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Achievements in Public Health, 1900-1999: Improvements in Workplace Safety -- United States, 1900-1999

At the beginning of this century, workers in the United States faced remarkably high health and safety risks on the job. Through efforts by individual workers, unions, employers, government agencies, scientists such as Dr. Alice Hamilton (see box, page 462), and others, considerable progress has been made in improving these conditions. Despite these successes, much work remains, with the goal for all workers being a productive and safe working life and a retirement free from long-term consequences of occupational disease and injury. Using the limited data available, this report documents large declines in fatal occupational injuries during the 1900s, highlights the mining industry as an example of improvements in worker safety, and discusses new challenges in occupational safety and health.

Decreases in Fatal Occupational Injuries

Data from multiple sources reflect the large decreases in work-related deaths from the high rates and numbers of deaths among workers during the early 20th century. The earliest systematic survey of workplace fatalities in the United States in this century covered Allegheny County, Pennsylvania, from July 1906 through June 1907 (Figure 1) (1); that year in the one county, 526 workers died in "work accidents"*; 195 of these were steelworkers. In contrast, in 1997, 17 steelworker fatalities occurred nationwide (2). The National Safety Council estimated that in 1912, 18,000-21,000 workers died from work-related injuries (3). In 1913, the Bureau of Labor Statistics documented approximately 23,000 industrial deaths among a workforce of 38 million, equivalent to a rate of 61 deaths per 100,000 workers (4). Under a different reporting system, data from the National Safety Council from 1933 through 1997 indicate that deaths from unintentional work-related injuries declined 90%, from 37 per 100,000 workers to 4 per 100,000 (3). The corresponding annual number of deaths decreased from 14,500 to 5100; during this same period, the workforce more than tripled, from 39 million to approximately 130 million (3).

More recent and probably more complete data from death certificates were compiled from CDC's National Institute for Occupational Safety and Health (NIOSH) National Traumatic Occupational Fatalities (NTOF) surveillance system (5; CDC, unpublished data, 1999). These data indicate that the annual number of deaths declined 28%, from 7405 in 1980 to 5314 in 1995 (the most recent year for which complete NTOF data are available). The average rate of deaths from occupational injuries decreased 43% during the same time, from 7.5 to 4.3 per 100,000 workers. Industries with the highest average rates for fatal occupational injury during 1980-1995 included mining (30.3 deaths per 100,000 workers), agriculture/forestry/fishing (20.1), construction (15.2), and transportation/communications/public utilities (13.4) (Figure 2).** Leading causes of fatal occupational injury during the period include motor vehicle-related injuries, workplace homicides, and machine-related injuries (Figure 3).

Improvements in Mining Safety

On December 6, 1907, a coal mine explosion in Monongah, West Virginia, killed a reported 362 men and boys (unofficial estimates exceeded 500 deaths), marking the largest coal mining disaster in U.S. history. Of the 2534 mining-related fatalities that occurred in bituminous coal mines that year, 911 (36%) resulted from explosions of gas, coal dust, or a combination; 869 deaths occurred in only 11 incidents. The Monongah catastrophe catalyzed public awareness and led to passage of the Organic Act of 1910, which established the U.S. Bureau of Mines (USBM).

From 1911 through 1997, approximately 103,000 miners died at work (Figure 4). During 1911-1915, an average of 3329 mining-related deaths occurred per year among approximately 1 million miners employed annually, with an average annual fatality rate of 329 per 100,000 miners. During the century, the average annual number of workers (operators and contractors combined) in the mining industry has declined to approximately 356,000, and deaths have dropped approximately 37-fold, from 3329 to 89; injury fatality rates have decreased approximately 13-fold, to 25 per 100,000 during 1996-1997.

Historically, the largest number of miners have been killed by collapsing mine roofs and vertical walls, followed by haulage-related incidents. However, methane gas and coal dust explosions have caused the largest number of deaths from "disasters" (i.e., incidents in which five or more deaths occurred); airborne suspension of dry coal dust and natural liberation of methane (present in all coal beds) create an environment susceptible to explosions. From 1911 through 1920, explosions accounted for approximately 84% of all disaster-related deaths. Workplace interventions (e.g., safer equipment and improved ventilation) during the first half of the century led to a dramatic decline in explosion-related fatalities, from an average of 477 per year in 1906-1910 to less than 3 per year in 1991-1995 (Figure 5). All other causes of death associated with underground coal mines (except machinery) declined similarly from the first to the last 20-year interval of this period.

