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Research letter

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Incidence and diseases burden of coal workers' pneumoconiosis worldwide, 1990-2019: evidence from the Global Burden of Disease Study 2019

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Abbreviations:

CWP: Coal workers' pneumoconiosis

GBD: Global Burden of Disease Study

ASIR: Age standardized incidence rate

ASMR: Age-standardized mortality rate

YLLs: Years of life lost

YLDs: Years lived with disability

DALYs: Disability-adjusted life years

GHDx: Global Health Data Exchange

AAPC: Average annual percentage changes

CI: Confidence interval

UI: Uncertainty interval

SDI: Socio-demographic index

Coal workers' pneumoconiosis (CWP) is one of the most serious occupational diseases caused by long-term inhalation of coal dust (including dust from coal mining or pure coal dust) in the workplace [1]. Although prevention efforts have been taken for many decades, CWP is still a public health issue around the world [2]. Especially in developing countries where coal is the main energy source, millions of workers are exposed to coal dust during their professional activities. Published literatures reported that more than 20 million workers are exposed to coal dust in the workplace in China and India alone [3, 4]. In addition, several international or national plans and programs were conducted to control industrial coal dust and prevent CWP since 1990. However, the global incidence and disease burden of CWP and their temporal trends over time are limited.

In this study, we used data from the Global Burden of Disease Study 2019 (GBD 2019) to comprehensively assess the geographic patterns and temporal trends of global CWP morbidity, mortality and diseases burden from 1990 to 2019. The number of incident cases, the age-standardized incidence rate (ASIR), the age-standardized mortality rate (ASMR), years of life lost (YLLs), years lived with disability (YLDs), and disability-adjusted life years (DALYs) of CWP from 1990 to 2019 were collected from the Global Health Data Exchange (GHDx) query tool (http://ghdx.healthdata.org/gbd-results-tool). The general methods used in the GBD study have been published previously [5]. Briefly, we first categorized 204 countries and territories into five regions (low, low-middle, middle, high-middle, and high) according to the socio-demographic index (SDI) used in the GBD study [6].

Furthermore, all countries were divided into 21 areas based on geography. Secondly, we examined the changes in CWP incidence trends globally and in SDI regions using the Join-point Regression Program (Version 4.5.0.1; NCI, Bethesda, MD). We determined the number of join-points using the Permutation Test with the default maximum number of three [7]. All analyses were performed using the R Statistical Software (Version 4.0.2). A *p*-value of less than 0.05 was considered statistically significant.

In 2019, the incident cases, ASIR and ASMR of CWP was 7,153 (95% uncertainty interval [UI] 5,870, 8,717), 0.09 (0.07, 0.11) per 10^5, and 0.04 (0.03, 0.05) per 10^5 globally, and the highest number of incident cases was in Mainland China (4,974 [3,976, 6,263]) (**Figure 1A**). For DALYs, YLLs, and YLDs, the global age-standardized DALYs, age-standardized YLLs and age-standardized YLDs were 0.92 (0.68, 1.17) per 10^5, 0.72 (0.49, 0.96) per 10^5 and 0.20 (0.13, 0.30) per 10^5, respectively (**Figure 1B**). Among 21 geographical areas, the highest incident case, ASIR, ASMR, the age-standardized DALYs, age-standardized YLLs and age-standardized YLDs were all in East Asia. The number of incident cases in East Asia were 5,224 (4,187, 6,573), which accounted for 73.03% of the global cases.

The global incident cases of CWP have decreased 3.06% (95% confidence interval [CI] 1.08%, 4.30%) from 1990 to 2019. The percentage of males among all the incident cases of CWP have also decreased from 89.35% (6,593/7,379) in 1990 to 86.16% (6,163/7,153) in 2019. As to the age, the largest number of CWP was 35-39 years old (n=1,003) in 1990 (**Figure 1C**), while it was 50-54 (n=804) in 2019 (**Figure 1D**). The

global ASIR also showed a decreased trend generally from 1990 to 2019, and the AAPC was -2.40% (-2.68%, -2.13%). However, the increasing trend of ASIR could also be found in some countries or regions, including Taiwan (3.39% [3.23%, 3.55%]), Iran (2.88% [2.83%, 2.93%]), South Korean (1.54% [0.95%, 2.13%]), etc (**Figure 1E**). In addition, the global age-standardized DALYs presented a downward trend from 1990 to 2019 (-3.90%, 95% CI [-4.01%, -3.78%]). However, five countries or regions showed an upward trend, namely Taiwan (5.45%, 95% CI [4.79%, 6.11%]), Bosnia-Herzegovina (4.69% [2.70%, 6.71%]), Serbia (3.88% [3.19%, 4.58%]), Spain (3.65% [2.07%, 5.25%]) and Georgia (3.19% [1.29%, 5.12%]) **(Figure 1F**).

