Disease and Illness in U.S. Mining, 1983–2001

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Objectives: *We describe inconsistencies in disease and illness reporting in U.S. mining, identify under-reporting of disease and illness in U.S. mining, and summarize selected disease and illness in U.S. mining from 1983 through 2001.* ***Methods:*** *We summarized information on mining-related disease and illness data for the years 1983–2001 from the Mining Safety and Health Administration database (MSHA).* ***Results:*** *Discrepancies exist in types of information collected by the Centers for Disease and Control, the National Institute for Occupational Safety and Health, and the Mining Safety and Health Administration database. Several factors, including a worker's fear of losing his or her job, health insurance, or other job-related benefits contribute to under-reporting of disease and illness information in the US mining industry.* ***Conclusions:*** *Since 1997, both number of workers employed in mining and disease and illness rates have decreased; however, the highest disease and illness rates in mining continue to be coal worker's pneumoconiosis and hearing loss.*

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Miners are exposed to various potentially toxic or harmful materials or agents, including, but not limited to, fuels, reagents, solvents, detergents, chemicals, coal dust, silica dust, diesel particulate matter (DPM), asbestos, noise, welding fumes, poisonous plants, trona dust, and metal dust. Disease and illness exposures can be classified as either chronic or acute. An acute or accelerated disease or illness develops during a brief period of time and is generally severe in nature, that is, a short exposure of high intensity.[1] A chronic disease or illness develops during a long period of time and is generally of low intensity.[1] The U.S. National Center for Health Statistics defines "chronic" as a condition lasting 3 months or more.[1] The process of contracting an occupational disease or illness can be slow (ie, months or years), and miners may be exposed to a toxic or harmful agent for years and not exhibit any effects of exposure.

For the purposes of this article, disease and illness are defined as "any disease or illness employees contract while employed as miners and which could be caused by mining activities." Specific mining disease and illness topics discussed in this article include coal worker's pneumoconiosis (CWP), silicosis, lung disorders caused by DPM, asbestosis, hearing loss or impairment, physical disorders resulting from exposure to lead and welding fumes, and dermatitis/skin disorders. The Mining Safety and Health Administration database (MSHA) data from 1983 to 2001 are used to frame the level of disease and illness.

For a toxic substance (gas, liquid, solid, or vapor) to produce a harmful

TABLE 1
Data Collection Categories by Agency

	NIOSH	CDC	MSHA
Lung disorders			
Occupational lung diseases	X		
Chronic obstructive pulmonary disease		X	
Dust diseases of the lungs			X
Coal-workers pneumoconiosis		X	X
Asbestosis		X	X
Silicosis		X	X
Byssinosis		X	
Asthma		X	
Respiratory conditions caused by toxic agents		X	X
Repetitive motion			
Carpal tunnel syndrome		X	
Tendonitis		X	
Disorders associated with repeated trauma			X
Other			
Neurotoxic disorders	X		
Noise-induced hearing loss	X	X	
Dermatologic conditions	X	X	X
Psychological disorders	X	X	
Severe occupational traumatic injuries	X		
Reproduction disorders	X		
Poisoning		X	X
Disorders caused by physical agents other than toxic agents			X
Malignant pleural neoplasm		X	
Occupational cardiovascular diseases	X		
Lead toxicity		X	
Pesticide and insecticide toxicity		X	
Hepatitis B		X	
Hepatitis C		X	
AIDS		X	

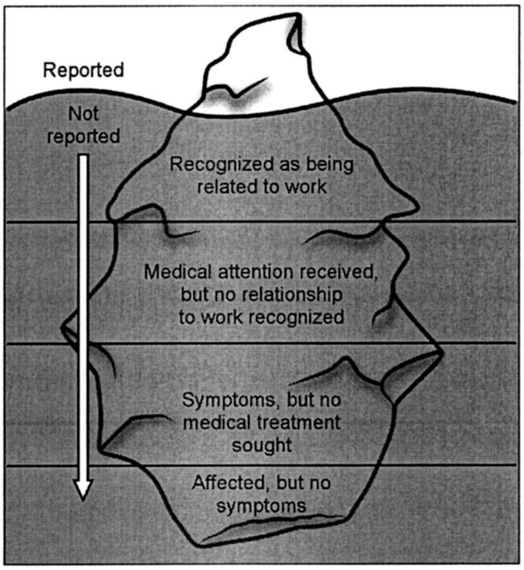

Fig. 1. Disease and illness in the mining industry.

effect on a miner, the miner must be exposed to the harmful material. Entry routes into a miner's body include inhalation; absorption through the skin, eyes, or mucous membranes; ingestion; or ears.