Factors Contributing to Worker Safety

The decline in occupational fatalities in mining and other industries reflects the progress made in all workplaces since the beginning of the century in identifying and correcting the etiologic factors that contribute to occupational health risks. If today's workforce of approximately 130 million had the same risk as workers in 1933 for dying from injuries, then an additional 40,000 workers would have died in 1997 from preventable events (CDC, unpublished data, 1999). The declines can be attributed to multiple, interrelated factors, including efforts by labor and management to improve worker safety and by academic researchers such as Dr. Alice Hamilton. Other efforts to improve safety were developed by state labor and health authorities and through the research, education, and regulatory activities undertaken by government agencies (e.g., USBM, the Mine Safety and Health Administration [established as the Mining Enforcement and Safety Administration in 1973], the Occupational Safety and Health Administration [OSHA] [established in 1970], and NIOSH). Efforts by these groups led to physical changes in the workplace, such as improved ventilation and dust suppression in mines; safer equipment; development and introduction of safer work practices; and improved training of health and safety professionals and of workers. The reduction in workplace deaths has occurred in the context of extensive changes in U.S. economic activity, the U.S. industrial mix, and workforce demographics (6). Societywide progress in injury control also contributes to safer workplaces--for example, use of safety belts and other safety features in motor vehicles (6) and improvements in medical care for trauma victims.

Only in some instances do data permit association of declines in fatalities with specific interventions. Before 1920, using permissible explosives and electrical equipment (which can be operated in an explosive methane-rich environment without igniting the methane), applying a layer of rock dust over the coal dust (which creates an inert mixture and prevents ignition of coal dust), and improved ventilation, such as reversible fans, led to dramatic reductions in fatalities from explosions (Figure 5) (7). New technologies in roof support and improved mine design reduced the number of deaths from roof falls. However, technology also introduced new hazards, such as fatalities associated with machinery. An approximately 50% decrease in coal mining fatality rates occurred from 1966-1970 to 1971-1975 (Figure 4); 1971-1975 is the period immediately following passage of the 1969 Federal Coal Mine Health

and Safety Act, which greatly expanded enforcement powers of federal inspectors and established mandatory health and safety standards for all mines. The act also served as the model for the 1970 Occupational Safety and Health Act. Following the 1977 Federal Mine Safety and Health Act, a 33% decrease in fatalities occurred in metal and nonmetallic minerals mining (1976-1980 compared with 1981-1985) (Figure 4).

Similarly, the impact of more recent targeted efforts to reduce workplace fatalities can be illustrated by data on work-related electrocutions. During the 1980s, there were concerted research and dissemination efforts by NIOSH, changes to the National Electrical Code and occupational safety and health regulations, and public awareness campaigns by power companies and others. During this decade, work-related electrocution rates declined 54%, from 0.7 per 100,000 workers per year in 1980 to 0.3 in 1989; the number of electrocutions decreased from 577 to 329 (6).

Although the decline in injuries in general industry since 1970 seems to have resulted from a variety of factors, some sources point to the Occupational Safety and Health Act of 1970****, which created NIOSH and OSHA (6,8). Since 1971, NIOSH has investigated hazardous work conditions, conducted research to prevent injury, trained health professionals, and developed educational materials and recommendations for worker protection. OSHA's regulatory authority for worksite inspection and development of safety standards has brought about safety regulations, mandatory workplace safety controls, and worker training. During 1980-1996, research findings indicated that training creates safer workplaces through increased worker knowledge of job hazards and safe work practices in a wide array of worksites (9).

Future Directions

Despite the accomplishments described in this report, workers continue to die from preventable injuries sustained on the job. Ongoing efforts to address important workplace hazards include conducting field investigations of fatalities in high-risk occupations and industries, such as the Fire Fighter Fatality Investigation and Prevention Program, establishing a research center to facilitate childhood agricultural injury prevention (National Children's Center for Rural and Agricultural Health and Safety), and developing educational materials for worker protection, such as Preventing Homicide in the Workplace (10). Despite major gains in workplace safety, mining remains the most dangerous industry, and mining safety research remains a national priority.

