.9	36.7
CAT scan/myelogram	10.9	16.0
TOTALS		

Given that, for whatever reason the injured miner was examined by a doctor, we must ask if there is any difference between the examinations received in LT and NLT injuries. Table 62 summarizes the examination data, presenting the percentage of miners in a given category who received a given procedure. The most commonly used procedures in each group were palpation for tender spots and an x-ray, with palpation occurring with equal frequency in both groups and x-rays being about 12% more common in LT cases. The same is true for range-of-motion tests. Smaller differentials are found for the other three tests, but they were more consistently used in the case of LT injuries. The number of procedures used by the examining doctor was also analyzed, and the percentages of time that one, two, three, or four procedures were used was about equal for LT and NLT injuries. The use of all five procedures was, however, six times more frequent for LT injury examinations than for NLT exams.

The data suggests that the LT injuries were more thoroughly evaluated, which indicates that they were perceived by the examining doctors to be severe enough to warrant a more in-depth evaluation. This could have been due to the injured's level of concern, his stated symptoms, or the facility (Emergency Room vs. Doctor's Office) in which examined.

TREATMENT

The forms of treatment received by the injured miners are summarized in Table 63. In many cases, more than one treatment was received by the injured miner, thus column totals do not equal 224. The most commonly received treatment was heat, with a number of others being half as frequent and roughly equal in frequency. It is interesting to note that the two treatments easily done by the miners for themselves, heat and ice, were received about equally

Table 63. - Treatment Modalities Received

<u>Treatment</u>	Lost Time	
	<u>NO</u>	<u>YES</u>
Heat	23	46
Ultrasound	10	26
Exercise(s)	3	22
Bed rest	3	23
Ice	11	16
Electrostimulation	6	15
Traction	3	10
Spinal alignment	10	8
Hospitalization	2	6
Injection	1	5
Other	3	9

by the two groups, and that spinal alignments were actually more common in NLT injuries (these people generally went to see a chiropractor on their own). In contrast, classical medical treatments such as injections, traction, and electrostimulation were more common in LT injuries. This again raises a question of whether it is the severity of the injury or the place you go for examination that determines the type of treatment received.

In summary, the reader should note that LT injuries received more treatment, and more forms of treatment.

MEDICATION

Medication was prescribed for a very high percentage of the miners who visited a doctor (93% of LT cases and 85% of NLT cases). In the case of NLT injuries, 30% received a pain reducer, 36% received muscle relaxants, and 23% received both. In the case of LT injuries, 43% received a pain reducer, 16% received a muscle relaxant, and 41% received both. The most seriously injured miner interviewed, who had a fifteen year history of back pain which began with a car accident in high school and progressed through a 30 foot fall into the mine shaft two years before, refused to use drugs because he (and his doctor) found that when he received enough drugs to eliminate the pain, all he could do was lie around. To him, pain was a far more acceptable life style. One must ask what role mental attitude plays in the injuries.

Based on the data collected, it is clear that miners who lost time were examined by doctors more often, and those miners who were perceived by doctors as being severely enough injured to warrant time off of work received more complicated examinations, more frequent and varied treatment, and considerably more drugs.

COMPARISON OF DIAGNOSIS AND TREATMENT

Next, Table 64 compared the injury diagnoses with the treatments received. This comparison was made to determine whether the treatments were appropriate given the diagnoses, consistent between LT and NLT injuries and consistent within and between the diagnoses. The evaluation of treatment appropriateness was made by a physical therapist with 20 years of experience specializing in backpain treatment. After reviewing the data, his conclusion was that while any of the listed treatments were theoretically appropriate, there was no logical pattern to the treatment -- i.e., the treatment assigned to a given miner appeared to be based more on the treatment patterns favored by the doctor than on the injury.

Consistency between LT and NLT injury treatment is really only appropriate for muscle and disc injury diagnoses because of the small number of cases with the other diagnoses. The LT/NLT balance was very consistent for muscle injuries and rather inconsistent for disc injuries, with large disparities favoring more treatment for the NLT cases.

Table 64. - Comparison of Diagnosis and Treatment

<u>Diagnosis/Treatment</u>	<u>% of LT Cases</u>	<u>% of NLT Cases</u>
Muscle injury/heat	39	39
/ice	14	16
/ultrasound	22	18
/electrostimulation	13	8
/rest	13	13
/traction	7	3
Disc injury/heat	31	40
/ice	19	10
/ultrasound	19	50
/electrostimulation	13	30
/rest	13	10
/traction	6	10
/spinal adjustment	19	10
Pinched nerve/heat	55	33
/ice	11	0
/ultrasound	33	0
/electrostimulation	11	0
/rest	11	0
/traction	22	0
/spinal adjustment	0	67
Facet joint sprain/ice	33	0
/back school	33	0
/electrostimulation	33	0
Torn ligament/heat	50	33
/ice	50	0
/ultrasound	0	67
/electrostimulation	100	67
/traction	0	67
Bruise/heat	50	14
/ice	0	29
/electrostimulation	25	0
/rest	25	0
/exercise	25	0

The between-diagnosis injury treatment pattern was somewhat consistent in that, for the four common diagnoses, heat was the most common treatment, with ultrasound and ice also being common. When the data pattern and the physical therapist's comments are considered together, one is tempted to conclude that the doctors specifying treatment for the injured miners in this study had a static approach to the treatment of backs-- same treatment assigned independent of diagnosis -- and the percentages observed reflect the distribution of doctor input (number of miners evaluated) rather than a scientific selection of treatment modalities.

COMPARISON OF DIAGNOSIS AND INJURY HISTORY

Table 65 addresses the question of whether an injured miner's history of back injury affects the type (doctor's diagnosis) of injury incurred subsequently. The data in Table 65 is broken into the three groups discussed previously -- no prior, one prior, and more than one prior back injury. The data shows that persons with prior back injuries are 40 to 50% more likely than persons without a prior back injury to be diagnosed as having had a muscle injury, whereas persons with no prior back injuries are about twice as likely to be diagnosed as having a disc injury.

As previously discussed, only muscle and disc injuries have a sufficient number of cases to allow in-depth

examination. These injuries were further explored in a comparative analysis which compared back injury history, whether the injury had a sudden movement origin, and muscle and disc injuries. Previously, it was hypothesized that persons with a history of back injury were physiologically more prone to sudden movement related injuries (which would generally manifest as muscle injuries). This appears to be supported by the data. In people with a history of back injury, almost 60% of the current injuries involved certain or questionable sudden movements, whereas in the no prior injury group, only 44% were so classified. The pattern is reversed for disc injuries; over twenty percent of the no prior group with a disc injury diagnosis resulted from sudden movement while only seven percent of the prior history group's disc injuries were the result of sudden movement. The data gathered by this research cannot quantitatively confirm or deny these hypotheses, but the data raises interesting questions which should be pursued in subsequent research. Of particular interest here is the injured's perception of the injury and its effect on the person, along with the injured's knowledge of his/her own physical limitations.

Table 65. - Comparative Analysis of Back Injury
History and Current Injury Diagnosis

<u>Current Diagnosis</u>	<u>0 Prior Injuries*</u>	<u>1 Prior Injury*</u>	<u>> 1 Prior Injury*</u>
Muscle injury	41.1	62.0	56.2
Disc injury	19.7	8.8	11.1
Pinched nerve	8.0	1.3	3.7
Bruise	5.7	10.1	0
Torn ligament	4.8	0	3.7
Fracture	3.2	1.3	0
Spinal misalignment	4.8	2.5	2.5
Cervical Sprain	1.6	0	0
Facet joint sprain	0	1.6	2.4
Genetic deficit	0	1.3	1.2

*: data presented as % of cases

INJURED MINERS BACK INJURY HISTORY

Many authors have published information indicating that persons who have experienced one or more back injuries are more likely to have another back injury than persons with no prior back injuries. This may be due to the fact that injured soft tissue is more susceptible to re-injury -- particularly if it did not heal properly after the prior injury. It may also be due to differential susceptibility within the population.

Table 66 summarizes the back injury history of the miners participating in this research.

Table 66. - Back Injury History of Injured Miners

<u># of Prior Back Injuries</u>	<u>Restricted Work</u>	<u>Lost Time</u>		<u>TOTAL</u>
		<u>NO</u>	<u>YES</u>	
Zero	4	32	31	63
One	2	38	41	79
Two	1	12	15	27
Three	0	8	12	20
More Than three	0	<u>18</u>	<u>17</u>	<u>35</u>
TOTALS		108	116	224

The table shows that in 37% of the cases the injured had already experienced more than one back injury, and in another 36% of the cases, there had been one prior back injury. Thus, we investigated a first injury in only 27% of the cases.

The reader should note that in this project, a back injury was defined as a significant episode of back pain regardless of the age of the victim and the circumstances under which the injury occurred. The frequency of reported injuries occurring off the job was 19%.

The injury history can be combined with the age and work history to determine whether a pattern exists. Table 67 summarizes this data.

Table 67. - Comparison of Back Injury History, Days Lost, Age and Work Experience

<u>Injury History</u>	<u>Days Lost Per Injury</u>	<u>Age</u>	<u>Yrs of Mining Experience</u>	<u>Years of Non-Mining Experience</u>
Zero Prior	22.47	36.81	11.10	4.90
One Prior	22.58	37.96	12.52	5.16
> One Prior	14.98	36.90	11.80	4.48

When preparing this table, the authors surmised that there would be either trends or statistical relationships between these variables. In particular, it seemed logical that persons with a history of back injury would have been older and would have had more work experience. It was also predicted that a person with multiple back injuries would be losing more time when injured than someone who was initially injured. Table 67 indicates that all of our assumptions were wrong. No significant relationships were found between back injury history and age, mining experience, or total industrial work experience. The only significant relationship found was that persons who had suffered more than one injury lost 33% less time per injury than persons in the other two groups.

There is of course no exact explanation for these phenomena. One can hypothesize a number of explanations. One is that miners who have experienced significant back

pain are more conscious of the situations and feelings associated with the onset of a back pain incident, and when they feel "something coming on" they stop working and take a little time off, thus preventing a major incident. A second and converse hypothesis is that miners who are familiar with back pain have adjusted to the pain and know what to expect from a back pain incident and how to cope with it. Further, they only take off the time they really need to keep coping. The third hypothesis is the other end of the second -- miners experiencing a first or second injury are hypercautious about returning to work because the pain is new, intense, and to be avoided. Thus they stay off work longer to insure all manifestations of pain are gone before returning to work.

This can be explored still further by considering the types of injury experienced by the different groups, and the activities which produced the injuries.

The activity table was too complex to reproduce, but it showed that the significant frequency differences between the three groups were in three areas. The more than one back injury group had more "riding in vehicle" related accidents than the other two groups combined. The same was true of "pull/drag" cable, hose, curtain, etc., related accidents. These activities both usually produce "sudden movement" injuries, and persons with a history of back injury are more prone to have trigger points in their

backs. This is particularly true if their prior injuries did not heal properly. The more than one back injury group had fewer back injuries than either of the other groups. This may be due to the fact that a person with a history of back pain is usually more careful about what he/she lifts, and is more likely to ask for help or to take the time necessary to get a mechanical lifting aid. This can be restated: persons with a history of back pain generally know their limits and will choose not to exceed them whenever possible.

The types of injuries sustained by the three groups are summarized in Table 68. It shows differential diagnosis patterns for the LT injuries sustained by each group. The most significant differences are between the zero prior injuries group and the other two groups. In the zero prior group, 13% were bruises and fractures, while in the one prior group 4.5% were due to bruises and fractures, and in the more than one prior group no injuries were due to bruises and fractures. Similarly for disc damage, the zero prior group had 12.9%, the one prior group had 4.5%, and the multi-prior group had 2.3%. Conversely, muscle injuries (strain, sprain, spasm, pull, etc.) accounted for 73% of the multi-prior group injuries, 70% of the one prior group injuries, and only 45% of the zero prior injuries.

Table 68. - Injury Diagnosis as a Function of Back
Injury History

Diagnosis	Injury History		
	Zero Prior	One Prior	> One Prior
Muscle damage	45.0%	70.0%	73.0%
Bruise/fracture	13.0%	4.5%	0
Disc damage	12.9%	4.5%	2.3%
Spinal misalignment	3.2%	2.3%	2.3%
Pinched nerve	9.7%	6.8%	7.0%
Facet joint sprain	0	2.3%	4.5%
Genetic abnormality	0	2.3%	0
None	12.9%	4.5%	9.0%
Other	3.3%	2.8%	1.9%

The differences in the first three rows of the table may be statistically significant, but given the real difficulties associated with back injury diagnosis, it is hard to determine whether the differences have practical significance. The reasons for the differences are hypothesized as follows. Miners with back pain experience react to new pain differently than those who have not previously felt it. They downplay or ignore bruises as being no different in the back than any other body part, whereas newly injured persons are more sensitive to them. Furthermore, a bruise, while painful, is not nearly as painful or limiting as a muscle strain/sprain or disc problem. Having experienced both, miners with back injury experience weight them appropriately in deciding whether they require care and time off.

The cause of the differential rates of muscle and disc damage is again speculative. Here again, it may be due to differing experience with back pain. The miners with prior back pain experience know that the pain will pass (albeit slowly) and accept the soft-tissue/muscle-strain-or-sprain diagnosis, whereas the newly injured person is driven by the slowly passing pain to seek help and a "better" diagnosis. Eventually the possibility of disc injury is hypothesized as a way of settling the injured's mind about the pain. The reader should note that, except in the cases of severe disc damage, fracture, and bruise, the exact injury diagnosis cannot be confirmed.

CHAPTER 8

SCREENING & TRAINING & REHABILITATION

This chapter concerns itself with another phase of the project -- identifying back injury control measures currently in use in underground coal mining and if possible, evaluating their effectiveness. The purpose of this effort was to try to determine the state of the mining industry in terms of back injury control measure technology.

The data collected in this phase of the project was obtained by a combination of observation forms and telephone interviews. Initially, the forms were developed and mailed to 76 mines, but the response was inadequate. The mailing was followed up with a telephone interview which was based on the observation forms. Three forms were used, one which addresses back injury prevention training, one which addresses employee selection, and one which addresses rehabilitation. Copies of the observation forms can be found in Appendix C. All three forms were developed by a physical therapist with a doctorate in engineering, a number of years of experience directing the Augusta Back School in Georgia, and a number of years of experience operating his own rehabilitation business.

A total of 36 observation forms was completed using the two methods. Initially, 76 forms were mailed to mines in West Virginia, Pennsylvania, and Illinois. They were

addressed to the mine's safety director and a stamped return envelope was provided. An explanation of the observation form's purpose was enclosed as was a statement of anonymity for mines. A total of nine responses were received. This response was deemed inadequate so a telephone follow-up was initiated. With great difficulty, and three months of phone calls, another 25 observations were completed. The difficulty resulted from a great reluctance of the mines to discuss their back injury control procedures. The data collected from the 36 completed forms is discussed in the balance of this chapter.

EMPLOYEE SELECTION

There are a number of ways to control back injuries in the workplace, one of which is to select people for physically stressful jobs based on a comparison between their physical abilities and the job's physical demands. Various studies have indicated that a carefully implemented employee selection program could reduce overexertion injuries by 15 to 40%. The employee selection data are summarized in Table 69

Most physical stress based employee selection programs used one or more measures of physical strength as a selection key. The observation form started by asking whether a strength test(s) is done. None of the companies actually did a test, although one company's physical exam

included a subjective strength estimate, and another company is in the development stage of a strength screen.

If a strength test is not used, the next likely procedure is a physical condition assessment. In effect this means a preplacement physical which typically provides little in the way of objective data about the applicant's job performance abilities. In the survey group 38.9% did do a preplacement physical, and of these 14% conducted some form of stress test. Unfortunately, the personnel interviewed were unaware of any use being made of the stress test results -- i.e., they were not part of an injury reduction related screening program.

In addition to the two steps described, there is an administrative control step that is used in most companies as a screen. This is to simply ask the person whether they have a history of back pain. Ninety-two percent of the survey group use this approach, 75% put it on the employment application, 78% put it on the written portion of their physical exam, 42% as a required part of their medical exam, and 27% by contacting previous employers. Obviously this is a good question to ask, but getting an honest answer to queries about past back injuries when applying for a physically demanding job is at best difficult.

What conclusions can we draw about the state of the mining industry with respect to physical stress based on

employee selection programs? Based on our limited sample of 36 mines, we can conclude there is essentially none being used. A broader sample would probably have found some mines using some type of screen, but the efficacy of those programs probably has not been evaluated. The most useful data currently being collected is that obtained from prior employers about the applicants work injury history since there is literature to support the fact that persons with a history of back pain are more likely to experience repeat episodes.

Table 69. - Summary of Employee Selection Procedures

1. When hiring new employees do you screen them for physical strength?

YES 1*, 2.8% NO 35, 97.2% DON'T KNOW 0

* Company makes a subjective estimate of the individual's strength, no real strength measurements are collected.

2. When hiring new employees do you try to evaluate their physical condition?

YES 14*, 38.9% NO 22, 61.1% DON'T KNOW 0

* All of these companies evaluate by physical examination, and five of these companies conduct cardiac stress tests.

3. When hiring new employees do you try to find out whether they have a history of back injury?

YES 33, 91.7% NO 3, 8.3% DON'T KNOW 0

How is this information collected?

	YES	NO	DON'T KNOW
a) A question on the employment application	25.8%	8.3%	0
b) A question on their pre-employment physical examination	26.8%	7.2%	0
c) Through medical examination	14.4%	19.6%	0
d) By contacting previous employers	9.3%	24.7%	0

BACK INJURY PREVENTION TRAINING

The classic approach to back injury prevention in both industry in general, including mining, is "training." This "training" comes in various forms, but is most often oriented toward teaching (and hopefully modifying) lifting behavior (this ignores the fact that a large percentage of injuries have nothing to do with lifting.) Unfortunately the "right way to lift" which is generally taught is perceived to take longer, has been documented to take more energy, is generally less convenient for the lifter, and is awkward or difficult for many people. As a result, it has not been very successful, and where it has been successful it has been due to an elaborate teaching and practice program. It is most successful with persons with a history of back pain.

Table 70 summarizes the data collected from the 36 mine survey group. Eighty-nine percent (32 mines) of the survey group used some formal one-time or periodic back injury prevention training. All of these mines used an oral presentation, and 78% supplemented the oral presentation with written handouts. Only half of these presentations covered the warning signs of serious back problems, or the medical/personal life style effects of a back injury.

All of the oral programs covered the standard lifting guidelines, although the depth and quality of the content is unknown. Ten of the oral programs included information

on human anatomy and 13 covered physical loading of body parts as a result of lifting. Seventy-five percent of the oral programs included a discussion of individual limitations (i.e., don't lift too much), but this information is somewhat useless given the fact that the miners are not taught how to determine their "too much" level. Furthermore, in many mines, a miner who tells the section foreman something is too heavy to lift may experience "personnel" problems.

All of the oral presentations stress the importance of housekeeping, but they do so without properly explaining why -- i.e., the sudden movement injury. Finally, 69% of the mines said their training includes a discussion of the decision making processes required to determine a safe method of doing the lift. This is the most important item on the list, because a carefully analyzed lifting task should result in a low to moderate stress lifting task, whereas a bent-knee/straight-back lift may still be outrageously stressful. The authors suspect this discussion is at best superficial -- nevertheless a good start -- since during the main study and this sub-study we found few administrative personnel with backgrounds appropriate to lead this discussion.

Of the 25 (78%) mines that used a written back injury training supplement, all felt it was written in readily understandable language -- although none had tested the

material to verify this. The other items listed in item two of Table 70 were covered in most programs with the notable exception of practical examples. The lack of practical lifting examples taken from the mining environment is a serious weakness in most such training programs. Furthermore, even when examples are shown, critical details are often missing.

There was one other outstanding shortcoming of all of the written and oral programs -- none of the mines had made any attempt to determine whether the training provided had changed lifting behavior or injury rates.

What conclusions can be drawn about back injury prevention oriented mine training? First, lots of training is being done. Second, while lots of training is being done, little is being evaluated for effectiveness. Third, the training is focusing on "proper lifting" technique -- and except for some narrowly defined lifting situations the "proper" technique has not been defined. Fourth, almost no attention is being paid to sudden movement as a source of back injury. Fifth, mining personnel are not being taught how to evaluate a lifting task from a physical stress viewpoint to identify alternative ways of accomplishing the task, and to select a method that balances injury risk with production efficiency. This last item is the real key to reducing back injuries in underground coal mines.

Table 70. - Summary of Low Back Injury Prevention
Training Questionnaire

* Thirty-two of the thirty-six companies surveyed provide some form of back injury prevention training.

	YES	NO	DON'T KNOW
1. Is an oral presentation part of the program?	32 (100%)	0	0
Oral presentation includes:			
Description of injury risks	32 (100%)	0	0
Description of medical conditions that could occur following injury	17 (53%)	15 (47%)	0
Reasons for probable non-diagnosis or misdiagnosis	6 (19%)	26 (81%)	0
Warning signs of dangerous back problems	18 (56%)	14 (44%)	0
Are the lifting risks covered?	32 (100%)	0	0
Keep the load close to the body			
Lifting bulky loads			
Distance moved during lift			
Starting position of the lift			
Influence of lifting frequency			
Effect of posture			
Effect of weight of load lifted			
Effect of using handles			

* All of the above information was covered by all 32 companies with back injury prevention programs.

	YES	NO	DON'T KNOW
Discussion of lifting and exerting forces as they relate to stress on the back and other body parts	13 (41%)	19 (59%)	0

Of the above 13 programs, 10 included information on:

Muscles			
Ligaments			
Discs			
Vertebral Bodies			
Nerves			
Effects of static work posture	11 (34%)	21 (66%)	0
Effects of vibration	6 (19%)	26 (81%)	0
Discussion of individual limitations	24 (75%)	8 (25%)	0

For the 24 programs the discussion of limitations as they related to back injury include:

Signs of over exertion			
Effects of cumulative trauma			
Effects of fatigue			
Stress the importance of house-keeping, planning, and workplace layout?	32 (100%)	0	0
Lifting and handling skills are taught	32 (100%)	0	0
Discussion of team lifting	32 (100%)		
Discussion of decision making processes necessary to assess the size of the load and the number of people needed for the lift	22 (69%)	10 (31%)	0

	YES	NO	DON'T KNOW
2. Is written handout material part of the program?			
2a. Is the material in layman's terminology?	25 (78%)	7 (22%)	0
Does the material: (for the 25)	25 (78%)	7 (22%)	0
Cover injury statistics	24 (96%)	1 (4%)	0
Emphasize responsibility for back care	25 (100%)	0	0
Cover basic anatomy	18 (72%)	7 (28%)	0
Cover proper sitting, standing and lying postures	22 (88%)	3 (12%)	0
Present practical work examples that are representative of your mine's tasks	16 (64%)	9 (36%)	0

MEDICAL TREATMENT AND REHABILITATION

Table 71 summarizes the results of the questionnaire about medical treatment. The first three questions address rehabilitation. Eleven of the thirty-six (31%) mines utilized some form of rehabilitation program, but in each case it was a program established by an outside health care facility. As such, they were generic rather than job specific. Furthermore, only eight of the mines required their injured personnel to take an active part in their recovery (active means something besides rest and medication, but not participation in a formal structured

program). This rather poor performance in rehabilitation is consistent with the relative remoteness of many mines, the long rural commutes experienced by many miners, and the practical difficulties associated with administering a meaningful light duty program at a coal mine. All of this is unfortunate since the results of "well administered" programs of this type in general industry have been very encouraging.

The next four questions address initial evaluation and treatment. In 86% of the injuries there is a clearly defined time of injury and in 80% of the cases treatment is initiated within one day of the injury. The injured miner is evaluated by a physician of the miner's choice in 80% of the cases. This often leads to some difficult administrative problems because many of the physicians who treat miners in small towns have known the miners for years and sometimes are rather liberal in dispensing time off.

