THE AGING WORKFORCE: AN EMERGING ISSUE IN THE MINING INDUSTRY

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ABSTRACT

According to the Bureau of Labor Statistics (BLS), workforce estimates of median age suggest that the median age of the mining workforce, which has been experiencing overall declines in numbers of employees, is rising more rapidly than for the overall U.S. civilian labor force. In the absence of detailed demographic data for the mining industry, the current study uses injury and illness data reported to the Mine Safety and Health Administration (MSHA) to examine differences, over time and by commodity, in the proportions of injured or ill workers aged 45 years and older. These data indicate that from 1988 to 1998, the percentage of injured or ill older workers (aged 45 years and older) have been steadily increasing. The most notable increase occurred at coal mining operations where the proportion of injured/ill older workers increased from 24 to 44 percent. A more detailed breakdown of the industry by commodity for 1998 showed the highest proportions of older injured/ill workers (over 40%) occurring in coal, iron ore, alumina mills, cement, and trona operations. In coal operations, as the employment size of the mine operation increased, so did its proportion of older injured/ill workers. Also, higher proportions of older injured/ill workers were observed at surface coal work locations than at underground locations. The distribution of older injured/ill miners by occupation for several select commodities shows the highest proportions for supervisors, electricians, mechanics, and surface equipment operators, and the lowest proportions for surface laborers and for underground coal roof bolters and scoop operators. With few exceptions, older injured workers have the highest median number of days lost per injury when examined by type of mining operation and by occupation. Given the high proportions of older injured or ill workers in many sectors of the mining industry, health and safety programs must consider the physiological changes associated with aging when evaluating job tasks and the working environment.

INTRODUCTION

According to the Bureau of Labor Statistics (BLS), the median age of the U. S. civilian labor force is projected to reach a record high of 40.7 in 2008 (Fullerton, 1999). This is a slight increase over the previous high of 40.5 attained in 1962, before the baby boomers entered the work force. After 1962, the median age declined steadily until 1980 and has been rising since. However, for industry segments such as mining, which have been experiencing overall declines in employment, statistics provided by BLS indicate that the median age for mining is rising even more rapidly (see Table I). Further, among the major sectors of the mining industry, the median age of the coal mining work force, estimated at 45.2 in 1998 (see Table II), is already well beyond the median age projected

for the civilian labor force in 2008. For comparison, also provided in Table II are the median ages of injured and ill workers reported to the Mine Safety and Health Administration (MSHA) in 1998. Although the BLS estimates of median age within the mining industry are based on relatively small sample sizes obtained from the Current Population Survey (CPS), note that both the CPS estimates and the median ages of injured or ill workers reported to MSHA, show the same relative order of differences in age between the major sectors of the mining industry.

Table I. Median age of the U. S. civilian labor force (Fullerton, 1999) and the mining industry, including oil and gas (BLS, 2000), for selected historical years and projected 2008.

	1962	*1978*	*1988*	*1998*	*2008*
Labor force	40.5	34.8	35.9	38.7	40.7
Mining	42.1	34.9	37.8	41.2	?

Table II. Estimates of the median age for sectors of the mining industry (BLS, 2000) from the Current Population Survey (CPS) and the median age of injured/ill workers reported to MSHA in 1998.

	Median age	
Mining sector	**CPS**	**MSHA**
Oil and gas	41.1	NA
Coal	45.2	43
Metal	41.3	42
Nonmetallic	39.1	39
Nonmetals	NA	40
Stone	NA	39
Sand and Gravel.	NA	37

These statistics are of concern for several reasons. Although most research studies indicate that occupational injury rates appear to decline with increasing age, the severity of these injuries appear to increase and injured older workers tend to require longer recovery periods (WHO, 1993).

Concerns about the problems of an aging workforce are not confined to the U.S. In many industrialized and developing countries, the increases in life expectancy and declining birth rates, has resulted in unprecedented increases in the mean age of the population. These increases have impacted the mean age of the working population, which is rising rapidly and expected to continue to rise (WHO, 1993). Increasing concerns about aging and its impact on worker capacity relative to worker demands prompted the World Health Organization (WHO) to form the Study Group on Aging and Working Capacity. The Study Group's published report defines work capacity to include the physical, mental, and social functional abilities necessary to perform a given type of work. The report examines those issues related to aging that may diminish worker capacity, because when job demands exceed the work capacity of the individual, decreased productivity, job-related stress, disease and disability are likely to result.