The National Occupational Research Agenda (NORA), developed by NIOSH and approximately 500 organizations and persons nationwide, identified traumatic injuries as one of its public health priorities. NORA was developed in recognition of the rapidly changing nature of the workplace and workforce and provides the framework for research to improve worker safety in the 21st century. The NORA Traumatic Injuries Team sponsored the first National Occupational Injury Symposium in 1997 and outlined priority needs (11). These include the need to identify new sources of surveillance data, to improve identification of work-related injuries and illnesses in existing databases, to link data from existing sources for improved information about injuries, and to better assess injury exposures and intervention outcomes. Increased attention to other NORA priority areas, such as intervention effectiveness research, surveillance research methods, and organization of work, should guide continued national efforts to reduce both occupational illnesses and injuries in the next century.

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* When a death occurs under "accidental" circumstances, the preferred term within the public health community is "unintentional injury."

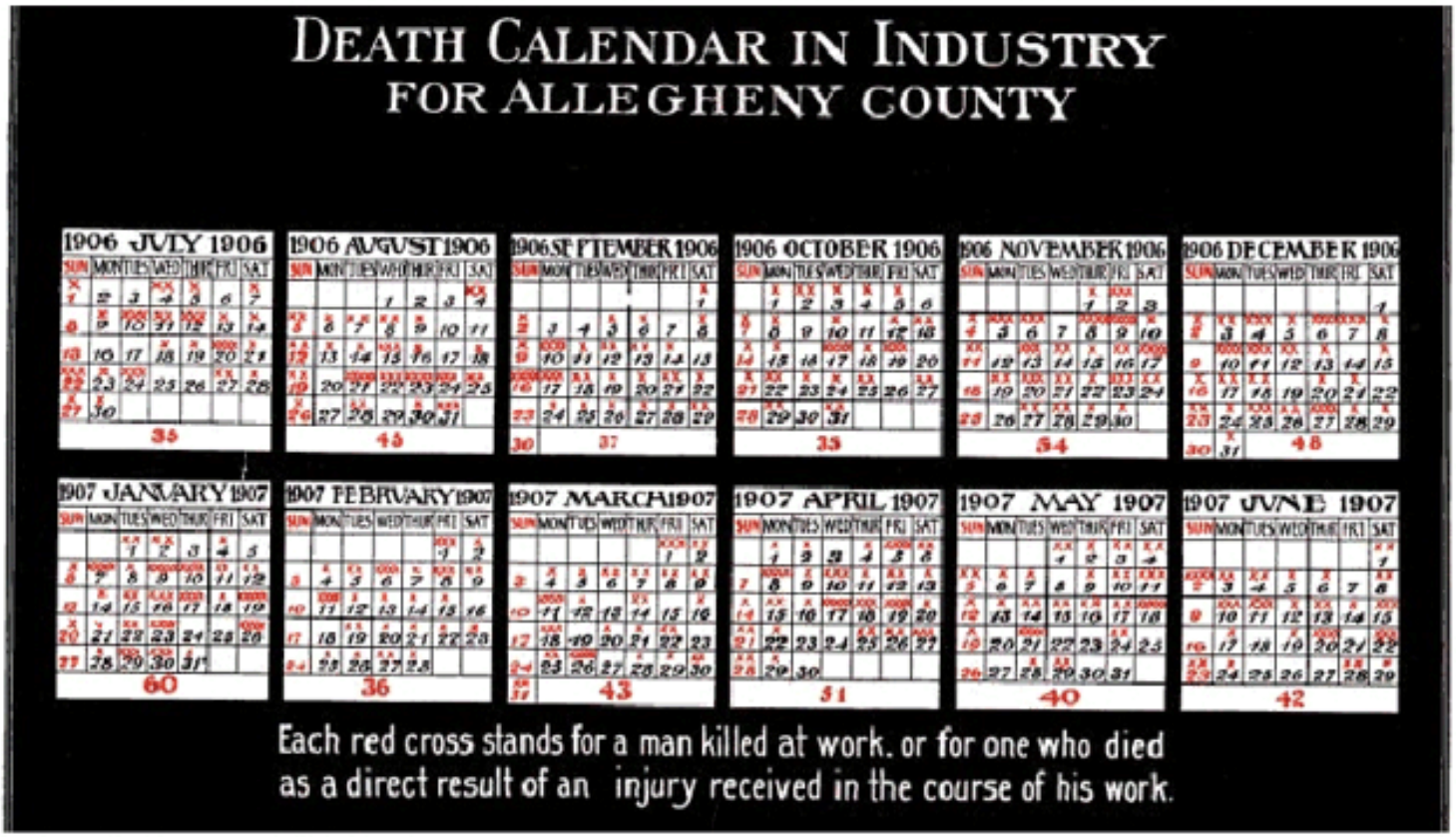
** The NTOF surveillance system classifies industries according to the Standard Industry Classification Manual, 1987, which, unlike the definition used by the Mine Safety and Health Administration (MSHA), includes the oil and gas sectors of mineral extraction in the mining industry.

