The trends in global, regional, and national incidence of pneumoconiosis caused by different etiologies: an analysis from the Global Burden of Disease Study 2017

Peng Shi
China Medical University

Xiaoyue Xing
China Medical University

Shuhua Xi (shxi@cmu.edu.cn)
https://orcid.org/0000-0003-4232-7258

Hongmei Jing
China Medical University

Jiamei Yuan
China Medical University

Zhushan Fu
China Medical University

Hanqing Zhao
China Medical University

Research

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Abstract

Pneumoconiosis has the potential to cause progressive and permanent physical disability. And continues to be one of major public health concern across the world. However, our literature searches identified a scarcity of data about global prevalence of pneumoconiosis. Accurate data on the incidence of pneumoconiosis is critical for health resource planning and health policy development. We therefore aimed to determine the pattern of pneumoconiosis incidence and temporal trends. Methods: Annual incident cases and age standardized incidence rates on pneumoconiosis etiology between 1990-2017 were collected from the Global Burden of Disease Study 2017. We calculate the average annual percentage changes of age standardized incidence rates by sex, region, and etiology to determine incidence trends of pneumoconiosis. Results: Globally, the number of pneumoconiosis cases increased 66.0% from 36,186 in 1990 to 60,055 in 2017. The overall age standardized incidence rate decreased by an average 0.6% (95% CI: 0.5%, 0.6%) per year in the same period. The age standardized incidence rate of silicosis, asbestosis, and other pneumoconiosis decreased between 1990 and 2017. The corresponding average annual percentage changes were -0.8%, -0.9%, and -0.5%, respectively. The age standardized incidence rate of asbestosis displayed an increasing trend. At the same time, we also found a significant negative association was found between average annual percentage changes and socio-demographic indexs when the socio-demographic index above 0.7. Conclusions: Pneumoconiosis remains a major occupational health illnesses in the world. Incidence patterns of pneumoconiosis caused by different etiologies were heterogeneous across regions and countries. We observed an unfavorable trend that asbestosis was predominant in countries with a high socio-demographic index, though we have attained great achievements in silicosis and coal workers' pneumoconiosis prevention. The information in this study suggests that some countries should establish more targeted and specific strategies to forestall the increase in pneumoconiosis.

Background

Pneumoconiosis is a group of serious occupational diseases associated with the inhalation of mineral dusts and the corresponding reaction of lung tissue, which eventually induce irreversible lung damage that afflicts tens of millions of workers in hazardous occupations, everywhere in the world [1]. Pneumoconiosis has the potential to cause progressive and permanent physical disability. And continues to be one of major public health concern across the world [2]. In America, pneumoconiosis caused 1000 to 2000 hospitalizations per year and accounted for 525 deaths in 2007 [3]. In Korea, there were 17,546 pneumoconiosis patients and about 3900 at-risk patients in 2008 [4]. However, the prevalence of pneumoconiosis in developing countries was even more severe. Between 1975 and 2007 in South Africa gold mine, the proportions of white miners and black miners with silicosis increased from 18% to 22% and from 3% to 32%, respectively [5]. Since the discovery of pneumoconiosis in the 19th century, the prevention of occupational diseases mainly concentrated on the control of dust-caused occupational hazards [6]. The Joint ILO/WHO Committee on Occupational Health established the ILO/WHO Global Program for the Elimination of Silicosis (GPES) following the recommendation of the 12th Session in

1995, which aimed to call on the world to take steps for silicosis prevention [7]. However, the number of newly diagnosed pneumoconiosis cases has increased across the world during the last few decades, although major public health measures have been made to counter this problem.

The etiologies of pneumoconiosis have been confirmed in previous epidemiological studies [8-11]. Therefore the heterogeneous incidence pattern of pneumoconiosis depends mainly on the prevalence of risk factors in different regions. For example, the National Occupational Disease Report of 2016 indicated that 26,873 new cases of pneumoconiosis were recorded in China, of which 54.3% were coal workers' pneumoconiosis and 39.7% were silicosis [12]. Whereas Australia is one of the countries with the highest incidence rates of asbestos-related lung disease across the world [13, 14]. Knowing the pattern of pneumoconiosis incidence and temporal trends facilitates rational allocation of health sources and health system functions to promote accurate prevention of pneumoconiosis.

The Global Burden of Diseases, Injuries, and Risk Factors Study (GBD) 2017 assessed 354 diseases and injuries across 195 countries and territories, and is therefore provided a unique perspective to understand the landscape of pneumoconiosis [15]. In the current study, we collected detailed information on the incidence of pneumoconiosis caused by four major etiologies from the GBD Study 2017. We further presenting the results of annual incident cases, age standardized incidence rate (ASIR), and average annual percentage change (AAPC) of pneumoconiosis, by sex, region, country, and etiology to determine incidence trends of pneumoconiosis caused by specific etiologies. We also report on the relation between disease burden and the socio-demographic index (SDI), a comprehensive indicator of development status closely related to health outcomes [16].