It is therefore important for employers to consider the needs of their aging workers when evaluating the safety and health aspects of the workplace.

Although detailed demographic data for various sectors of the mining industry are not available, the comprehensive set of injury and illness data collected by MSHA under 30 CFR Part 50 can be used to examine differences in the proportions of older injured or ill workers (aged 45 years or older) in specific sectors of the mining industry. The current study uses the MSHA accident/injury/illness files from 1988 through 1998 to examine trends in the proportions of older injured or ill workers for major sectors of the mining industry. Data from1998, the most recent reporting year for which close-out data are available, are used to profile differences in the proportions of older injured/ill workers for the various commodities. Within coal mining operations, differences in the proportions of these workers are examined by work location and by operation employment size. Additionally, the proportions of older injured/ill workers within various occupations are presented for several select commodities, with numbers adequate for comparison. And, finally, differences in recovery time from injuries are examined for three age groups, using the median number of lost workdays per incident. These differences are presented within commodities and within select occupations.

METHODS AND DEFINITIONS

MSHA mine operator accident/injury/illness files for the years 1988 through 1998 were used to examine trends in the proportions of injured or ill older workers by year and commodity. MSHA mine operator employment and accident/injury/illness files for 1998, the most recently released reporting year, were used to summarize mine-level information and to characterize injured and ill workers by commodity. The total numbers of employees were computed by summing the average annual number (averaged across four quarters) of employees reported for all operational subunits except office locations. Similarly, the total number of employee hours, used in the computation of incidence rates, was obtained by summing the hours reported for all subunits except office locations. Injuries and illnesses occurring in office locations were also excluded from all analyses. Additionally, the computations for the percentage of injured or ill employees included only reports of fatal and nonfatal injuries and illnesses (designated by MSHA as degrees of injury 1 through 7) to mine operator employees with a reported age of 18 through 79. Missing or invalid ages resulted in the exclusion of 2.9% of cases of injuries or illness in 1998. Similarly, 9% of the reports of injuries or illnesses had missing data for the years of total mining experience of the injured/ill person in 1998, and thus were excluded from computations involving years of total mining experience.

The median number of days lost reported for three age groups was examined only for those nonfatal injuries resulting in lost workdays during the three-year period from 1996 through 1998. The three most recent reporting years were examined to ensure adequate numbers of cases. These lost workday cases included those nonfatal injuries that resulted in partial or total permanent disabilities, as well as incidents involving actual days away from work and/or days of restricted work activity (designated by MSHA as degrees of injury 2 through 5). The number of lost workdays was computed by summing the actual days away from work and days of restricted work activity. Statutory days charged for permanently disabling injuries were used when days lost were not reported or when the statutory days exceeded the reported number of days lost. Lost workday cases with an invalid closing document number (indicating no return-to-work date reported) were excluded from the analyses. The invalid closing document number is used by MSHA to designate those cases for which the days lost were estimated using an algorithm that computes the average number of days lost for similar injuries. This estimate is used when a follow-up report from the operator of the actual number of days lost is not received

by MSHA prior to a close-out of the file for the report year. These cases accounted for about 10% of all lost workday cases used in the analyses for the three-year period from 1996 through 1998.

Mining industry segments were examined separately using MSHA's designation of canvass class, which differentiates the five primary commodities of coal, metal (metallic minerals), nonmetal (nonmetallic minerals), stone, and sand and gravel. The commodity classification codes assigned by MSHA were used to further differentiate specific commodities within canvass classes (e.g., differentiating iron ore, copper, and gold within the metal mining operations).

Consistent with recent literature on older workers, with an emphasis on workplace interventions to prevent injury, illness or disability among these workers, the term 'older workers' is used to designate workers aged 45 years and older (Wegman, 1999).