Data Collection

There are many limitations on the accuracy of illness reporting. Defining what constitutes disease or illness is sometimes confusing and often depends on which agency is reporting the data. Table 1 summarizes different ways Centers for Disease Control and Prevention (CDC), National Institute for Occupational Safety and Health (NIOSH), and MSHA categorize disease and illness in their databases. All three agencies list mining as an occupational category.

Comparing data from each agency (Table 1) is difficult. For example, if researchers wanted to compare reproduction disorders from each data set, the only agency that lists reproduction disorders is NIOSH. Another example is lead toxicity, which is only found in CDC's data set. Therefore, with so many different variables used by various agencies, it is nearly impossible for researchers to get a clear picture of disease and illness in US mining.

Under-Reporting

Under-reporting is one of the most serious issues in understanding disease and illness in the mining industry. Karr recognized that is was "difficult for the Occupational Safety and Health Administration (OSHA) or anyone else to recognize when health hazards at work cause illnesses, because there is often such a long lead time for the disease to develop."[2] Therefore, cancer and other deaths from such hazards, although significantly higher than the work site injuries, remain a murky area. Fig. 1 depicts the relationship between reported and unreported disease and illness and illustrates the magnitude of the problem.[3]

In the first case of under-reporting, an illness is recognized as being related to work. A miner is aware of the disease or illness but may be afraid of reporting the disease because of fear of losing his or her job, health insurance, or other job-related benefits. Therefore, the disease or illness is not reported. In the second case, medical attention is received, but neither the attending physician nor the miner associates the disease with the work environment. Again, the disease or illness is not reported. In the third case, the miner has symptoms of a disease, but no medical attention is sought, and the disease or illness is not reported. This again could be because of fear of losing one's job, health insurance etc. Fourth, a miner could be affected with a disease but has no symptoms of the disease. Finally, the only disease and illness data collected by MSHA is from miners who are employed when symptoms of the disease or illness are apparent. Disease and illness data from workers who have retired or left their job and subsequently develop a disease or illness that was work related will seldom be reported. In short, it is probable that even with the limited disease and illness data currently available, the number of miners who actually have a disease or illness caused by mining may be significantly greater than reported (based on Karr's work).

Disease and Illness Rates

The total number of miners (underground and surface metal and nonmetal) employed in the mining industry is shown in Fig. 2. Since 1984, there has been a steady decline in the number of workers employed in the mining industry, even though some years realized marginal growth.

As indicated in Fig. 3, mining had a nonfatal occupational illness incidence rate of 18.8 per 10,000 full-time workers, which is about the same rate as for construction workers.[4] Although this rate seems low compared with the rates in manufacturing or agriculture, the mining incidence rate of nonfatal occupational illness and disease could be improved by identifying why and under what specific conditions illnesses occur (ie, what are the primary causes of illness or disease in the mining industry?).

Table 2 shows U.S. mining disease and illness rates from 1983 to 2001 for all diseases and illnesses and for CWP, hearing loss, contagious disease and illness, silicosis, asbestosis, and skin disorders. Contagious disease and illness, silicosis, asbestosis, and skin disorders are all fewer than 1.2 per 10,000 workers and are not shown in Fig. 4.

Although the years 1997 through 2001 show a decrease in the rates of disease and illness, CWP, and hearing loss in the mining industry, these rates have not returned to the lower levels recorded in 1983 to 1984. This is true partly because of changes in reporting requirements, partly because of more faithful reporting of illness and diseases once ignored by miners, and partly because of increased recognition of the work-related nature of illness and disease. Many mining companies have emphasized the latter in recent years.