Methods

Study data

We collected annual incident cases and ASIRs of pneumoconiosis from 1990 to 2017, by sex, region, country, and etiology (silicosis, asbestosis, coal workers' pneumoconiosis, and other pneumoconiosis) across 195 countries and territories, were collected from the Global Health Data Exchange (GHDx) query tool. Moreover, the world was separated into 21 regions in terms of geography. Data used to make estimates of pneumoconiosis are predominantly from three main sources [15]. The first is literature data from systematic reviews, usually from smaller-scale studies of prevalence. The second source of data is inpatient hospital reports, and the third is claims data for the United States and Taiwan. For all aetiologies, we use a sex-specific correction factor of the hospital inpatient data where numbers are adjusted upward by the ratio of primary diagnosis to secondary diagnosis present in the claims data. Estimates for the pneumoconiosis aetiologies are produced using a standard DisMod-MR 2.1 approach. Incidence of coal worker's pneumoconiosis were set to zero in locations without a history of coal mining given the causal and necessary relationship between respective occupational exposure and disease. All ICD 10 codes pertaining to pneumoconiosis (J60-J65.0, J92.0) are being included in these estimates (Supplementary Box 1).

Statistical analysis

The incidence rate is reported per 100,000 people, that is described as the number of annual cases divided by the population size. Due to compare several populations with different age structures, so we used the GBD 2017 world standard population to calculation of ASIRs that to quantify the pneumoconiosis incidence trends [17]. We used the Joinpoint regression software (version 4.7.0.0), developed by the National Cancer Institute, to calculate the AAPC of ASIR, which is a summary measure of the ASIR trend over a pre-specified interval. These results are presented as AAPC with its 95% confidence interval (95% CI). The meaning of AAPC has been reported in previous studies [18]. Briefly, if the AAPC and its 95% CI were both >0, the ASIR was an increasing trend. In contrast, if they were both <0, the ASIR was deemed to be a decreasing trend. Apart from that the ASIR was deemed to be stable over time.

SDI is a summary metric of lagged distributed income per capita, mean years of education over the age of 15 years, and total fertility rate in women under the age of 25 years, used to estimate a location's position on the development spectrum [15]. The 195 countries and regions were classified into five regions according to the SDI value, including low, low-middle, middle, high-middle, and high (Supplementary Figure 1). We used LOESS regression to analyze all ASIRs and SDIs at 21 geographic regions and global from 1990 to 2017 to determine the expected relationship between them [16]. We compared the observed pneumoconiosis ASIR with this expected level to identify the state of development in regions, where performance was better or lower than expected. Additionally, we assessed the association between SDIs (2017) and AAPCs at the national level.

Apart from AAPCs analyses, other statistical analyses were performed using R program (Version 3.6.0). All statistical testing was two-sided with the level of significance set at 0.05.

Results

Globally, the incident cases of pneumoconiosis increased 66.0% from 36,186 in 1990 to 60,055 in 2017 (Table 1). For SDI regions, the number of pneumoconiosis cases increased across the five SDI regions (Figure 1), despite a decrease in the ASIR from 1990 to 2017 (Table 1). For geographical regions, except for the three regions (central Europe, eastern Europe, and western Europe), absolute numbers of pneumoconiosis cases increased in other regions (Figure 2). As for ASIR, the most significant decrease was detected in western Europe (AAPC = -2.5; 95% CI: -2.7, -2.2). The most significant increase was detected in Australasia (AAPC = 1.4, 95% CI: 1.3, 1.5) (Table 1).

The highest ASIR observed in Taiwan (China) (1·92 per 100,000 in 2017), followed by Papua new guinea (1·68 per 100,000 in 2017) and China (1·66 per 100,000 in 2017) (Figure 3A). As for the absolute number, more than half of newly diagnosed pneumoconiosis were recorded in China in 2017 (32,205), followed by India (5160) and the USA (3324) (Supplementary Table 2).

The ASIR decreased by an average 0.6% (95% CI: 0.5%, 0.6%) per year in the same period (from 0.52 per 100,000 in 1990 to 0.28 per 100,000 in 2017) (Table 1). The Netherlands (AAPC = -6.3; 95% CI: -6.9, -5.7) and Belgium (AAPC = -6.2; 95% CI: -6.9, -5.4) reported the largest decreasing in pneumoconiosis ASIR between 1990 and 2017. In contrast, the largest increase in ASIR was observed in the New Zealand (AAPC = 2.6; 95% CI: 2.6, 2.7) (Figure 3B, Supplementary Table 2).