The next two questions about treatment and medication had a large "unknown" response. This suggests that the mine personnel are not staying in close touch with the medical care givers. If the medical personnel do not understand the effect of their actions, they will not alter their treatment plans to consider the effects -- and they can only learn about the effects from mine management.

All of the mines require medical approval before a miner is allowed to return to work. In one third of the mines

this is handled by a company appointed physician, while in the rest a return-to-work slip is required from some physician. It would be interesting to conduct a study to determine the criteria used to determine whether a miner is ready to return to work -- particularly when most of the physicians do not really know what the miner's work consists of, and there are no good techniques for post injury evaluation.

Prior to drawing any conclusions about rehabilitation and treatment, the reader should ponder the following question. What is the purpose of post-injury treatment and rehabilitation? Is it to get the injured miner back to work? Is it to get the injured miner pain free? Is it to get the injured miner back relatively close to his/her functional condition before the injury? Each of these questions leads to a different treatment and rehabilitation approach. Getting the injured miner back to work has a limited amount to do with treatment and rehabilitation -- it has more to do with finding a doctor willing to sign a return to work release and to send the injured miner back to work. Getting the injured miner pain free may have something to do with treatment and rehabilitation, but it may also be a matter of time, since in almost all cases back pain subsides with or without treatment.

Getting the injured miner back to his/her preinjury condition is a complex problem because it means the injured tissues must heal at their pre-injury length. This means both the injured miner and the doctor/physical therapist

will have to exercise the injured tissues to stretch them during the healing process. It also means the doctor and therapist must have a thorough knowledge of back anatomy, back injury patterns, and back injury treatment. This is not a knowledge set that is routinely held by doctors and physical therapists -- only a small subset of them have this knowledge; thus mine management needs to seek out highly skilled persons in their area and work with them to ensure the desired treatment is obtained.

Rehabilitation programs seem to be receiving only cursory treatment from the mines. Only 20% of the mines had any form of light duty program, and none of these had an organized formal program. Only 30% had an affiliation with a rehabilitation program. These are the two program areas being seriously investigated and evaluated by general industry, and the preliminary results are very encouraging.

Table 71. - Summary of Medical Treatment/
Evaluation/Rehabilitation Questionnaire

	YES	NO	DON'T KNOW
Have any of your miners with low back pain acquired on the job attended a rehabilitation program?	11 (30.6%)	25 (69.4%)	0
Is the rehabilitation program job specific, or is it provided by the mining company?	0	36 (100%)	0
Is the injured employee required to take an active role in his recovery? (Active means more than rest & pills)	8 (22.2%)	25 (69.4%)	3 (8.3%)
Is there usually a clearly defined time of injury?	31 (86.1%)	5 (13.9%)	0
When is treatment usually initiated?			
Within 2 days of the injury	29 (80.5%)	7 (19.5%)	0
Within the first week after the injury	36 (100%)	0	0
Who is responsible for evaluating the injured miner?			
Local hospital or clinic	7 (19.5%)	29 (80.5%)	0
Physician of miner's choice	29 (80.5%)	7 (19.5%)	0
The medical person who evaluated the miner was paid by compensation	36 (100%)	0	0
What types of medical treatments are provided for the miner?			
Conservative treatments (heat application, pain medication, rest)	28 (77.8)	0	8 (22.2%)

How frequently were medications given to the injured miners?

Medication was prescribed for every miner	20 (55.5%)	1 (2.8%)	15 (41.7%)

Medication was given to only a few	1 (2.8%)	20 (55.5%)	15 (41.7%)

Which medications were prescribed?

Muscle relaxants	20 (55.5%)	1 (2.8%)	15 (41.7%)

Analgesics	21 (58.3%)	0	15 (41.7%)

Who provided the medical treatment?

Physician only	19 (53%)
Physician and Physical Therapist	11 (30%)
Physician and Chiropractor	6 (17%)

How was the injury diagnosis made?

Patient observation	36 (100%)	0	0

X-ray	8 (22.2%)

Do you examine the levels of health of your miners before they return to work after an injury?

13 (36.1%)	23 (63.9%)	0

Company appointed physician conducts the examination	13

Back to work slip is required for those not examined by appointed physicians	23

Is there any provision for early return to work or light duty for injured miner?

8 (22.2%)	28 (77.8%)	0

Who made the decision not to have light duty?

Company management	27 (97.0%)	1 (3.0%)	0

Union	1 (3.0%)	27 (97.0%)

Do miners undergo a pre-employment physical before they are hired?

31 (86.1%)	5 (13.9%)	0

Who conducts the examination?			
Local hospital or clinic	22		
	(61.1%)		
Local physician	9		
	(25.0%)		
Are there any low back injury prevention programs for your miners?			
	32	4	0
	(88.9%)	(11.1%)	

The data collected does not allow for an evaluation of the medical treatment received by the miners, but it does allow for an observation -- there is far too little interaction between the mine management teams and the attending physicians. If the mines seriously wish to address this part of the back injury problem, they must train some of their personnel in the medical aspects of these injuries, and in communication techniques for dealing with physicians. Furthermore, if the mines are going to rely on/allow attending physicians to make the judgment as to when a miner is ready to return to work then they need to insure that the physicians are fully aware of the actual physical loadings to which their patients will be subjected. Otherwise, the miners' descriptions will be taken as fact by the physicians and more time off will be given to the miners.

DISCUSSION

It would have been desirable to evaluate the efficacy of the programs in each of the three preceding areas, but evaluation requires data and measurement data for all of these programs which was non-existent. As a result we are unable to evaluate the few administrative control programs for back injuries that we did find. We can, however, reiterate a number of observations. Existing employee selection schemes are not oriented toward back injury prevention. Existing training schemes focus almost exclusively on lifting techniques which are applicable to a narrowly defined set of lifting conditions not generally found in underground mining. As a result they have limited effect. Management-medical interaction is limited or non-existent. This puts the mines at the mercy of an ill informed (with respect to mining work) medical profession when it comes to determining how much time is lost prior to receipt of a medical clearance to return to work. If management is serious about reducing excessive lost time, they will have to invest their time in working with the medical profession to establish meaningful job and personal evaluation techniques so that a rational match between the injured's limitations and mine-job demands can be made.

CHAPTER 9

SUDDEN MOVEMENT INJURIES

The human body is an incredibly sophisticated response mechanism that is capable of creating and undergoing very large forces without sustaining an injury. In some cases however, these forces, or even more moderate forces result in back injuries. The difference is often due to the person's expectation about the timing of the force application and the magnitude of the force application. Put more directly, when a person expects a force to be applied, and has a reasonable estimate of the size of the force, he/she can usually flex/relax the appropriate muscles and assume a posture which is protective such that the person absorbs the force without injury. If on the other hand, the force is applied suddenly, or the force magnitude is very different from what was expected, an injury frequently results. This is best demonstrated by an example. A person walking along on a sidewalk steps off a three inch curb that he/she did not know was present. The person experiences a severe jolt in spite of the fact that it was only a three inch drop. The reason is the musculoskeletal system is prepared for a given loading pattern, and in a matter of milliseconds the loading changes to something different. The neuromuscular system cannot compute the actual loading that is going to occur fast enough to contract the necessary muscles to protect itself. In addition, sometimes the neuromuscular response pattern is inappropriate for the loading that occurs, and the wrong muscle contractions may

themselves result in an injury. A final scenario is the case where the body is exerting a large force on something that will not move and it suddenly releases. Just before release, the resistive force on the body is very high, but at the instant of release the resistive force drops to zero. The muscles are still exerting the very large force against no resistance. This may cause some part of the body to go beyond its normal range of motion -- resulting in an injury-- or the muscles may contract to try to stop the resulting motion and produce the injury. The preceeding scenarios produce sudden movement injuries.

Common examples of these scenarios include pulling on a door that is stuck, being pushed unexpectedly from behind, slipping with or without falling, and swinging a racquet and missing the ball completely.

In this research, sudden movement was not initially of interest, but our initial data analysis about one third of the way through the project indicated sudden movement is a frequent source of back injury in underground coal mining.

This led us to carefully investigate the details associated with the back injuries to try to quantify sudden movement's contribution to the problem. Table 72 provides a general summary of the sudden movement data which are broken into five categories. The first is sudden movement clearly occurred (as in a slip or a vehicle collision). The second

is a sudden movement may have occurred. The third is the injury occurred due to falling top, so while sudden loading did occur it was not musculoskeletal in nature. In the third scenario, a typical sudden movement injury may occur when the injured moves or twists suddenly to avoid being struck by falling top or to exit the area. The fourth is the injury was due to static postural loading and sudden movement did not occur. The fifth is no sudden movement occurred.

Table 72. - Sudden Movement as a Source of Back Injury*

Sudden Movement Category	Lost Time%		Total
	No	Yes	
SM <u>did</u> occur	25.0	27.7	52.7
SM may have occurred	9.8	9.8	19.6
Caused by falling top	3.1	2.2	5.3
Caused by awkward or static posture	2.7	3.2	5.9
SM did <u>not</u> occur	7.6	8.9	16.5

* Tabular entries reported as % of cases

Table 72 shows that in 52.7% of the injuries sudden movement occurred, in 19.6% it may have occurred, and in 5.3% the injury resulted from falling top -- still an unexpected load. This means that 58.0% of the injuries investigated did involve sudden movement and another 19.6% may have. There was no significant difference between LT and NLT injuries in any category.

Identifying the importance of sudden movement is an extremely significant result, because while it is known that slips, trips, and falls produce back injuries, the high frequency of generalized sudden movement induced injuries has not been reported. In this study, slips, trips, and falls, sudden starts and stops while pulling or pushing on things, collisions, bouncing in vehicles, suddenly shifting loads, and dodging falling top were all associated with sudden movement injuries. To better understand these injuries, they are further investigated in the following table.

Table 73 compares the way in which the injured miner was exerting force on some object within the five sudden movement categories which are further subdivided into LT and NLT. The NA category relates to injuries such as walking and slipped, riding in a vehicle, etc. The data provides some interesting comparisons. Seventy-seven percent of the NA category was clearly sudden movement induced, with another 15.3% due to falling top (which is an unexpected load), and another 4.2% may have been due to sudden movement. In contrast only 2.8% were clearly not due to sudden movement. Pulling injuries were also usually sudden movement induced with 44.4% clearly sudden movement and another 55.6% which may have been due to sudden movement. Other activities such as pushing, carrying, pulling and

Table 73. - Sudden Movement as Injury Cause
in Selected Ways of Exerting Force on Job⁽¹⁾

Way Force Exerted ⁽²⁾	Yes	Maybe	Posture	No	Struck by Falling Top
Push	57.2	14.2	0	28.6	0
Pull	44.4	55.6	0	0	0
Lift	21.4	26.2	9.5	40.4	2.4
Push/Pull	33.3	0	0	66.7	0
Push/Lift	60.0	0	20.0	20.0	0
Pull/Lift	47.8	30.4	4.3	17.4	0
P/P/Lift	33.3	33.3	33.3	0	0
Lift/Twist	62.5	12.5	0	25.0	0
Shovel	12.5	37.5	0	50.0	0
Carry	66.7	0	33.3	0	0
Lift/Carry	27.3	45.5	9.1	18.2	0
Lift/Twist/ Throw	100.0	0	0	0	0
NA	77.8	4.2	0	2.8	15.3

(1) Tabular entries are percent of row due to specified sudden movement condition

(2) Not all categories listed

lifting, lifting and twisting, and lifting and carrying were all likely to be caused by a sudden movement. The notable exceptions are shoveling (which is a movement intensive task), and lifting. In the lifting cases, less than half of the injuries were in any way related to sudden movement, and only 21% were clearly sudden movement induced.

A better understanding of the relationship of sudden movement to these injuries can be obtained by reviewing some injury scenarios. First, consider pulling accidents.

- 1) Walking backward pulling RB cable and tripped over box of resin -- NLT
- 2) Removing drill steel from new hole, drill steel stuck and twisted him sideways -- NLT
- 3) Mechanic repairing scoop cylinder with "cheater pipe" on wrench, wrench broke throwing man backwards -- 9 days lost.
- 4) Pulling miner cable around scoop, cable hung up on bucket and miner unsuccessfully tried to jerk it free -- 100 days lost.
- 5) Pulling miner cable through mud - slipped and fell -- 8 days lost.

Knowing the types of activities that required pulling in underground mines, and having read the preceding scenarios, it makes intuitive sense that these injuries should pose a problem. The relative contribution of these injuries to the overall back injury problem was unexpected.

Next consider some scenarios of sudden movement injuries which occurred while lifting

- 1) Two miners lifting a 200 lb. sheet of steel when one lost control and dropped his end jerking the other miner -- NLT
- 2) Lifting the water line and miner cable off CM hook, cable was under tension, tried to jerk cable off hook and it did not move -- NLT
- 3) Carrying tripod and transit along haulageway, tried to switch hands and lost control of items, should have just dropped them -- NLT
- 4) Lifting a wooden tie out of the mud, and it suddenly popped free throwing miner backward -- 10 lost days
- 5) Lifting a stretcher while practicing mine rescue techniques, foot slipped and miner twisted and fell -- 45 lost days
- 6) Housekeeping after building stopping, lifting empty pallet which was stuck in mud, it popped loose very suddenly -- 2 lost days

The mining community is well aware of the hazardous lifting that goes on in mining, and efforts are made to teach miners "proper" lifting. These efforts do not however teach pallet lifting techniques (it is unwieldy and often has splinters) nor do they adequately address the question of lifting items that stick, nor do they stress dropping items that are out of control.

Most of the sudden movement scenario's observed were predictable and, given some forethought, preventable -- but preventable only when additional time is taken to complete the work. Until the mines and miners commit themselves to taking the extra time to think and prevent, sudden movement will continue to make its numerically significant and physically painful contribution to back injuries occurrence in underground mining.

CHAPTER 10

REGRESSION MODELING

One logical use of the data collected is to develop a model for back injuries which would predict the risk of back injury as some function of the variables on which data was collected. There was an inherent problem in doing this because the risk of back injury is measured by the number of injuries that occur in some exposure period (hours worked, cables pulled, etc.). The exposure data were not available thus no frequency rate (risk) data were available. Thus, modeling to predict the risk of a back injury could not be done.

The next logical step is to model injury severity using days lost from work as a dependent variable. This was possible because LT data were collected. The results of this modeling effort are described in detail in Appendix D. Two regression models were developed and tested. Both models had a mix of continuous and categorical variables. The independent variables used in the first model are listed in Table 74, and those used in the second model are listed in Table 75. The models were developed using the independent variables which the authors expected to have a major impact on injury severity.

In the first analysis five variables were found to be statistically significant. The horizontal location at the start of a lift was significant at the .05 level. The facts

that a person was a roof bolter, that the activity involved pulling, whether sudden movement was involved, and that the starting vertical location of a lift were all significant at the .15 level. The R-square value for the model was .14.

The results suggest that regression modeling may not be appropriate for this type of descriptive data since the R-square value is so low. In spite of the low R-square, the model does identify the variables which are most important in determining injury severity. It is interesting to note that of the five variables identified as significant predictors of back injury severity, two (presence of sudden movement and pulling) are key factors in sudden movement injuries, and two (horizontal distance from body and vertical starting point of lift) are the most important variables in the NIOSH lifting equation. The last variable, working as a roofbolter, is consistent with the second regression in which the roofbolter as a piece of equipment also was significant, and is the subject of another Bureau contract studying roofbolting injuries.

The independent variables used in the second regression model are listed in Table 75. In this model, three variables were found to be significant: involvement of the scoop at the .05 level, and involvement of the roofbolter and pulling activities at the .15 level. Here again, the model R-square value was extremely low, being equal to only .14.

In the beginning of this section, the authors indicated that the type of data collected in this project was, at best, only marginally appropriate for regression analysis. This is primarily because much of the data could only be represented by categorical variables, and because lost days which is a weak measure of severity is not a choice dependent variable.

The results indicate our intuition was correct: the variables identified as significant by the regression models are intuitively correct, but the R-square values for the models are so low that their use as predictors of injury severity is inappropriate. This is consistent with the balance of the data which show that the sources of back injuries in underground coal mining are extremely diverse. This diversity precludes making good predictions about injury severity in a given set of circumstances.

Table 74. - Description of Independent Variables
for Regression I.

<u>Variable Name</u>	<u>Variable Description</u>
X1	How high was load at start
X2	How high was load at end
X3	How far away
X4	How was load grasped
X5	Weight of load
X6	Mine height at injury site
X7	Push - Pull - Lift
X8	Body posture during injury
X9	Age of injured person
X10	Sex of injured person
X11	Height of injured person
X12	Weight of injured person
X13	Job working during injury
X14	Sudden Movement

Table 75. - Description of Independent Variables
for Regression II

<u>Variable Name</u>	<u>Variable Description</u>
X5	Weight of load
X7	Push - Pull - Lift
X14	Sudden Movement
X15	Activity at time of injury
X16	What type of equipment involved
X17	Number of prior strains/sprains

CHAPTER 11

SPECIAL TOPICS IN BACK INJURY ANALYSIS

SHOVELING INJURIES

The shoveling injuries were investigated in more depth by reviewing the following variables:

1. Case descriptions
2. Alternate method
3. Evaluate alternative method
4. Why alternative method not used
5. What type of equipment was involved
6. How was equipment involved
7. How much LT.

This resulted in the identification of eight cases where shoveling was the primary activity and three cases when the injured miner thought the shoveling activity contributed to the injury.

In eight cases shoveling was the primary activity during injury; and of these, six cases involved shoveling coal and/or rock from the mine bottom onto a belt. In five of these cases the miner was shoveling to a belt which was over four feet high and in two of these cases the belt was eight feet or more high. In addition, three of these five cases involved continuous shoveling over one or more shifts.

Four of the six cases which involved shoveling to a beltline were LT injuries. The numbers of days lost were 2, 5, 9 and 45 days. Three of the five cases where the beltline was over four feet high were LT injuries including both cases when the beltline was eight to ten feet high.

These included the lost times of 2, 9, and 45 days. One of the three continuous shoveling cases was a LT injury (45 days).

The sixth case involved a beltline three and a half feet high. Shoveling included lifting the shovel and twisting to place the shovel load on the beltline. This was a LT injury which resulted in five days lost.

From the above cases, the factors which appear to increase the risk of back injuries when shoveling are high beltline (four feet or higher), continuous shoveling, and twisting of the body. In investigating these cases the issue of shovel size became important in terms of handle length and blade size. These dimensions are relevant since handle length will determine reach and will have an impact on the loading of the musculoskeletal system of the body as the shovel is maneuvered. The area and shape of the blade will determine the volume of the load; this combined with the type of material --coal or rock-- determines the weight of the load. The availability of a variety of shovel sizes was limited in most mines, particularly at the point of use; and therefore, the injured used whatever was available. Even if several sizes were available, most had never considered shovel size to be important.

The other two cases in which shoveling was the primary activity involved shoveling gob from around the feet of the longwall shields and throwing it onto the panline. The

heights of these two injury sites were 54 and 60 inches, which required the miners to be in a stooped posture; and, due to the restricted area around the shields, this type of shoveling required the miner to twist his body in order to get the shovelful from the LW shields to the panline.

The three cases in which the shoveling activity was thought to have contributed to the injury included shoveling on a beltline, longwall panline and teletram. A miner was shoveling in the mud alongside a beltline. She obtained several crib blocks which she kept lifting and throwing ahead of her as stepping stones. The pain occurred while throwing the blocks, and shoveling may have contributed to muscle fatigue and injury.

The longwall panline shoveling injury occurred as the result of shoveling and lifting rock onto a panline. The vertical clearance was 60 inches. This was a NLT injury. In the last case, which was NLT, the miner shoveled the mud out of a teletram cargo hold and then was hurt stacking blocks at a stopping.

The following are recommendations regarding shoveling:

1. During beltline design and installation the height of the beltline should be kept below 42 inches where possible.
2. Since much shoveling involves beltline cleanup, beltline design, installation, operation, and maintenance should be geared toward reducing

spillage particularly in areas where beltlines are over 42 inches high.

3. Shoveling should not be assigned as a continuous activity for an entire shift or multiple shifts. Instead, the employee should be assigned other work which permits an upright posture and reduces twisting and loading the lowback. Furthermore, he/she should be instructed to rest and relax muscles between periods of shoveling.
4. The employee should position him/herself when shoveling to eliminate or reduce body twisting as much as possible.
5. Several shovel sizes, including handle length and blade size, should be made available to permit the employee to vary his/her load. Training is also needed in terms of selecting the appropriate shovel size for the task.

WALKING INJURIES

Twenty-seven miners suffered a back injury while walking. Fourteen were LT back injuries with the range of days lost 1 to 111. The average was 14.9 lost days for all fourteen cases. If the one case which had 111 lost days is excluded from the calculation, the average drops to 7.5 lost days. The number of lost days for eleven cases were 7 or less. The remaining three cases had 13, 48 and 111 lost

days. Twenty-five of the twenty-seven back injuries which occurred during walking involved a sudden movement.

A breakdown of the 27 walking injuries showed the following:

- 1) seven back injuries occurred while the injured person was walking downhill;
- 2) seven incidents happened as the miner stepped or slipped into a hole as he/she was walking;
- 3) four injuries resulted from carrying an object while walking;
- 4) two persons were injured while walking backwards;
- 5) two foremen hit their hard hats against the top while walking to check on operations;
- 6) two miners were walking the LW face and tripped;
- 7) the remaining three injuries involved slipping and falling while taking a shower, walking the LW face bent over due to just three feet of vertical clearance, and walking across a beltline belt on top of a supply car and slipped.

Studying the seven walking downhill back injuries revealed that four were LT cases and included lost day totals of 4, 5, 7 and 13. Sudden movement was present in six of these seven injuries. Two of the four LT injuries happened while walking downhill and resupplying the RB machine. In one case the miner was carrying a box of resin from the scoop to the RB when his foot slipped. The

surface was wet and slippery, which contributed to this sudden movement injury. He caught himself before he fell and the back pain followed. In this case the scoop was located several cross cuts away, requiring the miner to carry the load a greater distance than normal. This miner lost four days of work. In the next case the employee was carrying a bundle of roof bolts from the cross cut to the RB machine. The bottom consisted of loose rock and coal. He slipped, but did not fall. Sudden movement was involved in this injury scenario and the bottom did not provide good traction. He was off work for seven days.

The third LT back injury occurred when two miners were walking downhill carrying a timber on their right shoulders. They had also thrown some timbers over a beltline earlier that day. The bottom conditions were average. They were engaged in building permanent roof support. The injured miner lost five days.

In a fourth case the miner was walking down a steep (16 degree) slope entry with a concrete bottom when he slipped (sudden movement) and fell. The concrete surface was wet and slippery. The injured was not carrying anything and he lost thirteen days.

The three NLT injuries in the walking downhill category included a maintenance employee, a fire boss and a foreman. Each of these cases involved sudden movement. The maintenance employee was walking down a slope which was

wet and slippery. He slipped and started to fall, catching himself with his right hand, and twisted to his left. He was not carrying anything. A better boot sole design may help reduce this type of situation.

The miner performing the activities of a fire boss was walking the beltline. The surface was wet and slippery and he slipped and fell. In the last case in this category a foreman was walking down a slope when his lead foot slipped and he caught himself while falling. He was going to check on the progress of a job and was not carrying anything. In six of these seven cases a sole design which provided better traction while walking downhill under wet and slippery conditions would be helpful.

The next category, of walking and stepped or slipped into a hole, also had seven cases. All seven cases involved sudden movement and three were LT injuries with 1, 4 and 48 lost days. The most severe LT injury involved a general laborer who was walking through an entry with average floor conditions except for a hole, in which he stepped. He was in an upright posture and was not carrying anything.

