Commentary

30-Year Trends in the Disease Burden, Incidence, and Prevention of Pneumoconiosis

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The global incidence of pneumoconiosis, a lung disease caused by inhaling industrial dust, has increased by 61.5% from 1990 to 2019, according to a recent report. China had the highest number of cases in 2019, followed by India and the United States. The all-age standard incidence rate for pneumoconiosis was 2.39 per 100,000 population in 2019, with China also having the highest rate. However, there was a decrease in the incidence rate in Belgium and Italy during the same period. The report also highlights regional variations in the changing trend, with the largest increase in cases observed in North Africa and the Middle East. Improved dust prevention and control measures are urgently needed to reduce workplace dust exposure and combat the rising cases of pneumoconiosis globally.

Pneumoconiosis, marked by pulmonary interstitial fibrosis, is predominantly induced by inhalation of industrial dust. This exposure typically results in diminished lung function and gradual loss of work capability (*1–4*). Given the global prevalence of industrial dust exposure, affecting millions of workers, pneumoconiosis consistently garners significant public health attention (*5–6*). Despite targeted public health efforts, the disease remains the deadliest occupational disease, particularly in low- to middle-income countries and developing regions such as China (*7–11*). Data from the Global Burden of Disease research carried out by the Institute for Health Metrics and Evaluation (IHME) report the number of new cases rising from 60,055 in 2017 to 199,125 in 2019 (*10*). In China alone, the former Ministry of Health (now known as National Health Commission of China, NHC) reported over 271,000 new cases between 2010 and 2022. This recent surge in case numbers underscores the need for stringent preventative measures to control dust concentration in workplaces.

Pneumoconiosis can be categorized further based on the type of industrial dust inhaled. The most prevalent types in China are silicosis, resulting from inhalation of free crystalline silicon dioxide, and coal worker's pneumoconiosis (CWP), caused by coal mine dust; both account for 90% of pneumoconiosis cases as per epidemiological studies (*12*). Incidence estimates for pneumoconiosis etiologies are derived using a standard DisMod-MR 2.1 approach and informed by the 2017/2019 global disease burden data and published studies (*13*). Incidence is gathered from systematic literature reviews, inpatient hospital reports, and claims data (https://ghdx.healthdata.org/gbd-2019). In the Global Burden of Disease (GBD) study, diseases coded in the International Classification of Diseases (ICD) 9 (500–505.9) and ICD 10 (J60–J65.0 and J92.0) are used for incidence estimation (*13*). This paper presents reported incident cases and age-standardized incidence rate (ASIR) of total pneumoconiosis, silicosis, and CWP. It also provides an overview of changing pneumoconiosis disease burden trends globally and particularly in China from 1990 to 2019. A literature review was conducted for studies reporting pneumoconiosis prevalence, utilizing databases such as PubMed, CNKI, and Web of Science. Additionally, we summarize recent advancements in dust prevention technology to support the prevention and treatment of pneumoconiosis.

Trends in the Global Number and Incidence of Pneumoconiosis

The global incident cases of pneumoconiosis escalated by 61.5% [95% uncertainty interval (*UI*): 44.6%–77.6%] from 123,271 cases in 1990 to 199,125 in 2019. The top three nations with the highest incidence in 2019 were China, with 136,755 cases, followed by India and the United States, with 11,670 and 10,014 cases, respectively. The ASIR for pneumoconiosis was 2.39 per 100,000 population in 2019, and demonstrated notable variability across the globe. China exhibited the highest ASIR, at 6.73 per 100,000 population, while Lesotho and South Africa followed with ASIR of 5.08 per 100,000 and 4.89 per 100,000, respectively. The period from 1990 to 2019 saw an average annual percentage change (AAPC) of

−0.62% [95% confidence interval (*CI*): −0.85% to −0.39%] in the ASIR, implying a decrease. Belgium manifested the most substantial decrease, with an AAPC of −3.70% (95% *CI*: −4.33% to −3.07%), followed by Italy and Bermuda with respective AAPCs of −3.69% (95% *CI*: −4.10% to −3.29%) and −3.53% (95% *CI*: −3.73% to −3.34%). Conversely, Iran reported the most significant increase with an AAPC of 3.82% (95% *CI*: 3.19% to 4.45%), followed by Libya (AAPC=3.55%; 95% *CI*: 3.24% to 3.87%) and Georgia (AAPC=3.52%; 95% *CI*: 3.30% to 3.75%).

