Letter to the Editor

Geographic Distribution of Coal Enterprises and Workers Exposed to Coal Dust in China in 2020*

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Prolonged exposure to coal dust may lead to various lung diseases, especially coal workers' pneumoconiosis (CWP)[1]. Developed countries such as the United States experienced a resurgence of pneumoconiosis in the early 20th century[2], and this phenomenon has become even more critical in developing countries[3] such as China and India. As the world's largest producer of raw coal, and with millions of workers engaged in coal mining, washing, and dressing, China has the highest number of pneumoconiosis cases worldwide. Among these, more than 60% are CWP cases, accounting for a substantial proportion of the global disease burden and an average annual economic loss of 3 billion yuan for new cases between 2007 and 2016[4]. According to the 2019 Global Burden of Disease results, it was estimated that deaths caused by CWP in China account for 43.30% of global deaths and 54.95% of global disability-adjusted life years[5]. The International Labor Organization and World Health Organization jointly launched a global program to eliminate pneumoconiosis with the long-term goal of eliminating it worldwide by 2030. To develop evidence-based strategies in China, it is essential to understand basic information about the number of colliery enterprises and coal miners. However, epidemiological data are lacking in this regard. The Occupational Disease Hazardous Items Reporting System (ODHIRS) was established by the Chinese Center for Disease Control and Prevention. All enterprises with occupational disease hazards must be identified within this system. In 2020, according to the requirements of the National Health Commission of the People's Republic of China, the Centers for Disease Control and Prevention at the provincial and municipal levels repeatedly reviewed and modified the declared data. The ODHIRS included 24 provinces, autonomous regions, and municipalities because all collieries in the other seven provinces (Zhejiang, Hainan, Tibet, Guangdong, Beijing, Shanghai, and Tianjin) were closed according to published policies, and no data were available from the system. To ensure good representativeness of the data, the scientific nature and accuracy were further improved. Additionally, this information could provide a theoretical reference for a global prevention and control strategy for CWP.

The enterprise scale was defined according to the *Measures of Statistical Classification for Large, Medium, Small, and Micro Enterprises* issued by the National Statistics Bureau in 2017, and the registration type was defined according to the *Regulations on the Classification of Enterprise Registration Types*. The geographic distribution of raw coal production, scale and type of enterprises, number of coal workers, and coal production per coal worker across China were analyzed using statistical descriptions. R4.0.5 software was used for the analysis. It should be noted that because coal washing enterprises only perform the further processing of raw coal without increasing the production volume, the coal volume of these enterprises was not included in the data calculation. However, because these workers are exposed to coal dust, their numbers are added to the total number of coal workers.

In 2020, the total production of raw coal in China

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was 3,463.51 million tons. This production was mainly distributed across northern, northwestern, and eastern China. The main six provinces that accounted for more than 80% of the production of raw coal are Shanxi (975.17 million tons; 28.16%), Inner Mongolia (930.43 million tons; 26.86%), Shaanxi (472.66 million tons; 13.65%), Xinjiang (198.91 million tons; 5.74%), Shandong (128.14 million tons; 3.70%), and Anhui (121.74 million tons; 3.52%). More detailed information is provided in Supplementary Figure S1 (available in www.besjournal.com). Our results are close to the 3,900 million tons released by the National Bureau of Statistics in 2021[6]. Additionally, the distribution of raw coal production was consistent with the distribution of mineral resource reserves reported by the National Mineral Resources Reserves Statistical Table in 2020 released by the Ministry of Natural Resources of China[7]. This indicates that, because of the updated ODHIRS, the quality of the data has improved significantly, and the results are reliable. However, the total raw coal production reported by the ODHIRS is slightly lower than that reported by the National Bureau of Statistics bulletin, which means that not all enterprises strictly follow legal regulations regarding the reporting of relative information. Additionally, it suggests that the differences between the results of the ODHIRS and those of the National Bureau of Statistics bulletin should be compared in depth, and the supervision and management of coal enterprises should be reinforced to improve the quality of data available from the ODHIRS.