The next LT injury (1 lost day) was a maintenance employee who was carrying several hand tools when he stepped in a hole 15 inches deep which was located next to a derailer and was filled with water. The rerailer had been cleaned out on the previous shift and this hole was left next to it. The water disguised the hole. The

last LT injury (4 lost days) was a roof bolter operator who was walking out of the mine at the end of the shift when he stepped in a hole and twisted his back as he caught himself. The bottom conditions were average

The four NLT injuries in this category included three miners injured while performing fire boss activities. In one case the miner was checking for methane when his right foot slipped into a deeper area while walking in slushy/muddy bottom conditions. In the second fire boss case, the miner was coming through a mandoor and stepped in a hole. The bottom was rough and rutted. In the third case, the miner slipped into a hole and fell. The bottom was wet and slippery.

The fourth injury occurred during a LW move when a roofbolter was working as a general laborer and walking in a bottom covered by water. He stepped in a hole and fell down.

In two cases the bottom was described as average except for the holes. In one case each it was described as rough and rutted or wet and slippery. In three cases the bottom was slushy and muddy. In each scenario a hole was present. This points to the importance of keeping bottom conditions free from holes. When water is present it becomes impossible to determine if a hole is present or not.

The third category includes four injuries due to walking and carrying. Three of these cases involved sudden movement and two were LT injuries with 1 and 2 lost days. In one case, the injured went into the scoop bucket and lifted two five-gallon cans of hydraulic fluid. As he turned to leave the scoop bucket he slipped on the wet metal of the bucket. The next LT scenario occurred in the LW face area as a miner was carrying a five-gallon can of oil on top of his right shoulder. He slipped on the toe of a LW shield and fell to his knees. The bottom conditions were slushy and muddy.

In the first NLT injury a foreman was helping out by carrying a 35 pound gear. His upper torso was bent forward and the gear was resting on his lower back; he was holding the gear with one hand while carrying a small item in the other hand. He placed the gear on his back since it was too large to carry in just one hand. He walked 900 feet in this posture. The bottom was dry and the mine height at this point was fifty inches. A back pack could have helped this situation as it would have permitted him to carry both items while keeping his hands free.

The last injury (NLT) in this category resulted from walking while carrying a prop during a LW move. He had been lifting, carrying and putting props through a mandoor and then was carrying props one at a time down entry. The bottom was slushy/muddy. It was felt, given the conditions

that this overall activity was a two person task.

For two scenarios in category four the injured were walking backwards and suffered NLT injuries. Both involved sudden movement. In one instance the miner was applying mandoseal to the haulageway and was walking backward when he tripped over loose rock and fell backwards. This is normally a two-person task, but they were short one miner that day. In the second case an employee was mopping the beltline, swinging from side to side while walking backward in six inches of rock dust. Normally he used a piece of canvas to perform this task and felt it was easier, but it was inconvenient to get the canvas.

In category five two foremen struck the roof. One hit the plate of a roof bolt and the other hit his hard hat against the head of the roof bolt; both were walking in the mines. Both resulted in LT injuries of 3 lost days for each injury plus each had restricted duty several days after returning to work. Both cases were sudden movement related injuries. Each injured party was a foreman on his way to check on operation. The ceiling height at the site of injury was about the height of the men. In each instance, the miner admitted to being in a hurry to evaluate the operation.

Category six which involves walking and tripped, includes two situations on the LW face where miners tripped and

injured their backs. The first case resulted in 111 lost days. As the miner was walking over to fix the LW stage loader, his foot caught on a roll of cable and in an effort to keep from falling he jerked his leg. The bottom was slushy/muddy. In the second case the miner was walking to the LW face and tripped on a RB. The bottom was dry.

Both of these are housekeeping issues in terms of cable and RB being in the normal walkways.

The remaining three accident scenarios are briefly discussed. Two were LT injuries involving 1 and 6 lost days while all three included sudden movement. In one case a miner slipped in a shower and fell injuring his back and was off one day. The floor surface of the shower was painted concrete which was slippery. A non-skid surface in the bath house area is needed.

The second LT injury resulted in 6 lost days. The miner was performing the activities of a fire boss and was walking bent over along a LW panel where the vertical clearance under the shields was about three feet. The bottom was obstructed due to the feet of the shields. When he stood up he felt a pinch in his lower back.

The NLT injury in this group occurred as a miner was loading belt on a supply car. The belt was oily and slick. He slipped and fell on the coupler of the supply car, hurting his back.

In summarizing the walking injuries the following recommendations can be made:

- 1) Move supplies as close as possible to the point of use thus reducing the length of a manual transport. This is most important in wet/slippery and slushy/muddy conditions.
- 2) There is a need for a traction rating system for the soles of boots versus bottom conditions. This may identify conditions where current designs are not satisfactory.
- 3) Attention must be given to eliminating holes and deep ruts in the bottom area. While this is a difficult task it is even more important in areas where there is sufficient water to fill holes which then become hidden hazards.
- 4) Miners need to be keenly aware of the potential for hidden holes and ruts when standing water is present. The water should be removed in areas with significant walking activity, or those areas need to be avoided when possible.
- 5) A backpack may prove helpful in transporting small parts, tools, etc. It would permit the miner to have two hands free.
- 6) Place non-skid surfaces in the scoop bucket, shower room, change room, other metal surfaces where miners must walk, etc., to provide improved traction.

- 7) When handling heavy, bulky items such as props, mandoseal hose, etc., particularly in slushy/muddy conditions, a mechanical means is preferable to the use of an additional person.
- 8) Develop an easier manual method for handling larger, heavier items such as props, timbers, 5 gallon cans of fluids, etc., which does not require the miner to support the total weight of the object.
- 9) While walking, maintain a pace based on the mine conditions. When wet/slippery or slushy/muddy or standing water conditions are encountered, the walking pace must be reduced to permit the individual to anticipate potential problems and adjust to them. Eight of the twenty-seven back injuries which occurred during the walking activity involved foremen or fire bosses. Most appeared to be in a hurry.
- 10) Housekeeping must be maintained in order to avoid tripping types of injuries. Supplies, cables, etc., must be stored properly and not be located in common walkways.
- 11) Be alert for low clearances and potential slick spots. Avoid walking on slick areas when possible.

CABLE HANDLING INJURIES

A total of twenty-five back injuries were associated with cable handling and five more back injuries occurred on similar activities. Forty-three percent of these were LT injuries and 50% involved a sudden movement. These handling activities were divided into the following categories:

- 1) Lifting and pulling cable and/or water hose or ventilation curtain or rock dust hose (18 cases - 9LT)
- 2) Lifting cable and/or water hose (5 cases - 1LT)
- 3) Lifting and throwing the cable and/or water hose (2 cases - 2LT)
- 4) Lifting and hanging cable and/or water hose (2 cases - 0LT)
- 5) Untangling and coiling cable and/or water hose (2 cases - 1LT)
- 6) Carrying piece of cable (1 case - 0LT)

The first category included 18 cases which involved the lifting and pulling of cable and/or water hose, ventilation curtain, or mandoseal or rock dust hose. These injuries were associated mainly with the moving of a continuous miner or roof bolter during the production cycle. Fifty percent, or nine of the injuries, involved sudden movement. The nine LT injuries ranged from 2 to 120 lost days. The following five LT injuries did not involve a sudden movement.

-- The injury with 120 lost days resulted when a miner unplugged a roof bolter cable from a load center, placed the plug on his right shoulder and pulled the cable by himself 135 feet. He did not slip during the pull as the floor conditions were average. The mine height was not a problem and he was not obstructed during his effort. He was in a standing posture leaning forward with the cable over his right shoulder. The alternative method which was suggested was to use a mechanical means, but the miner felt this was inconvenient at the time since there were several pieces of equipment in the way so he performed the task manually. The farther the miner went down the entryway from the power center, the greater became the amount of cable he was pulling. This created an increasing load.

-- The next LT injury (41 lost days) involved a miner dragging forty feet of curtain through a section. Since the bottom conditions were slushy and muddy, the curtain was also wet and heavy. There were no obstructions to be avoided. The injured party did not slip, but was walking briskly in an upright matter.

-- A third LT injury resulted in 31 lost days when a miner was pulling a section of cable to install it along the beltline. He was standing upright walking backwards with his arms extended and pulling. He was not sure whether he slipped or was jerked, but he had no obstructions to deal with.

-- A fourth LT injury (2 lost days) occurred when dragging 80 feet of empty mandoseal hose with the end placed on the miner's right shoulder. This amount of empty mandoseal hose weighs about 120 pounds. He was walking forward in a crouch over wet and slippery bottom. He had been pulling the hose for twenty minutes.

-- Six miners were pulling miner cable and water hose. The injured was pulling while walking backwards in a stooped posture due to the 55 inch mine height. As he was turning a corner the slack in the cable was taken up and, since he was between the cable and the rib, he was pinned against the rib, injuring his back. Due to the position of his body the miner was injured and off the job for ten days.

The following four LT injuries involved a sudden movement in the injury scenario:

-- The bottom was wet and slippery and no obstructions were present. The miner slipped while pulling on the cable as he was walking backwards with his arms extended. He lost eight days.

-- In another case, an employee was dragging canvas around a RB in the face area when suddenly the curtain caught on the RB and jerked him. The miner was walking with his hands behind his back pulling the canvas. He lost seven days.

-- Five people were pulling a length of CM cable. The bottom was rough and rutted and one miner was pulling the cable with his hands chest high. Unexpectedly, the cable hung up around a timber and jerked the man. He lost six days. The scoop was out of service and unavailable for the task.

-- A miner was pulling a steel cable while climbing over a scoop in a stooped posture leaning forward while pulling. The scoop was in his path and his boots were muddy. The winch locked, eliminating the slack, and pulled him backward and he fell. He lost four days.

Eight of the NLT injuries in this category also exhibited the same general scenario, which involved trying to pull or drag too much cable or hose at a time. The following is a summary of each of these incidents.

- The bottom was muddy, mine height was 55 inches, and there were no other obstructions to movement. The miner was pulling 150 feet of miner cable and water hose. He was in a stooped posture leaning forward. He slipped and fell. Normally this is a two person task.
- Bottom conditions were muddy and the mine height was only 50 inches. The miner was in a stooped posture walking backwards as he pulled the cable off the reel of the RB to get slack for a splice. Limited vertical clearance was a problem. Normally this is a two-person task.
- The bottom was muddy and mine height was 58 inches. A miner was pulling a muddy curtain toward the face. He was bent at the waist with arms behind his back grasping the curtain. Normally, this is a one person task.
- The bottom area was dry and the mine height was over seven feet. The miner was dragging 100 feet of full rock dust hose through a belt area.
- The bottom consisted of loose coal and rock, there were no limiting obstructions and the mine height was 81 inches. The CM helper was moving a length of cable and hose when he hurt his back and he fell down with pain..

- There were no obstructions, mine height was 6 1/2 feet, and the bottom was dry. Three persons were moving the CM to the beltline area to clean the area so the beltline could be extended. The injured was in a stooped posture pulling several hundred feet of cable.
- Mine height was eight feet, there were no obstructions and the bottom area was dry. The injured lifted 75 feet of RB cable and started pulling it by walking backwards. Cable pulled against the miner's body, causing his body to twist.
- In this case the CM was being moved out of the haulageway so the RB could pass. The bottom was rough and rutted and the mine height was seven feet. The miner stooped, bending at the knees, and reached forward to grasp the cable, lifted and pulled. This was a task normally performed by two miners, but one performed the lift this time.
- The ninth NLT injury was a tripping injury. The miner was pulling RB cable while walking backward and he tripped over a box of resin; as he fell he twisted his back. The bottom was dry and mine height was six feet.

Each of these injuries involved the employee dragging or pulling a large load. In several cases mechanical

assistance would have been preferable, or miners should have used an additional person to assist them. In the mandoseal hose case the hose could have been uncoupled reducing its weight and length. Thus, the miner would make two trips. In the pinning against the rib injury the miner failed to think ahead and position his body on the outside of the pinch point created by the cable and rib. The reasons given for not taking these steps are inconvenience, short one miner, in a hurry or failed to size up the task.

In three of the four LT injuries that involved sudden movement a cable or canvas unexpectedly stopped moving and jerked the miner. In these instances the miner needs to be aware of possible catch points and should guard against their occurrence by moving the object being pulled away from the potential snag point, moving smaller sections of the cable or canvas at a time or moving the potential snag point. In the other injury which involved slipping on wet bottom, it appeared the miner was trying to move too great a length of cable for the slippery condition and the resistance force from the cable exceeded the traction between his boots and the bottom.

Fifty percent of the scenarios contained sudden movement as an element of the injury with four of the nine LT injuries included

Each of the eighteen injuries in this category involved the employee(s) pulling or dragging a load. In several

cases mechanical assistance in the form of a mobile piece of equipment could have been used to move the longer sections of cable; in other situations, obtaining an additional person to assist with the task or perhaps moving shorter sections of the cable at a time would suffice. Another factor associated with these injuries was asymmetric loading of the body, which required certain muscles to support a greater load than others.

In the mandoseal hose case, one option was to uncouple the hose and move the sections separately. Where the miner was pinned against the rib, he did not think ahead to the possible pinch point created by a cable rounding a corner of the rib. Several reasons were put forth for not taking these measures; they varied from inconvenient, to being in a hurry, to failing to size up the task.

However, it is easy to tell a person to pull just the length of cable for which they will not get hurt, but how do you determine this "safe" length, and under what conditions? Is there a better way to move cable and other loads in the mine than having people performing the tasks, or can these tasks be made easier? Would a means of dragging the cable, such as a double loop of rope with a good handle provide an advantage? The loop of rope would go around the cable with the handle inserted through the loop. This would permit the miner to pull the cable in a nearly upright posture. In addition, the miner would not

be lifting the cable to waist or shoulder level nor supporting the weight of this length of cable which is now off the bottom and being lifted by the miner. Instead, the cable would remain on the ground except for a short section which is lifted when the miner applies the pulling force to the handle. This simple aid might be called a Dragster.

The second category of cable handling injuries involved just lifting the cable and/or water hose. This category contains five cases with one being a LT injury resulting in three lost days. Two of the five injuries involved sudden movement. A summary of the accident scenarios follows:

-- CM operator was lifting cable and the water hose and placing them on a hook on the CM preparing for a move. At the front of the CM the cutter head was raised and was shoulder level. The miner had to strain to lift the cable and water hose this high. The floor was in average condition, there were no obstructions and ceiling height was six feet. He bent at the waist to lift the cable and water hose and then performed an asymmetric lift to reach the height of the cutter. This resulted in a LT injury with three lost days.

-- In this injury the bottom was wet and slippery and mine height was 76 inches. The miner was lifting the CM cable and water hose off the CM. The cable was under tension and he tried to jerk the cable

up and off the hook. He was standing slightly bent to the left performing an asymmetric lift.

-- The mine height was 55 inches, the bottom was wet and slippery. The miner bent over at the waist to lift the cable from the bottom. He lifted the cable 24 inches to place it on a hook, He bent at the waist during the lift.

-- Mine height was 74 inches and bottom conditions were average. They were getting ready to move the CM when a miner bent over to lift cable from the bottom to waist high. The cable was under tension. He stooped and reached slightly forward during the lift.

In three of the cases the cable was under tension. If the miner would have moved the CM to relieve the tension the lifting task would have been easier. In two cases the response was that it was too inconvenient and in the third case the miner failed to realize this. In the case where the cutter head was shoulder high the miner could have made the task less stressful by simply lowering the cutter head. At the time he did not think of that as a solution. In the fifth case the injured bent at the waist instead of bending his knees while keeping the back straight. A better lifting posture may have avoided his injury.

The third category involved lifting and throwing cable and/or water hose. This activity usually takes place in

the haulageway as the cable and hose are moved to the edge of the entry. Two cases are included in this category, each involved a sudden movement and both were LT injuries.

-- The bottom area was dry and the CM operator was unobstructed as he went about lifting and throwing the cable out of the roadway. The mine height was nine feet at the accident site. He was bent at the waist, reaching asymmetrically and throwing the cable, which required twisting his body. This resulted in 23 lost days.

-- A miner lost 17 days from the second injury. The bottom consisted of loose coal and rock and the mine height was eight feet. The injured had no obstructions to avoid while he went about lifting, throwing and hanging CM cable to move it out of the roadway. He was stooped with his knees slightly bent and was reaching forward while lifting. Three persons were performing this task at the time of injury.

In the first injury the miner bent his lower back instead of bending his knees and keeping his back straight. However, both of these LT cases involved the throwing of the cable which represents a sudden movement during the throwing activity. This may lead to an increased risk of injury.

The fourth category involved lifting and hanging cable.

Both of these injuries were NLT and neither contained a sudden movement. The injury scenarios follow:

- The miner was standing leaning forward and reaching overhead as he was lifting a 7200v power center cable out of a hanger which was 78 inches high. His body was twisted at the waist due to an obstruction. He was lifting 15 to 20 feet of cable and the bottom was dry.
- A four person crew was lifting and handling CM cable. The mine height was 79 inches and bottom conditions were muddy. The injured miner was lifting fifteen feet of cable overhead in an asymmetric posture with his head bent forward. This crew had been performing this activity for a period of time.

In the first case a second miner would have reduced the stress. The miner indicated that it was inconvenient to get a second person. The second situation may be a case of fatigue and asymmetric loading of the body being factors as this man repeated this asymmetric body loading activity time after time. A period to loosen the muscles may have helped.

Category five includes two cases where the injured were untangling and coiling cable and/or water hose. One of the two cases involved sudden movement and also was a LT injury lasting three days. These cases are described as follows:

-- The LT injury had two miners coiling a three inch CM cable on a pallet. The conditions were good. The injured was standing, pulling, and walking backwards. He was reaching pulling and pushing. Immediately after completing the coiling he bent over to pick an eight pound object off the floor. Muscle fatigue was thought to have played a role in this injury.

-- Miner cable and water hose were on the ground tangled together. The injured was engaged in straightening the cable. He was pulling with his entire weight with the cable and water hose over his shoulder. He was creating a large asymmetric loading on his body. The bottom was in average condition and mine height was 66 inches. No obstructions were present.

The 3 day LT case appears to be fatigue related. He had been asymmetrically loading his back muscles and exerting near maximum forces. The second injury is a case where an additional person would have been helpful. The reason given for not getting assistance was that it was inconvenient.

The last category contains one NLT injury and the injury scenario follows:

-- The miner was carrying eight feet of miner cable plus a connector over his shoulder. His body was

asymmetrically loaded. When he arrived at the scoop, he leaned to let the cable slide off his shoulder; and when he got into the cab of the scoop, the pain hit.

This may be a case of muscle fatigue and the asymmetric loading of the back during the transporting part of this task.

In summary, the injuries which were evaluated in the cable handling section appear to happen most often under lifting and pulling and lifting and throwing situations. Cases where the body is subjected to a sudden movement, twisting motion and/or asymmetric loading increase the risk of back injury. The magnitude of the load is also a factor.

Improved cable handling procedures are needed, such as the authors suggestion with the double loop of rope and handle which is referred to as a "Dragster." An alternative to hanging cable high on the rib would also save time and reduce injuries.

ROOF BOLTING INJURIES

The 18 injuries associated with the RB job included 12 or 72% LT injuries which had a range of 1 to 110 lost days. Sudden movement was an element in 56% of the cases. The following categories of RB injuries were identified from the interviews.

- 1) Groundfalls which struck RB operator (4 cases -- 3 LT)

- 2) RB process (7 cases -- 6 LT)
- 3) Resupplying RB (4 cases -- 2 LT)
- 4) Cable handling (2 cases -- 0 LT)
- 5) Maintenance (1 case -- 1 LT)

In the first category, all four injuries were caused by groundfalls. Three injuries resulted in LT with the values for lost days being 36, 45 and 100. This represents lost days values higher than the eightieth percentile for this study. In each case the injured miner was involved in the drilling cycle. This leads to the recommendation that the canopies on the RB need to cover the entire operating area of the operator during the drilling cycle. Also if a canopy is used which has openings, the openings should be small enough so that material which falls through will not have sufficient mass to injure the operator.

In the second category the injuries occurred during the drilling cycle, but did not involve groundfalls. Of these seven injuries, six or 86% were LT with the same percentage including sudden movement as a factor in the injury. The lost days ranged from 1 to 110. The injury scenarios are presented below.

- An experienced RB was using a new RB with controls that were different from the RB machine he had been using. He inadvertently hit the wrong control and was struck by the drill head support. This sudden impact injury resulted in 110 days lost.

- RB operator was working in bad top conditions where the mine height was thirteen feet. He was standing on the head of the drill holding a RB in his right hand and a wrench in his left hand. He slipped off the drill head and fell on his belt. Due to the very high top the operator could not insert the RB from his normal position. Fourteen days were lost.
- This case occurred in a 50 inch seam where seven feet RBs were being used due to poor top conditions. The injured was a general laborer performing the RB job. He was trying to bend the seven foot RB by inserting the tip of the RB into the drilled hole and gradually bending it by applying a wedging force. The RB spun around and caused the operator to twist his body. Five days were lost due to this injury.
- An employee was receiving training on a RB machine when he hit the wrong control and the boom swung and struck him in his pelvic region knocking him to the floor. He was off work for three days.
- This RB operator was bolting in high top due to poor top conditions. He was standing on the RB machine with a roof bolt in his left hand when he stepped off the bolter. His foot stepped onto loose rock and he slipped, injuring his back. Two days were lost.

-- A miner was bolting high ceiling and was standing on the head of the bolter in order to perform his job. He lost his footing and fell three feet landing solidly on both feet. It was an unexpected impact and he was off one workday.

-- The only NLT injury in this group occurred when the RB operator bent over to retrieve a piece of five foot plastic pipe he was using as a transfer tube.

Three of the LT injuries involved RB operators standing on the head of the drill or on the machine. The operators did this in order to perform the job because the top had fallen or it was removed due to unstable conditions. In these situations a RB machine with a work platform, including the controls which elevates with respect to the position of the drill head, is needed. In two cases, RB operators inadvertently activated the wrong control lever. This points to the need for a standardized coding of control knobs by shape indicating the function of the control, plus durable labeling of the controls to provide a reference as to control function. This is particularly important as workers switch between machines. This recommendation is applicable to all equipment. The problem of bending the roof bolt could be solved by welding a piece of pipe of sufficient diameter to accommodate the roof bolt to the body of the bolter at an appropriate height and location. Then while the RB operators are waiting for the

CM to complete its cut they could pre-bend the proper number of roof bolts needed for the cut. The pipe would be located such that the operator would insert the roof bolt and simply lean on the roof bolt using his body weight to perform the bending. The NLT injury involved with lifting the plastic pipe from ground level is probably not preventable.

In the third category, which deals with resupplying the RB, there were four injuries of which three were LT; two LT injuries also included a sudden movement.

-- The RB operator had just arrived on the section and started to resupply the RB. The first thing he lifted was a 4 inch x 8 inch x 16 foot header which he brought to the RB, lifted one end to the body of the machine, pushed it toward a roller on the body of the bolter and then lifted the header up to the roller. This activity resulted in 90 lost days.

-- The injured miner was a RB operator who was carrying a bundle of ten roof bolts weighing 52 pounds at knee height. As he approached the bolter, he was standing with his head bent forward. The clearance between the roof bolter and rib was right. In placing the roof bolts on the bolter, the miner had to lift, reach forward and extend in an asymmetric position. In doing this he experienced back pain. He was off ten days.

-- The second LT resupply injury occurred when a SC operator was operating the scoop to move a dust box for a RB. He was attempting to get the dust box out of the bucket of the scoop, which had some mud in the bucket. When it would not move he jerked on it. Two days were lost.

-- The one NLT injury in this resupply category involved a scoop operator who was carrying a box of resin and was carrying it to the RB. As he was approaching the machine, he bent forward to throw the box of resin across the cab. The pain struck when he started to throw the box; and he fell to the ground, dropping the box.