In the GBD study, the globe was segmented into 21 geographical regions. Between 1990 and 2019, the total number of reported pneumoconiosis cases rose in nearly all areas, barring Central Europe, Eastern Europe, Western Europe, and high-income Asia Pacific. The most significant increase was seen in North Africa and the Middle East (222.6%; 95% *UI*: 196.3%–254.3%), trailed by Oceania (205.1%; 95% *UI*: 177.0%–234.9%), and Southern Latin America (189.0%; 95% *UI*: 159.0%–222.0%). Concerning the ASIR, out of the 21 GBD regions, 10 exhibited an upward trajectory in ASIR, as evidenced by both AAPC and its 95% *CI*. The highest ASIR was documented in East Asia. However, fluctuations in ASIR differ amongst regions; the most noticeable decrease was observed in high-income Asia Pacific (AAPC=−2.85%; 95% *CI*: −3.44% to −2.26%), while the most substantial increase was marked in Southern Latin America (AAPC=1.59%; 95% *CI*: 1.21%–1.97%).

The socio-demographic index (SDI) segregates the world into five distinct regions: low, low-middle, middle, high-middle, and high. The incident cases of pneumoconiosis were observed to be most prevalent in the middle region, followed by the high-middle region (*10*). Overall, the ASIR of pneumoconiosis initially rose and then declined in response to an increase in SDI. When the SDI value reached or exceeded 0.7, a negative correlation was observed between the AAPC in ASIR for pneumoconiosis and the SDI (*10*). These findings indicate a relationship between higher SDI values and a decrease in pneumoconiosis incidence rate.

In 2019, silicosis accounted for approximately 69.8% (138,971) of total new pneumoconiosis cases globally. The number of reported silicosis cases increased significantly by 64.6% (41.1%–87.7%) from 84,426 in 1990 to 138,971 in 2019. There was considerable disparity worldwide in the ASIR of silicosis, which stood at 1.65 per 100,000 population. The highest ASIR was observed in East Asia at 5.78 per 100,000 population. The ASIR for silicosis exhibited a decreasing trend over the study period, with an AAPC of −0.56% (95% *CI*: −0.84% to −0.27%). However, an increasing trend in silicosis ASIR was noted in more than half (118 out of 204) of the countries and regions studied, primarily in developing nations.

In 2019, CWP accounted for approximately 3.5% (7, 153) of all new pneumoconiosis cases globally. The incident cases of CWP were 7,379 in 1990, falling slightly to 7,153 by 2019. The ASIR for CWP globally was 0.09 per 100,000 population in 2019, reflecting a decrease characterized by an AAPC of −2.41% (−2.68% to −2.13%) from 1990 to 2019. It's important to note that ASIR for CWP significantly varies among countries [most affected Poland (0.31/100,000) and the Democratic People's Republic of Korea (0.27/100,000)] and regions [most affected Taiwan, China (0.42/100,000)] in 2019. Particularly, the ASIR for CWP in East Asia was markedly greater than in other regions. On a global scale, the ASIR for CWP has demonstrated a decline between 1990 and 2019, with an AAPC of −2.40% (−2.68% to −2.13%) (*14*). Alongside an increase in SDI, the ASIR of CWP has been on a downward trend, more so in East Asia.

The Shift in the Number and Incidence of Pneumoconiosis in China

The incident cases of pneumoconiosis in China surged by 63.7% (95% *UI*: 40.5%–86.7%), from 83,550 in 1990 to 136,755 in 2019. In 2019, incident pneumoconiosis cases in China represented 68.7% of the global total. However, with the implementation of national standards and control measures on dust concentration, there has been a gradual decline in the incidence of pneumoconiosis. The ASIR of pneumoconiosis dropped from 7.82/100,000 in 1990 to 6.73/100,000 in 2019, with an AAPC of −0.58% (−0.99% to −0.17%).

Similar patterns were observed for both silicosis and CWP. In 1990, incident cases of silicosis and CWP were recorded at 68,236 and 5,450 respectively, and these figures rose to 120,775 and 4,974 in 2019. The ASIR of silicosis decreased from 6.34/100,000 in 1990 to 5.92/100,000 in 2019, with an AAPC of −0.34% (−0.67% to −0.01%). Additionally, the ASIR of CWP decreased from 0.52/100,000 in 1990 to 0.25/100,000 in 2019, with an AAPC of −2.61% (−2.91% to −2.31%).

It should be noted, however, that the count and

ASIR of CWP reported in GBD data differs from those reported by the NHC. In the latter's report, CWP cases reported were either equivalent to or higher than those of silicosis. These discrepancies may result from differences in the categorization of silicosis. In the GBD, any pneumoconiosis resulting from exposure to industrial dust with free silica is classified as silicosis, while in China, silicosis is attributed to exposure to dust with a free silica content of 10% or more. As per GBD, CWP is specifically tied to exposure to pure coal dust.