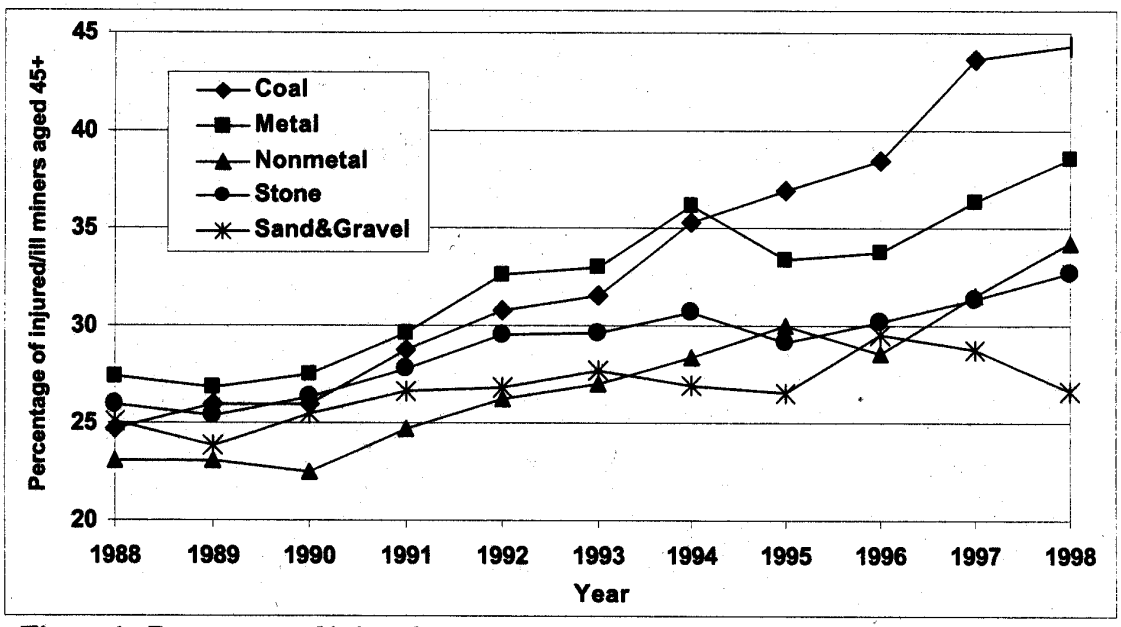

Figure 1. Percentage of injured or ill miners, aged 45 years and over, by operator canvass class and year, MSHA, 1988-98.

DISTRIBUTION OF OLDER INJURED OR ILL WORKERS IN MINING

The annual proportion of injuries and illnesses accounted for by older workers (aged 45 and older) from 1988 to 1998 is illustrated in Figure 1 for each of the five classes of mine operators. In 1988, the percentage of injuries and illnesses accounted for by older workers differed by less than 5% among the five types of operators, ranging from 23% for nonmetal operators to 27% for metal operators. Since 1988, the gaps between these operators have widened considerably, ranging from a low of 27% for sand and gravel operators to a high of 44% for coal mine operators. During this same period, the incident rates of injuries and illness have been steadily declining for all five classes of operators. Overall, the incidence rate of injuries/illnesses declined by about 36%, from a high of 10.6 injuries/illnesses per 200,000 employee hours in 1999 to a low of 6.8 in 1999.

A more detailed breakdown of the major types of mining operations, their general employment characteristics, and demographic

information of the injured/ill workers reported from those operations in 1998 is presented in Table III. Among the metal, nonmetal, and stone operations, the proportions of injured/ill older workers vary considerably. Iron ore operations and alumina mills report the largest proportions of injured/ill older workers, at 46.3% and 44.9 %, respectively. Conversely, the lowest proportions of injured/ill older workers occur at dimension stone (17.8%) and sand and gravel operations (26.7%). These operations are also among the smallest in terms of average mine size, employing fewer than 10 employees per operation. Additionally, these two types of operations report the highest proportions of injured/ill workers with one year or less of total mining experience. In fact, in this same category, at dimension stone mines the reported proportion (42.4%) is over three times the proportion of 12.3% reported for the mining industry overall. Conversely, the proportion of inexperienced injured/ill workers at coal mining operations (3.9%) is less than one-third of the overall rate. These differences are certainly substantial, but should be interpreted with caution. Lower proportions of injured/ill inexperienced workers in coal may reflect its declining employment (down 40% since 1998) as well as the availability of experienced miners for hire, and/or low employee turnover. Conversely, the high percentage of injured/ill inexperienced workers at dimension stone mines may reflect increasing employment rates and high employee turnover. In fact, both stone and sand and gravel operations are most likely to be seasonal operations, reporting lower employment in the winter months, which may contribute to a high employee turnover. However, it is also possible that these high rates reflect a higher rate of injury for inexperienced workers at these operations.