The miner in the first case, who was handling the sixteen foot header by himself, was handling a heavy load which is normally a two person task, plus it was his first lifting activity of the day which means his muscles had not had an opportunity to warm up. The recommendation for this scenario would be to use an additional person and to warm up before tackling such a heavy lifting task. While lifting the bundle of RBs the injured miner reached forward with his load. This greatly increased the stress on his back. Instead, one should keep the center of mass of the bundle as close as possible to the body. He should have moved his body closer to the bolter, eliminating or reducing the reach. In moving the dust box the miner could

have used the ram in the scoop bucket to push the dust box out of the bucket. Anytime one thinks about jerking on a load, that probably means the load is too large to be safely handled. The scoop operator who was attempting to pitch the 50 pound box of resin across the cab area while in a bentover posture was engaged in a high risk activity from a back injury standpoint. One may slide the box across or walk around and place it at the desired location, but should avoid throwing objects, particularly, heavy ones. This can be risky for the thrower as well as the receiver.

The two cable handling injuries associated with roof bolting were both NLT injuries and both involved sudden movements.

-- In the first case, a maintenance employee lifted a RB cable and started dragging about 75 feet of cable. He was standing and pulling the cable when the upper part of his body twisted suddenly due to the force of the cable pulling against him.

-- The second cable handling injury occurred when a maintenance worker who was pulling cable from the take up reel on a RB failed to get slack for a splice.

Both of these cable handling tasks may have been better served by using a second person to reduce the load or by an improved handling technique such as described in the Cable Handling Injuries section of this report.

The last accident in this RB category was an injury to a maintenance employee who suffered a LT injury resulting in three lost days.

-- The mechanic lifted a rotation drill motor for a RB and placed it in a gofer. He was standing and bent at the waist as he carried the motor over to the gofer and placed it inside. The mechanic was involved in a breakdown situation and was trying to get the job done.

The lifting of this drill motor is a two person task, or better, an instance where a mechanical lift should be used.

In summary, the seventeen RB injuries had a high percentage (72%) of LT injuries. Not counting the groundfall injuries, eight of thirteen, or 62%, were sudden movement as well. The keys to reducing these types of injuries are:

- 1) larger protective canopies over the operator
- 2) work platform for high top areas which elevates with the drill head
- 3) standardizing of controls by function, shape coding of control knobs and labelling the controls with durable labels
- 4) roof bolt bending attachment fastened to RB (described in previous section)
- 5) use mechanical means to reduce lifting, pulling, pushing, etc., where possible -- Do not try to

manhandle heavy objects.

- 6) if mechanical means are not available, a second choice is to use additional help; and
- 7) avoid throwing, twisting, etc., when handling moderate to heavy loads.

JOB TITLE VS. JOB WORKING COMPARISON

Table 76 describes the job titles of the injured miners. The job groups having the most injuries were mechanics, laborers, roof bolters, continuous miner operators, and foremen. This data would be most meaningful when combined with exposure hours during the relevant period of the study. Exposure data was not made available by the participating mines. In lieu of exposure hours, the rough distribution of personnel on a "typical" section (#1 in parentheses in Table 76) can be used. The typical section was developed based on input from the larger participating mines, but does not represent any given mine. Some mines may differ substantially from this.

Most of the mines that participated in this study had either two or three active continuous mining sections, and eight of them had a longwall section as well. The following analysis of back injury frequency per job is based on an "average" mine with three CM and one longwall mining sections.

The relative risk comparisons are provided in table 81. The relative risks were computed by dividing the number in a given job category in Tables 77 and 78 by the estimated number of persons in a given job at an "average" mine. Since the denominator is an estimate, the relative risk figure is also an estimate. This does not detract from its utility, however, since its role is to provide an index of back injury risk across mining jobs in a variety

Table 76. - Job Title of Injured Miner

<u>Job Title</u>	<u>Lost Time</u>		<u>TOTAL</u>
	<u>NO</u>	<u>YES</u>	
Mechanic (1)*	25	16	41
General Laborer(5)*	21	19	40
Roof Bolter(2)*	10	21	31
Cont. Miner Operator/Helper(2)*	8	13	21
Foreman Supervisor(1)* and **	9	9	18
Shuttle Car Operator(2)*	5	6	11
Beltman	4	6	10
Electrician	3	5	8
Longwall Helper(2)*	2	3	5
Scoop Operator(1)*	4	1	5
Safety Inspector	3	1	4
Jack/Prop. Man(4)**	1	3	4
Shearer Operator(2)**	2	2	4
Examiner	4	0	4
Other	<u>7</u>	<u>11</u>	<u>18</u>
TOTALS	108	116	224

* Distribution of personnel on a typical continuous mining section -- this will vary for individual mines.

** Longwall.

Notes:

- (1) Along with the 1 mechanic/section, there is typically a maintenance crew assigned as necessary in the mine. This usually has 3 to 5 mechanics and 2 electricians.
- (2) There is generally a belt extension crew of about 4 miners who keep the beltline up with the section development. There is also one belt cleaner per 2000 to 3000 feet of belt. Some or all of these persons may be titled as beltman.
- (3) The number of mine examiners varies with the size of the mine and the state where the mine is located. Three or four per mine shift would be typical.
- (4) There are a variety of other titles including pumper, motorman, supplyman, utilityman, trackman, brattice-man. There are very few persons in these job classifications.

of coal mines. Six relative risks are calculated, two each for LT, NLT, and total. Within each pair, relative risks are presented for the job title held by the individual when injured, and for the job the person was actually doing when injured. (Note that while many miners were injured while working outside of their jobs, in a large majority of these cases they considered what they were doing to be a routine, normal part of their jobs.)

First, let us consider the in-job working patterns for total injuries (Table 77). The top five categories are supervisor, roof bolter, mechanic, electrician, and continuous miner operator/helper. These were the job titles most likely (2 to 5 times greater), to suffer a back injury in the mines, with the supervisor being at highest risk. For LT injuries, the roof-bolter and supervisor have the highest risk, while for NLT injuries the supervisor and mechanic have the highest risk. Readers familiar with the mining-back-injury literature will note two job groups missing from the high risk list. The highest back injury frequency rates have been the general laborer, shuttle car operator and mechanic.

Table 77. - Job Working When Injured

<u>Job Title</u>	<u>Lost Time</u>		<u>TOTAL</u>
	<u>NO</u>	<u>YES</u>	
General Laborer	24	17	41
Mechanic	12	11	23
Jack/Prop. Man	18	17	35
Roof Bolter	6	20	26
Cont. Miner Op./Helper	8	11	19
Beltman	7	10	17
Shuttle Car Op.	5	5	10
Scoop Op.	6	1	7
Foreman (Supervisor)	4	3	7
Safety Inspector	2	3	5
Bratticeman	1	3	4
Electrician	1	2	3
Shear Operator	1	2	3
Others	<u>13</u>	<u>11</u>	<u>24</u>
TOTALS	108	116	224

Table 78 also presents injury data for persons working out of their jobs when injured. This data presents a completely different pattern of relative risk. Now, the jack/propman is by far at the greatest risk, followed by the roof bolter, beltman, general laborer, and mechanic. There was some shifting of apparent relative risk. Unfortunately, it points to the longwall as a major source of back injury -- too many very heavy items being handled in awkward postures in cramped work places, and the future of underground coal mining is the longwall.

No matter which data set one prefers to use, there are certain jobs which have a noticeable increase in the risk of back injury -- jack/propman, roofbolter, mechanic, and continuous miner operator/helper. The problem now is to

determine what activities these miners perform that increases their risk.

Obviously, precisely which job has the greatest risk of back injury cannot be determined without considerable exposure data. Furthermore, even if one could make this distinction, it would be of limited value since it is not the job titles that get people injured -- it is the activities they perform.

This analysis also puts emphasis on a fact that became extremely clear during this project -- accident research which is based on conventional "first report of injury" accident records cannot provide the answers sought in solving the accident/injury problem. It takes understanding the details of the accidents to identify corrective measures. The relatively simple analysis done with Tables 76, 77, 78 and 79, shows us that by pooling job title data across mines we can easily be led astray because in different mines -- even within the same company -- persons with the same job title do different jobs with completely different exposures to known back injury risks. Even within a mine, we see that a person's job title may be misleading as an indicator of risk because in our data only 59% of the LT and 47% of the NLT injuries occurred while a person was doing work which was associated with his/her job title. Using the typical accident records, this would never have been determined because there simply is not enough detail.

Table 77 describes the job being worked at the time of injury. A quick comparison with Table 78 shows that many of the miners were working outside their jobs when injured. The general pattern of job titles injured is similar, with two main differences. Only four of the injured were jack/propmen, but thirty five of the injured were doing jack/propman work when hurt, and eighteen of the injured were foremen but only seven were acting as foremen when hurt.

Table 78 carries the job title analysis one step farther by comparing the job title/job-working. Due to its complexity, not all possible combinations are reported. Rather, a few combinations are described to show the variability in job title/job-working combinations. First, let us consider foremen. As previously indicated, 18 of the injured were foremen, but only seven miners were injured while working as foremen. The additional analysis in Table 78 reveals that only five of the eighteen supervisors were working as foremen when injured. The other two persons working as foremen were a general laborer and a mine examiner. Of the 13 foremen who were injured while performing non-supervisory work, four were acting as laborers, three were setting jacks, three were doing maintenance, one was fire bossing, one was working on the beltline, and one was doing ventilation work. When miners are hurt while working out of their jobs, the nature of

their out-of-job work deserves exploration. The 13 foremen injuries are explored below. Ten of the 13 were doing what they considered a routine activity for them and six of these ten were helping out. The injury scenarios follow. The first was helping with longwall maintenance and was handing a sheave block to another miner. The second was helping another miner move posts during retreat mining. The third was helping pull a section of belt off of a roll to expedite a belt move. The fourth was helping get the shields ready for advancement by shoveling loose rock and coal out of the area between the shields. The fifth was helping lift a section of miner cable so it could be hung on the rib. The sixth was helping install a section of ventilation tubing because there was a methane buildup.

TABLE 78. - Selective Comparison of Job Title
and
Job Working When Injured*

<u>JOB TITLE</u>	<u>JOB WORKING</u>	<u>FREQUENCY</u>
Roof bolter	Roof bolter	23
	Laborer	2
Laborer	Laborer	25
	Beltman	5
	Roof bolter	2
	Scoop op.	2
Shuttle Car Op.	Shuttle car op.	8
Cont. Miner Op.	Cont. miner op.	18
Beltman	Beltman	9
Mechanic	Mechanic	16
	Jack/propman	24
Safety Inspector	Safety inspector	1
	Scoop op.	2
Foreman (Supervisor)	Foreman (Supervisor)	5
	Mechanic	3
	Jack/propman	3
	Laborer	4
	Fire bossing	1
	Beltline	1
	Ventilation work	1
Electrician	Electrician	3
	Safety inspector	4
Scoop Op.	Scoop op.	2
	Section move crew	2
Jack/Propman	Jack/propman	4
Shear Op.	Shear op.	2

* Note: only selected comparisons made

Table 79. - Estimated Relative Back Injury Risk
Comparison by Job

JOB	Non Lost Time		Lost Time		Total	
	Frequency Rate		Frequency Rate		Frequency Rate	
	In Job	Out of Job	In Job	Out of Job	In Job	Out of Job
Mechanic(9)	2.8	1.3	1.8	1.2	4.6	2.5
General						
Laborer(15)	1.4	1.6	1.3	1.1	2.7	2.7
Roofbolter(6)	1.7	1.0	3.5	3.3	5.2	4.3
CM op/h(6)	1.3	1.3	2.2	1.8	3.5	3.1
Supervisor(3)	3.0	1.3	3.0	1.3	6.0	2.3
SC op.(6)	.8	.8	1.0	.8	1.8	1.7
Scoop op.(3)	1.3	2.0	.3	.3	1.7	2.3
Jack/propman(4)	.3	4.5	.8	4.8	1.0	9.3
Shear op(2)	1.0	.5	1.0	1.0	2.0	1.5
Electrician(2)	1.5	.5	2.5	1.0	4.0	1.5
Beltman(5)	.8	1.4	1.2	2.0	2.0	3.4

Notes:

- (1) Number in parentheses is the estimated number of personnel in this job at average mine.
- (2) Frequency rate calculated by dividing frequencies in Tables 76 and 77 by estimated personnel in () in this table.
- (3) In-job means injured was working in his job category when injured.
- (4) Out-of-job means injured was working out of job category when injured.

The other four considered the injury producing task to be a normal part of their job. Their injury scenarios follow. The first was moving some crib blocks so a ventilation fan could be set. The second was pushing a portable rock duster into a scoop. The rockduster chain hung up under the bucket, and the rockduster stopped suddenly. The third stepped in a hole when going through a man door. The fourth was on his way to restart the belt, and fell while climbing over a pile of coal on the belt.

Three foremen felt they were hurt while doing non-routine work. Two of them were helping out, one by helping to site-in the tail piece (he was climbing and his foot slipped on a guy-wire), and the other was carrying a gear out to the track (he walked 900 feet in a stooped position with the gear on his back). The other injured foreman was training a group of new miners on shield movement when a rock fell between the shields striking his back.

It is ironic that the other five injured foremen who were injured while performing supervisory work were all injured while walking and either slipped, stepped in a hole, or walked into low top.

What conclusions can be drawn about supervisors' back injuries? Most (72%) occurred while they were doing non-supervisory work, assisting their crew in some way to expedite the completion of the work in progress. The logical conclusion is that foremen should stick to

supervising, and they will not get hurt. This is unfortunately in direct conflict with what makes an efficient foreman -- someone who does what is necessary to get the job done. The second conclusion is that foremen need to be careful about being preoccupied -- all five supervisory injuries occurred when foremen were transiting the mine and walked into, or stepped on/into, something.

It is also instructive to analyze the data in the opposite direction -- on a given job being worked which job titles were injured. First, consider setting jacks on the longwall. There were only four jack/prop men injured, but 35 persons were hurt while doing the jack/propman job. Of these, 24 were mechanics, three were foremen, four were jack/propmen, two were longwall helpers, and there was one laborer and one beltman. Similarly, of the 41 miners injured doing laborer work, only 25 were actually laborers. The balance were spread over 12 other job titles including four foremen. This is in direct contrast to jobs being worked such as roof bolter (23 of 26) and shuttle car operator (8 of 10) where the job being worked and the job titles corresponded closely.

CHAPTER 12

CONCLUSIONS AND RECOMMENDATIONS

Industrial back injuries are one of the oldest identified occupational medical problems. Numerous studies of the problem have been done, but none have come up with "THE FIX"; that is, the magical simple solution that will cause all of these injuries to stop -- for example, a new way of teaching miners to lift. Historically, government, industry, and researchers in the field have used first report of injury data to try to understand the back injury phenomena and develop control measures. While this has contributed to the significant reduction in the physical demands placed on miners, in actual fact most of the improvements have resulted largely from production system changes designed to improve productivity rather than from a desire to reduce accidents and injuries in the mines. Furthermore, back injury frequency is staying constant or increasing. The goal of this project was to conceive and implement a new approach to the evaluation of back injuries in underground coal mining.

To accomplish this goal, the authors drew on their prior experience in evaluating accident/injury problems in both mining and general industry. This experience had taught them that the level of detail commonly available in worker's compensation style injury reports was simply inadequate to understand the injury situations well enough to functionally address them. Therefore, this research was structured to obtain accident/injury detail. Furthermore,

the authors sought details not only about the accident itself, but also about the workplace/production environment that was in place at the time the injury occurred. They felt that an understanding of the tasks, processes, procedures, etc. that resulted in the injuring activity being done the way it was done was absolutely critical to finding ways to correct the situation. There was only one source for this data -- the miners who were injured. Data was also collected about the injuries themselves, and their associated medical treatment because most of the costs that result from a back injury are the result of the actions of the medical community (i.e., medical costs plus the cost of medically mandated time off from work.)

The discussion that follows is divided into general topic areas with a series of comments followed by one or more recommendations. The first topic area is that of excessive force exertion, the most common source of injury identified in this report. The most common corrections were to use more people or to use a mechanical assist to exert the force. Additional miners were generally not used because they were not present and there was a perception among the miners present at the time that there was not enough time to get the extra help. In all but a couple of the mines in this study, there were no mechanical assists available in the mine. When they existed, they were often

not used because they were not conveniently available. This presents an interesting dilemma. Clearly, the forces produced the injuries, but the reasons that the forces came to be exerted on or by the injured person were the personnel allocations in the mine, equipment designs, and a perception that there is not enough time to wait for the "proper circumstances" to proceed with the task. These are all factors which are under the direct control of mine management.

Production costs are important, and more miners on a section means increased labor cost. Fewer miners on a section may mean increased intangible cost (worker's compensation, training, administrative time, etc.). Modifying equipment designs to reduce operator stress or to increase the maintainability of the equipment may increase equipment costs, but failure to do so may increase intangible cost as much or more. Waiting for the extra miner to be available to assist in lifting a part or dragging a hose means lost labor time and potentially less coal being mined. Not waiting may increase compensation cost, and in reality much of the work is done with a "hurry up and wait" approach. Furthermore, most of the mines in this study told their miners to wait for help when something was too heavy, but somehow, by the time the miners and supervisors reached the section a sense of

urgency had developed which precluded waiting. One can only speculate that regardless of what was said during training, production was the thing that was rewarded.

The point of the preceding discussion is that mine management, and to a lesser extent labor, must recognize the tradeoffs between immediate productivity (obvious and tangible) costs and accident/injury and inefficiency (hidden and intangible) costs. They then need to make conscious decisions based on these tradeoffs.

This message has been sent before, but mining continues as usual -- why? Obtaining the cost data and going through the decision process is non-trivial. This report covers 224 back injuries which occurred in 156 different situations. Many of these would have required someone to evaluate the alternatives and make a decision. This takes time, the likelihood of the various outcomes is unknown, and the risk is generally perceived to be minimal in any given single situation. Management must address the hardware side of the problem with capital, but it must address the decision process side of the problem by "meaning" it when they say take time to do it safely, by training both supervisors and hourly personnel to recognize the physical stresses that occur with various approaches to a task, and by supporting decisions made on that basis.

Let us explore this further by looking at injuries to mechanics. For simplicity, this discussion is confined to lifting situations where the mechanic was lifting over 60 pounds -- a heavy lift by the authors standards. There were twelve injuries associated with this situation (29% of the mechanics injuries). Six of the twelve involved equipment design (either maintainability or mechanical assist availability). One involved use of the wrong tool (too small for job), and two involved handling steel in the welding shop (shop layout, extra person, or mechanical aids). Three involved cable handling -- not really a part of the mechanics job, but they were assisting in expediting production work (extra person or cable handling device). As indicated, it is a matter of weighing tradeoffs and making decisions; in one of the twelve cases, the injury resulted in a decision to redesign the equipment such that the part being replaced is readily accessible. In this subset of the data where only simple lifting tasks were considered, six different solutions were available. The point is that there is no simple solution to the problem.

Training is another way of approaching the problem, and as part of the project, two sets of data were collected: 1) an interview to determine what type of training the injured miners had with respect to the situation in which they were injured, and lifting in general; 2) a survey of

thirty-six mines to determine the status of their back injury control related training. Both data sets led to the same conclusion: most mines today give training that is inadequate with respect to lifting in general, and in evaluation of the physical stress potential of various approaches to job tasks. Lifting training must be made relevant to the mine environment and preferably to the specific mine environment in which the training is occurring. Supervisors and employees must be trained to evaluate task stress and be supported for choosing work methods appropriately. Supervisors must also be encouraged to intervene when physical stresses may be too great.

The medical aspects of the injuries often determine the LT/NLT pattern for an injury. A variety of data were collected about the injuries themselves, and the medical evaluation and treatment of the injuries. This was supplemented by input from thirty-six mines on their approach to managing the medical aspects of back injuries. Again, both activities led to the same conclusion: the medical evaluation and treatment, as well as management's interaction with the medical community, are inadequate. More specifically, many mines are located in relatively remote areas where access to medical specialties is limited, and most miners went to physicians of their choice. The evaluation and treatment of back injuries is not a recognized medical specialty and it requires

extensive technical knowledge, years of experience, sensitive intuition, and excellent patient handling skills. While no criticism of the medical profession is intended, many doctors do not have the training or back injury intuition to accurately assess and treat back injuries. The problem is compounded by the fact that doctors are not miners and do not really understand a miner's job duties and their associated physical stresses. Also, doctors are not mine managers and can not fully understand the implications of "giving" time off. Mine management has generally made little or no attempt to enlighten their treating physicians about both aspects of the problem, nor have they worked with the medical profession on a case by case basis to find ways of bringing injured persons back to work quickly by placing them in work appropriate to their temporary physical limitations.

There are numerous myths about the source of mining back injuries, and the interview and data collection process has challenged a number of the commonly held myths about back injuries.

MYTH

1. Back injuries occur on unusual or non-routine work.
2. Lifting heavy loads is the primary cause of back injuries.

FACT

1. Almost all of the injuries occurred while doing work considered a normal part of the injured's job.
2. Loads greater than 60 pounds accounted for less than half of the lifting injuries and about 30% of all the back injuries.

MYTH

3. Malingerers are the real problem.
4. Off-the-job lifting, as in hunting, is a major cause of back injuries.
5. Lifting training is the solution to the problem.

FACT

3. Only a small percentage of the cases involved questionable injuries.
4. Non job related activities may have been a factor in very few cases.
5. Eighty-nine percent of the mines surveyed provide lifting training and the problem continues unabated. Lifting training alone cannot alleviate the problem. Equipment design, mechanical aids, appropriate work procedures, and stress evaluation training are also necessary.

A major finding of the research was the identification of sudden-movement/unexpected-loading as a major factor in back injury causation. Our initial expectation was that lifting related biomechanical loading of the back would be the dominant source of back injuries. Our data confirmed the fact that lifting activities were frequently a factor in back injuries, but it also identified sudden movement as a more frequent contributor than lifting. Furthermore, sudden movement is also a factor in a sizeable percentage of the lifting accidents. Sudden movement apparently works by loading the body in a manner and at a rate which exceeds

the body's response capability. This results in tissue damage and pain either by forcing a body segment beyond its normal range of motion, or by actual tissue tearing. Situations where relatively large forces can be placed upon the body unexpectedly and within a few milliseconds should be avoided to eliminate these injuries.

Finally, this research suggests two ways of pursuing further study of back injuries. The first is through intense investigation of the events that led up to the injury, the reasons for doing what was done the way it was done, and implementation of corrective measures determined from the investigation -- not just to the specific injury situation, but to all similar situations in the mine. The second is to investigate non-lost time injuries as well as lost time injuries. From the data collected, we were unable to identify any differences between the LT and NLT injury scenarios. Most mines have too few LT back injuries for a thorough analysis, and the addition of NLT data will increase the base on which they can make corrective decisions.

SUMMARY

The purpose of this investigation was to develop and implement a new approach to back injury investigation. A new approach was sought because previously used approaches had failed to find "the solution" to back injuries in underground coal mines. During the project, 224 back injuries which were the product of 156 different accident scenarios were investigated. A quick comparison of these two numbers indicates there was little repetition of accident scenarios; in fact, there was considerable diversity in the situations which produced back injuries. Of the 156 scenarios, 130 occurred only once, 17 occurred twice, 4 occurred three times, 1 occurred six times, 2 occurred eight times, and 2 occurred ten or more times. This may seem to suggest that unusual or non-routine events caused the injuries, but 188 (84%) of the injuries occurred while the injured was doing a normal part of his/her job and 193 (86%) occurred while doing a routine activity.

