Preplanned Studies

Distribution of Asbestos Enterprises and Asbestosis Cases — China, 1997–2019

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Summary

What is already known on this topic?

Asbestos is classified as a Class I Carcinogen by the International Agency for Research on Cancer (IARC) because exposure causes mesothelioma and lung cancer in addition to asbestosis and plaques. So far, asbestos has been banned in 67 countries, but chrysotile, a commonly encountered form of asbestos, is still widely used in China and most developing countries. Most asbestos-caused cancers are not reported, recorded, and compensated in many countries.

What is added by this report?

Enterprises manufacturing asbestos products have been migrating from economically developed Eastern China to relatively underdeveloped central and western regions between 2010 and 2019. Asbestosis cases reported in Tianjin, Beijing, Shandong, Xinjiang, Gansu, Qinghai, and Sichuan accounted for a large proportion of the total cases in China, which was inconsistent with the distribution of asbestos-related enterprises (AREs). The reported asbestosis cases versus total pneumoconiosis cases declined from 2.81% to 0.39% from 2006–2017, and this proportion reached 0.69% in 2018.

What are the implications for public health practice?

Robust occupational and environmental health assessments and reporting are needed to define the epidemiology of asbestos-related lung diseases, and management of using asbestos and existing products containing asbestos need strengthening and follow-up. Enterprises should be encouraged to use safer substitutes and gradually ban asbestos materials in China.

Asbestos refers to six naturally-occurring fibrous magnesium silicate minerals that can be separated into durable thin threads characterized by extraordinary tensile strength, poor heat conductance, and resistance to chemical degradation. In addition to insulation in buildings, asbestos is widely used in a variety of products such as roofing shingles, water supply lines, fire blankets, and adhesives (*1*). However, asbestos produces a large number of clouds of dust during mining, processing, and application, and once released into the air and inhaled, it causes serious health problems such as asbestosis, plaques, pleuritis, diffuse pleural thickening, even cancers of the lungs, larynx, and mesothelioma (*2*–*4*). In this study, the data was gathered from the occupational disease reporting system and industry-commerce registration system in China. Asbestosis cases and asbestos products were analyzed and characterized by years, enterprise, and regional distribution. There were a total of 1,611 asbestos-related enterprises (AREs) with a total of 188,739 employees across China in 2010 and 1,936 enterprises in 2019. A total of 3,831 asbestosis cases were reported in China between 1997 and 2018. Robust occupational and environmental health assessments and reporting are needed to define the epidemiology of asbestos-related lung diseases. Management of using asbestos and existing products containing asbestos need strengthening and follow-up.

Furthermore, the latest estimate of the global number of asbestosis deaths from the Global Burden of Disease estimate 2016 is 3,495 (*2*). Epidemiological studies indicate that lung cancer accounts for 54%–75% of all occupational cancers, and asbestos accounts for 55%–85% of these lung cancers while causing other cancers and other asbestos-related diseases today (*5*). In 2006, the International Labor Office (ILO) officially affirmed that "all forms of asbestos, including chrysotile, are considered as known human carcinogens" (*6*). International Agency for Research on Cancer (IARC) announced asbestos as a Class I carcinogen (*7*). So far, asbestos is completely banned in 67 countries, including the United Kingdom, the European Union, and Japan (*8*), but chrysotile, a commonly encountered form of asbestos, is still widely used in China and most developing countries. An estimated 2,030,000 tons were consumed annually according to the latest available consumption data. Every 20 tons of asbestos produced

and consumed kills a person somewhere in the world. The present asbestos consumption and exposure will cause negative outcomes 30–50 years later (*3*). China started to ban the production, import, and use of amphibole asbestos in 2002, but chrysotile products are allowed to be safely produced and consumed in compliance with occupational health standards. Currently, China not only has the third-largest asbestos reserve but also is the second-largest producer and consumer of asbestos products in the world.