Distribution of Older Injured or Ill Workers in Coal Mining Operations

With over 7,500 injuries and illnesses reported by coal mining operations in 1998, 44% of which involved workers aged 45 or older, these operations accounted for the largest numbers of older injured or ill workers. Within these operations, the proportions of older injured/ill workers vary with the work location and with the employment size of the operations (see Table IV). Based on the distribution of these workers, proportionately more injured/ill older workers are found in surface work locations than in underground locations, and among surface workers proportionately more older injured/ill workers are in preparation plants than at surface production operations. It also appears that as the employment size of a coal mining operation increases, so do its proportion of older injured/ill workers.

These differences in the proportions of older injured/ill workers may reflect the tendency of older workers to select out (transfer or terminate) or to be selected out (e.g., due to disability) of particular occupations and work environments. Research indicates that older workers are less likely to be involved in occupations requiring excessive physical demands or in stressful and dangerous work environments (WHO, 1993). In general, underground work locations exhibit all the elements of a stressful and dangerous work environment, particularly at small underground operations, which are more likely to operate in thin coal seams where the working height of the mine further restricts the posture, mobility, and visibility of the worker. In terms of risk of injury, historically, both fatal and nonfatal injury rates are highest in underground mines than in surface mines or preparation plants. Differences in the proportion of older workers by employment size may reflect the ability of larger operations to be more flexible in relation to job assignments or task selection within jobs, such that the physical demands on the older worker are reduced. Additionally, larger operations may invest more resources in ergonomic programs that reduce worker stress related to both job task and the workplace in general.

Table III. Mine-level characteristics and characteristics of injured or ill workers by commodity, MSHA, 1998.

Canvass class/ Commodity	Mine-level characteristics			Injured or ill workers		
	Total no. of employees (thousands)	No. of mines	Average employee size	No. injuries/ illnesses	% aged 45+	% 1 yr. exp. or less
Coal	**85.2**	**2,459**	**35**	**7,543**	**44.4**	**3.9**
Anthracite	1.7	202	9	143	44.8	9.8
Bituminous	83.5	2,257	37	7,400	44.4	3.8
Metal	**40.0**	**337**	**119**	**2,440**	**38.5**	**11.1**
Iron ore	7.4	30	246	549	46.3	6.0
Alumina mill	2.9	8	363	287	44.9	16.7
Lead/zinc ores	1.9	28	68	122	42.6	8.2
Silver ores	1.7	12	141	134	38.1	20.4
Copper	11.5	45	255	460	37.4	8.0
Gold	11.3	158	71	568	35.9	6.8
Other metals	3.3	56	60	320	24.4	22.1
Nonmetal	**23.5**	**789**	**30**	**1,164**	**34.2**	**17.7**
Trona, potash, borate minerals	4.5	17	262	204	44.1	8.7
Phosphate rock	3.4	29	117	129	39.5	16.7
Clay, common	6.8	236	29	305	31.5	19.1
Other nonmetals	8.9	507	18	526	30.6	19.9
Stone	**68.0**	**3,808**	**18**	**4,262**	**32.7**	**21.8**
Cement	10.8	101	107	917	43.8	12.5
Lime	3.2	66	49	256	37.9	8.5
Crushed stone	49.2	3,138	16	2,768	30.2	24.4
Dimension stone	4.7	503	9	321	17.8	42.4
Sand&Gravel	**35.2**	**6,403**	**5 – 6**	**1,627**	**26.7**	**26.7**
Totals	**251.9**	**13,796**	**18**	**17,036**	**38.2**	**12.3**

Table IV. Percentage of injuries and illnesses for workers aged 45 years and older by work location and employment size for Bituminous Coal operations (MSHA, 1998).