What then, is suggested? The authors found that underground coal mining is an incredibly diverse work environment in which all of the conditions historically known to cause back injuries are very common. In general industry, similar conditions also cause back injuries, but, for any given job, there is considerable workplace and workpractice structure, only a few causal conditions exist,

and thus control of the causal conditions may be a matter of "fixing" a few job designs or workpractice factors. In mining, however, the data show that the reverse is true. There is little structure to mining jobs, there are many, many causal conditions present, and considerable thought and ingenuity will be required to "fix" the diversity of conditions (69 types of equipment involved in 61 ways with 44 design factors which contributed to the injuries, 80 different loads or agents of injury, 74 ways of avoiding the situations encountered in this study, and 30 different types of outside-the-mine planning that could have prevented this study's accidents).

The authors' conclusion is that there is "NO SIMPLE FIX" which will eliminate or substantially reduce the frequency of back injuries in underground coal mines. Rather, the data clearly show that what is needed is to inform mine management, mine safety persons, and the miners themselves about the main causal factors that may result in back injuries. Then they must be given the freedom to make corrections which will eliminate, or at least mitigate the effects of, the causal factors.

It may be that one of the mine engineers develops new specifications for operator cab design; the mine safety person may review accident data and detect a trend in material handling injuries after switching to a new

rockdust supplier; a section foreman might intervene to prevent a miner from lifting something too heavy; or one of the miners could shovel some loose rock and coal out of the way before working in an area. All of the above - plus - will be required to reduce the frequency of back injury occurrence.

Even though this research did not find "The Fix", it did identify some common injury scenarios, and it did present corrective actions for their associated causal factors. The causal factors and corrections are summarized in the balance of this report.

<u>CAUSAL FACTOR</u>	<u>CORRECTIVE ACTION</u>
Excessive force exertion	* Use additional person(s) * Use mechanical lifting aid. * Position lifting aids so they are convenient to use. * Attach lifting eyes to parts and equipment. * Repackage materials into lighter less bulky packages. * Redesign equipment for maintainability.

- * Match tool to task to avoid tool failure and tool slipping.
- * Avoid jerking on loads and tools.

Equipment design problems

- * Add suspension system to vehicle seats.
- * Provide operator and passenger restraint system for vehicle seats.
- * Attach lifting eyes to equipment.
- * Match vehicle height to mine conditions to improve both operator vision and operator posture while reducing neck injury from canopy contact.
- * Code vehicle controls using labels, shape, and location.
- * Design ATRS canopies to cover RB operator during as much of bolting cycle as possible.

- * Develop mechanical lifting aids that can be easily mounted on mine vehicles.
- * Develop high line system for longwalls to move heavy parts from the end of the haulage way to the use location on the panline.
- * Hinge equipment panel covers and manddoors on the side rather than the top.
- * Attach work platform to boom of RB so operator can access high top.
- * Use non-skid materials on metal surfaces that people will work or walk on.
- * Develop assist device for cable handling to reduce bending and the amount (weight) of cable which is lifted.

Work practices and
lifting

- * Deliver supplies as close as possible to the point of use.
- * Avoid low lifts - do NOT store supplies on the ground.
- * Store supplies on carts to facilitate movement and eliminate low lifts.
- * Maintain high housekeeping standards for both debris and loose rock and coal.
- * Use backpack to transport small tools, parts, etc.
- * Follow reasonable lifting procedures by minimizing reaching, twisting, etc.
- * Use enough people for lifting and/or moving large items, especially cables.
- * Train supervisors and miners in task related physical stress evaluations.

- * Demonstrate and encourage the use of mechanical lifting aids.
- * Make material handling and lifting training specific to a given mines environment.
- * Encourage all personnel to intervene when they see another miner attempting what appears to be an unsafe lift.

Medical treatment and
treatment

- * Identify health care providers who specialize in the evaluation and treatment of back injuries.
- * Establish appropriate levels of physical activity for miners returning to work after an injury.
- * Maintain contact with miners who are off work for extended periods due to an injury.

- * Communicate the requirements of mining jobs to the health care providers that service their mine.

Sudden movement syndrome

- * Walk slowly and carefully in wet/slippery/slushy/muddy bottom conditions.
- * Avoid jerking on loads or tools.
- * Add suspension system to vehicle seats.
- * Provide operator and passenger restraint system for vehicle.
- * Mark unusually bumpy places in roadway with a warning signal so equipment operators can slow down before hitting bumps.
- * Match tool to job to avoid sudden force release.

- * Mark low spots in walkways and haulageways so miners do not walk into them.
- * Lift and pull cables carefully and with sufficient personnel to avoid sudden stops or starts.
- * Evaluate all work situations where moderate to large forces will be exerted to identify and prevent sudden force release.

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APPENDIX A. - INJURED PARTY INFORMATION/
OBSERVATION GUIDE

BACK INJURY RESEARCH PROJECT:
Injured Party Information/Observation Guide

ACCIDENT SUMMARY

- A1. Case # _____ # Days Lost
- A2. Description of accident.
- A3. Shift working at time of accident.
- A4. Time of accident. Date of injury. Date reported.
- A5. What was being done at the time of injury? How?
- A6. Why was task being done? How did it relate to overall activity? Was it routine?
- A7. Why were you doing the task? (Normal part of job; just filling in; helping out; emergency; etc.)
- A8. Is there a standard method for task? (SKI, JSA, etc.) What is it and what related training did you have?
- A9. If 5 and 8 are different, Why?
- A10. Would 8 have improved situation?
- A11. Are there alternate methods for task? Describe and evaluate. Why weren't they used? (Hoist, etc.)
- A12. How many normally do task? This time? If different, why?
- A13. If more than one miner involved, was/were other miners a factor in injury? How or why? Where did injury occur? Were communications or training a factor?
- A14. Does task have any special hazards?
- A15. Was equipment related? How? Design factors?
- A16. How could a situation be avoided in future?

MATERIAL HANDLING SUMMARY

- B1. Describe load (size, handles, shape, cg, stability, slippery, etc.) If shoveling, what is typical load and how is it handled, shovel design?

- B2. Where was load? At start? At end?
- B3. How was load grasped (specify hand position)?
- B4. How much did load weigh?
- B5. What was bottom condition?
- B6. Were there obstructions to movement of load?
- B7. Obstructions to movement of body (housekeeping)?
- B8. Mine height at injury site (use posture based estimate).
- B9. Were you pushing, pulling and/or lifting?
- B10. How often do you handle this load and in what time period? (hr., stopping, shift, etc.)
- B11. What lifting technique was used (normal, this case, lordosis, kyphosis, free style.)?
- B12. If not normal, why?
- B13. Body posture at time of injury (sketch).
- B14. What was material handling summary of current job (tasks; loading; frequency; mean; and range)?
- B15. What environmental conditions prevailed when injury occurred (Lighting, Noise, Dusty, Other)?
- B16. Did injury occur on overtime?
- B17. If yes, what was done on straight time?

INJURY SUMMARY

- C1. Describe injury (what did you feel, where, when) (relate back to description).
- C2. Location of pain?
- C3. Description of pain.
- C4. What examination procedures were used?
- C5. What treatment was received?
- C6. What diagnosis was made?
- C7. Were physical therapy or medication prescribed?

- C8. What prescription(s) were given?
- C9. What was the injured's opinion of injury cause?

PERSONAL DATA SUMMARY

- D1. Age
- D2. Sex
- D3. Job Title
- D4. Job working at time of injury
- D5. Experience on task being done at time of injury
(time/frequency).
- D6. Height
- D7. Weight
- D8. Physique and physical fitness (subjective).
- D9. Grip strength results R1? R2? L1? L2? (circle
preferred hand)

HISTORICAL SUMMARY

- E1. Mining related work history.
Job title? # Years? Lifting/material handling
activity?

List years and codes for all mining jobs held

Years	Code	Other
1.		
2.		
3.		
4. _____	_____	
5. _____	_____	

E2. Non-mining related work history

Job title? # Years?

Lifting/material handling activity?

List years and codes for all non-mine jobs held

Years	Code	Other
1.		
2.		
3.		
4. _____	_____	
5. _____	_____	

E3. Has injured had a back injury(s) in the past? How many?

E4. What leisure activities are usually pursued?

F1. Could outside mine planning have helped the situation? If so, describe.

F2. Was this a lost time injury? Number of days lost? _____

F3. Was this a restricted work injury? Nature of restriction? Number of days restricted? _____

G1. Was reported date different from date of injury? If so, why?

G2. Were non-work related events involved?

G3. Mine height classification.

G4. Injury site location.

G5. Cost of property damage.

G6. Did mine management feel that the injury was not real or that it did not happen as described?

APPENDIX B. - Variable List

SHIFT BEING WORKED

Day/
2nd or Swing/
Night/Midnight/

ACTIVITY AT TIME OF INJURY

Climbing off machine
Shoveling
Dragging piece of wet curtain
Dragging hose
Walking backwards
Reaching for 5 ft. plastic pipe
Walking downhill
Moving miner cable and water line
Building cribs
Bending roof bolt in ceiling
Restocking bolter
Repairing teletram differential
Rolling 4' spool of miner
Hit feeder -- conveyor -- with shuttle car
Resetting cable and water line in cuts
Prying on gathering motor on bolter
Teletram operator hit continuous miner
Driving shuttle car -- hit bump
Drilling hole for roof bolt -- falling slate
Removing drill steel
Shuttle car steering failed and hit rib
Driving spads into low roof
Reached over sidescoop -- lift motor cvr
Turning over box of 6 shuttle car SR
Pry bar to hold bracket in place
Pushing dust box out of scoop bucket
Lifting 4"x8"x18' header
Picking up 2 bags rock dust from scoop
Walking -- stepped in hole
Operating continuous miner cutting bottom -- large hole
Loading tool box onto bucket of scoop
Picking up fallen top -- new piece fell
Pushing rock duster into scoop bucket
Lifting oxygen cylinder
Lift hand sheave
Six miners flipping railcar stop with plate
Lifting timbers and pulling thru mandoor
Lifting shuttle car or continuous miner panel cover
Transferring tool box between low boys
Loading elevator with box of metal
Handling 6" x 16' long I-beams
Carrying gear
Reloading roof bolt with rock dust
Lifting wooden and metal tie from bottom
Standing and lifting 7200V power cable

Standing on drill head with roof bolt and wrench
Bending over and stood up
Using pry bar to move hydraulic jack-long wall
Prying refrax plate out of box -- 150 lbs.
Removing slate top with pry bar
Walking across supply car
Carrying 5 gallon jug of water
Moving crib blocks
Fell off roof bolter while working in HT
Standing on roof bolt head using torque wrench
Inspecting top and/or rib
Lifting steel bar
Roof bolting -- rock fell knocking hard hat
Switching hands -- carying transit and tripod
Lifting mandoor
Exiting vehicle -- mantrip, forklift
Carrying two five gallon cans of oil
Pulling cable, jerked backward
Walked into roof bolt plate in low top
Bent over to read continuous miner meter
Install push blocks on longwall
Tying cable at ceiling height
Maintenance on long wall stage loader
Driving into and from work area
Adjusting tilted long wall shield
Walking; tripped on cable
Stopping rotation shaft with a belt
Picking up section of chain
Lifting air pressure tank from ramcar
Carrying beltline roller
Operating continuous miner, checking position
Carrying props
Operating feeder controls
Lift/drag section of belt to beltline
Lifting pallet out of mud
Lifting DA ram (long wall)
Using pry bar to lift frozen roller
Lifting stretcher
Lifting group pump
Lifting ventilation tube
Picking up a cap wedge
Dumping mode bucket
Lifting, jerking on waterpipe
Lifting timber and tossing to side
Walking and slipped on wet board
Running away from failed pressure line
Assembling panline
Lift and carry timbers
Carrying 5 gallon of oil
Repair long wall shield flipper
Position roller on belt structure
Climbing onto beltline
Swinging 5 gallon oil pail along shields

Lifting belt starter plug
Driving bobcat on surface
Welding in prep plant
Climbing down ladder to exit vehicle
Prybar to lift heavy size
Using wrench to tighten bolt
Pounding nails into board
Repairing slam door
Using jack leg drill
Walking panline
Maintenance on continuous miner
Putting up cable hooks
Carrying 20 lb foot rail
Woke up with muscle spasm after building overcast
Unroll new section belt material
Emptying vehicle so could use
Operating roof bolt controls
Lifting and carrying panel cover for loader
Bending over trying to attach low boy tongue to motor
Picked up crib block and threw it
Placing crib under axle of rail car to change wheels
Throwing resin on bolter
Riding on mantrip
Handling hydraulic pipe on long wall
OJT on roofbolter
Cutting metal
Removing fittings from long wall haulage box to clean it
Lifting 40 lb. metal sheet off low cart
Lifting and carrying 75 lb. modules for power center
Using wrench to loosen bolts
Two miners carrying 200 lb. piece of steel when one
dropped it
Repositioning forks on lift truck
Bent over and picked up piece of metal from crib
Making water spray boom bracket
Lifted and dragged roof bolt cable
Stepping off bus
Throwing scrap into scrap bin
Lifting 8" I-beam to 30" high saw table
Driving scoop
Supporting 18" diameter vent tube overhead
Attempting to restart main belt
Cutting tailgate using long wall sheaver
Pulling roof bolt cable while walking backwards
Pushing broken gofer out of haulageway
Walking to face and tripped on roof bolt
Lifted and threw continuous miner cable
Picked up rotation drill motor and put in gofer
Was helping to pull track idler closer to continuous miner
Tightening truss bolt with 0.5" racket
Lifting rock out of way
Trying to move a coil of power cable
Walking backward sweeping belt line

OVERALL TASK

Roof bolter
Shoveling beltline
Moving longwall shield
Handling curtain
Spraying mandoseal
Maintenance
Building cribs
Switching continuous miners
Taking shower
Haulage
Repositioning of cables and water lines
Surveying
Inspecting safety equipment (6 SCSR's)
Building permanent roof support
Material handling
Walking to or from workplace
Operating continuous miner
Manually clearing beltline of fallen top
Routine rock dusting
Cable splicing
Housekeeping
Longwall move
Laying track
Moving power center for long wall
Scaling top
Replacing bolt
Setting ventilation fan in place
Moving track vehicles
Building stoppings
Transport to section
Operating tail piece of long wall
Moving equipment
Pump water off longwall section
Align feeder to belt
Fire boss
Clear jam at belt convergence PT
Practicing for mine rescue
Foreman's job
Extending vent tubing
Cleaning bath house
Installing pressure pipe line for long wall
Resupply bolter
Setting timber for retreat mining
Extending beltline
Carrying oil to long wall shear
Removing pipe line on surface
Building bridge
Drill and blast
Building overcast
Welding
Rock dust with hose pod

Using endloader at prep plant
Restock bolter
Continuous miner move
Cutting face with longwall
Surveyor
Longwall shearer operator
Shoveling on longwall panline
Setting props at stageloader
Putting away tools
Sweeping belt line
Supervisor checking ventilation
Installing air conditioning, washing wheelbarrow
Putting dump car back on track

WHY WAS TASK BEING PERFORMED

Bad top
Rib roll
Keep ground around shield level
Moving ventilation curtain
Prevent roof and rib deterioration
Preventive-routine maintenance
Breakdown maintenance
Taking shower after shift
Shovel or clean beltline
Transferring supplies to bolter
Routine haulage
Routine housekeeping
Routine roof bolting
Routine equipment moves
Routine material handling
To get to or from assigned work area
Routine continuous miner operation
Clearance for long wall shields to advance
Resupply section
Longwall move
Moving section shop
Handling repair parts
Moving rail ties to point of use
Insulating pipes
Roofbolting in high top--had fallen out
Surveying
Inspecting safety equipment
Modifying ventilation system
Methane inspection
Routine continuous miner move
Moving equipment
Moving power center
Routine rock dusting
MSHA Requirement, fire boss
Mine rescue training
Building beltline
Preventing environment contamination
Checking permissability of scoop
Improving footing in wet area
Repairing broken door

Ran into rock, had to blast
Extending beltline
Equipment needed elsewhere
Foreman going to check roof bolt
Turning
Cutting solid rock with continuous miner
Cutting longwall face
Walking to shearer
Moving continuous miner cable to clear path for other equipment

TASK RELATION TO OVERALL ACTIVITY

Part of roof bolting activity
Part of beltman's job
Required for longwall operation
Ventilation control
Roof and rib stabilization
Maintenance
Taking shower after shift
Haulage
Maintaining safe and productive environment
Surveying
Rock dust
Part of continuous miner move
Operating continuous miner
Walking to or from assigned work area
Providing necessary supplies to section
Material handling
Transferring tool boxes
Building rail line
Rearranging cars -- tramline for proper supply
Transportation to section
Bobcat used to move dirt
Welding structure in prep plant
Could not mine rock, too hard
Equipment needed on section
Part of power center move
Part of beltline extension
Providing required materials to work area
Driving haulage shuttle car
Part of foreman's responsibilities
Open access panel to perform PM
Pushing broken gofer out of haulageway
Part of cutting face with long wall
Remove equipment after rerailing car
Preparation for mechanical rockdusting
Post job cleanup

WAS TASK ROUTINE

No
Yes
Non-routine due to bad top
Beltline unusually high

Moving 600' of continuous miner cable and water
Non-routine cutting rock with continuous miner

WHY WERE YOU DOING TASK

Normal part of job
Someone else failed to do job
No one else available
Helping out
Production emergency
Being trained by another person
Training another person
Section down, reassigned
On overtime doing jobs as assigned
Emergency

IS THERE STANDARD METHOD

No
Yes
Using normal procedure -- not written

TRAINING RECEIVED

Training not applicable to situation
General labor task training
None
On job training
Roof bolter task training
Shuttle car task training
Mechanic task training
Continuous miner operator task training
General task training for trackman
Motor operator training
Face boss, had all available training
Injured was trainer
Learned elsewhere
Injured was being trained

GENERAL LIFTING TRAINING

No
Yes
Specific to task

IF ACTIVITY AT TIME OF INJURY AND STANDARD METHOD ARE DIFFERENT,
WHY?

NA

Failed to follow rules, unrealistic
Failed to follow rules, realistic
Failed to use correct equipment
May not have followed the rules
Circumstances prevented normal procedure
Proper equipment not available
Foreman failed to use proper equipment

WOULD STANDARD METHOD HAVE HELPED?

NA

No

Yes

Partially

Using standard method

ALTERNATE METHODS FOR TASK

NA

No

Yes

DESCRIBE ALTERNATE METHOD

NA

Use hinged pipe to insert resin and bolt
Use different shovel to reduce load
Check for potential snag points
Place transfer pipe on roof bolt
Use an additional person
Use scoop or shuttle car to pull cable
Non-slip in potentially slippery areas
Package in suitable weight bundles
Aid to assist Operator in positioning shuttle car
Relieve the tension-cable and water line
Use drill motor to loosen bound drill
Extend canopy to cover roof bolt controls
Reposition body to get better leverage
Lift less items each time
Use ram in scoop bucket to pull; push equipment material
Use ram in scoop bucket to lift timbers
Wear seat belt in vehicle
Redesign seat
Bend knees and lift with legs
Scale top
Smaller and lighter sheave block

Use mechanical means to move objects
 Load timbers into scoop and transport
 Partially fill bucket reducing load
 Position load to minimize physical stress
 Break manoseal or rockdust hose every two joints
 Back pack to carry smaller, heavy items
 Do not twist trunk of body while lifting
 Design roof bolt with standing platform
 Keep supply car with materials close to usage
 Longer handle on tool, socket extension
 Watch for low top
 Lower cutter head to reduce lift distance
 Locate continuous and displays so easily accessible
 Use safest walking path
 Design transport vehicle with carry space
 Use handled tool to reach unsupported area
 Install mechanical break
 Load cart to reduce physical stress
 Design special tool for task
 Use chain to pull to DARAM out to fork lift
 Move items in the way before lifting
 Don't use body jerk to throw heavy objects
 Test equipment on surface
 Job rotation to reduce fatigue
 Use stretcher with tall handle
 Stay under shield
 Add shear oil at intake end
 Secure footing while climbing
 Lift drill motor to relieve pressure on bit
 Locate beltline anchors properly
 Put in belt splice on surface
 Use chain to pull timbers off vehicle
 Slide one bucket at a time to edge of shuttle car bucket before
 picking up
 Cover hole around derail with steel mesh
 Could have the tongue on a block
 Do not throw heavy objects
 Position body to avoid pinch point
 Motorman should take more care
 Use resin or combination bolt
 Take short back extension breaks
 Train people on surface on simulator
 Use two additional miners
 Housekeeping and get closer to load before lifting
 Use two wheel hand truck
 Use pry bar to move fork
 Housekeeping
 Blast rock instead of cutting it with continuous miner
 Longwall operator must be careful not to cut into soft bottom
 Do not stand on tailgate motor
 Use pneumatic socket or longer, larger handle for socket
 Use canvas to mop beltline
 Bolt ribs and leave more block support
 Mandoor which opens sideways
 Stay within canopy
 Kneel rather than stoop

EVALUATE ALTERNATE METHOD

NA

Questionable impact

Adequate

Very good

WHY ALTERNATE METHOD NOT USED

NA

Not currently available

Prescribed method not used

Failed to size up job

Short one miner

Inconvenient

Proper equipment not conveniently available

In a hurry

Not MSHA legal

Never given consideration

Supervisor would not allow

Failure to plan for stress reduction

Horseplay

Costly

WHY # PEOPLE DIFFER THIS TIME

NA

Extra miner was assigned elsewhere

Just no one else around

In hurry and did not bother to ask

No room for second miner

2nd person was sick

WERE OTHER MINERS A FACTOR

NA

No

Yes

WHY, HOW OTHER MINERS A FACTOR

NA

Scoop operator tilted bucket

Someone else failed to do job correctly

Injured person holding part for welder

Position of co-worker required twisting

They failed to size up the job

COMMUNICATION A FACTOR

NA

No

Possibly

TRAINING A FACTOR

NA

No

Training may have covered activity

Train employees to keep area clean

Train longwall operator not to cut into soft bottom

SPECIAL HAZARDS

No

Yes

Bolter operator couldn't reach hole

Low seam height causes awkward position

Snag and sudden stop

High frequency moderate lifting

Slippery walking surface

Bad top

Shoveling to high belt

High frequency low weight lifting

Object too heavy

Bar could slip

Rough roadway

Continuous miner was jolting operator while cutting bottom

Lifting posture -- didn't bend knees

Deenergize line before working on it

Heavy timbers

I-beams heavy and awkward

Trying to carry too many items at once

Excessive push/pull force

Excessive sitting and jarring vibrations

Deep water; unseen obstacles

Limited cab area and vision

Multiple floor obstacles

Heavy weight, awkward position

Awkward position

Two persons carrying heavy load

Cluttered floor

Shoveling to panline from shield requires twisting, bending

Shoveling all shift onto belt requires bending, lifting,
twisting

Opening door of mandoor from bottom up against high velocity air

EQUIPMENT INVOLVED

NA

No

Yes

WHAT TYPE EQUIPMENT INVOLVED

NA

Roof bolter

Shovel

Mandoseal or rockduster pad-hose

Sole of foot

Miner cable

Belt

Shuttle car

Scoop

Teletram

Pry bar

Access door on scoop

Dust box in bucket of scoop

Feeder at end of belt

Continuous miner

Rock duster

Tool box

Shuttle car access panel

Sheave block

3 ft. torque wrench

Motor -- locomotive

Transit and tripod

Mandoor

Wheelbarrow

Prop

Beltline roller

Ventilation fan

Shield jack

Jack leg drill

Longwall push block

Transportation vehicle

Hydraulic cable

Air tank on ramcar

Transfer chute

Grout pump

Stretcher

Vent tube

Mop bucket

Pipe

Pressure hose couples

Tow of long wall shield

Long wall shield

Panline

5 gallon container

Bobcat

Ladder on end loader

Sledge hammer

20 lb/ft. overcast rail

More than one item

Loader

Derailler

Tongue of low boy

Supply car

7' roof bolt

Socket wrench and cheater pipe
Low cart (4" above floor) for handling steel
Power center module
Longwall head drive
Power center cover
Lift truck
Water spray bracket
Saw table
Longwall tailgate motor
Gofer
Rotation drill motor for roof bolt
Track idler for continuous miner
Racket wrench
Beltline power cable
Sections of chain
Rerailer
Track-pod rock duster