The proportions of pneumoconiosis caused by specific etiologies at the global and regional level in 1990 and 2017 are presented (Figure 4). Globally, approximately 40% of pneumoconiosis was caused by crystalline silica, followed by coal dust, other causes, and asbestos. The proportions significantly changed in some regions over time. For instance, in the global, the proportion of asbestosis increased from 11.98% in 1990 to 15.65% in 2017, while the proportion of coal workers pneumoconiosis decreased from 27.13% to 25.11% during the same period. In the Australia, the proportion of asbestosis increased from 46.12% in 1990 to 77.85% in 2017, while the proportion of coal workers pneumoconiosis decreased from 27.13% to 7.98% during the same period. Similar result was observed in the high-income north America.

Globally, 39.46% of total pneumoconiosis (23,695) was ascribed to silicosis in 2017 (Figure 4; Table 1). For SDI regions, silicosis cases increased across all five regions, while the ASIR decreased in all SDI regions (Figure 1; Supplementary Table 1). For geographical regions, five regions (central Europe, eastern Europe, high-income Asia Pacific, western Europe, and Caribbean) reported a decreasing silicosis cases (Figure 2; Supplementary Table 1). In parallel, the ASIR of silicosis displayed a minor increasing trend in southeast Asia (AAPC = 0.4; 95% CI: 0.2, 0.5), north Africa and Middle East (AAPC = 0.2; 95% CI: 0.1, 0.3), and western sub-Saharan Africa (AAPC = 0.3; 95% CI: 0.2, 0.4), AAPC of silicosis decreased in other regions (Supplementary Table 1). The highest ASIR observed in China (Supplementary Table 2). From 1990 to 2017, the ASIR of silicosis displayed a decreasing trend (AAPC = -0.8; 95% CI -0.9, -0.7). The highest AAPC was found in the Singapore (AAPC = 2.2; 95% CI: 1.8, 2.6), followed by the New Zealand and the American Samoa (Supplementary Table 2).

In 2017, asbestosis precipitated nearly 15.65% (9397) of the total number of pneumoconiosis cases (Figure 4; Table 1). For SDI regions, the increasing trend in asbestosis were observed in High SDI regions (AAPC = 1.6; 95% CI 1.4, 1.7) and Low-middle SDI regions (AAPC = 0.2; 95% CI: 0.1, 0.3) (Supplementary Table 1). For geographical regions, except for the two regions (eastern Europe and western sub-Saharan Africa), absolute numbers of pneumoconiosis cases increased in other regions. The greatest increase was found in Australasia (AAPC = 3.5; 95% CI: 3.2, 3.7) (Supplementary Table 1).Globally, the ASIR of asbestosis displayed an increasing trend from 1990 to 2017, with the AAPC of 0.6 (95% CI: 0.5, 0.6) (Table 1), despite the incidence of pneumoconiosis due to asbestosis was under 0.10 per 100,000 in 2017 in most countries. The highest rate was observed in south Africa (0.50 per 100,000), followed by Swaziland and the United States. At the national level, the highest increase in asbestosis ASIR was observed in the Australia (AAPC = 3.5; 95% CI: 3.3, 3.8), followed by the New Zealand and Spain (Supplementary Table 2).

In 2017, coal workers' pneumoconiosis accounted for 25.11% (15,080) of total pneumoconiosis cases, despite only 78 countries and territories reported coal workers' pneumoconiosis cases (Figure 4; Table 1). The ASIR of coal workers' pneumoconiosis decreased in all SDI regions over time (Supplementary Table 1). For geographical regions, only four regions (Oceania, western sub-Saharan Africa, north Africa and Middle East, and southeast Asia) reported a increasing ASIR of coal workers' pneumoconiosis, the greatest increase was found in Oceania (AAPC = 1.0; 95% CI: 1.0, 1.1), AAPC of coal workers' pneumoconiosis decreased in other regions (Supplementary Table 1). The highest absolute numbers observed in China (10,287) (Supplementary Table 2). From 1990 to 2017, the ASIR of coal workers' pneumoconiosis displayed a decreasing trend (AAPC = -0.9; 95% CI: -0.9, -0.8) (Table 1). With respect to countries, the relatively higher ASIRs were observed in Taiwan (China) (0.76 per 100,000 in 2017), followed by China (0.53 per 100,000 in 2017) and North Korea (0.48 per 100,000 in 2017), with the highest increase in ASIR observed in New Zealand (AAPC = 2.5; 95% CI: 2.2, 2.8), followed by Taiwan (China) (AAPC = 1.7; 95% CI: 1.5, 1.9) and Montenegro (AAPC = 1.6; 95% CI: 1.3, 2.0) (Supplementary Table 2).