Work location/Employment size	Total no. of injuries/ illnesses	% aged 45+
Underground	**5,397**	**42.2**
Fewer than 20 employees	271	29.5
20 – 49 employees	1,202	28.9
50 – 99 employees	816	27.9
100 – 249 employees	1,269	43.2
250 or more employees	1,839	58.5
Surface (excluding prep plants)	**1,509**	**49.0**
Fewer than 20 employees	150	44.0
20 – 49 employees	324	36.7
50 – 99 employees	278	36.7
100 – 249 employees	459	58.8
250 or more employees	298	61.1
Preparation Plants	**488**	**53.5**
Fewer than 20 employees	105	34.3
20 – 49 employees	159	47.8
50 – 99 employees	128	70.3
100 – 249 employees	35	60.0
250 or more employees	61	62.3

Distribution of Older Injured or Ill Workers by Occupation

The proportion of older injured/ill workers by occupation in 1998 was examined for a select set of occupations within five work locations with numbers sufficient for reliable analysis. The proportions of older injured/ill workers by occupation are listed in Table V for underground bituminous coal, surface bituminous coal, surface crushed stone, cement, and sand and gravel operations. Surface operations include preparation plants and mills as well as surface extraction operations such as strip mines and quarries. Occupations are listed in order of decreasing proportions of older injured/ill workers.

In general, the proportion of older injured/ill workers is substantially higher for supervisory occupations and electricians than is observed for the operation overall. Although less substantial, the proportions of older injured/ill mechanics and surface equipment operators (operators of cranes, bull dozers, and front-end loaders) are also higher than the proportions of older injured/ill workers observed for the operation overall. Conversely, the lowest percentages of injured/ill older workers are observed for laborers in all but underground coal mines. In fact, the proportions of older injured/ill laborers in crushed stone, cement, and sand and gravel mines are substantially lower than the overall proportions of older injured/ill workers at these operations. This is particularly evident in

cement operations where 43.8% of all injured/ill workers were aged 45 or older, but only 14.2% of the injured/ill laborers were older workers. In underground coal, the lowest proportions of injured/ill older workers are observed for roof bolters and scoop operators. Roof bolting is physically demanding work, often requiring awkward postures and body movements. Additionally, risk of injury to roof bolters by falls of roof is higher than for any other occupation (Peters and Randolph, 1991). The lower proportion of injured/ill older scoop operators may be due to the higher prevalence of scoops in thin-seam mines, where the low working heights require the low clearance afforded by scoops. And, as noted previously, the low working heights associated with thin seam mines make these environments particularly stressful for the older worker.

In a study of age and occupational change among underground coal miners, Powell (1973) reported considerable differences in the proportion of older workers for different mining occupations. The study found proportionately fewer older workers in the most physically demanding and highly paced occupations. An increase in the number of miners leaving work or moving from heavier to lighter work was markedly noticeable at about the age of 45.

AGE DIFFERENCES IN INJURY RECOVERY TIMES

The total number of valid lost workday incidents for the three-year period from 1996 to 1998 was 29,227. The number of lost workdays for these incidents varied from one day to 6,000 days for cases of total permanent disability. Because a single extremely high score can increase the mean dramatically, the median number of days lost for nonfatal injuries resulting in lost time was used to examine differences in the number of days lost for three age groups of injured workers (18 - 34, 35 - 44, 45+). The median number of days lost for the three age groups is presented by canvass and commodity in Table VI. The total number of valid lost workday incidents With the exception of anthracite coal, the median number of days lost for injured older workers (aged 45+) consistently exceeds that observed for both groups of younger workers (aged 18 - 34 and 35 - 44). With minor exceptions, this trend persists within occupational groupings as well (see Table VII). Additionally, the median number of days lost shows significant variations among the different types of operations and occupations as well as among age groups.

Although the focus in this study is on workers aged 45 years and older, it is also worth noting that the median number of days lost for injured workers aged 35 to 44 exceed those for younger workers in most of the commodities and occupations examined. In a study conducted in the New South Wales underground coal mining industry, the mine worker's age was also identified as a significant factor associated with occupational injury severity as measured by the number of lost workdays (Hull et al., 1996). The study also found that the part of the body injured, the type of accident, the source of the injury, and the mine worker's activity at the time of injury contributed to the severity of the injury as well. However, what remains unclear is the degree to which the biological aging process contributes to the decreased resilience of older workers to recover from injury versus other factors that may accelerate the effects of aging, such as the cumulative effects of a poor working environment and the prevalence of chronic health conditions (Wegman, 1999).

Table V. Percentage of injured or ill workers aged 45 years and older by occupation for five types of mining operations (MSHA, 1998).