HOW EQUIPMENT INVOLVED

NA

Person standing on bolter
Person overloaded shovel
Too heavy and awkward
No storage location on roof bolt
Sole design may improve traction
Beltline too high
Shuttle car hit feeder
Bucket of scoop suddenly tilted
Teletram hit continuous miner
Slate bar used to lift gathering motor
Canopy on roof bolt too small
Lack of seat suspension
Equipment failure
Supply car loaded incorrectly
Continuous miner had to be moved
Dust box moved out of scoop bucket
Equipment maintenance
Trying to move rock duster into scoop
Moving LW jack cylinder with pry bar
Too much force to operate wrench
Using slate bar on well anchored top
Egress path not visible enough
Trying to switch hands -- transit and tripod
Equipment was unstable
Low meter in poor location
Person jumped off equipment
Equipment in walkway
Lack of visibility
Equipment anchors create space problem
Design caused jams
Had to be lifted to empty
Lack of well placed handles
Limited area to handle pump
Overturned

Entry/exit ladder poorly designed
Wrong tool for task
No easy way to handle cable
No tool available to grab belt
Slipped in bucket of scoop
Derailer was cleaned out creating a hole
Person lifting up 16' header to get on roof bolt roller
Trying to attach tongue to motor
Changing rail wheels
Operator was involved in horseplay
Trying to bend roof bolt
Hit canopy
Roof bolt controls not familiar
Too much at one time
Used to transport metal sheets
Had to be moved
Fork on lift truck was struck
Being lifted
Dragging cable
Stepping off bus
Shoveling to panline
Miner stood on longwall tailgate motor
Opening door of mandoor from bottom up
Being cleaned
Being transferred from track to lowboy

DESIGN FACTORS IN EQUIPMENT

NA

Work platform access problem
Shovel blade too large
Weight
No place to lay transfer pipe
Beltline too high
Canopy too low and restricted vision
Canopy on roof bolt too small
Improve seat design
Restraint system
Layout of first aid sled improper
Continuous miner cable had to be moved
Lower cable hook on continuous miner
Redesign cable reel on roof bolt -- cable catches
Improve handle design for tool boxes
Longer handle on wrench
Motor -- locomotive -- too high to see over
Reposition the low meter
More stable jacks
Rust on equipment
Tank relocated on newer models
Anchors not located correctly
Hinge access panels for maintenance access
No way to grab item handled, needed handle or tool
Chute design was poor

Mop dump station too high
Toes of shield are slick
Access for maintenance hard
Cab design not suited to rollover
Ladder rungs not self cleaning
No easy way to handle cable
Bucket of shuttle car is slick especially if wet
Flange welded to tongue which made it difficult
Use scoop to move cable
Roof longer than seam is high
Use air wrench
Cart is very low (4" high)
Stronger wrench
Roof bolt controls not familiar
Had to reach thru canopy to store supply
Mandoor opens from bottom
Unstable

SECONDARY EQUIPMENT INVOLVED

NA

No

Handle length of shovel and grip inappropriate

Mandoseal mixer requires extra lifting

Shovel blade too large

Feeder

Continuous miner

Foam filled tires are solid

Improve seat design

Restraint system

Handle location on motor compartment

Need special tool to do job

No clearance due to longwall hoses

Use longer handle for tool

No seatbelt available

Need a mechanical means to assist with rail wheel changes

Too hard to take hose apart

Limited vision

COULD SITUATION BE AVOIDED

NA

No

Yes

HOW COULD SITUATION BE AVOIDED

NA

Redesign bolter

Don't overload shovel

Size up task before doing

Use scoop to clean floor

Sign slippery spots

Use vehicle to drag cable

Scale roof

Non-skid on change shower floor

Use wheelbarrow in place of shovel

Lift less weight

Provide alignment aids to help shuttle car at feeder

Redesign cable hooks

Raise canopy to improve vision

Use mechanical lifting and handling aids

Proper maintenance

Not man handling things

Redesign seat and restraint system

Check roof area

Positioning self properly to lift

Position heavy items on sled perimeter

Take tension off cable before lifting

Get additional miner

Wear seat belt

Check roadway for holes and roughness

Use ram in scoop to move rock duster

Use scoop to move timbers

Use backpack to carry small, heavy items

Don't twist trunk while lifting

Use equipment to drag cable long distance

Move supplies on supply car closer

Move slowly

Avoid overhead hazards

Watch out for slick spots in path

Watch foot placement

Design new jack

Reposition low meter

Lower cutter head

Use tool to reach unsupported spots

Hang cable out of way

Add a mechanical brake to stop fan

Don't put feeder in cross-cut

Pull shorter length of hose

Use cable covers on ground

Use chain to drag heavy objects to access point

Pretest equipment on surface

Provide lifting handle or tool

Use expanded metal on longwall toes

Stay under longwall shield

Position equipment for easy maintenance access

Check ground before using heavy equipment

Take periodical rests

Lift drill before pulling out steel

Use dipped steel plate in bottom of shuttle car bucket

Cover hole

Support tongue with block
Do not throw heavy objects
No horseplay
Use resin or combination roof bolt
Better training on new equipment
Use two additional miners
Change pipe fitting to strap fitting
Eliminate restricted work area
Use air impact tool
Use pry bar
Housekeeping
On longwall do not cut into soft bottom
Do not stand on tailgate motor
Have person loosen muscles every 10 minutes
Bolt rib and leave larger block
Redesign mandoor to open sideways
Adequate cab area
Use different posture
Install permanent rerailer

HOW COULD SITUATION BE AVOIDED

NA

Design special tool on sled
Redesign tool shovel (4)
Use more people
Gravel slippery spots
Do not shovel overhead
Relieve cable and water line tension
Change teletram operator behavior
Enlarge roof bolt canopy
Reposition handle and or motor door lighter
Use roller conveyor -- each side of mandoor
Don't manhandle -- use mechanical means
Position body to eliminate twisting
Proper maintenance
Check roadway for holes and debris
Better planning
Check for overhead hazards
Bend at knees instead of waist
Get additional miner to help
Keep walkway clear of obstacles
Better seat design
Rest more often or rotate task
Eliminate mop dump lip
Move obstructions out of way before lifting
Safer cab interior
Redesign entry and exit ladder
Design equipment for easy maintenance access
Prepare equipment for use on surface
Move supplies as close as possible on supply car

Take apart hose before handling
Use simulators for training
Use wrench with longer handle
Design equipment for easy transfer
Redesign rerailer for easy handling in tight place

LOAD - AGENT

NA
No
Yes
Rock
Coal and rock
Curtain
Mandoseal or rockdust pod hose
Transfer pipe
Cable
Roof bolt and hold board or endcap
Bundle of roof bolts
Spool of cable
Cable and/or water line
Gathering head motor
Five foot drill steel
Portable drill -- 6 lbs.
Cover -- door over motor
6-self contained self rescuers
Pry bar - 18"
Bags of rock dust
Timbers and headers
Rock dust box for roof bolt
Tool box
Rock duster
Five gallon bucket of shear bits
Shuttle car access panel
Oxygen cylinder
Sheave block
I-beam
Gear - 35 lbs.
Box of metal -- 10 lbs.
Wooden tie with metal tie attached
7200V power center cable
Refrax plate
Pry bar under 800 lb. cylinder
12 foot roof bolt and wrench
Slate bar in well anchored top
Checking torque with wrench
5 gallon bucket of water
Steel bar 12 ft. long
Crib block
Mandoor
Transit and tripod
2-5 gallon of oil
Section of belt

Light item not otherwise specified
Beltline roller
Air pressure tank
Chain
Tongue on Low Boy
Jack leg drill assembly
Longwall push blocks
DA ram
Prop
Pallet
Stretcher
Grout pump
Vent tube
Mop bucket
Pipe
Moderate weight handtool
Concrete block
Power center plug and cable
4' pry bar
Wrench
Sledge hammer
20 lb. foot rail
Roof bolt
Box of resin
Piece of sheet metal (50 lb)
2 ft. socket wrench with 4 ft. cheater
10 inch wide by 8 ft., 40 lb. steel sheet
Power center module 75 lb.
Power center panel 200 lb.
24" x 18" x 0.5" inch metal 80 lb.
50 lb. water spray bracket
Pieces of scrap metal up to 75 lb.
90 lb. I-beam
Gofer
Rotation drill motor for roof bolter
Track idler for continuous miner
Door of mandoor which opens from the bottom
Wash rag
Rerailer

LOAD - BULKY

NA
No
Yes
Yes, mandoseal hose, cable
200 lb. gathering motor for bolter
Bags of rock dust
Tool box
Rock duster
Large oxygen cylinder
I-beam - 350 lbs.
Wooden tie with metal tie attached

Refrax plate
Long wall cylinder
Mandoor
2-5 gallon of oil
20 ft. of chain
Longwall prop -- 100 lbs.
Section of belt, no grab
130 lb. vent tube
8 ft. round timber
Beltline roller structure
30 ft. long rail
2'x4'x0.25" steel panel
6"x8"x6' timbers
6"x8"x16' timbers
Crib block 36" x6" x8"
Continuous miner cable
7' roof bolt
200 lb. power center panel
Scrap metal
90 lb. I-beam
18" diameter by 20 ft. long vent tube
Broken down gofer
Rotation drill motor for roof bolt
Track idler for continuous miner
Rerailer

LOAD - UNSTABLE & SLIPPERY

NA
No
Yes
Yes, mandoseal hose will whip
Yes, miner cable is stiff
Yes, I-beam -- 350 lbs.
800 lb. long wall cylinder
Mandoor
Mop bucket full of water
Jack leg drill
Tongue on low boy
Bending roof bolt inserted partway in hole
200 lb. power center panel
90 lb. I-beam
Track idler for continuous miner

LOAD - SHAPE

NA
Hoses, cable
Five foot plastic pipe
12 ft. roof bolt plus end cap
4 ft. spool
200 lb. gathering motor

5 ft. drill steel
Less than 10 lbs.
52 lbs. and 50" long x 13" wide x 5" high
50 lb. rock dust bags
4" x8"x18' headers and timbers
400 lb. dust box for roof bolt
Rock -- 200 lb.
Rock duster -- 150 lbs.
Tool box -- 140 lbs., 48" long
5 gallon bucket of wheat bits
550 lb. piece of steel
Muddy curtain -- 7' x70'
Scoop panel -- 1/2"x48"x30" plus 10 ton jack
Five foot long cylinder
250 lbs. of I-beam
Gear -- 35 lbs.
Box of metal -- 10 lbs.
Wooden tie and metal tie -- 75 lbs.
Refrax plate -- 150 lbs.
Round cylinder -- 800 lbs.
Slate bar -- 25 lbs. or pry bar
Torque wrench
5 ft. roof bolt with plate
5 gallon container
Crib block 36" x6" x 8"
12'-3" diameter steel bar
Mandoor
Transmit and tripod
2-5 gallon cans of oil
150 lb. longwall push block
20 ft. of log chain -- 100 lbs.
50 lb. air pressure tank
50 lb., 4 ft. belt roller
130 lb. DA ram
6"x8"x6' prop
Belt section
Shovel with mud
Grout pump
2 ft. drain vent tube
20 ft. of pipe
Box of bolting glue
Bundle of roof bolts
42" roller structure
Power center plug & cable
Jack leg drill
30 ft. long rail
8"x8"x10' timber
2'x4'x0.25" panel door
Tongue on low boy
7' roof bolt
Box of resin
Piece of sheet metal 0.5x10x12 inch
2 ft. socket wrench plus 4 ft. cheater
10" by 8 ft. long steel sheet
Power center module

Wrench
5 ft. square steel
24 X 18 X 0.5 inch metal sheet
50 lb. water spray bracket
Pieces of scrap metal
3 ft. I-beam
20 ft. by 19" vent tube
Gofer
Rotation motor for roof bolter
Track idler for continuous miner
Rock - 20 to 30 lbs.
Pulling up to open a vertical mandoor
Rag
Rerailer
Block and rails

LOAD - GRIPPABLE

NA
No
Yes

HOW HIGH AT START

Inches

HOW HIGH AT END

Inches

HOW FAR AWAY

Inches

HOW WAS LOAD GRASPED

NA

Sym with handles
Sym without handles, hands on side
Sym without handles, hand underneath
Asym with handles
Asym without handles, hands on side
Asym without handles, hands underneath
Asym grippable, not lifted
Sym without handles, arms extended, push
Asym on one hand

Sym, one hand with handle
Asym, two hands over shoulder
Sym, grippable, hands on top
Sym, 2 hand grasp behind back, grippable
Asym, 2 items in each hand -- shoulder level
Asym, one hand, handle
Asym, two hands in front, lift
Sym, extended reach, using tool
Sym, without handles, hand on top
Asym, one under -- one behind
Asym, one hand on top

WEIGHT OF LOAD

Lbs.
Unknown

FORCE ON BODY

Lbs.
Roof material fell on man
Max force applied with tool
Load, unknown, fall
Load but unknown -- jolts in vehicle on road
Load but unknown
Load but unknown -- but large -- collisions

FLOOR CONDITION

NA
Loose rock and coal
Average floor conditions
Wet and slippery
Dry
Rough and rutted bottom
Cluttered with cribs and concrete blocks
Very obstructed area -- longwall shield area
Slushy and muddy
On top of equipment
Wet scoop bucket
Cluttered floor

OBSTRUCTED TO MOVEMENT OF LOAD

NA
No
Limited vertical and horizontal clearance
Equipment in movement path
Limited ceiling height - 55"
Floor cluttered with cribs and concrete blocks

Had to lift over edge
Item wedged between timbers
Drill stuck in hole
Pinned against rib
Floor cluttered with pieces of metal

OBSTRUCTED TO MOVEMENT OF BODY

NA

No

Low overhead

Tight clearance between equipment and rib

Couldn't get close enough to lift

Limited ceiling height -- 55"

Equipment in path

Couldn't get close enough to apply force

Body twisted due to obstruction

Stuff in walkway

MINE HEIGHT AT INJURY SITE

Inches

PUSH; PULL; LIFT

Push

Pull

Lift

Push or pull

Push and lift

Pull and lift

Push, pull, lift

Lift and twist

Lowering load

Shoveling

Carry

Hold

Lift and carry

Lift, twist and throw

Lifting lying down

Swinging sledge

Lifted and started to turn

HANDLING FREQUENCY AND NORMALIZER

30 minutes continuous shoveling
Frequent, more than 3 per hour
One to three per hour
Infrequent, less than 1 per hour
Rare, less than 1 per shift
Full shift continuous shoveling

LIFTING TECHNIQUE

Lordosis
Kyphosis
Free style normal
Lift, twist
Standing, leaning to one side
Dragging
Lifting from deep squat with back not legs
Lifting lying down
Squat lift

IF ABNORMAL LIFT TECHNIQUE, WHY

NA
Posture restricted -- poor footing
Posture restricted due to low ceiling
Miner on knees
Posture restricted due to access
Drill was stuck

BODY POSTURE DURING INJURY

Stepping backwards
Stoop-knees slightly bent--shoveling
Walking backwards
Stoop
Stoop - knees slightly bent
Walking, caught self with right hand
Standing, leaning to one side
Standing head bent forward
Sitting
Upright -- arm lift
Lying on his side in cab
Stooping, reaching way forward
On knees
Squatting
Standing, leaning forward, and pushing
Standing, pulling on cable -- walking back
Bent at waist, lifting
Walking with hands behind back

Standing leaning backward
 Carrying I-beam walking
 Stooping, carrying load on lower back
 On knees -- leaning forward -- lifting
 Deep squat
 Climbing in and out of motor
 Walking in crouch
 Walking briskly (straight up)
 Stooping, leaning forward, pulling
 Jumping, landing on both feet
 Walking, jerked body to catch fall
 Handling
 Standing, twisting
 Standing
 Climbing thru man door
 Walking, fell
 Running away from failure
 Lying on back on panline
 Climbing onto beltline
 Climbing down ladder
 Standing reaching up
 Various - fatigue
 Exiting mandoor, body part in and part out
 Stooping, knees slightly bent, throwing thru canopy opening
 Two persons carrying panel walking sideways
 Standing, bent at waist lifting
 Standing, reaching overhead and pulling
 Standing, arm extended over head
 Slipped off tailgate motor and landed on feet but uneven
 Bent over at twist

REACH, ASYMETRIC DURING INJURY

NA

Reaching, asym, throwing twist
 Hold curtain with hands behind body
 Bending, asym reaching to one side
 Reaching forward while lifting
 Reaching forward while pushing
 Reaching overhead, asym
 Bending forward -- sym
 Arms extended forward -- pulling and backing up
 Walking, kyphosis, arms behind back
 Reaching forward while pushing, lifting and pulling
 Reaching overhead--sym
 Lifting and pulling across body with twisting motion
 Reaching sideways lying down
 Leaning sideways to drop object
 Standing and turning with arms at side, each with 5 gal. oil can
 2 persons carrying panel, asym. load on right hand
 Reaching, stooping, washing movement

MATERIAL HANDLING SUMMARY

NA

Roofbolts, resin, timbers, etc.

Shoveling, beltline repair, rockdust, MH

Large amount of shoveling

General laborer type of handling

Mechanic handles variety of repair items

Limited handling

Foreman -- fills in as required

Cable handling

Stoper -- jackleg drill

Electrician -- parts, grease, in buckets etc.

Trackman type of handling

Motorman

Maintenance man

Beltman & beltline maintenance

Limited material handling

Moderate, cables

Moderate

Heavy

Usually limited, sometimes heavy

ENVIRONMENTAL CONDITIONS

Cold

Excessive water

Muddy wet conditions

Cluttered floor

ON OVERTIME

No

Yes

IF OVERTIME, STRAIGHT TIME

Loaded bolter, hung cable, curtains

Mason work

Mechanic

8 hr. shift on weekend

Section foreman

Roofbolter

Shoveling on panline

LOCATION OF PAIN

Back - NEC
Left cervical
Left thoracic
Left soft tissue
Left belt line
Left hip, buttock
Left leg
Center cervical
Center thoracic
Center soft tissue
Center beltline
Center hip, buttock
Right cervical
Right thoracic
Right soft tissue
Right beltline, top of sacrum
Right hip, buttock
Right leg
Lower back and hips

LOCATION OF PAIN

NA
Back - NEC
Left thoracic
Left soft tissue
Left beltline
Left hip, buttock
Left leg
Center soft tissue
Center beltline
Center hip, buttock
Right cervical
Right soft tissue
Right beltline
Right hip, buttock
Right leg
Beltline -- all the way across

DESCRIPTION OF PAIN

Sharp
Similar to muscle spasm
Dull ache
Sharp in certain postures, otherwise dull
Numbness and tingling
Burning sensation
Sharp pain followed by numbness in leg
Sharp and burning
Bruise
Soreness and uncomfortable

Pinch and burning
Pull
Tightness
Jar and pain after several days
Sting followed by tightness
Sharp & pinching
Tearing sensation
Burning and tingling
Felt like something popped
First pull, later sharp

EXAMINATION PROCEDURE

NA
No doctor or hospital
Range of motion
Straight leg raise
Palpation
X-ray
CAT scan, myelogram
Neurological
Unknown but examined
Saw doctor, hospital, not examined

EXAMINATION PROCEDURE

NA
Range of motion
Straight leg raise
Palpation
X-ray
CAT scan, myelogram
Neurological

EXAMINATION PROCEDURE

NA
Range of motion
Straight leg raise
Palpation
X-ray
CAT scan, myelogram
Neurological

EXAMINATION PROCEDURE

NA
Straight leg raise
Palpation
X-ray
CAT scan, myelogram
Neurological

EXAMINATION PROCEDURE

NA

Range of motion

Straight leg raise

Palpation

X-ray

CAT scan, myelogram

Neurological

EXAMINATION PROCEDURE

Neurological

TREATMENT RECEIVED

NA

None

Heat

Ultrasound

Exercise

Traction

Electro-simulation

Spinal alignment

Hospitalization

Bed rest

Physical therapy

Ice

Back school

Injection

Hospital recommended but declined

Rest

Pain Shot

TREATMENT RECEIVED

NA

Heat

Ultrasound

Massage

Exercise

Traction

Electro-stimulation

Spinal alignment

Bed rest

Physical therapy

Ice

TREATMENT RECEIVED

NA
Heat
Ultrasound
Massage
Exercise
Traction
Electro-stimulation
Spinal alignment
Hospitalization
Bed rest
Physical therapy
Ultrasound, heat, exercise, spinal alignment
Back school
Take it easy

DIAGNOSIS

NA
Muscle strain
None
Fracture
Disc damage
Pinched nerve
Bruise
Pinched nerve and muscle strain
Pulled muscle and slipped disc
Torn ligament, disc damage, muscle strain
Severe lumbar sprain
Spinal misalignment
Pulled muscle or disc problem
Muscle spasm
Pulled muscle
Facet joint sprain
Genetic structural defect
Cervical strain or lumbar strain
Pulled muscle and strain

PT-MEDICATION

NA
Physical therapy
Medication
PT and medication
None
Chiropractor

PRESCRIPTION

NA

Pain killer

Muscle relaxants

Both

None

Unknown prescription

INJURED'S OPINION OF INJURY CAUSE

NA

Poor footing

Too heavy of a load

Fatigued

Unexpected jerk

None

Poor footing and sudden twist

Sudden impact

Lack of seat suspension

Slippery floor

Jerked on cable

Twisting, pushing on drill, low ceiling

Unknown, but has done many times before

Improper lifting

Improper posture

Roof fall

Pulled too much cable

Reinjury

Faulty reel design on roof bolt

Two people lifting of unequal size

Sudden twist

Too heavy of load with obstruction

Extended carry distance with load on back

Moving too quickly after being bent over

Accumulated wear and tear

Weight of wooden and metal ties and mud

Socket tool, slipped

Weak back

Lack of clearance

Awkward position of object

Awkward position of person

Wrong place at wrong time

Jerking on stuck object

Object much heavier than expected

Failure to check roof

Poorly designed stairs

Should not have done task

Fatigue and heavy load

Fatigue and in a hurry

Tried to hustle to get job done

Hole filled with water, did not realize it was 15" deep
No opinion
Lifted and held tongue in awkward position for 30 seconds
Horseplay
Rough bottom
Roadway condition, hit bump like 11
Canopy too low -- limited vision
Pulling, load too heavy
Hit wrong roof bolt control
Cluttered work area
Stiff back due to prior awkward position
Tool broke
Poor housekeeping
In too big a hurry
Mandoor opening from bottom
Operator error
Sloppy equipment loading

AGE OF INJURED PERSON
Years

SEX OF INJURED PERSON
Male
Female

JOB TITLE OF INJURED PERSON
Roof bolter
General laborer
Shuttle car operator
Continuous miner operator
Beltman
Bratticeman
Maintenance; mechanic
Surveyor -- rod man
Safety inspector
Foreman
Electrician
Stoper operator
Manoseal
Supply man
Longwall helper
Trackman
Motor operator
Loader Operator
Scoop operator
Jack or prop man
Examiner (checks for methods)
Construction
Lampman

Shearer operator
Welder
Load point operator

JOB WORKING DURING INJURY
Roof bolter
General laborer
Shuttle car operator
Continuous miner operator
Beltman
Bratticeman
Setting jacks -- long wall
Ventilation person
Maintenance
Safety inspector
Scoop operator
Electrician
Part man
Motor operator
Surveyor
Wireman
Foreman
Moving crew
Examiner
Prop man
Fire boss
Lampman
Jackleg drill operator
Welder
Shearer operator
Longwall helper
Load point operator

EXPERIENCE ON TASK BEING DONE
Years

HEIGHT OF INJURED PERSON
Inches

WEIGHT OF INJURED PERSON
Lbs.