A total of 74.09% (n = 2,219) of the 2,995 enterprises in the ODHIRS were coal mining enterprises with or without washing and dressing industries (hereafter referred to as coal mining enterprises), and the others were pure coal washing and dressing enterprises. Regarding scale, small-scale and micro-scale enterprises accounted for the majority (46.48%), whereas large enterprises accounted for the lowest proportion (21.20%). In terms of the registration type, limited liability enterprises accounted for the highest proportion (40.43%), followed by state-owned enterprises (29.85%) and private enterprises (20.87%). The state-owned enterprises were large-scale, whereas the others were grouped into small-scale and micro-scale enterprises (Supplementary Table S1, available in www.besjournal.com). Most enterprises were located in northern China. The provinces with more than 200 enterprises were Shanxi (n = 1,048; 34.99%), Inner Mongolia (n = 400; 13.36%), and Shaanxi (n = 278; 9.28%). The blue backgrounds in Figure 1 show the distribution of enterprises. Among the 635 large-scale enterprises, 56.85% were located in Shanxi, Henan, Shandong, and Inner Mongolia. Among the medium enterprises, 62.50% were mainly located in Shanxi, Inner Mongolia, and Shaanxi; furthermore, 59.99% of small-scale and micro-scale enterprises were also found in these three provinces. The pie charts in Figure 1A show the enterprises according to scale for each province. Large-scale enterprises (> 50%) were located in Liaoning, Anhui, Jiangsu, Shandong, and Hebei. Fewer enterprises were located in Hubei, Fujian, Yunnan, Jiangxi, and Qinghai; more than 70% of enterprises within these provinces were small-scale and micro-scale enterprises. Of the state-owned enterprises, 62.98% were located in Shanxi, Inner Mongolia, Henan, Shandong, and Shaanxi. Among the limited liability enterprises, 65.32% were mainly distributed in Shanxi, Inner Mongolia, and Shaanxi, and 57.44% of private enterprises were also found in these three provinces. The pie charts in Figure 1B show the registration types within each province. More than 50% of the state-owned enterprises were found in Jiangsu, Anhui, Shandong, Liaoning, and Hebei; most of these provinces are in eastern China. Private enterprises were concentrated in Jilin, Guizhou, and Yunnan, accounting for approximately 40% of the enterprises in each province. Considering coal resources, this study implied that the proportions of enterprise scales and registration types within each province were unbalanced. Although the distribution of the number of enterprises mirrored raw coal production across the country and was largely concentrated in northern areas (such as Shanxi, Inner Mongolia, and Shaanxi), the proportions of large-scale and state-owned enterprises within each coal-rich province were not high; these provinces were dominated by small-scale, micro-scale, and private enterprises. Therefore, it is pivotal for the Chinese government to balance its investment in resources and transform or upgrade existing enterprises.

The total number of coal workers in 2020 was 1,639,897, with four provinces, Shanxi (483,917; 29.51%), Inner Mongolia (316,793; 19.32%), Shaanxi (141,505; 8.63%), and Henan (116,564; 7.11%), having more than 100,000 coal workers. The distribution of the total number of coal workers is shown in Supplementary Figure S2 (available in www.besjournal.com). Furthermore, 97.69% (160,198,001) of coal workers worked in coal mining enterprises, and the other 37,916 coal workers

worked in the pure coal washing and dressing enterprises. The average annual raw coal production per coal worker was 2,112.0 tons, indicating a gradual decrease in production by the small-scale and micro-scale (2,952.8 tons), medium-scale (2,714.0 tons), and large-scale (1,835.9 tons) enterprises. Regarding the registration type, the annual raw coal production per coal worker of private enterprises (2,606.2 tons) was higher than that of limited liability (2,301.6 tons) and state-owned 1,975.9 tons) enterprises (Table 1). Considering the geographic distribution, three provinces (Hubei, Inner Mongolia, and Xinjiang) produced more than 3,000 tons per coal worker (Supplementary Figure S3, available in www.besjournal.com). After consulting managers