Both the incidence of asbestosis and the number of employees, the business scope, type and regional distribution of AREs in the mainland of China were analyzed in this study. The number of employees in AREs was missing in 2019. The inclusion criteria were enterprises whose business scope involved raw materials or products involving asbestos. The raw materials category involved mining or trading asbestos and using asbestos to manufacture primary products. The products category included products involving asbestos such as vinyl asbestos tiles, asbestos cement, asbestos roofing felt, asbestos reinforced plastics, asbestos adhesives, sealants, asbestos cloth, and coatings. All statistical analyses used the R software package (version 3.6.2, 2019 The R Foundation for Statistical Computing).

The distribution of AREs in 2010 and 2019 was shown in Figure 1. There were 1,611 and 1,936 AREs registered in mainland China, respectively. In 2010, AREs were mainly concentrated in the coastal areas of Eastern China and a few central regions with 188,739 employees in all at an average of 117 per enterprise. AREs were mainly concentrated in Hebei, Jiangsu, Zhejiang, and the other 10 provincial-level administrative divisions (PLADs), accounting for 82.9% of the total. Among them, 289 enterprises located in Dacheng County, Hejian City, Yuyao City, Cixi City, and Jiangyan City, accounting for 17.9% of all AREs. Fewer enterprises were located in asbestos deposit and mining areas. There were only 73 asbestos enterprises in Qinghai, Xinjiang, Sichuan, Gansu, and Shaanxi, accounting for 4.5% of the total. In 2019, 68.6% of AREs migrated from Eastern China to central and western regions, mainly Gansu, Yunnan, Xinjiang, and Guizhou. Among these, Dacheng County, Guangzhou City, Hejian City, Jiuquan City, and Lingshou County were the most concentrated areas of AREs, accounting for 498 (25.7%). There were 46 asbestos mining enterprises located in Gansu, Xinjiang, Qinghai, Yunnan, Sichuan, and other PLADs, which represented a significant increase and a clustering tendency in asbestos mining areas. The number of AREs in Zhejiang, Jiangsu, Shanghai, Henan, Beijing, and other regions decreased significantly when compared to 2010, especially in Zhejiang where the number was reduced to 85.1%. The distribution of AREs exhibited a concentrating pattern in 2010 and a scattering pattern in 2019. The AREs in Zhejiang, Jiangsu, and Shanghai decreased significantly.

The business types of AREs were shown in Table 1. In 2010, The primary business types were private enterprises, sole proprietorship, and limited liability companies, accounting for 86.1% of the total. The 44 joint-venture companies that mainly located in Zhejiang, Shanghai, and Shandong were invested from Hong Kong, Macao, and Taiwan of China and foreign countries. Sole proprietors accounted for a relatively large proportion in Hebei (27.3%) and Zhejiang (15.6%). Because these enterprises were

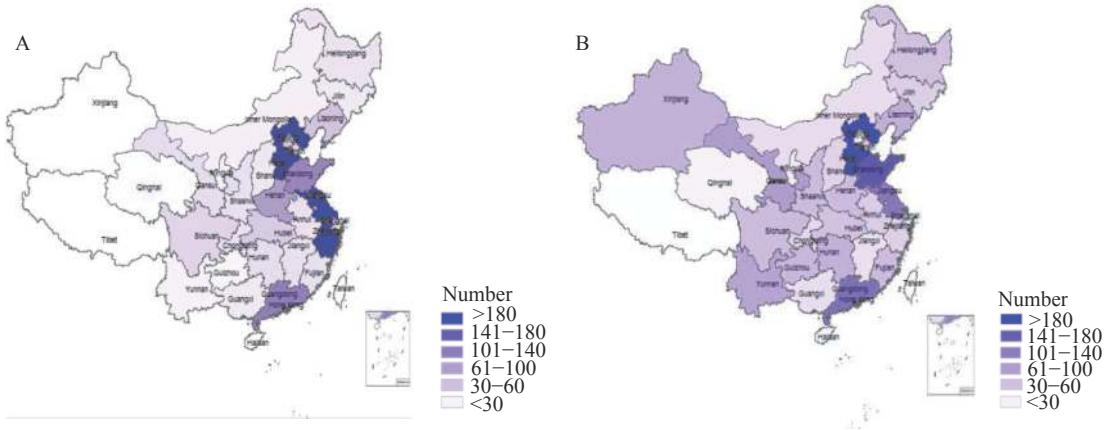

FIGURE 1. Distribution of asbestos enterprises in mainland China in 2010 (A) and in 2019 (B).