PHYSIQUE AND PHYSICAL FITNESS
Good
Fair
Light build
Overweight--below average
Poor

GRIP STRENGTH - PREFERRED
Lbs.

GRIP STRENGTH - NONPREFERRED
Lbs.

SIGNIFICANT MINING EXPERIENCE
Years

MINING JOB
Roof bolter
General laborer
Shuttle car operator
Continuous miner operator; helper
Beltman
Bratticeman
Headgate operator
Maintenance
Scoop operator
Ventilation person
Surveyor -- rodman
Electrician
Safety inspector
Office job
Foreman
Prep plant
Fire boss
Shot man
Part time operator
Stoper or jackleg operator
Loader operator
Trackman
Longwall shield person
Motor operator
Outside supply
Surface - heavy equipment operator
Wireman
Construction
Cutter operator
Prop man
Contract miner in non-coal mine
UG - heavy equipment operator
Mine examiner
Lampman
Pump man
Shearer operator
Welder
Longwall maintenance
Mandoseal operator

SIGNIFICANT NON-MINING EXPERIENCE

Years

Decline to answer

SIGNIFICANT NON-MINING JOB

Refrigeration
Jet mechanic
Construction laborer
Press operator
Truck driver
Maintenance foreman in factory
Saw mill operator
Auto plant
Military -- communications
Foundry worker
Factory worker
Crane operator
School teacher
Mechanic
Timbering
Rovstabout, oil & gas wells
Railroad laborer
Parts sales
Gas station attendant
Meatcutter
Chemical plant worker
Police officer
Mining surveying crew member
Farmer
Marine gunner
DOH employee
Janitor
Maintenance
Salesman
Navy -- flight deck
Welder
Loaded trucks
Cabinet maker
Forklift operator
Military
Professional wrestling
Plumbing
Production supervisor
Phone installer
Carpenter, painter, etc.
Cook
Heavy equipment operator
Postman
Lead smelter laborer
Army - artillery
Office worker
Machinist
Boat building
Secretary
Fireman
Decline to answer

HISTORY OF STRAINS & SPRAINS

NA

1 Injury

2 Injuries

3 Injuries

More than 3 injuries

LEISURE ACTIVITIES

No

Yes

TYPE OF LEISURE ACTIVITIES

Golf

Swimming

Hunting

Weightlifting

Baseball

Fishing

Hiking

Softball

Basketball

Motorcycles, off road vehicles

Water skiing

Karate

Skiing

Photography

Farming, gardening

Woodwork

Running

Sports

Musical instruments

Bowling

Outdoors

Mechanic

Drag racing

Target shooting

Traveling

Preacher

Baseball coach

Decline to answer

OUTSIDE MINE PLANNING

No

Yes

Planning during previous shift

Provide roller conveyor

Keep supplies on supply car, don't dump

Provide suitable tools

Cover holes

Better design for coupler mechanic for low boy

TYPE OF OUTSIDE PLANNING

NA

Non-skid on slippery surfaces

Position the SCSR's on perimeter of sled

Had scoop to lift timbers with bucket

Supply correct equipment to section

Supply 6' sections of roller conveyor

Provide mechanical aids to move I-beams

Provide proper loading of supply cars

Design special jack for changing tires and rail wheels

Proper storage

Proper equipment design

Packing materials in safe weights

Plan maintenance where accessible

Prepare materials for day on surface

Plan section layout to avoid crush points

Emphasize to cover holes

Better design of coupler for low boy

Emphasize no horseplay

Change type of roof bolt

Keep bottom smoother

Ensure adequate training on new equipment

Training on surface

Better housekeeping

Provide mechanical handling equipment

Provide large tools or air tools

Improve seat design

Provide a pole to support vent tube in high top

Use proper method for situation

Person shouldn't shovel without taking breaks to loosen up

Bolt ribs

Select manddoors which open sideways

Improve cab room

Track design and rerail location

LOST TIME

No

Yes

HOW MUCH LOST TIME

Days

RESTRICTED WORK

No

Yes

NATURE OF RESTRICTION

Light duty

RESTRICTION # DAYS
Days

COVERED BY MSHA TRAINING
No
Yes

IF DATE REPORTED DIFFERENT, WHY
Same date
Unknown
Pain didn't start till later
Miner not immediately concerned
Unknown, no company policy

NON-WORK RELATED EVENTS INVOLVED
Perhaps

MINE HEIGHT CLASSIFICATION
Crawling, ducking-walking
Bent to some degree
Walking

INJURY SITE LOCATION DESCRIPTION
Longwall shield
Face area
Haulageway
Beltline
On surface--office area
Underground away from active face area
Underground maintenance shop
Track heading
Elevator
Returns
Travelway
Bathouse
Prep plant
On surface, heavy equipment
Longwall, T-gate, H-gate areas
Surface shop
Dump car loading area
Surface storage

COST OF PROPERTY DAMAGE
Dollars

SUDDEN MOVEMENT

No

Yes

Questionable

Posture

Struck by object from above

APPENDIX C. - MEDICAL TREATMENT OBSERVATION FORMS

MEDICAL TREATMENT EVALUATION DATA SHEET

1. Have you have any underground miners with low back pain that was acquired on the job who have gone to a rehabilitation program for their low back pain?

___Yes ___NO

If you have answered YES to question number 1, please complete the rest of the form.

2. Is there usually a clearly defined time of injury?
___YES ___NO

3. When, in relation to the injury, is treatment usually initiated?

___ Within 1 day of the injury
___ Within the first week after the injury
___ Within 2nd to 4th week after the injury
___ Greater than 6 months after the injury
___ Don't know

4. Who was responsible for evaluating the miner(s)?

___ DON'T KNOW

5. Was the medical person who evaluated the miner:

___ Paid a salary per month by the mining company
___ Paid per patient seen from the mining company
___ Not paid by the mining company for the number of patients seen
___ Paid by the compensation system
___ Don't know

6. Was any treatment provided for the miner(s)

___YES ___NO ___DON'T KNOW

What treatments are provided for what types of injuries?

7. If treatment was provided, which of the following people provided that treatment(s)?

___ Physician	___ Physical Therapist
___ Chiropractor	___ Nurse
___ Other _____	___ Don't know

8. How was the injury diagnosis made?

___ Don't know

9. How frequently were medications given to the injured miners?

- ☐ Medicines were given for every injured miner
☐ Medicines were given to only a few of the miners
☐ No medicines were given to any of the miners
☐ Don't know

10. Which medications were given to the miners?

How often?

☐ Muscle relaxants	
☐ Depressants	
☐ Analgesics (pain medicines)	
☐ Other	
☐ Don't know	

11. Is there any provisions for early return to work or light duty for injured miners? ☐ YES ☐ NO
☐ DON'T KNOW

12. If there any provisions for light duty, who made the decision not to have light duty?

- ☐ Company management
☐ Union
☐ Medical officials
☐ Don't know

13. Is there a rehabilitation center for your miners to go to? ☐ YES ☐ NO
☐ DON'T KNOW

14. Do miners undergo a preemployment physical before they are hired? ☐ YES ☐ NO
☐ DON'T KNOW

15. Do you examine the levels of health of your miners before they return to work after an injury? ☐ YES ☐ NO
☐ DON'T KNOW

Who conducts the examination
Extent of physical

16. Are there rehabilitation programs that your miners all go through following injury? ☐ YES ☐ NO
☐ DON'T KNOW

17. Is the miner required to take an active role in his own rehabilitation program? (Is the miner required to actively work through his rehabilitation process or does he only receive moist heat, electrical stimulation, etc?)

☐ YES ☐ NO
☐ DON'T KNOW

18. Are there any control processes that review your rehabilitation programs for your injured miner? (peer review organizations, workmen's compensation reviews, insurance company reviews, mining company reviews)?

☐ YES ☐ NO
☐ DON'T KNOW

If so, which _____

19. Are there any low back injury prevention programs for your miners?

☐ YES ☐ NO
☐ DON'T KNOW

DATA RECORDING FORM

EMPLOYEE SELECTION

Research has shown that there is a close relation between how strong a person is, how good a person's physical condition is, and how likely they are to be hurt on a job.

When hiring new employees, do you evaluate any of these factors, and if so, how? (Note, most locations don't, so a negative answer won't make you look bad -- we are just trying to understand the state of the art in employee selection procedures used in coal mining).

If you are doing any or all of the evaluations, do you feel they help? Why/why not?

1. When hiring new employees do you screen them for physical strength?

Yes _____ No _____ Don't Know _____

2. If yes, briefly describe how the screening is done (for example - actual strength test using special apparatus, have person try job and observe them, have medical department make subjective estimate of person's strength, etc.)

3. When hiring new employees, do you try to evaluate their physical condition - i.e., how good of shape they are in?

Yes _____ No _____ Don't Know _____

4. If yes, please describe briefly how this is done

5. When hiring new employees do you try to find out whether they have a history of back injury?

Yes _____ No _____ Don't Know _____

6. If yes, how is this done?	Yes	No	Don't know
a) A question on the employment application	___	___	___
b) A question on their pre-employment physical exam	___	___	___
c) Through medical examination	___	___	___
d) By contacting previous employers	___	___	___
e) By other means - please describe	___	___	___

DATA SHEET FOR LOW BACK INJURY PREVENTION TRAINING

I. Content of Prevention Training Programs

A. Handout material, content and readability.

1. Is there handout material?

___YES ___NO ___DON'T KNOW

(If no, go to part B)

2. Is there material in laymen's terminology?

___YES ___NO ___DON'T KNOW

3. Does the material:

i. Cover injury statistics?

___YES ___NO ___DON'T KNOW

ii. Emphasize the attitude of active employee responsibility for the care of his/her own back?

___YES ___NO ___DON'T KNOW

iii. Cover basic anatomy?

___YES ___NO ___DON'T KNOW

iv. Cover proper sitting, standing, lifting and lying postures?

___YES ___NO ___DON'T KNOW

v. Present practical work examples that are representative of your plant's tasks?

___YES ___NO ___DON'T KNOW

vi. Cover any additional material?

___YES ___NO ___DON'T KNOW

If so, what? _____

B. Are risks of injury described?

___YES ___NO ___DON'T KNOW

1. Are various medical conditions described that could occur following injury?

☐ YES ☐ NO ☐ DON'T KNOW

2. Are the reasons for probable nondiagnosis or misdiagnosis covered?

☐ YES ☐ NO ☐ DON'T KNOW

3. Are the warning signs of dangerous back problems covered so the employees know when it is absolutely necessary to contact a physician following injury?

☐ YES ☐ NO ☐ DON'T KNOW

- C. Are the following lifting risks explained?

☐ YES ☐ NO ☐ DON'T KNOW

1. Like keeping the load close to the body?

☐ YES ☐ NO ☐ DON'T KNOW

2. Like the effect of lifting bulky loads?

☐ YES ☐ NO ☐ DON'T KNOW

3. Like the effect of the distance moved?

☐ YES ☐ NO ☐ DON'T KNOW

4. Like the starting position of the lift?

☐ YES ☐ NO ☐ DON'T KNOW

5. Like the influence of lifting frequency?

☐ YES ☐ NO ☐ DON'T KNOW

6. Like the effect of posture?

☐ YES ☐ NO ☐ DON'T KNOW

7. Like the effect of the weight of the load lifted?

☐ YES ☐ NO ☐ DON'T KNOW

8. Like the effect of using handles?

☐ YES ☐ NO ☐ DON'T KNOW

D. Are lifting and exerting force discussed as they relate to their efforts on the back and other body parts?

____YES ____NO ____DON'T KNOW

1. Are the functions of the following covered?

____YES ____NO ____DON'T KNOW

i. Muscles?

____YES ____NO ____DON'T KNOW

ii. Ligaments and fascia?

____YES ____NO ____DON'T KNOW

iii. Discs?

____YES ____NO ____DON'T KNOW

iv. Vertebral bodies?

____YES ____NO ____DON'T KNOW

v. Nerves?

____YES ____NO ____DON'T KNOW

2. Are the effects of static work postures covered?

____YES ____NO ____DON'T KNOW

3. Are the effects of vibration covered?

____YES ____NO ____DON'T KNOW

E. Is the worker taught to know their limitations?

____YES ____NO ____DON'T KNOW

1. Are the signs of over exertion covered?

____YES ____NO ____DON'T KNOW

2. Are the effects of cumulative trauma covered?

____YES ____NO ____DON'T KNOW

3. Are the effects of fatigue covered?

____YES ____NO ____DON'T KNOW

F. Is the importance of housekeeping, planning, and workplace layout stressed?

___YES ___NO ___DON'T KNOW

1. Like floor conditions, i.e. wetness?

___YES ___NO ___DON'T KNOW

2. Like loose objects?

___YES ___NO ___DON'T KNOW

3. Like cables, rocks, equipment, etc.?

___YES ___NO ___DON'T KNOW

G. Are lifting/handling skills taught?

___YES ___NO ___DON'T KNOW

1. What posture is recommended?

_____ DON'T KNOW

2. Is team lifting covered?

___YES ___NO ___DON'T KNOW

3. Are the decision making processes covered as to the size of the load, the number of people necessary for the lift, etc.?

___YES ___NO ___DON'T KNOW

II. Format Used In the Prevention Program

A. Are the participants actively involved in the training sessions?

___YES ___NO ___DON'T KNOW

B. Do the participants passively watch or listen to a presentation on lifting techniques?

___YES ___NO ___DON'T KNOW

C. Do the participants practice the techniques?

___YES ___NO ___DON'T KNOW

D. Do the participants constructively criticize their fellow employees during practice sessions?

___YES ___NO ___DON'T KNOW

E. What is the size of the group during the training sessions?

_____ DON'T KNOW

F. How many sessions are provided?

_____ DON'T KNOW

G. How much time is there between each session?

_____ DON'T KNOW

H. Are work-station simulations used in training?

____YES ____NO ____DON'T KNOW

I. Are the supervisors trained?

____YES ____NO ____DON'T KNOW

If so:

1. Before the employees?

____YES ____NO ____DON'T KNOW

2. With the employees?

____YES ____NO ____DON'T KNOW

3. After the employees?

____YES ____NO ____DON'T KNOW

J. Are performance checklists used for each trainee?

____YES ____NO ____DON'T KNOW

III. In your opinion did the training program work, i.e. reduce the injuries to low back pain?

____YES ____NO ____DON'T KNOW

APPENDIX.D. -- REGRESSION ANALYSIS

INTRODUCTION

The objective of this analysis is to investigate the possible effects of several (independent) variables on the number of work days lost due to an accident. This may help identify tasks, equipment, or circumstances that may have caused relatively more "severe" accidents and need future analysis.

A regression equation is a statistical model that shows the relationship between a quantitative variable and a number of independent or regressor variables. Generally, regression analysis is useful in unplanned experiments. Unplanned usually means that the data was taken from historical records instead of performing an experimental run and collecting the subsequent data. This analysis results in a model that relates the important factors to the dependent response.

Due to the "passive" nature of data at hand in this research regression analysis was deemed more appropriate compared to ANOVA methods that are used to analyze data collected in an "active" fashion. Unfortunately, as can be seen later, the predictive power of the regression equations obtained were not large enough to make them of much practical value.

However, as mentioned in the original research plan, regression analysis is useful for prediction purpose as well as a means of comparing the relative effect of various independent variables on the dependent variable (number of days lost due to occupational accidents). In the following analyses, several tables are presented in which the output from SAS is reproduced to show the parameter estimates and their relative significance, as measured by the p-value of the test. The level of significance of each statistical test is designated as $PR > |T|$ in the SAS output.

Two regression models were constructed. The number of lost work days was used as the dependent variable in both models. The set of independent variables for each regression was different. Additionally, for each regression two cases were considered. In case I all accidents were included, whereas in case II only accidents for which the number of lost work days was at least 1 and at most 60 were considered. In the following, each regression analysis is explained separately. SAS procedures General Linear Models (GLM) and STEPWISE were used to perform the analysis.

Additionally, all independent variables were combined and regressed against the dependent variable, days lost. Results from this regression did not improve upon the results obtained from the two original regressions. Hence, it was discarded.

REGRESSION I

In this analysis, the number of lost work days is defined as the dependent variable. It is assumed to be a function of 14 independent variables. These variables are summarized in Table D-1.

TABLE D-1 Description of Independent Variables
for Regression I

Variable Name	Variable Description
X1	How high was load at start
X2	How high was load at end
X3	How far away
X4	How was load grasped
X5	Weight of load
X6	Mine height at injury site
X7	Push - Pull - Lift
X8	Body posture during injury
X9	Age of injured person
X10	Sex of injured person
X11	Height of injured person
X12	Weight of injured person
X13	Job working during injury
X14	Sudden movement

Six of the above 14 variables (X4, X7, X8, X10, X13, and X14) are qualitative, i.e. discrete categorical variables. The classes of these qualitative variables are originally identified by codes in the original data base. Since most of these variables have too many classes, the regression function becomes prohibitively large and inefficient. Hence, it was necessary to regroup the codes to create smaller classes for each qualitative variable.

The next step is to create a number of independent

indicator variables to represent the new classes of the qualitative independent variables. Indicator variables take on the values of 0 or 1 and are used to perform regression analysis on categorical variables. Generally speaking, a qualitative variable with C classes is represented by C-1 indicator variables, each taking on the values 0 or 1.

The classification of the independent variables is explained in the following. Variable X1, X2, X3, X5, X6, X9, X11, and X12 are continuous and were used as collected.

Variable X4, how was load grasped, was classified into three groups; so two indicator variables are needed to represent the variable. The codes for each group and the description for each code in each group are given in Table D-2. The recoding was designed to separate lifts into symmetric and asymmetric.

The two new indicator variables are designated as X41 and X42. If X4 takes on the codes in group one, X41 is set equal to 1; otherwise, X41 is set equal to 0. Similarly, X42 is set equal to 1 if X4 takes on the values in group two; otherwise it is set equal to 0. If X4 takes on the codes in group three, both X41 and X42 are set equal to 0.

TABLE D-2 Description of Each Code for Variable X4

Group	Code	Indicator Variable	Description
1	4	X41	Sym. with handles
1	5	X41	Sym. w/o handles hands on side
1	6	X41	Sym. w/o handles hands underneath
1	11	X41	Sym. w/o handles arms extended push
1	13	X41	Sym. one hand with handles
1	15	X41	Sym. grippable, hands on top
1	16	X41	Sym. 2 hand grasp behind back
1	20	X41	Sym. extended reach, using tool
1	21	X41	Sym. without handles, hand on top
2	7	X42	Asym. with handles
2	8	X42	Asym. w/o handles hands on side
2	9	X42	Asym. w/o handles hands underneath
2	10	X42	Asym. grippable, not lifted
2	12	X42	Asym. on one hand
2	14	X42	Asym. two hands over shoulder
2	17	X42	Asym. 1 item in each hand
2	18	X42	Asym. one hand, handle
2	19	X42	Asym. two hands in front, lift
2	22	X42	Asym. one under-one behind
2	23	X42	Asym. one hand on top
3	Others		

Variable X7, Push-Pull-Lift, was classified into 5 groups. The codes, the description for each code, and indicator variable names used in the regression analysis for each group are listed in Table D-3. The recoding was designed to separate the activities into twisting, pushing, pulling, and lifting/carrying.

TABLE D-3 Description of Each Code for Variable X7

Group	Code	Indicator Variable	Description
1	11	X71	Lift and twist
1	13	X71	Shoveling
1	17	X71	Lift /twist and throw
2	4	X72	Push
2	8	X72	Push and lift
3	5	X73	Pull
3	7	X73	Push or pull
3	9	X73	Pull and lift
4	6	X74	Lift
4	10	X74	Push, pull, lift
4	12	X74	Lowering load
4	14	X74	Carry
4	15	X74	Hold
4	16	X74	Lift and carry
4	20	X74	Lifted and started to turn
5	Others		

X71 is set equal to 1 if X7 is equal to 11, 13 or 17; otherwise, X71 takes on the value of 0. The coding for variables X72, X73, and X74 is done in a similar manner.

Variable X8, body posture, was classified into seven groups: walk, stoop, stand, sit, squat, and climb. The codes, indicator variable names used in the regression analysis, and the description for each code in each group are shown in Table D-4.

TABLE D-4 Description of Each Code for Variable X8

Group	Code	Indicator Variable	Description
1	4	X81	Stepping backwards
1	7	X81	Walking backwards
1	51	X81	2 persons carrying panel walking sideways
1	10	X81	Walking, caught self w/right hand
1	22	X81	Walking w/hands behind back
1	24	X81	Carrying I-beam walking
1	29	X81	Walking in crouch
1	30	X81	Walking briskly (straight up)
1	33	X81	Walking jerked body to catch fall
1	40	X81	Walking, fell
1	41	X81	Running away from failure
1	45	X81	Standing reaching up
2	5	X82	Stoop-knees slightly bent-shoveling
2	8	X82	Stoop
2	9	X82	Stoop-knees slightly bent
2	16	X82	Stoop, reaching way forward
2	21	X82	Bent at waist, lifting
2	25	X82	Stoop, carrying load on lower back
2	31	X82	Stoop, leaning forward, pulling
2	50	X82	Stoop, knees slightly bent, throwing thru canopy opening
2	56	X82	Bent over at waist
3	11	X83	Standing, leaning to one side
3	12	X83	Standing head bent forward
3	14	X83	Upright - arm lift
3	19	X83	Standing, leaning forward & pushing
3	20	X83	Standing, pulling on cable-walking back
3	23	X83	Standing leaning backward
3	35	X83	Standing, twisting
3	36	X83	Standing
3	52	X83	Standing, bent at waist lifting
3	53	X83	Standing, reaching overhead and pulling
3	54	X83	Standing, arm extended over head

TABLE D-4 Description of Each Code for Variable X8
(Continued)

Group	Code	Indicator Variable	Description
4	13	X84	Sitting
5	18	X85	Squat
5	27	X85	Deep squat
6	28	X86	Climbing in/out of motor
6	32	X86	Jumping, leaning forward, pulling
6	37	X86	Climbing thru man door
6	43	X86	Climbing onto beltline
6	44	X86	Climbing down ladder
6	47	X86	Exiting man door body part in and part out
6	55	X86	Slipped off tailgate motor and landed on feet but uneven
7	Others		

Variable X10, sex, has only two classes, male and female. Therefore, one indicator variable, called X101, is needed to represent this variable.

Variable X13, job working, was classified into 6 groups. The codes, indicator variable names used in the regression analysis, and the description of each code in each group are summarized in Table D-5. The recoding grouped similar jobs together based on the type of work done. Variable X14 is set equal to 1 if sudden movement was included, and set equal to 0 otherwise.

TABLE D-5 Description of Each Code for Variable X13

Group	Code	Indicator Variable	Description
1	4	X131	Roof bolter
2	5	X132	General laborer
2	8	X132	Beltman
2	34	X132	LW helper
3	10	X133	Setting jacks - LW
3	27	X133	Prop man
4	13	X134	Safety inspector
5	6	X135	Shuttle car operator
5	7	X135	Continuous miner operator
5	15	X135	Scoop operator
5	18	X135	Motor operator
6	Others		

RESULTS OF REGRESSION I -- CASE I

The output from SAS GLM procedure is shown in Table D-6. The coefficient of multiple determination, R-square, is 0.16. Therefore, the estimated regression equation may not be powerful enough for prediction purposes. Based on the computer output, the estimated regression function to predict the expected number of days lost is as follows.

$$\begin{aligned}
 \text{Days Lost} = & 6.90 - 0.14 X_1 - 0.03 X_2 - 0.36 X_3 \\
 & + 6.52 X_{41} + 1.37 X_{42} - 0.007 X_5 - 0.004 X_6 \\
 & - 7.88 X_{71} - 18.72 X_{72} - 1.70 X_{73} - 10.81 X_{74}
 \end{aligned}$$

$$\begin{aligned}
& + 2.66 X81 - 2.39 X82 + 6.43 X83 + 0.41 X84 \\
& + 1.54 X85 -11.12 X86 + 0.19 X9 -17.14 X101 \\
& + 0.36 X11 + 0.02 X12 +15.09 X131- 0.64 X132 \\
& + 0.99 X133- 4.06 X134- 8.47 X135- 7.68 X14
\end{aligned}$$

The Stepwise procedure in SAS was also used to find the most important set of variables to be included in the regression model. The output for this procedure is shown in Table D-7.