However, 1997 nonfatal mining occupational illness rates reported by CDC were 18.8 per 10,000 and 1997 nonfatal mining occupational illness rates reported by MSHA were 35 per 10,000. This difference can be attributed to the categories of disease or illness assigned by each agency and is an excellent example of the need for uniform data reporting and how rates can vary from one agency's reporting compared to another.

Coal Dust

The Federal Coal Mine Health and Safety Act of 1969 defines CWP as a "chronic dust disease of the lung arising out of employment in an underground coal mine."[5] Progressive massive fibrosis is a complicated form of CWP and is generally associated with breathlessness, chronic bronchitis, recurrent chest illness, and even heart failure. Other complications can be increased risk of tuberculosis and mycobacterial infections. Progressive massive fibrosis is

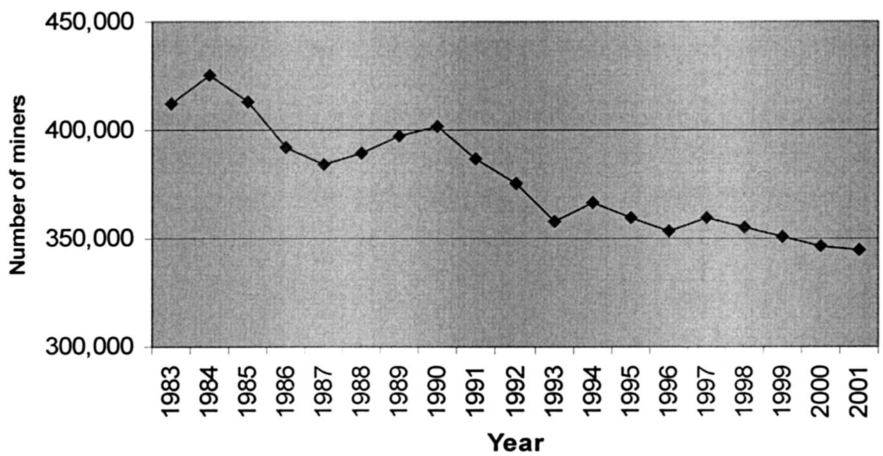

Fig. 2. Number of persons employed in the mining industry 1983 to 2001.[3]

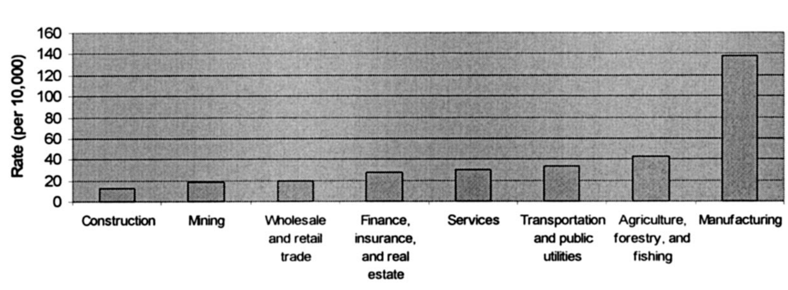

Fig. 3. Incidence rates of nonfatal occupational illness by industry (1997).

TABLE 2
US Mining Disease and Illness Rates, 1983 to 2001 (per 10,000)

Year	Disease and Illness	CWP	Hearing Loss	Contagious Disease/Illness	Silicosis	Asbestosis	Skin Disorders
1983	7.0	4.1	0.5	0.2	0.2	0	0.4
1984	5.8	3.7	0.5	0.2	0.3	0	0.4
1985	11.3	7.6	2.2	0.2	0.1	0.2	0.3
1986	26.5	16.5	8.3	0	0.2	0.3	0.2
1987	40.7	26.1	11.5	0.8	0.5	0.3	0.4
1988	32.9	19.0	7.9	0	0.2	0	1.1
1989	26.5	12.3	5.5	0	0.2	0.3	1.5
1990	23.3	9.9	4.1	0.5	0.7	0	0.8
1991	28.7	13.5	5.0	0.3	0.8	0	1.7
1992	32.5	16.8	5.7	0	0.5	0.5	0.8
1993	31.9	15.2	4.9	1.1	0.5	0.3	0.4
1994	29.1	11.8	4.6	0	0.4	0	0.7
1995	21.9	5.8	4.8	0.6	0.4	0.3	0.7
1996	18.5	2.8	3.5	0.8	0.2	0	0.6
1997	35.3	10.3	6.2	0.6	0.5	0.8	1.3
1998	31.7	6.4	7.0	0.8	0.8	0.3	1.1
1999	25.1	3.4	4.6	0	0.2	0.6	0.9
2000	22.4	3.2	4.5	0	0.2	0	0.7
2001	22.2	2.2	4.4	0.3	0.4	0	0.3