We conducted join-point analyses of the CWP by five SDI regions from 1990 to 2019, and the increasing trend was only found in the 2012–2019 time period in low SDI region (1.52% [1.41%, 1.64%]). The associations of SDI with ASIR and age-standardized DALYs in 21 geographical areas are presented in **Figure 1G and Figure 1H**. Overall, the ASIR or age-standardized DALYs decreased with increasing SDI. It is worth noting that with the increase in SDI in East Asia, ASIR and age-standardized DALYs have dropped sharply.

This article provides a comprehensive overview of the temporal trends in the incidence and diseases burden of CWP at the global, regional, and national levels. Generally, ASIR and diseases burden of CWP is declining globally from 1990 to 2019, but the number of incident cases of CWP did not change a lot. Furthermore, more aged workers with CWP occurred in 2019, compared with that in 1990. The age change of CWP from 1990 to 2019 may explain the decreasing trend of ASIR. And

these results may indicate that more aged people are in urgent need of protection from coal dust exposure. Meanwhile, the declining trend of CWP are more pronounced in developed countries than developing countries in the present study. The results were consistent with previous studies in specific regions [8, 9]. However, the current published literatures still report that the resurgence of CWP in some developed countries, such as United States and Australia [10, 11], indicating that CWP deserves more attention.

Our findings showed that CWP cases are predominant in the middle and middle-high SDI regions. And this conclusion could be verified by the correlation results of SDI with ASIR and age-standardized DALYs in 21 areas. In addition, the increasing trend was only significant in the low SDI region during 2012–2019 period with joint-point analyses. All these results indicated that the focus of CWP prevention and control is in low- and middle-income countries or developing countries and regions. The rapid economic development and the large demand for coal energy have caused more people to be exposed to coal dust. In some developing countries, due to more emphasis on economic development, the incidence and the number of CWP cases have remained at a high level for a long time [12, 13]. In India, for example, the prevalence of CWP in coal workers remains high, the overall prevalence was found to be 3.03%, ranging from 1.52% to 4.76% in different areas [14]. In China, it is reported that the prevalence of CWP was 6.02% (3.43%, 9.26%) according to published studies [12]. What is exciting is that several plans have

been included in the Health China 2030 Action Plan to address occupational health issues, and a pneumoconiosis prevention and control action requires that at least 95% of occupational dust-exposed workers must undergo health examinations, and 80% of coal industry workers should be covered by work-related injury insurance by 2020 [15].

This study systematically describes the incidence and diseases burden of CWP and the temporal trends at global levels with the latest data of GBD 2019. Several limitations should be noted. Firstly, the robustness of GBD data depends on the quality of the data source. For instance, inpatient hospital reports underestimate CWP cases because some patients with early-stage disease are less likely to be hospitalized. However, the GBD estimates are updated each year with improvements in the modelling strategy and complementation of data sources. Taking the aforementioned into consideration, integrating multiple health data sources could give a more accurate and complete picture of incidence trends of CWP. Secondly, the GBD estimates are not validated for approximate studies because no ranges of initiatives are available for comparison. However, the modelling strategies of GBD estimates are evaluated by international collaborators, and the incompatible data or unexpected results are further confirmed.

In summary, CWP remains a public health issue worldwide because millions of people exposed to coal dust in the workplace. Although ASIR and the disease burden of CWP is declining globally from 1990 to 2019, the number of incident cases of CWP has been maintained at a high level. Especially, the number of incident case and

ASIR of CWP are not significantly decreased in the past 10 years in developing countries. Based on this severe situation, more efforts are needed to control or reduce exposure to coal dust in the workplace and protect workers from CWP.