In 2017, other pneumoconiosis accounted for 19.79% (11,883) of total pneumoconiosis cases (Figure 4; Table 1). The ASIR of other pneumoconiosis remained stable in High SDI regions, decreased in other SDI regions (Supplementary Table 1). For geographical regions, only five regions (high-income north America, southeast Asia, Oceania, Andean Latin America, and north Africa and Middle East) reported a increasing ASIR of other pneumoconiosis, the greatest increase was found in high-income north America (AAPC = 0.8; 95% CI: 0.6, 0.9), AAPC of other pneumoconiosis decreased in other regions (Supplementary Table 1). The global ASIR of other pneumoconiosis decreased by an average 0.5% (Table 1) per year from 1990 to 2017. The highest ASIR was observed in Taiwan (China) (0.76 per 100,000 in 2017), followed by Papua New Guinea (0.71 per 100,000 in 2017), with the highest increase in ASIR observed in Denmark (AAPC = 2.5; 95% CI: 1.7, 3.4) (Supplementary Table 2).

The GBD regions of east Asia, Oceania, southern sub-Saharan Africa, central Europe, central Latin America, high-income Asia Pacific, and high-income North America had higher ASIRs due to pneumoconiosis than expected based on their SDI. Regions with better-than-expected pneumoconiosis ASIRs included Caribbean, western Europe, western sub-Saharan Africa, central Asia, Andean Latin America, north Africa and Middle East, and southeast Asia (Figure 5). Further evaluation of the relationship between ASIR and SDI in different categories of pneumoconiosis, we observed that east Asia, Oceania, southern Latin America, central Europe, and high-income Asia Pacific had higher ASIRs due to silicosis than expected based on their SDI; southern sub-Saharan Africa, high-income North America, Australasia, Oceania, central sub-Saharan Africa, and eastern sub-Saharan Africa had higher ASIRs due to asbestosis than expected based on their SDI; east Asia, and central Europe had higher ASIRs due to coal workers' pneumoconiosis than expected based on their SDI; oceania, central Latin America, east Asia, central Europe, eastern Europe, and high-income Asia Pacific had higher ASIRs due to other pneumoconiosis than expected based on their SDI (Supplementary Figure 2).

As shown in Figure 6, a significant negative association was found between AAPCs and SDIs in 2017 when the SDI above 0.7. In contrast, a SDI was limited to below 0.7, the association disappeared. Similar relationships were observed when we further evaluated the association between AAPCs and SDIs in silicosis, coal workers' pneumoconiosis, and other pneumoconiosis, while the association between AAPCs and SDIs in asbestosis is not significant (Supplementary Figure 3).

Discussion

Incidence pattern of exposure to risk factors was heterogeneous, which leads to markedly diverse incidences of pneumoconiosis across the world and complicates the prevention of pneumoconiosis [19, 20]. In this study, we comprehensively analyzed the incidence trends of pneumoconiosis caused by four etiologies at the global, regional, and national levels. Globally, number of pneumoconiosis cases increased, despite a decrease in the ASIR from 1990 to 2017. These trends were mainly due to an increase in asbestosis and decrease in silicosis, coal workers' pneumoconiosis, and other pneumoconiosis. However, there are significant differences in the incidence trends across the world. This can be illustrated briefly by the significant decreasing trend in pneumoconiosis ASIR was primarily dominated by the reduction in silicosis and coal workers' pneumoconiosis, in Middle SDI and Low SDI regions. Conversely, in High SDI regions, the minor decreasing trend in pneumoconiosis ASIR was most likely due to the dramatic decrease in silicosis and increase in asbestosis. Therefore, knowing the exact pattern of pneumoconiosis incidence and temporal trends is critical for the accurate prevention of pneumoconiosis.

These results are in line with those of previous studies that crystalline silica remains the most important risk factors for pneumoconiosis [21, 22]. Although silicosis has higher ASIRs in High SDI and Middle SDI regions such as East Asia (mainly China) and Oceania, they have been declining over the last couple of decades. A possible explanation for this might be that the prevention of pneumoconiosis through take steps and the increasing awareness of self-protection. For example, in order to strengthen the surveillance for occupational diseases, the Network Direct Report System of Occupational Diseases was constructed in 2006 in China. Moreover, the latest Diagnostic Criteria of Pneumoconiosis (GBZ70-2009) has been implemented since 2009, which requires relatively more frequent health examinations for observation objects [2, 6]. On the contrary, silicosis has not improved significantly over the same period in Singapore, increasing by 2.2% per year from 1990 to 2017. Surprisingly, though a significant negative association was found between AAPCs and SDIs when the SDI above 0.7 in silicosis, the incidence rates of silicosis relatively fast growth in some High SDI and High-middle SDI countries, including Singapore, New Zealand, and American Samoa. Therefore, we recommend that these countries should readjust their silicosis prevention strategies in a timely manner, despite the fact that the number of cases and ASIRs are still at a low level.