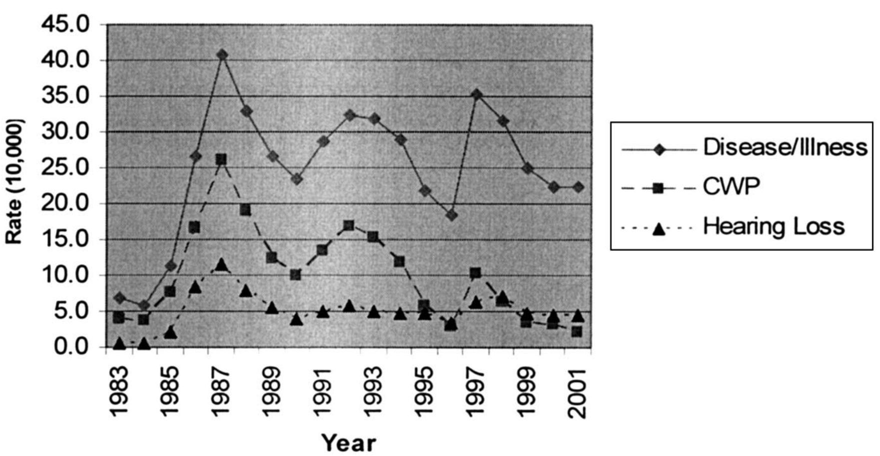

Fig. 4. Disease and illness, CWP, and hearing loss rates from 1983–2001.[3]

a distinct disease and is associated with increased mortality. According to Kissell and Colinet,[6] a study in the 1990s showed an average of 2.8% prevalence of CWP; however, miners with more than 30 years of exposure to coal dust had a prevalence of 14%. Kissell and Colinet further attributed 18,245 deaths between 1987 and 1996 to CWP as a direct or contributing cause of death, with 70% of the death certificates listing "mining machine operator" as the occupation.[6]

The permissible exposure limit (PEL; unadjusted for quartz content greater than 5%) for underground coal dust is 2 mg/m^3 using an 8-hour time-weighted average (TWA). According to Kissell and Colinet, 7.4% of all coal mine air samples collected from 1987 through 1996 exceeded this PEL.[6] Table 2 and Fig. 4 show the rate of CWP for the years 1983 to 2001. An acknowledged 20- to 30-year latency period for CWP does not permit recent exposures to be considered as disease. Nonetheless, a definite improvement in the CWP rate has been recorded, especially since 1997.

Silica Dust

Kissell and Colinet stated that chronic silicosis involves at least 15 years of exposure to silica and that from 1987 to 1996, approximately 421 miners and construction workers died from silicosis.[6] Again, mining machine operators accounted for 14.7% of the deaths. A nuisance dust standard of 10 mg/m^3 triggers regulation by MSHA, and from 1987 to 1996, 15.6% of the dust samples collected from metal mines exceeded the PEL. Table 2 shows the rate of silicosis in the mining industry. The rate of silicosis in mining from 1983 to 2001 was less than 0.8 cases per 10,000 employees and is not considered to be a major threat to the mining community today.