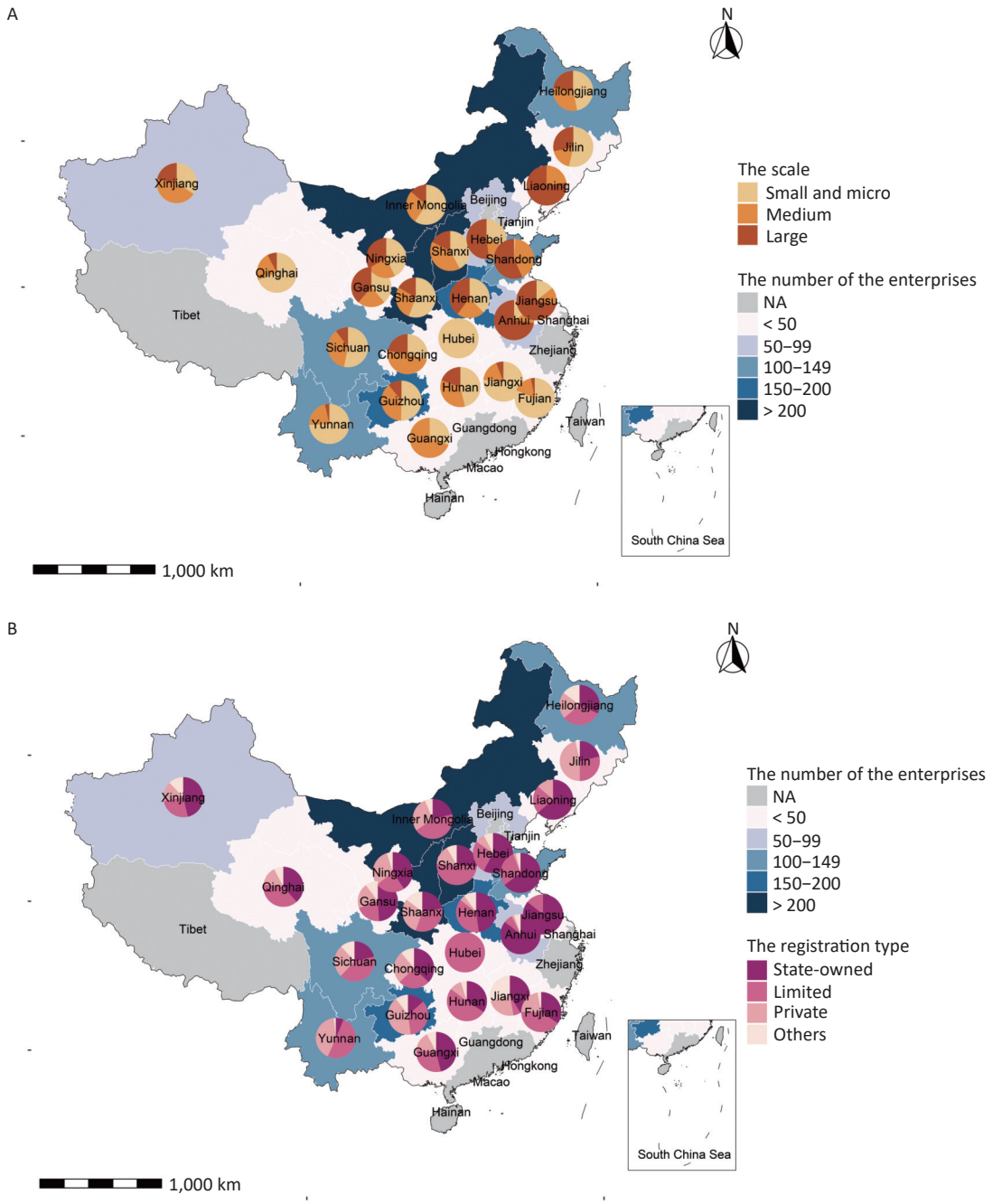

Figure 1. Geographic distribution of coal enterprises in each province in 2020. (A) Enterprises according to scale in each province. (B) Registration types in each province.