In contrast to silicosis, asbestosis has higher numbers of cases and ASIRs in High SDI regions, including Australasia (mainly Australia) and high-income North America. Mining, processing and transportation of raw asbestos are high-risk occupations of asbestosis [23-25]. Moreover, the economic issues surrounding

asbestos, and the financial implications from growing worldwide legal implications have largely affected the incidence of asbestosis [24-27]. For example, due to the ban on the use of asbestos in Europe for about 30 years, we have found that the incidence of asbestosis has decreased significantly [23]. Australia is one of the countries with the highest incidence of asbestos-related lung disease in the world, and the ban on the importation of asbestos was issued only in 2004. It reflects the extent of asbestos mining and the manufacture and use of asbestos-containing materials in the 20th century [13, 25]. Despite these promising results, questions remain, that we found the Netherlands reported the largest decreasing in pneumoconiosis ASIR between 1990 and 2017, while the ASIR of asbestosis increased over the same period. As a result, the prevention of further asbestos exposure is a major public health issue that reducing asbestos use, careful monitoring and improving the levels of management, diagnosis, treatment, and compensation for asbestosis cases, and strengthening cooperation between government and non-governmental organizations in the prevention of asbestosis.

Similar situation to silicosis was observed in coal workers' pneumoconiosis. In 2017, coal workers' pneumoconiosis accounted for 25.11% of total pneumoconiosis cases, despite only 78 countries and territories reported coal workers' pneumoconiosis cases. Thereinto, coal workers' pneumoconiosis have the highest absolute numbers in China, while the ASIR has been decreasing over the last couple of decades. On the contrary, in New Zealand, Taiwan (China), and Montenegro, there has been an increasing trend. Government and coal mines choose to put more energy and money into production safety in the trade-off between "visible and immediate accidents" and "invisible and chronic lung diseases", which seriously damages coal miners' lives and health, and restricts the healthy development of the coal industry [28-31].

Apart from silicosis, asbestosis, and coal workers' pneumoconiosis, diseases such as aluminosis, bauxite fibrosis, berylliosis, graphite fibrosis, siderosis, stannosis, unspecified pneumoconiosis, and pneumoconiosis associated with tuberculosis were integrated into "other pneumoconiosis" in this study [16]. From 1990 to 2017, the overall ASIR of other pneumoconiosis showed a minor decreasing trend. Although the ASIR in the high SDI region did not change, compared to the significant decrease in ASIR in the other four SDI regions, other pneumoconiosis in the high SDI region was not negligible. For example, in Denmark, other pneumoconiosis increased at the fastest rate.

The GBD 2017 estimates probably underestimate numbers of cases and ASIRs associated with pneumoconiosis, despite it fill a gap where actual data on disease burden are scarce or unavailable [15, 16, 32]. First, the quality and quantity of data used in the modeling determine the accuracy and robustness of GBD estimation of number of cases. Second, clinical data records have a selection bias in the subsets of the population who have access to healthcare. Finally, data reported by some countries and territories are based only on diagnosed cases, and there are still the high number of unreported and undiagnosed cases.

In summary, pneumoconiosis continues to be one of major occupational health illnesses in the world. On the one hand, although we have attained great achievements in prevention of silicosis and coal workers'

pneumoconiosis, they are still an important health problem in some countries and territories. On the other hand, asbestosis is increasing at a higher rate in some High SDI countries. However, the most severe challenge might be the government's neglect of pneumoconiosis, due to the number of cases and the ASIR are at a lower level in these countries and territories, although these etiologies of pneumoconiosis are highly preventable. The findings reported here shed new light on the global disease burden of pneumoconiosis, and can be used to develop targeted interventions aimed at establishing more effective and targeted pneumoconiosis prevention strategies.

Abbreviations

GBD: The Global Burden of Diseases, Injuries, and Risk Factors Study; SDI: Socio-demographic Index; ASIR: Age Standardized Incidence Rate; AAPC: Average Annual Percentage Change; UI: Uncertainty Interval; CI: Confidence Interval; LOESS: Locally Weighted Regression and Smoothing Scatterplots; CWP: Coal Workers' Pneumoconiosis; OP: Other Pneumoconiosis.

Declarations

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Authors' contributions

All authors contributed to the study concept and design. PS wrote the first draft of the report. PS, XX, HJ, JY, ZF, and HZ did the collection and analysis. PS, XX, and SX reviewed and revised the manuscript before submission. All authors approved the final submitted version.