Diesel Particulate Matter

MSHA's new Standard on Diesel Particulate Matter Exposure of Underground Metal and Nonmetal Miners went into effect July 20, 2002. An MSHA DPM exposure level of 400 μg of total carbon per cubic meter of air (equivalent to 500 μg of DPM per cubic meter) was set, and compliance was mandatory July 19, 2003.[7] Noncompliance after that date resulted in MSHA citations. Metz noted that in 1998, the American Conference of Governmental Industrial Hygienists (ACGIH) proposed a threshold limit value-time weighted value (TLV-TWA) of only 50 μg/m^3 for diesel particulates less than 1 μm in size and classified diesel exhaust as a suspected human carcinogen.[8] Of interest, again noted by Metz, was the fact that the ACGIH TLV-TWA would require occupational air to be cleaner than ambient air.[8] Importantly, Schnakenberg estimated the technically feasible level of DPM control today at 90 μg/m^3.[9]

Metz[8] provided a detailed summary of the sources of DPM, how particulates affect the body, and a list of particulate fractions and their toxicity. He further categorized the clinical manifestations of exposure to diesel particulates as either nonneoplastic (acute or chronic) or neoplastic (cancer). Although lung cancer can be caused in rats exposed to diesel exhaust, the long-term health effect on miners is not known.

Asbestos

Table 2 shows a nearly negligible rate for miners' exposure to asbestos, which was less than 0.8 cases per 10,000 from 1983 to 2001.

Noise

Table 2 and Fig. 4 show the rates for hearing loss from 1983 to 2001, which ranged from as low as 0.5 cases per 10,000 in 1983 and 1984 to as many as 11.5 cases per 10,000 in 1987. The rate from 1999 to the present seems to have leveled; however, as of 2001, it was the highest rate of the six selected disease and illness topics discussed. Noise-induced hearing loss (NIHL) begins gradually and progressively gets worse. Problems with this disease include loss of the ability to communicate and reduced response to environmental and occupational noise and danger. In the mining environment, the effects of NIHL can be deadly in specific work situations. Bise listed several factors that influence occupational hearing loss.[10] These factors include the following.

- Age of employee
- Pre-employment hearing impairment;
- Diseases of the ear
- Sound pressure level of the noise
- Length of daily exposure
- Duration of employment
- Ambient conditions of the workplace
- Employee lifestyle outside the workplace

MSHA began enforcing its "noise rule" in the year 2000. It did so in response to its estimate that 13% of US miners (~37,000) would suffer significant loss of hearing (25 dBA [decibals] or higher) at previously prevailing conditions over a working lifetime. Eight hours of exposure to 90 dBA is the current MSHA-permissible noise level, with no exposure to exceed 115 dBA. Bise concluded that, although some controversy exists on whether the 8-hour exposure should be 90 or 85 dBA, "current steps taken by the mining industry should enable future generations of mine workers to lead productive and safe lives without fear of suffering from occupationally based NIHL."[10]

Lead

The MSHA occupational PEL for lead is 0.01 mg/m^3. Lead miners are normally exposed to lead sulfide. Lead sulfide is poorly absorbed when inhaled and only slightly soluble in gastric juice, therefore posing a relatively insignificant problem to miners.[11] However, lead oxide and lead sulfate are more soluble and do pose problems. The good news is that most lead mined is in the form of galena (lead sulfide); therefore, lead poisoning is normally not a threat to miners. However, mill and smelter workers are exposed to lead oxide, which does pose a disease or illness threat.

Welding Fumes

NIOSH lists four gases (acetylene, carbon monoxide, oxides of nitrogen, and phosgene) and 18 metals (arsenic, beryllium, cadmium, chromium, cobalt, copper, iron, lead, magnesium, manganese, molybdenum, nickel, silver, tin, titanium, tungsten, vanadium, and zinc) as hazardous agents associated with the welding process.[12] Furthermore, it lists asbestos, fluorides, and silica as other minerals that create hazards during welding. Finally, it views electricity, hot environments, noise, vibration, ionizing radiation, ultraviolet light, and visible light as physical agents that could be harmful to welders. All of the above-listed agents can cause short and long term toxic or harmful effects (including cancer), as well as death. The importance of studying welding fumes is that no current data exists to track miners who are exposed to welding fumes. Many of the symptoms of overexposure to welding fumes may be confused with other exposures in mining (ie, certain chemical exposures). Health agencies (CDC, NIOSH, and MSHA) responsible for tracking disease and illness in miners need to begin tracking miners exposed to welding fumes.