TABLE 1. Distribution and changes of asbestos-related enterprises in different business types and regions in mainland China in 2010 and 2019.

Business types	Number of Enterprises in 2010 (%)				Number of Enterprises in 2019 (%)			
	Eastern	Central	Western	Total	Eastern	Central	Western	Total
Private	507(31.5)	94(5.8)	52(3.2)	653(40.5)	11(0.6)	6(0.3)	10(0.5)	27(1.4)
Sole proprietorship	292(18.1)	39(2.4)	45(2.8)	376(23.3)	174(9.0)	53(2.7)	136(7.0)	363(18.8)
Limited liability	291(15.6)	50(3.1)	19(1.8)	360(22.3)	879(45.4)	238(12.3)	299(15.4)	1,416(73.1)
Corporation	58(3.6)	10(0.6)	7(0.4)	75(4.7)	14(0.7)	4(0.2)	4(0.2)	22(1.1)
Collective	33(2.0)	10(0.6)	2(0.1)	45(2.8)	45(2.3)	33(1.7)	25(1.3)	103(5.3)
Foreign-invested	31(1.9)	3(0.2)	0(0.0)	34(2.1)	2(0.1)	0(0.0)	2(0.1)	4(0.2)
Hong Kong, Macao, and Taiwan-invested	10(0.6)	0(0.0)	0(0.0)	10(0.6)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
Others	41(2.5)	13(0.8)	4(0.2)	58(3.6)	0(0.0)	0(0.0)	1(0.0)	1(0.0)
Total	1,263(78.4)	219(13.6)	129(8.0)	1,611(100.0)	1,125(58.1)	334(17.3)	477(24.6)	1,936(100.0)

mainly in Eastern China (78.4%), those in Western China only accounted for 8.0%. The business scope of most enterprises included processing raw materials and manufacturing primary products of asbestos, but a majority of these products such as vinyl asbestos tiles, asbestos cement, asbestos roofing felt, asbestos reinforced plastics, asbestos adhesives, sealants, asbestos cloth, and coatings were discontinued. Some companies used asbestos insulation in steam engines, piping, and locomotives, while others used it in boilers, gaskets, cement, roofing materials, and automotive brake pads. In 2019, AREs were mainly limited liability companies, sole proprietorship, and collective enterprises, accounting for 96.5%. The four enterprises receiving foreign-investment were in Zhejiang, Chongqing, Liaoning, and Xinjiang. AREs in Eastern China decreased by 10.9% when compared to 2010, while the number in Western China increased by 269.8%, approximately 3.7 times as much as in 2010. Especially in relatively underdeveloped regions such as Xinjiang, Guizhou, Gansu, and Yunnan (increased from 2.2% to 14.5% in the 4 PLADs), several safer substitutes such as polyurethane foam, amorphous silica fabric, thermoset plastic powder, and cellulose fiber became available. Although asbestos products were only part of the business, cement tiles were the primary asbestos products, especially in Western China, and the proportion increased from 4.0% to 16.2%.

The distribution of 3,831 asbestosis cases reported between 1997 and 2018 was shown in Figure 2. Among them, 1,470 and 2,361 cases were reported in 1997–2007 and 2008–2018, respectively (increased by 60.6%). In particular, the number of cases reported in Tianjin increased from 187 to 1,175 (increased by 528.3%), while significant increases were also observed in Gansu, Xinjiang, and Jilin. The cases in reported Tianjin, Beijing, Shandong, Xinjiang, Gansu, Qinghai, Sichuan, Zhejiang, and Jiangsu accounted for 90.7% of the total. Nevertheless, the number of cases in Beijing, Qinghai, Sichuan, Zhejiang, and Jiangsu decreased significantly, especially in Beijing where the reported cases decreased by 68.3% (from 394 to 125). No cases were reported in Guizhou, Hainan, and Tibet. The reported asbestosis cases showed a downward trend in 1998–2017 (from 294 to 89 cases). The decline was steeper in 2009–2011 (from 244 to 102 cases). The proportion of reported pneumoconiosis cases also exhibited a downward trend from 3.55% in 1998 to 0.39% in 2017. This proportion continued to decline in 2006–2017 (from 2.81% to 0.39%) and reached 0.69% in 2018.