The observed decrease in the ASIR of pneumoconiosis in China over the past three decades reflects improvements from implemented dust prevention measures. Notwithstanding, it is paramount to highlight that current data on pneumoconiosis, incorporating silicosis and CWP, indicates a considerable increase in the number of new cases compared to 1990. Although recent reports from the NHC show a gradual decrease in new pneumoconiosis cases over the last five years, the aggregate number remains rather high. The simultaneous rise in new pneumoconiosis cases alongside a declining incidence suggests an increase in the overall number of workers exposed to dust. Consequently, the need for protective measures for this susceptible population has also escalated. Thus, it is clear that considerable efforts are still required to advance dust prevention and containment in China.

The Shift of CWP Prevalence in Recent Years

Recent industrial growth and increased demand for coal energy have led to a rise in coal mine workers' exposure to coal mine dust (*15–17*). Consequently, the prevalence of CWP has garnered increased focus in recent years (*18–21*). A comprehensive meta-analysis, encompassing 11,214,584 coal miners, among whom 202,668 developed CWP, was conducted across 37 studies (*22*). Nineteen of these studies reported a CWP prevalence exceeding 5%.

The aggregated prevalence of CWP decreased from 23.33% (95% *CI*: 18.03% to 8.62%) before 1970 to 6.00% (95% *CI*: 4.11% to 7.90%) during 1981–1990, which then saw a resurgence to 10.35% (95% *CI*: 8.08% to 12.62%) in 1991–2000. However, it significantly dropped to 2.29% (95% *CI*: 2.06% to 2.51%) between 2011 and 2020. Over the past three decades, the highest pooled prevalence rates of CWP were observed in Europe, China, and the USA, respectively. Few studies reported prevalence in developing regions, but available evidence suggests that these regions possess higher prevalence compared to developed regions.

The worldwide prevalence of CWP has seen a downward trend in recent years. Nonetheless, the prevalence in developing regions remains comparatively higher than in developed areas. This underlines the need for increased attention and strategic interventions towards controlling CWP, specifically in developing regions.

Advancements in Dust Control Technology

The previous analysis regarding the incidence of pneumoconiosis across various SDI illustrates a negative correlation between the SDI and pneumoconiosis incidence. More formidable challenges in preventing and controlling pneumoconiosis exist in regions of middle to middle-high economic development, due to rapid economic growth and a substantial number of workers being exposed to dust (*3*). The global community is encouraged to provide support to these developing regions in creating enhanced occupational health surveillance systems and integrating advanced technology for occupational environmental monitoring, dust mitigation, and personal protection.

Dust control engineering technologies and strategies are crucial methods for decreasing dust concentrations in workplaces. The predominant example of reducing dust concentrations through optimized process operations is utilizing wet operations to diminish the production and transmission of industrial dust (*23*). For instance, in the field of coal mining, water injection into coal seams is employed to regulate dust emission during mining (*24*). The addition of a surfactant enhances the water's wettability to coal, which proves beneficial in reducing coal dust production during the water injection process (*25–26*).

Furthermore, air curtain technology is implemented to create a trapezoidal protection area, separating the dust-producing surface from the operator within the workplace (*27*). Recently developed environmental dust suppressors, which include simple composite materials and polymer products, demonstrate a commendable ability to absorb coal dust. This ensures the practicality and durability of these dust suppressors (*28–30*).

In addition, ultrasonic spray dust removal technology satisfies the needs of narrow and wind-impacted areas effectively capturing and lowering small particle size dust levels (*31*). These dust-prevention strategies lead to a reduction in dust concentration, but potential health benefits require additional research.

Furthermore, to accommodate an array of conditions such as high temperatures, high humidity, and high levels of dust, the performance of various masks and respirators, including tightness, filtration, and inspiratory resistance, has been progressively enhanced (*32–33*). In recent years, the development of techniques for early pneumoconiosis detection, including sensitive biomarkers for pulmonary fibrosis and high-resolution CT, has been continuously progressing. These serve the crucial function of enabling the early identification of dust-related health hazards and timely protection of workers (*2*,*34–41*).

Future Prospects

Moving forward, pneumoconiosis continues to present challenges in various countries, despite numerous global, regional, and national initiatives to eradicate it. As part of the *Healthy China 2030 Action Plan*, China has incorporated specific strategies to address occupational health issues, including ones related to pneumoconiosis (*42*). The plan mandates health surveillance for a minimum of 95% of workers exposed to dust (*42*). Moreover, globally, there is a need for additional resources for health education targeting workers, providing respiratory protective equipment, and raising awareness about occupational health issues. Future advancements in the domains of dust prevention technology, online dust monitoring, and intelligent health monitoring for dust-exposed workers are essential along with enhancements in personal respiratory protection. Developing a comprehensive understanding of pneumoconiosis incidence trends and levels derived from robust, multinational data is crucial to inform policy, target prevention efforts, and highlight the importance of treating pneumoconiosis.

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