From this analysis, we can draw the conclusion that X3, how far away, is the most significant variable and should be included in the model. The next four important variables are X131, roof bolter, X73, pull, pull or push, and pull or lift, X14, sudden movement, and X1, how high was load at start. The rest of the variables included in the above regression do not exhibit a strong correlation with the dependent variable, number of days lost. The level of significance used for entering or deleting a variable for the regression equation was set at 0.15.

TABLE D-6 Output From SAS GLM Procedure
for Regression I, Case I

DEPENDENT VARIABLE: DAYS LOST				
SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	
MODEL	27	13453.86579239	498.29132564	
ERROR	119	70817.44033006	595.10454059	
CORRECTED TOTAL	146	84271.30612245		
MODEL F =	0.84		PR > F = 0.6957	
R-SQUARE	C.V.	ROOT MSE	DAYS_LST MEAN	
0.159649	235.7679	24.39476461	10.34693878	
PARAMETER	ESTIMATE	T FOR H0: PARAMETER=0	PR > T	STD ERROR OF ESTIMATE
INTERCEPT	6.90025203	0.11	0.9131	63.06839264
X41	6.52111297	0.40	0.6884	16.22383606
X42	1.36933009	0.09	0.9312	15.82253531
X71	-7.87737692	-0.43	0.6647	18.12663992
X72	-18.72319851	-1.08	0.2830	17.36188078
X73	-1.69626702	-0.10	0.9236	17.64370281
X74	-10.80530378	-0.63	0.5306	17.18054042
X6	-0.00354744	-0.03	0.9748	0.11200631
X81	2.65563889	0.20	0.8414	13.24388595
X82	-2.38908792	-0.21	0.8373	11.61056742
X83	6.43054553	0.55	0.5857	11.76598959
X84	0.40984139	0.02	0.9807	16.92626722
X85	1.54824385	0.10	0.9236	16.11274406
X86	-11.11831789	-0.51	0.6096	21.71403181
X9	0.19044289	0.64	0.5230	0.29727503
X101	-17.13933453	-0.88	0.3831	19.57967848
X131	15.09449186	1.71	0.0906	8.84699383
X132	-0.64180097	-0.09	0.9250	6.80728461
X133	0.98978226	0.10	0.9227	10.17497454
X134	-4.06161158	-0.57	0.5675	7.08427046
X135	-8.47037573	-1.03	0.3060	8.23905168
X11	0.35646626	0.40	0.6907	0.89352684
X12	0.02194372	0.26	0.7962	0.08476754
X1	-0.14130853	-1.08	0.2836	0.13120148
X2	-0.02941562	-0.22	0.8235	0.13162289
X3	-0.35549331	-1.50	0.1355	0.23653068
X5	-0.00744331	-0.34	0.7339	0.02184579
X14	-7.67862025	-1.60	0.1123	4.79927608

Table D-7 Output From SAS STEPWISE Procedure
for Regression I, Case I

SUMMARY OF
STEPWISE REGRESSION PROCEDURE FOR DEPENDENT VARIABLE DAYS LOST

STEP	VARIABLE		NUMBER	PARTIAL	MODEL	
	ENTERED	REMOVED	IN	R**2	R**2	C(P)
1	X3		1	0.0354	0.0354	-6.40500
2	X131		2	0.0243	0.0597	-7.84050
3	X73		3	0.0144	0.0741	-7.88291
4	X14		4	0.0163	0.0904	-8.19392
5	X1		5	0.0137	0.1041	-8.13942

STEP	VARIABLE		F	PROB>F
	ENTERED	REMOVED		
1	X3		5.3210	0.0225
2	X131		3.7152	0.0559
3	X73		2.2275	0.1378
4	X14		2.5477	0.1127
5	X1		2.1623	0.1437

RESULTS OF REGRESSION I -- CASE II

This regression was used on cases where the number of days lost is between 1 and 60. The output from SAS GLM procedure is shown in Table D-8. The coefficient of multiple determination, R-square, is 0.29, which is a considerable improvement over case I. Based on the computer output, the estimated regression function to predict the expected number of lost days is as follows.

$$\begin{aligned}
 \text{Days Lost} = & -84.59 + 0.11 X_1 - 0.13 X_2 - 0.26 X_3 \\
 & + 6.78 X_{41} + 5.37 X_{42} - 0.002 X_5 + 0.03 X_6 \\
 & + 12.83 X_{71} + 1.21 X_{72} + 8.90 X_{73} + 6.83 X_{74} \\
 & - 7.15 X_{81} - 9.03 X_{82} - 9.13 X_{83}
 \end{aligned}$$

$$\begin{aligned}
& + 1.17 X85 - 2.76 X86 + 0.42 X9 - 10.13 X101 \\
& + 1.27 X11 + 0.03 X12 - 8.42 X131 - 6.23 X132 \\
& - 3.71 X133 - 3.66 X134 - 8.31 X135 - 1.81 X14
\end{aligned}$$

The Stepwise procedure in SAS was also used to find the most important set of variables to be included in the regression model. The output for this procedure is shown in Table D-9.

From this analysis, we can draw the conclusion that X9, age of injured person, is the most significant variable and should be included in the model. Another important variable is X85, indicating that the body posture is either squat or deep squat. The rest of the variables included in the above regression do not exhibit a strong correlation with the dependent variable, number of days lost. The level of significance used for entering or deleting a variable for the regression equation was set at 0.15.

TABLE D-8 Output From SAS GLM Procedure
for Regression I, Case II

DEPENDENT VARIABLE: DAYS LOST				
SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	
MODEL	26	3363.24980624	129.35576178	
ERROR	46	8322.50361842	180.92399170	
CORRECTED TOTAL	72	11685.75342466		
MODEL F =	0.71		PR > F = 0.8189	
R-SQUARE	C.V.	ROOT MSE	DAYS LST MEAN	
0.287808	125.8857	13.45079892	10.68493151	
PARAMETER	ESTIMATE	T FOR HO: PR > T	STD ERROR OF ESTIMATE	
INTERCEPT	-84.59328478	-1.46	0.1506	
X41	6.78273199	0.38	0.7075	
X42	5.36816110	0.31	0.7596	
X71	12.83424522	0.76	0.4508	
X72	1.20999553	0.07	0.9459	
X73	8.90395515	0.53	0.5959	
X74	6.83039235	0.42	0.6791	
X6	0.02913055	0.37	0.7142	
X81	-7.15478171	-0.76	0.4522	
X82	-9.03108356	-1.06	0.2926	
X83	-9.13307417	-1.03	0.3087	
X84	0.00000000 B	.	.	
X85	1.17412453	0.10	0.9191	
X86	-2.75775584	-0.19	0.8491	
X9	0.41587499	1.79	0.0793	
X101	-10.12701236	-0.88	0.3836	
X131	-8.41993287	-1.19	0.2392	
X132	-6.23260214	-1.03	0.3094	
X133	-3.71065654	-0.48	0.6340	
X134	-3.65750617	-0.58	0.5659	
X135	-8.30758861	-1.19	0.2391	
X11	1.26570351	1.54	0.1311	
X12	0.02842650	0.45	0.6517	
X1	0.10795682	0.93	0.3594	
X2	-0.13138665	-1.27	0.2104	
X3	-0.26306136	-1.14	0.2618	
X5	-0.00202393	-0.07	0.9460	
X14	-1.80947264	-0.38	0.7046	

TABLE D-9 Output From SAS STEPWISE Procedure
for Regression I, Case II

SUMMARY OF						
STEPWISE REGRESSION PROCEDURE FOR DEPENDENT VARIABLE DAYS LOST						
STEP	VARIABLE		NUMBER	PARTIAL	MODEL	
	ENTERED	REMOVED	IN	R**2	R**2	C(P)
1	X9		1	0.0867	0.0867	-10.0085
2	X85		2	0.0292	0.1158	-9.8918

VARIABLE					
STEP	ENTERED	REMOVED	F	PROB>F	
1	X9		6.7373	0.0115	
2	X85		2.3084	0.1332	

REGRESSION II

In this analysis, the number of lost work days is again used as the dependent variable. However, this variable is assumed to be a function of only six independent variables, as listed in Table D-10. Three of these variables, X5, X7, and X14, were also used in regression I.

TABLE D-10 Description of Independent Variables
for Regression II

Variable Name	Variable Description
X5	Weight of load
X7	Push - Pull - Lift
X14	Sudden movement
X15	Activity at time of injury
X16	What type of equipment involved
X17	Number of prior back injuries

The data for the above qualitative variables are treated in the same way as in regression I. They are regrouped and represented by various indicator variables.

Variable X15, activity, was classified into six groups. The codes, indicator variable names used in the analysis, and the description of each code in each group are summarized in Table D-11. The recoding grouped the activities by general work task such as vehicle riding, walking, maintenance, cable/hose handling, and shoveling/lifting/carrying.

Variable X16, what equipment, was classified into seven groups. Variable X17, number of prior back injuries, was classified into three groups. The codes, indicator variable names used in the analysis, and the description of each code in each group for variables X16 and X17 are shown in Table D-12. For an explanation of the classification and description of variables X5, X7, and X14, refer to the explanation given for regression I.

TABLE D-11 Description of Each Code for Variable X15

Group	Code	Indicator Variable	Description
1	17	X151	Hit feeder- conveyor- with shuttle car
1	20	X151	Teletram operator hit CM
1	21	X151	Driving SC - hit bump
1	24	X151	SC steering failed and hit rib
1	34	X151	Operating CM cutting bottom - large jolt
1	86	X151	Driving into/from work area
1	93	X151	Operating CM, checking position
1	117	X151	Driving bobcat on surface
1	156	X151	Riding on mantrip
1	172	X151	Driving scoop
1	176	X151	Pulling RB cable while walking backwards
1	178	X151	Walking to face & tripped on RB
1	187	X151	Walking backward sweeping belt line
1	190	X151	Moving CM between x cuts
2	8	X152	Walking backward
2	10	X152	Walking downhill
2	33	X152	Walking - stepped in hole
2	56	X152	Walking across supply car
2	69	X152	Carrying rock dust and stepped in hole
2	79	X152	Walking into RB plate in low top
2	88	X152	Walking - tripped on cable
2	107	X152	Walking & slipped on wet board

TABLE D-11 Description of Each Code for Variable X15
(Continued)

Group	Code	Indicator Variable	Description
2	108	X152	Running away from failed pressure line
2	125	X152	Walking panline
3	15	X153	Repairing teletram diff.
3	19	X153	Prying on gathering motor on bolter
3	26	X153	Reaching over sidescoop-lift motor cover
3	28	X153	Prying bar to hold bracket in place
3	29	X153	Pushing box out of scoop bucket
3	35	X153	Loading tool box onto bucket of scoop
3	39	X153	Lift, hand sheave
3	41	X153	6 miners flipping railcar stop
3	43	X153	Lifting SC or CM panel cover
3	44	X153	Transferring tool box between low boys
3	53	X153	Using pry bar to move hydraulic jack-LW
3	54	X153	Prying refrax plate out of box - 150 lbs
3	81	X153	Install push blocks on longwall
3	84	X153	Maintenance on LW stage loader
3	87	X153	Adjusting tilted LW shield
3	89	X153	Stopping rotating shaft with a belt
3	90	X153	Picking up section of chain
3	91	X153	Lifting air pressure tank from ramcar
3	99	X153	Using pry bar to lift forzen roller
3	109	X153	Assembling panline
3	112	X153	Repair LW shield flipper
3	113	X153	Position roller on belt structure
3	118	X153	Welding in prep plant
3	120	X153	Pry bar to lift heavy size
3	121	X153	Using wrench to tighten bolt
3	123	X153	Repairing slam door
3	126	X153	Maintenance on CM
3	135	X153	Lifting and carrying panel cover for loader

TABLE D-11 Description of Each Code for Variable X15
(Continued)

Group	Code	Indicator Variable	Description
3	138	X153	Placing crib under axle of rail car to change wheels
3	157	X153	Handling hydraulic pipe on LW
3	159	X153	Cutting metal
3	160	X153	Removing fittings from LW haulage box to clean it
3	163	X153	Using wrench to loosen bolts
3	167	X153	Making water spray boom bracket
3	170	X153	Throwing scrap into scrap bin
4	6	X154	Dragging piece of wet curtain
4	7	X154	Dragging hose
4	11	X154	Moving miner cable or water line
4	18	X154	Resetting cable and water line in cuts
4	50	X154	Standing and lifting 7200V power cable
4	78	X154	Pulling cable, jerked backward
4	83	X154	Tying cable at ceiling height
4	168	X154	Lifted and dragged RB cable
4	179	X154	Lifted and threw CM cable
4	186	X154	Tried to move a coil of power cable
5	5	X155	Shoveling
5	9	X155	Reaching for 5 ft plastic pipe
5	12	X155	Building cribs
5	14	X155	Restocking bolter
5	16	X155	Rolling 4 foot of miner cable
5	23	X155	Removing drill steel
5	27	X155	Turning over box of 6 SCSR
5	30	X155	Lifting 4"x8"x18' header
5	31	X155	Picking up 2 bags rock dust from scoop
5	38	X155	Lifting oxygen cylinder
5	42	X155	Lifting timbers and pulling thru mandoor
5	45	X155	Loading elevator with box of metal
5	46	X155	Handling 6"x16' long I-beams
5	47	X155	Carrying gear
5	48	X155	Reloading RB with rock dust

TABLE D-11 Description of Each Code for Variable X15
(Continued)

Group	Code	Indicator Variable	Description
5	49	X155	Lifting wooden and metal tie from bottom
5	57	X155	Carrying 5 gal. jug of water
5	58	X155	Moving crib blocks
5	62	X155	Lifting steel bar
5	66	X155	Switching hands-carrying transit tripod
5	67	X155	Lifting mandoor
5	73	X155	Carrying two five gallon cans of oil
5	92	X155	Carrying beltline roller
5	94	X155	Carrying props
5	96	X155	Lift, drag section of belt to beltline
5	97	X155	Lifting pallet out of mud
5	98	X155	Lifting DA ram (LW)
5	101	X155	Lifting grout pump
5	102	X155	Lifting vent tube
5	106	X155	Lifting timber & tossing to side
5	110	X155	Lifting & carrying timbers
5	111	X155	Carrying 5 gal of oil
5	115	X155	Swinging 5 gal oil pail along shields
5	128	X155	Carrying 20 lbs ft rail
5	130	X155	Woke up with muscle spasm after building overcast
5	132	X155	Emptying vehicle so could use
5	131	X155	Unrolling new section belt material
5	137	X155	Picking up crib block and throwing it
5	155	X155	Throwing resin off bolter
5	161	X155	Lifting 40 lbs metal sheet off low cart
5	162	X155	Lifting and carrying 75 lb modules for power center
5	164	X155	Two miners carrying 200 lb piece of steel when one dropped it
5	166	X155	Bending over and picking up piece of metal from crib

TABLE D-11 Description of Each Code for Variable X15
(Continued)

Group	Code	Indicator Variable	Description
5	171	X155	Lifting 8" I-beam to 30" high saw table
5	173	X155	Supporting 18" dia. vent tube overhead
5	180	X155	Picking up rotation drill motor
6	Others		

TABLE D-12 Description of Each Code for
Variables X16 & X17

Group	Code	Indicator Variable	Description
1	4	X161	Roof bolter
2	8	X162	Miner cable
3	10	X163	Shuttle car
3	12	X163	Teletram
4	18	X164	CM
5	11	X165	Scoop
6	5	X166	Shovel
7	Others		
1	0	X171	None
2	100	X172	1 injury
3	>100		> 1 injury

RESULTS OF REGRESSION II -- CASE I

The output from SAS GLM procedure is shown in Table D-13. Coefficient of Multiple Determination, R-square, is 0.11. Therefore, similar to regression I, the estimated regression equation may not be powerful enough for prediction purposes. Based on the computer output, the estimated regression function to predict the expected number of lost days is as follows.

$$\begin{aligned}\text{Days Lost} = & 12.85 - 0.007 X_5 - 0.53 X_{71} - 8.14 X_{72} \\ & + 3.25 X_{73} - 5.22 X_{74} - 6.46 X_{14} - 3.22 X_{151} \\ & + 8.54 X_{152} - 0.93 X_{153} - 1.40 X_{154} - 4.69 X_{155} \\ & + 9.77 X_{161} + 3.57 X_{162} + 0.68 X_{163} - 9.54 X_{164} \\ & + 43.91 X_{165} - 3.53 X_{166} + 3.09 X_{171} + 5.14 X_{172}\end{aligned}$$

The Stepwise procedure in SAS was then used to find the most important set of variables to be included in the regression model. The output for this procedure is shown in Table D-14.

From this analysis, we can draw the conclusion that X165, indicating the accidents in which the equipment used is scoop, is the most significant variable and should be included in the model. The next two important variables are X161, roof bolter equipment, and X73, pull, pull or push, and pull or lift. The rest of the variables included in the above regression do not exhibit a strong correlation

with the dependent variable, number of days lost.

TABLE D-13 Output From SAS GLM Procedure
for Regression II, Case I

SAS GENERAL LINEAR MODELS PROCEDURE				
DEPENDENT VARIABLE: DAYS LOST				
SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	
MODEL	19	9688.07522858	509.89869624	
ERROR	144	75900.16867385	527.08450468	
CORRECTED TOTAL	163	85588.24390244		
MODEL F =	0.97		PR > F = 0.5026	
R-SQUARE	C.V.	ROOT MSE	DAYS_LST MEAN	
0.113194	235.3228	22.95832103	9.75609756	

PARAMETER	ESTIMATE	T FOR H0: PARAMETER=0	PR > T	STD ERROR OF ESTIMATE
INTERCEPT	12.85097664	1.90	0.0597	6.77163898
X151	-3.21838547	-0.28	0.7809	11.55101226
X152	8.53980328	0.91	0.3647	9.39173863
X153	-0.93227846	-0.16	0.8743	5.88398070
X154	-1.39808703	-0.16	0.8705	8.55758781
X155	-4.69330118	-0.80	0.4247	5.86280823
X71	-0.53281754	-0.07	0.9465	7.92594733
X72	-8.13534400	-0.70	0.4872	11.67822467
X73	3.25108564	0.48	0.6306	6.74544485
X74	-5.22462578	-0.84	0.4007	6.19877556
X161	9.76829971	1.21	0.2264	8.04123384
X162	3.56817764	0.37	0.7134	9.69668821
X163	0.67666811	0.03	0.9729	19.86645728
X164	-9.53994039	-0.82	0.4152	11.67528328
X165	43.90963883	2.51	0.0133	17.51254147
X166	-3.52863550	-0.34	0.7324	10.29906555
X171	3.09034853	0.65	0.5187	4.77653364
X172	5.14822184	1.18	0.2406	4.36896099
X5	-0.00682150	-0.45	0.6501	0.01500642
X14	-6.46477348	-1.60	0.1124	4.04686384

TABLE D-14 Output From SAS STEPWISE Procedure
for Regression II, Case I

SUMMARY OF
STEPWISE REGRESSION PROCEDURE FOR DEPENDENT VARIABLE DAYS LOST

STEP	VARIABLE		NUMBER IN	PARTIAL R**2	MODEL R**2	C(P)
	ENTERED	REMOVED				
1	X165		1	0.0294	0.0294	-2.39091
2	X161		2	0.0164	0.0458	-3.05532
3	X73		3	0.0144	0.0602	-3.38985

STEP	VARIABLE		F	PROB>F
	ENTERED	REMOVED		
1	X165		4.9043	0.0282
2	X161		2.7685	0.0981
3	X73		2.4476	0.1197

RESULTS OF REGRESSION II -- CASE II

Similar to regression I, this case refers to the accidents that resulted in lost work days between 1 and 60. The output from SAS GLM procedure is shown in Table D-15. Coefficient of Multiple Determination, R-square, is 0.17. Based on the computer output, the estimated regression function to predict the expected number of lost days is as follows.

$$\begin{aligned}\text{Days Lost} = & 13.06 + 0.003 X5 + 5.49 X71 - 10.16 X72 \\ & - 2.05 X73 - 2.00 X74 - 4.03 X14 - 2.03 X151 \\ & - 4.70 X152 + 2.16 X153 + 7.85 X154 - 3.86 X155 \\ & - 5.50 X161 - 9.40 X162 - 15.94 X164 - 1.37 X165 \\ & - 8.87 X166 + 1.46 X171 + 2.05 X172\end{aligned}$$

The output of STEPWISE regression procedure is shown in Table D-16. From this analysis, we can draw the conclusion that X153 and X154, indicating the accidents in which the activities involved cable/hose handling and maintenance, are the most significant variables and should be included in the model.

TABLE D-15 Output From SAS STEPWISE Procedure
for Regression II, Case II

SAS GENERAL LINEAR MODELS PROCEDURE				
DEPENDENT VARIABLE: DAYS LOST				
SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	
MODEL	18	2103.11907016	116.83994834	
ERROR	65	10321.58331080	158.79358940	
CORRECTED TOTAL	83	12424.70238095		
MODEL F =	0.74		PR > F = 0.7622	
R-SQUARE	C.V.	ROOT MSE	DAYS_LST MEAN	
0.169269	123.2261	12.60133284	10.22619048	
PARAMETER	ESTIMATE	T FOR H0: PARAMETER=0	PR > T	STD ERROR OF ESTIMATE
INTERCEPT	13.05676839	2.61	0.0112	5.00234163
X151	-2.02549167 B	-0.15	0.8810	13.47588018
X152	-4.70058686	-0.64	0.5256	7.36567449
X153	2.16040581	0.46	0.6506	4.74705381
X154	7.84922968	1.14	0.2591	6.89477827
X155	-3.86077603	-0.78	0.4377	4.94372018
X71	5.48911669	0.92	0.3612	5.96884648
X72	-10.16078228	-1.22	0.2252	8.29862142
X73	-2.04678443	-0.37	0.7097	5.47332728
X74	-2.00164948	-0.43	0.6656	4.60961576
X161	-5.49607257	-0.77	0.4462	7.17112784
X162	-9.39861913	-1.14	0.2566	8.21130310
X163	0.00000000 B	.	.	.
X164	-15.94195047	-1.62	0.1095	9.82525698
X165	-1.36794076	-0.10	0.9186	13.33352477
X166	-8.86667247	-1.22	0.2263	7.25826504
X171	1.45882234	0.39	0.6994	3.76105766
X172	2.04563452	0.61	0.5466	3.37507362
X5	0.00259335	0.21	0.8334	0.01228098
X14	-4.03387007	-1.19	0.2365	3.37595531

TABLE D-16 Output From SAS STEPWISE Procedure
for Regression II, Case II

SUMMARY OF						
STEPWISE REGRESSION PROCEDURE FOR DEPENDENT VARIABLE DAYS_1ST						
STEP	VARIABLE		NUMBER	PARTIAL	MODEL	
	ENTERED	REMOVED	IN	R**2	R**2	C(P)
1	X153		1	0.0297	0.0297	-4.08034
2	X154		2	0.0309	0.0606	-4.49891

VARIABLE				
STEP	ENTERED	REMOVED	F	PROB>F
1	X153		2.5109	0.1169
2	X154		2.6653	0.1064