DISCUSSION

In contrast with the distribution of asbestos mines, asbestos manufacturing enterprises were mainly located in coastal areas of Eastern China in 2010. AREs flourished in economically developed regions due to the large demand for asbestos products. Despite the asbestos abundance, few AREs selected underdeveloped regions due to poor transportation infrastructure among many other reasons. Henan and Hubei became transit areas of asbestos materials and finished products for their central geographic location and convenient transportation. Many AREs selected Hebei Laiyuan Asbestos Mine, Shandong Rizhao Asbestos Mine, and Liaoning Chaoyang Asbestos Mine based on resource location and economic demands.

Based on the available data of 2010 and 2019, AREs gradually migrated from economically developed

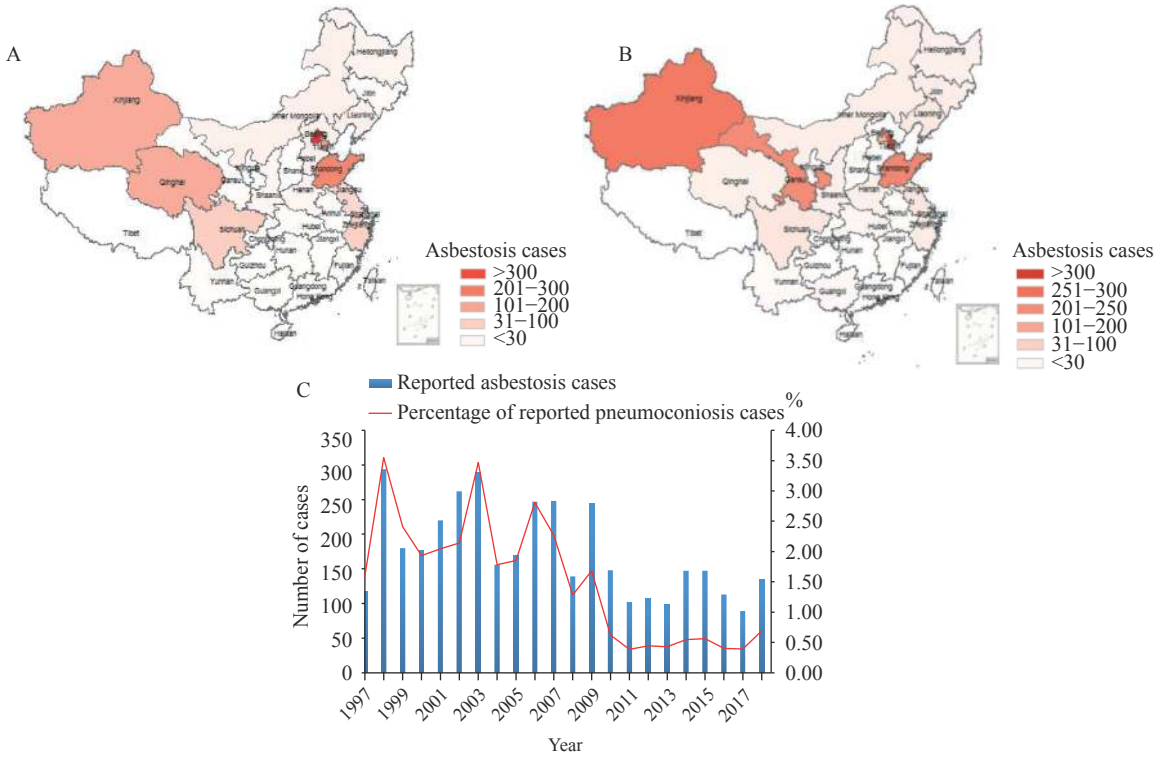

FIGURE 2. Distribution of reported asbestosis cases in mainland China from 1997 to 2007 (A) and from 2008 to 2018 (B); Number of asbestosis cases and the percentage of total pneumoconiosis cases reported in mainland China, 1997–2018 (C).

coastal regions of Eastern China to relatively underdeveloped western and central regions. This trend may be ascribed to China's developmental strategy, investment, and policy to promote the development of western regions. The tightened environmental control in large Eastern Chinese cities may also play a role.