from various coal enterprises, we learned that large-scale state-owned enterprises implemented better national policies than others. For example, they provide safe and healthy working environments for all employees. These enterprises typically have more logistics staff members to provide security for frontline workers; however, these staff members are also exposed to coal dust. Therefore, the annual raw coal production per coal worker of large state-owned enterprises is lower than that of small-scale and micro-scale enterprises. This indicates that the quality of life of workers at small-scale and micro-scale enterprises might be generally lower than that of workers at state-owned enterprises. The prevalence of lung disease may be higher and more serious among workers at small-scale, micro-scale, and private enterprises[8]. A 1992 survey showed that the average prevalence of CWP among local coal mine workers (8.11%) was significantly higher than that among key state-owned coal mine workers (6.33%). Additionally, a review based on studies published between 2001 and 2011[9] similarly concluded that the rates of CWP were 9.86% among local coal mine workers and 4.83% among state-owned coal mine workers. Therefore, the working environment and safety and security of coal workers require strengthening, especially at small-scale and micro-scale enterprises. The Chinese government has issued a series of policies indicating the following: by the end of 2020, the average scale of coal enterprises should be upgraded significantly; the number of low- and medium-level coal mines should be reduced effectively; and the quality and efficiency of the coal industry should be enhanced. This study showed that the production efficiency of the coal mining industry in China is relatively low, with approximately 2,112.0 tons of raw coal produced per coal worker. According to the Annual Coal Report for 2020 released by the Energy Information Administration[10], this amount was estimated to be 11,518.5 tons in the United States. This indicates that the mechanization level of coal enterprises is currently low, resulting in a large amount of human resources engaged in the coal mining industry.

The working environment, safety, and security of coal workers must be improved. Based on the results of this study, follow-up research will focus on summarizing and verifying the data regarding coal mining enterprises, raw coal production, number of employees, number of coal workers, and CWP patients in China, and on analyzing the methods of verifying the number of coal workers and CWP cases to describe the current situation of the CWP epidemic and future incidence trends in China. The updated ODHIRS in 2020 included almost all information across the country. However, because some enterprises were upgraded, transformed, or closed, the information was inevitably underreported or missing. To reduce the influence of outliers on the results, 5% of the data were corrected using a statistical method; however, it might have caused bias.

WANG Yu Tong and LI Xin Xin performed the analyses, interpreted the results, and wrote the initial draft of the manuscript. HU Wei Jiang conceived the study design, contributed to data analysis, interpreted the results, and drafted the manuscript. WANG Dan, ZHANG Si Yu, and LIU An Qi collected and verified the underlying data and

Table 1. Annual raw coal production per coal worker based on the enterprise scale and registration type in 2020

Variables	Coal enterprises (*n*)	Raw coal production (tons)	Coal workers (*n*)	Annual raw coal production per coal worker (tons/person-years)
Scale				
Small and micro	1,392	319,096,773.5	108,067	2,952.8
Medium	968	1,026,518,939.0	378,232	2,714.0
Large	635	2,117,891,200.3	1,153,598	1,835.9
Registration type				
State-owned	894	2,057,679,390.3	1,041,368	1,975.9
Limited liability	1,211	844,543,671.5	366,934	2,301.6
Private	625	287,097,851.0	110,160	2,606.2
Others	265	274,186,000.0	121,435	2,257.9
Total comprising all registration types	2,995	3,463,506,912.8	1,639,897	2,112.0

contributed to the drafting of the manuscript. SUN Xin and WAN Xia conceived the study design, contributed to the data analysis, interpreted the results, and critically revised the manuscript. All authors had access to the study data and accepted responsibility for its validity.

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