*** MSHA data are used in this section of the report; these data exclude oil and gas extraction, and data collection for mining according to MSHA includes only deaths that occur on mine property. Deaths likely to occur off mine property, such as during operation of a motor vehicle (the overall leading cause of death during 1980-1994 [Figure 3]), are excluded.

**** Public Law 91-596.

Figure 1

FIGURE 1. Number of work-related deaths, by day — Allegheny County, Pennsylvania, July 1906–June 1907*



*In the original figure, each X is in red.
Reprinted by permission of the Russell Sage Foundation (1).

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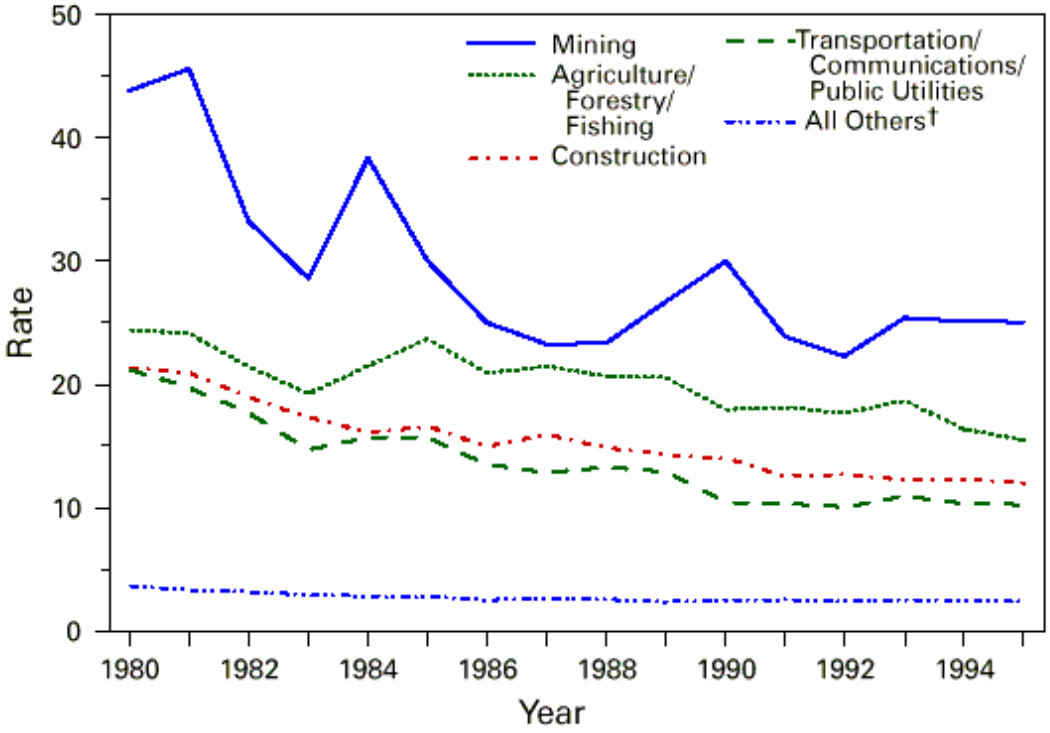
Figure 2

FIGURE 2. Occupational injury death rates*, by industry division and year — United States, 1980–1995



*Per 100,000 workers.
†Includes public administration, manufacturing, wholesale trade, retail trade, services, and finance/insurance/real estate.