For more than a decade, the transportation infrastructure in Western China has improved significantly. Local economic development increased the demand for asbestos products. Particularly, the construction of roads and buildings greatly increased the demands for asbestos cement products. In response to extensive market demands, AREs were concentrated in selected regions across China.

Nonetheless, AREs were still characterized by miniaturization, individualization, and cooperation. Many enterprises somewhat concealed the health hazards of asbestos. The word "asbestos" was used in corporate names only by 114 (9.8%) of the 1,611 enterprises in 2010 and by 182 (9.4%) of 1,936 enterprises in 2019, respectively. Some of the enterprises used finished product names such as construction materials company and sealing materials factory. Asbestos business nature was difficult to determine by corporate names. Meanwhile, most AREs also handle a variety of products other than asbestos. Only 12.5% (202/1,611) in 2010 and 25.9% (502/1,936) in 2019 of these enterprises specialized in or mainly handled asbestos products.

Asbestosis cases were mainly found in Tianjin, Beijing, Shandong, and Xinjiang, which was inconsistent with the distribution of AREs. In particular, AREs operating in Hebei ranked first in China in 2010 (348/1,611) and 2019 (470/1,936), but only 26 asbestosis cases were reported in two decades from 1997 to 2018. In contrast, there were 67 AREs in Tianjin in 2010 and 2019 (67/3,547), but 1,362 asbestosis cases were reported. Despite the obvious presence of AREs, few asbestosis cases were reported in Guangdong, Guizhou, and Hunan. More strikingly, zero asbestosis cases were reported in Guizhou in the past two decades. This may be ascribed to several factors such as the limited diagnostic capability and clinical experience of local occupational health institutions. The histopathologic diagnosis of asbestosis requires the presence of uncoated or coated asbestos fibers (asbestos bodies) in association with interstitial pulmonary fibrosis that is similar in appearance to usual interstitial pneumonitis (UIP) (*9*), so it can be easily misdiagnosed as other lung diseases. Moreover, serious under-diagnosing or non-diagnosing is a major

source of error for recording cases (*3*). Other influencing factors include inadequate reporting, off-site reporting of relevant cases, and feeble regulations. Especially 188,739 employees totally in 2010. Therefore, there may be a large number of asbestosis patients that have not been found, and its harm is seriously underestimated.

Asbestosis cases showed a downward trend, which was closely related to banning amphibole asbestos in China in 2002. Studies have confirmed that asbestos exposure causes a variety of diseases such as asbestosis and malignant mesothelioma with a latency period of up to 10–15 years, and the highest risk of asbestosis is observed 40–60 years after first exposure (*3*,*9*). Notwithstanding, the policy incentives for asbestos substitutes encourage asbestos enterprises to switch raw materials, and the reduced asbestos exposure has decreased the incidence of asbestosis.

This study was subject to at least a few limitations. Due to the limited information we collected, we cannot provide asbestos exposure information, which is critical in occupational health. In addition, we cannot evaluate reported asbestosis cases in various regions for authenticity, comprehensiveness, and preciseness, and this may have an impact on the regional distribution of reported asbestosis cases.

The distribution of AREs and asbestosis cases highlight the importance of a sounding occupational health strategy on asbestosis management. Based on the study findings, several targeted strategies can be implemented. First, the supervision of AREs can be centralized according to the distribution patterns in key provinces and municipalities; meanwhile, information and incentives on safer asbestos substitutes should be provided to encourage improved behavior. Secondly, fragmented contracting, on-site supervision, and demonstrative promotion can be adopted according to cooperative miniaturization and private individualization. To resolve the concealment of business nature, to incorporate naming, and to strengthen the declaration of occupational hazards, an information database of asbestos enterprises can be established through cooperation with the Departments of Commerce, Fire, and Security. Finally, early diagnosis, treatment, and rehabilitation of asbestos-related diseases can be improved, especially in areas with insufficient diagnostic capacity. Robust occupational and environmental health assessments and reporting are needed to define the epidemiology of asbestos-related lung diseases.

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