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Availability of data and materials

The datasets generated and/or analysed during the current study are available in the Global Health Data Exchange (GHDx) query tool [http://ghdx.healthdata.org/gbd-results-tool].

Ethics approval and consent to participate

All data were publicly available, no patient contact was made, and no individual identifiers were required. Therefore, ethical approval for the study was not required.

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

References

1. Worth G. Roentgenologically demonstrable changes in pneumoconiosis (author's transl). Prax Klin Pneumol. 1979;33 Suppl 1:622-6.
2. Zhang Z, Zhao Y, Sun D. China's occupational health challenges. Occup Med (Lond). 2017;67(2):87-90.
3. Laney AS, Weissman DN. The classic pneumoconioses: new epidemiological and laboratory observations. Clin Chest Med. 2012;33(4):745-58.
4. Choi BS, Park SY, Lee JO. Current status of pneumoconiosis patients in Korea. J Korean Med Sci. 2010;25(Suppl):S13-9.
5. Nelson G. Occupational respiratory diseases in the South African mining industry. Glob Health Action. 2013;6:19520.
6. Han L, Yao W, Bian Z, Zhao Y, Zhang H, Ding B, et al. Characteristics and Trends of Pneumoconiosis in the Jiangsu Province, China, 2006(-)2017. Int J Environ Res Public Health. 2019;16(3).
7. Mandrioli D, Schlunssen V, Adam B, Cohen RA, Colosio C, Chen W, et al. WHO/ILO work-related burden of disease and injury: Protocol for systematic reviews of occupational exposure to dusts and/or fibres and of the effect of occupational exposure to dusts and/or fibres on pneumoconiosis. Environ Int. 2018;119:174-85.
8. Leung CC, Yu IT, Chen W. Silicosis. Lancet. 2012;379(9830):2008-18.
9. Morgan J. Black lung is still a threat. Lancet Respir Med. 2018;6(10):745-6.
10. Culver DA. Beryllium disease and sarcoidosis: still besties after all these years? Eur Respir J. 2016;47(6):1625-8.
11. Furuya S, Chimed-Ochir O, Takahashi K, David A, Takala J. Global Asbestos Disaster. Int J Environ Res Public Health. 2018;15(5).

12. Zhang M, Wang D, Zheng YD, Du XY, Chen SY. [Analyses on the characteristics and the trends of pneumoconiosis notified between 1997 and 2009, in China]. Zhonghua Lao Dong Wei Sheng Zhi Ye Bing Za Zhi. 2013;31(5):321-34.
13. Soeberg MJ, Leigh J, van Zandwijk N. Malignant mesothelioma in Australia 2015: Current incidence and asbestos exposure trends. J Toxicol Environ Health B Crit Rev. 2016;19(5-6):173-89.
14. Van Oyen SC, Peters S, Alfonso H, Fritschi L, de Klerk NH, Reid A, et al. Development of a Job-Exposure Matrix (AsbJEM) to Estimate Occupational Exposure to Asbestos in Australia. Ann Occup Hyg. 2015;59(6):737-48.
15. GBD Collaborators. Global, regional, and national incidence, prevalence, and years lived with disability for 354 diseases and injuries for 195 countries and territories, 1990-2017: a systematic analysis for the Global Burden of Disease Study 2017. Lancet. 2018;392(10159):1789-858.
16. GCRD Collaborators. Global, regional, and national deaths, prevalence, disability-adjusted life years, and years lived with disability for chronic obstructive pulmonary disease and asthma, 1990-2015: a systematic analysis for the Global Burden of Disease Study 2015. Lancet Respir Med. 2017;5(9):691-706.
17. Hankey BF, Ries LA, Kosary CL, Feuer EJ, Merrill RM, Clegg LX, et al. Partitioning linear trends in age-adjusted rates. Cancer Causes Control. 2000;11(1):31-5.
18. Liu Z, Jiang Y, Yuan H, Fang Q, Cai N, Suo C, et al. The trends in incidence of primary liver cancer caused by specific etiologies: Results from the Global Burden of Disease Study 2016 and implications for liver cancer prevention. J Hepatol. 2019;70(4):674-83.
19. Fernandez Alvarez R, Martinez Gonzalez C, Quero Martinez A, Blanco Perez JJ, Carazo Fernandez L, Prieto Fernandez A. Guidelines for the diagnosis and monitoring of silicosis. Arch Bronconeumol. 2015;51(2):86-93.
20. Perlman DM, Maier LA. Occupational Lung Disease. Med Clin North Am. 2019;103(3):535-48.
21. Hoy RF, Baird T, Hammerschlag G, Hart D, Johnson AR, King P, et al. Artificial stone-associated silicosis: a rapidly emerging occupational lung disease. Occup Environ Med. 2018;75(1):3-5.
22. Mazurek JM, Wood JM, Schleiff PL, Weissman DN. Surveillance for Silicosis Deaths Among Persons Aged 15-44 Years - United States, 1999-2015. MMWR Morb Mortal Wkly Rep. 2017;66(28):747-52.
23. Accinelli RA, Lopez LM. [Asbestos, an epidemic that still needs to be controlled]. Gac Sanit. 2017;31(5):365-7.
24. Leong SL, Zainudin R, Kazan-Allen L, Robinson BW. Asbestos in Asia. Respirology. 2015;20(4):548-55.
25. Hoy RF, Brims F. Occupational lung diseases in Australia. Med J Aust. 2017;207(10):443-8.
26. Rosner D. Deregulating Safety: The Case of the Effort to Ban Asbestos. Milbank Q. 2017;95(2):257-60.
27. Poyatos G, Diego Roza C. Asbestos and the law. Arch Bronconeumol. 2017;53(1):5-6.