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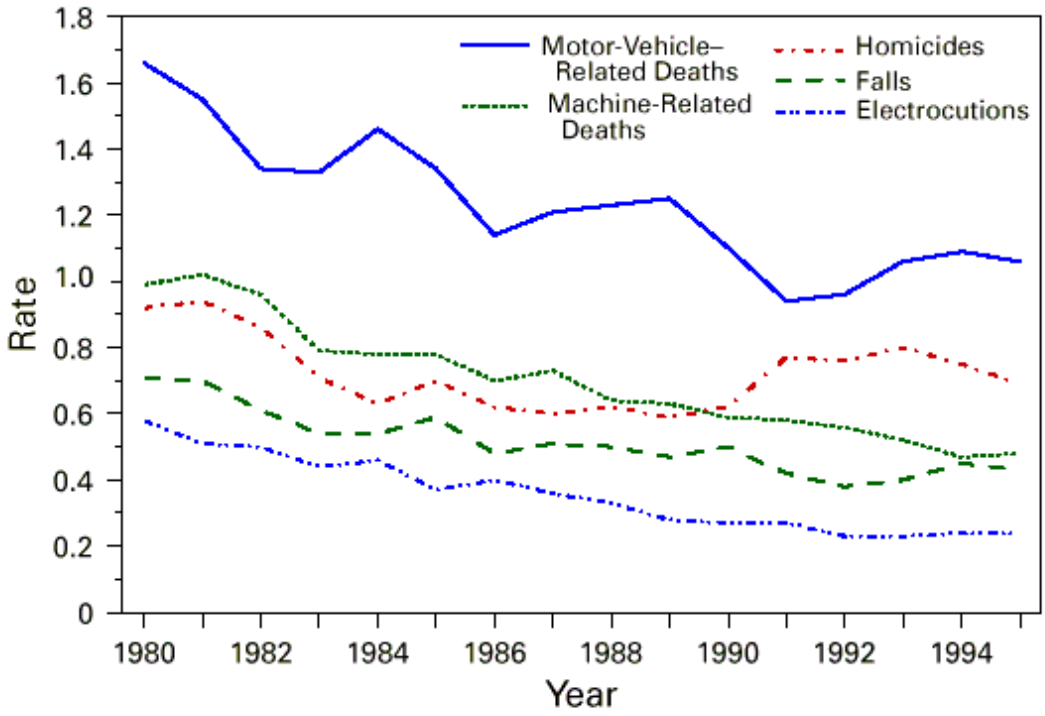
Figure 3

FIGURE 3. Rates* for leading causes of occupational injury deaths, by cause and year — United States, 1980–1995



*Per 100,000 workers.

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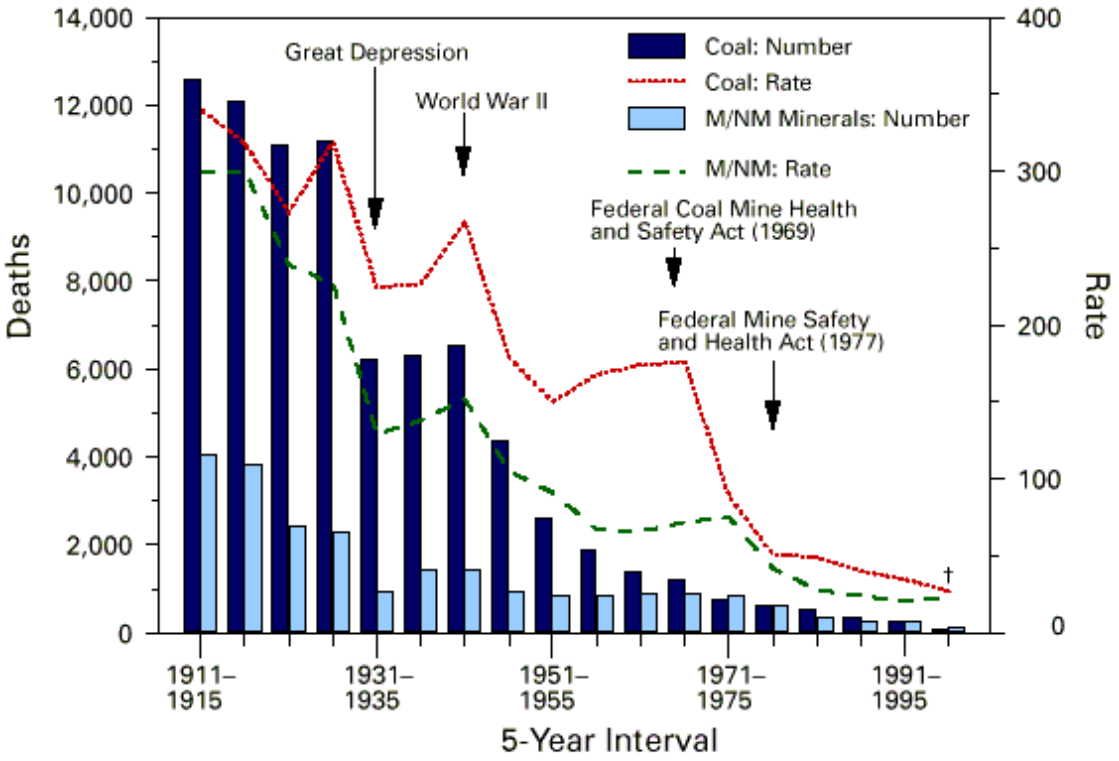
Figure 4