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Figure Legends

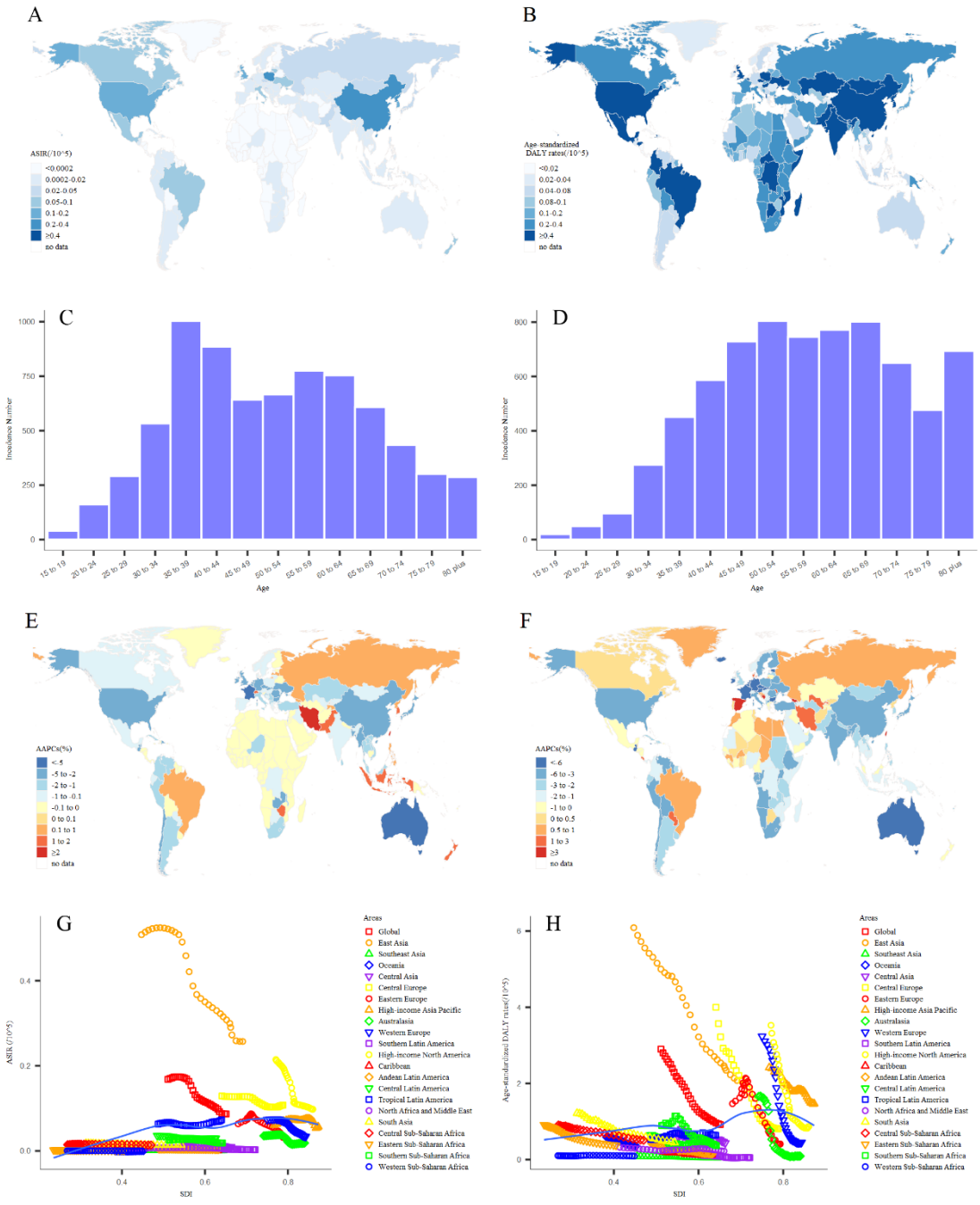

Figure 1 (A) ASIR of CWP in 204 countries and territories in 2019; (B) Age-standardized DALY rates of CWP in 204 countries and territories in 2019; (C) The age distribution for the global incident cases of CWP in 1990; (D) The age distribution for the global incident cases of CWP in 2019; (E) AAPCs for ASIR of CWP in 204 countries and territories from 1990 to 2019; (F) AAPCs for age-standardized DALY

rates of CWP in 204 countries and territories from 1990 to 2019; (G) Change of ASIR in global and 21 GBD areas of CWP by SDI from 1990 to 2019; (H) Change of age-standardized DALY rates in global and 21 GBD areas of CWP by SDI from 1990 to 2019.

ASIR: age-standardized incidence rate, CWP: coal workers' pneumoconiosis, DALY: disability-adjusted life year, AAPCs: average annual percentage changes, GBD: Global Burden of Disease Study; SDI: socio-demographic index.