Skin Disorders

Table 2 shows the rate of skin disorders in the mining industry. The highest number of skin disorders was attributed to unspecified dusts (200 cases from 1983 to 2001) followed by 169 cases attributed to poison ivy or poison oak. Although the rate of skin disorders is not exceptionally high, a review of MSHA records shows that many of these illnesses can be prevented. Unspecified dusts and poison oak or poison ivy contributed to more than 350 illnesses, which could have been prevented if miners had used the proper personal protective equipment.

Lost Work

The number of days lost to disease and illness from 1983 through 2001 is shown in Fig. 5. Although the mining workforce has declined during these years, the number of lost workdays resulting from disease and illness from 1985 through 2001 are greater than the levels reported in 1983 and 1984. Again, it is possible that earlier reporting inconsistencies in the 1980s compared with later

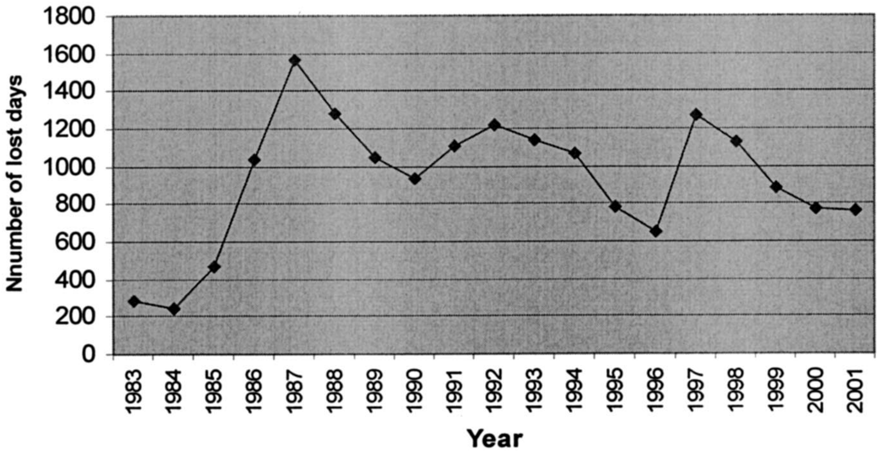

Fig. 5. Number of lost workdays 1983–2001 (MSHA, 2002).

reporting in the late 1990s and through 2001 are responsible for the large difference in the number of lost days. However, as of 2001, nearly 800 days per year had been lost because of a miner's disease or illness, which had a significant impact on production.

Discussion

The inconsistencies in the types of disease and illness data collected by NIOSH, CDC, and MSHA are an obstacle to researchers attempting to frame the magnitude of disease and illness in US mining. A need for one government agency to collect detailed disease and illness data for all workers who have worked or are working as miners is paramount. Under-reporting is recognized as another obstacle in assessing the magnitude of illness and disease in mining. It may not be practical to stop under-reporting of disease and illness in US mining; however, it may be necessary to change reporting procedures to MSHA to get a more accurate reporting of all disease and illness that may have been associated with occupational exposure. For example, workers must never be afraid of losing their jobs from reporting an occupational disease or illness. Improvements have been made since 1977 in reduction of the CWP rate; however, CWP continues to be the highest reported rate of disease and illness in US mining. Because of the 20- to 30-year latency period for CWP it is difficult to project whether the rate will continue to decrease. Because the rate of silicosis, asbestosis, skin disorders, and contagious disease and illness in miners are all less than 1.2 per 10,000, these diseases and illnesses are not considered a major threat to miners. No data exists on DPM exposure in miners, which is another obstacle for researchers to evaluate the magnitude of disease and illness in US mining. Hearing loss rates in miners have decreased since 1998; however, noise levels considered hazardous have not been identified or studied sufficiently. Because lead sulfide is not bioavailable to the body, miners engaged in mining lead ores are not at risk to overexposure. Finally, since 1997, the number of workers employed in mining has decreased and disease and illness rates have also decreased, which is good news for the mining industry.

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