Type of operation/Occupation	Total no. of injuries/ illnesses	% aged 45+
Underground Bituminous Coal	**5,403**	**42.3**
Supervisor	427	54.8
Electrician/helper/wireman	279	53.4
Mechanic/repairman/helper	500	48.8
Belt/conveyor man	326	45.4
Laborer/utility man	942	45.1
Continuous miner op	342	38.9
Shuttle car/ram op	399	38.1
Continuous miner helper	107	32.7
Roof bolter op	1,075	29.6
Scoop/load-haul-dump op	245	26.5
Surface Bituminous Coal	**1,997**	**50.1**
Crane op	83	77.1
Electrician/helper/wireman	83	63.9
Supervisor	107	61.7
Prep plant worker	108	52.8
Bulldozer op	219	52.1
Mechanic/repairman/helper	464	51.3
Truck driver	115	49.6
Welder	123	44.7
Laborer/utility man	192	41.7
Surface Crushed Stone	**2,682**	**30.1**
Supervisor	146	45.9
Bulldozer op	136	41.2
Frond-end loader op	161	34.8
Welder	166	33.1
Mechanic/repairman/helper	562	31.5
Truck driver	283	27.9
Mill worker	437	26.8
Laborer	371	16.2
Cement	**917**	**43.8**
Mechanic/repairman/helper	332	52.4
Mill worker	163	36.8
Laborer	162	14.2
Sand&Gravel	**1,627**	**26.7**
Supervisor	105	42.9
Front-end loader op	140	33.6
Mill worker	211	28.4
Bulldozer op	131	28.2
Mechanic/repairman/helper	253	27.3
Truck driver	105	26.7
Welder	82	20.7
Laborer	282	14.5

Table VI. Median number of days lost by commodity and age group for lost workday cases reported to MSHA from 1996 to1998.

Canvass class/ Commodity	Age group			
	18 - 34	35 - 44	45+	Total
Coal	**8**	**16**	**21**	**16**
Anthracite	12	23	22	18
Bituminous	8	15	21	16
Metal	**8**	**12**	**18**	**12**
Iron ore	7	12	17	13
Alumina mill	12	14.5	16	14
Lead/zinc ores	11	25	32.5	22
Silver ores	6	10	19	8
Copper	11	18	25	17
Gold	8	8	12	8
Other metals	8	12	18	12
Nonmetal	**7**	**11**	**17**	**10**
Trona, potash, borate minerals	9	19.5	23	17
Phosphate rock	13	17	21	18
Clay, common	7	8	15	8
Other nonmetals	7	10	13	8
Stone	**7**	**10**	**13**	**9**
Cement	8	11	13	11
Lime	10	14	18	14
Crushed stone	6	10	12	9
Dimension stone	6	5	11	6
Sand&Gravel	**6**	**8**	**11**	**8**
Totals	**7**	**13**	**18**	**12**

Table VII. Median number of days lost by age group, commodity, and occupation for lost workday cases reported to MSHA from 1996 to 1998.

Type of operation/Occupation	Age group			
	18 - 34	35 - 44	45+	Total
Underground Bituminous Coal	**8**	**16**	**22**	**16**
Supervisor	20	14	25.5	20
Electrician/helper/wireman	6	14	12.5	13
Mechanic/repairman/helper	11	17	22	19
Belt/conveyor man	5	16	20	15
Laborer/utility man	7	18	21	17
Continuous miner op	20.5	15	22	18
Shuttle car/ram op	7	11	20.5	12
Continuous miner helper	7	21	21	19
Roof bolter op	9	14	24	15
Scoop/load-haul-dump op	6.5	19	21	15
Surface Bituminous Coal	**6**	**14**	**19**	**14**
Crane op	NC	15	24	18.5
Electrician/helper/wireman	10.5	24	22	20
Supervisor	NC	19.5	17	18
Prep plant worker	7	18	21	17
Bulldozer op	7	11	19.5	13
Mechanic/repairman/helper	6	15	17	14.5
Truck driver	6	16	28	15
Welder	11	13	20.5	17
Laborer/utility man	5	13	18.5	10
Surface Crushed Stone	**6**	**10**	**12**	**9**
Supervisor	14	7.5	14	10.5
Bulldozer op	6	12	8.5	8.5
Frond-end loader op	7	7.5	10	7.5
Welder	8	12	13.5	12
Mechanic/repairman/helper	7	11	15.5	11
Truck driver	6	9	10	8
Mill worker	7	11	12	9
Laborer	5	9	12	7
Cement	**8**	**11**	**13**	**11**
Mechanic/repairman/helper	7	11	13	11
Mill worker	10	10	14.5	11.5
Laborer	7	12	11.5	9
Sand&Gravel	**6**	**8**	**11**	**8**
Supervisor	6	8	22	10
Front-end loader op	6.5	11	18	8
Mill worker	7	8	10	8
Bulldozer op	6.5	7.5	24	10
Mechanic/repairman/helper	6	9	10	8
Truck driver	6	8	9	8
Welder	9	9	8.5	9
Laborer	5.5	9	9.5	7