28. Perret JL, Plush B, Lachapelle P, Hinks TS, Walter C, Clarke P, et al. Coal mine dust lung disease in the modern era. Respirology. 2017;22(4):662-70.
29. Han S, Chen H, Harvey MA, Stemn E, Cliff D. Focusing on Coal Workers' Lung Diseases: A Comparative Analysis of China, Australia, and the United States. Int J Environ Res Public Health. 2018;15(11).
30. Mazurek JM, Wood J, Blackley DJ, Weissman DN. Coal Workers' Pneumoconiosis-Attributable Years of Potential Life Lost to Life Expectancy and Potential Life Lost Before Age 65 Years - United States, 1999-2016. MMWR Morb Mortal Wkly Rep. 2018;67(30):819-24.
31. Blackley DJ, Reynolds LE, Short C, Carson R, Storey E, Halldin CN, et al. Progressive Massive Fibrosis in Coal Miners From 3 Clinics in Virginia. JAMA. 2018;319(5):500-1.
32. Stanaway JD, Shepard DS, Undurraga EA, Halasa YA, Coffeng LE, Brady OJ, et al. The global burden of dengue: an analysis from the Global Burden of Disease Study 2013. Lancet Infect Dis. 2016;16(6):712-23.

Table

Table 1 The incident cases and age-standardized incidence rate of pneumoconiosis in 1990 and 2017, and its temporal trends from 1990 to 2017.