FIGURE 4. Number of deaths and fatality rates* in mining coal and metal/nonmetallic (M/NM) minerals, by 5-year interval — United States, 1911–1997



*Per 100,000 workers.
†Data are for 1996 and 1997.

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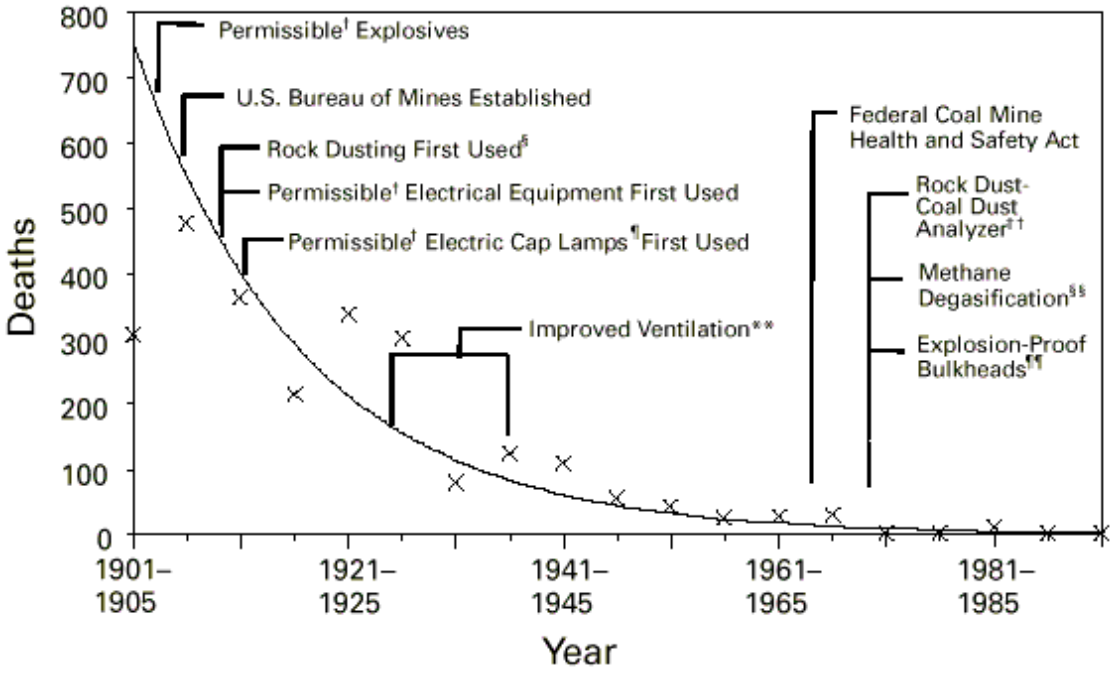
Figure 5

FIGURE 5. Five-year averages of annual number of deaths related to coal mine explosions — United States, 1901–1995*



*Each X represents the 5-year average of the number of deaths resulting from explosions; the line is a smoothed regression line through the 5-year averages.
†Explosives and equipment that can be used in an explosive methane-rich environment without causing a methane explosion.
§The process of applying a layer of rock dust over the coal dust, which creates an inert mixture and inhibits a coal dust explosion.
¶Lamps worn on minors' caps.
**Ventilation improvements, including the use of reversible fans, reduce the concentration of methane and remove the explosive gas from the mine.
††A hand-held monitor that provides instantaneous readings of the rock-to-coal dust mixture to ensure that it is inert.
§§Techniques to remove methane from the coal bed before mining the coal.
¶¶Explosion-proof walls used to seal abandoned (mined-out) areas to protect workers in active parts of the mine.

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