NC – not computed (fewer than 10 observations)

SUMMARY AND DISCUSSION

The current study identified increasing trends in the proportions of older injured or ill workers over the past decade for various sectors of the mining industry. The most recent release of the MSHA injury/illness data, the 1998 reporting year, indicates that the highest concentrations of older injured or ill workers occur in coal, iron ore, alumina mills, cement, and trona operations. Coal operations account for a substantial portion of the injuries and illnesses reported for older workers. Within these operations, the distribution of older injured/ill workers indicates that the highest proportions are found at large surface operations, while the lowest proportions occur in small underground mines.

In general, among the different occupations examined, higher proportions of older injured/ill workers were observed for supervisors, electricians, mechanics, and surface equipment operators (excluding truck drivers). Conversely, the lowest proportions of older injured or ill workers occurred for the occupations designated as laborers at surface operations. And in underground coal mines, the occupations of roof bolters and scoop operators had the lowest percentages of older injured/ill workers. Regardless of occupation or type of operation, the median number of days lost from work due to injury was higher for older workers than for younger workers.

Given the relatively high proportions of older injured/ill workers in the mining industry, particularly in coal, occupational health and safety programs need to address the problems of an aging workforce. Physiological changes associated with aging that may impact the capacity of older workers include decreases in the sensory functions (particularly auditory and visual senses), in the motor functions (muscular strength and endurance, reaction time), and in cardiorespiratory functions (aerobic power) (Robertson, 1998). However, researchers are quick to point out that these changes with age are highly variable and should not be applied indiscriminately to all aging workers (Brant et al., 1994). To prevent premature declines in work capacity among aging workers, the World Health Organization (1993) recommends that health and safety programs target three primary factors for intervention:

1. Excessive physical demands including static muscular work, lifting and carrying, repetitive movements, and awkward postures;
2. Stressful and dangerous work environments with a high risk of injury, or that are poorly lit or expose workers to extreme temperatures;
3. Poor work organization resulting in conflicts of responsibility and poor work planning or rigid working conditions.

Designing and applying effective interventions for older workers should be of critical importance in mining health and safety. Although the issue of an aging workforce is more urgent for some sectors of the mining industry than others, as workers continue to age, the health and safety of aging workers will be of increasing concern to all segments of mining.

REFERENCES

BLS. Private e-mail communication. Washington, DC: U.S. Department of Labor, U. S. Bureau of Labor Statistics, Division of Labor Force Statistics, May 18, 2000.

Fullerton HN. Labor force projections to 2008: steady growth and changing composition. *Monthly Labor Review*, November, 1999.

Hull BP, Leigh J, Driscoll JM. Factors associated with occupational injury severity in the New South Wales underground coal mining industry. *Safety Science*, 1996, 21:191-204.

MSHA. Quarterly employment and coal production, accidents/injuries/illnesses reported to MSHA under 30 CFR Part 50. Denver, CO: U.S. Department of Labor, Mine Safety and Health Administration, Office of Injury and Employment Information, 1988-1998.

Peters RH, Randolph, RF. Miners' views about why people go under unsupported roof and how to stop them. U.S. Dept of Interior (USBM), Information Circular #9300, 1991, 59 pp.

Powell M. Age and occupational change among coal-miners. *Occupational Psychology*, 1973, 47:37-49.

Robertson A, Tracy CS. Health and productivity of older workers. *Scandinavian Journal of Work, Environment & Health*, 1998, 24(2):85-97.

Wegman DH. Older workers. *Occupational Medicine: State of the art reviews*, 1999, 14(3):537-557, Philadephia, Hanley & Belfus, Inc.

WHO, Aging and working capacity. *WHO Technical Report Series 835*, Geneva: World Health Organization, 1993, 49 pp.