Characteristics	1990		2017		1990–2017
	Incidence cases No. (95% UI)	ASIR per 100,000 No. (95% UI)	Incidence cases No. (95% UI)	ASIR per 100,000 No. (95% UI)	AAPC No. (95% CI)
Overall	36186 (32504, 40004)	0.52 (0.44, 0.61)	60055 (53088, 67017)	0.28 (0.26, 0.29)	-0.6 (-0.6, -0.5)
Sex					
Male	32359 (28959, 35915)	1.11 (0.92, 1.34)	53730 (47417, 60282)	0.56 (0.53, 0.59)	-0.6 (-0.7, -0.6)
Female	3827 (3332 , 4377)	0.08 (0.05, 0.10)	6324 (5456, 7240)	0.05 (0.04, 0.06)	-0.7 (-0.8, -0.6)
SDI					
High SDI	7070 (6437, 7730)	0.52 (0.50, 0.54)	11333 (10285, 12460)	0.25 (0.24, 0.27)	-0.2 (-0.3, -0.2)
High-middle SDI	10005 (8756, 11258)	0.47 (0.39, 0.56)	15973 (13645, 18382)	0.22 (0.21, 0.23)	-0.6 (-0.7, -0.5)
Middle SDI	12818 (11367, 14412)	0.59 (0.47, 0.84)	21481 (18865, 24497)	0.32 (0.30, 0.34)	-1.0 (-1.1, -1.0)
Low-middle SDI	3930 (3551, 4329)	0.39 (0.29, 0.51)	7087 (6298, 7936)	0.24 (0.21, 0.27)	-0.5 (-0.5, -0.4)
Low SDI	2020 (1817, 2242)	0.54 (0.32, 0.82)	3619 (3186, 4098)	0.34 (0.25, 0.48)	-0.9 (-0.9, -0.8)
Causes					
Silicosis	14973 (12402, 17714)	0.29 (0.23, 0.36)	23695 (19069, 28969)	0.14 (0.13, 0.16)	-0.8 (-0.9, -0.7)
Asbestosis	4337 (3492, 5494)	0.04 (0.03, 0.05)	9397 (7652, 11637)	0.04 (0.03, 0.05)	0.6 (0.5, 0.6)
Coal workers' pneumoconiosis	9816 (7995, 12542)	0.13 (0.09, 0.18)	15080 (12004, 19799)	0.04 (0.04, 0.05)	-0.9 (-0.9, -0.8)
Other pneumoconiosis	7061 (5956, 8320)	0.07 (0.05, 0.09)	11883 (9900, 14278)	0.05 (0.04, 0.06)	-0.5 (-0.5, -0.5)
Region					
East Asia	20158 (17620, 22838)	0.98 (0.77, 1.35)	33954 (29050, 39105)	0.48 (0.45, 0.52)	-0.9 (-1.0, -0.9)
Southeast Asia	986 (850, 1142)	0.04 (0.03, 0.06)	2357 (2015, 2744)	0.03 (0.03, 0.04)	0.3 (0.2, 0.4)
Oceania	41 (36 , 46)	0.79 (0.56, 1.08)	95 (81, 112)	1.10 (0.80, 1.52)	0.2 (0.1, 0.3)
Central Asia	167 (144, 193)	0.17 (0.14, 0.20)	229 (195, 269)	0.09 (0.08, 0.11)	-0.5 (-0.5, -0.5)
Central Europe	1278 (1167, 1404)	0.47 (0.43, 0.50)	1150 (1015, 1298)	0.11 (0.10, 0.12)	-1.5 (-1.6, -1.4)
Eastern Europe	1411 (1265, 1581)	0.20 (0.17, 0.24)	1213 (1046, 1407)	0.08 (0.07, 0.09)	-1.2 (-1.3, -1.1)
High-income Asia Pacific	1519 (1352, 1705)	0.57 (0.53, 0.61)	2509 (2176, 2868)	0.29 (0.26, 0.32)	-1.3 (-1.4, -1.2)
Australasia	79 (68, 92)	0.19 (0.18, 0.21)	248 (217, 280)	0.31 (0.26, 0.38)	1.4 (1.3, 1.5)
Western Europe	1735 (1529, 1931)	0.60 (0.58, 0.62)	1398 (1218, 1594)	0.25 (0.23, 0.27)	-2.5 (-2.7, -2.2)
Southern Latin America	199 (179, 223)	0.35 (0.32, 0.38)	349 (299, 404)	0.23 (0.21, 0.27)	-0.2 (-0.2, -0.1)
High-income North America	1965 (1736, 2221)	0.34 (0.32, 0.35)	3724 (3294, 4194)	0.18 (0.17, 0.19)	0.5 (0.4, 0.6)
Caribbean	37 (32, 44)	0.07 (0.05, 0.08)	67 (55, 79)	0.04 (0.04, 0.05)	-0.2 (-0.3, -0.1)
Andean Latin America	78 (69, 86)	0.34 (0.27, 0.44)	169 (140, 206)	0.22 (0.19, 0.27)	-0.5 (-0.7, -0.4)
Central Latin America	753 (667, 842)	0.29 (0.27, 0.30)	1502 (1295, 1721)	0.11 (0.10, 0.12)	-0.9 (-1.0, -0.8)
Tropical Latin America	506 (449, 567)	0.19 (0.18, 0.20)	966 (856, 1084)	0.22 (0.20, 0.23)	-0.6 (-0.7, -0.5)
North Africa and Middle East	709 (621, 809)	0.16 (0.12, 0.21)	1711 (1496, 1972)	0.12 (0.11, 0.13)	0.2 (0.2, 0.3)
South Asia	3471 (3082, 3891)	0.50 (0.31, 0.73)	6307 (5427, 7291)	0.28 (0.22, 0.35)	-1.0 (-1.1, -0.9)
Central Sub-Saharan Africa	153 (136, 172)	0.52 (0.35, 0.72)	329 (287, 375)	0.38 (0.25, 0.63)	-0.4 (-0.4, -0.3)
Eastern Sub-Saharan Africa	468 (420, 524)	0.51 (0.32, 0.80)	888 (777, 1013)	0.31 (0.21, 0.52)	-0.7 (-0.7, -0.6)
Southern Sub-Saharan Africa	307 (276, 341)	0.60 (0.52, 0.73)	514 (444, 590)	0.46 (0.42, 0.51)	-0.3 (-0.4, -0.2)
Western Sub-Saharan Africa	166 (137, 202)	0.05 (0.04, 0.06)	376 (304, 466)	0.03 (0.03, 0.04)	0.2 (0.1, 0.3)

ASIR, age standardized incidence rate; UI, uncertainty interval; AAPC, average annual percentage change; CI, confidence interval; SDI, socio-demographic index.

Figures

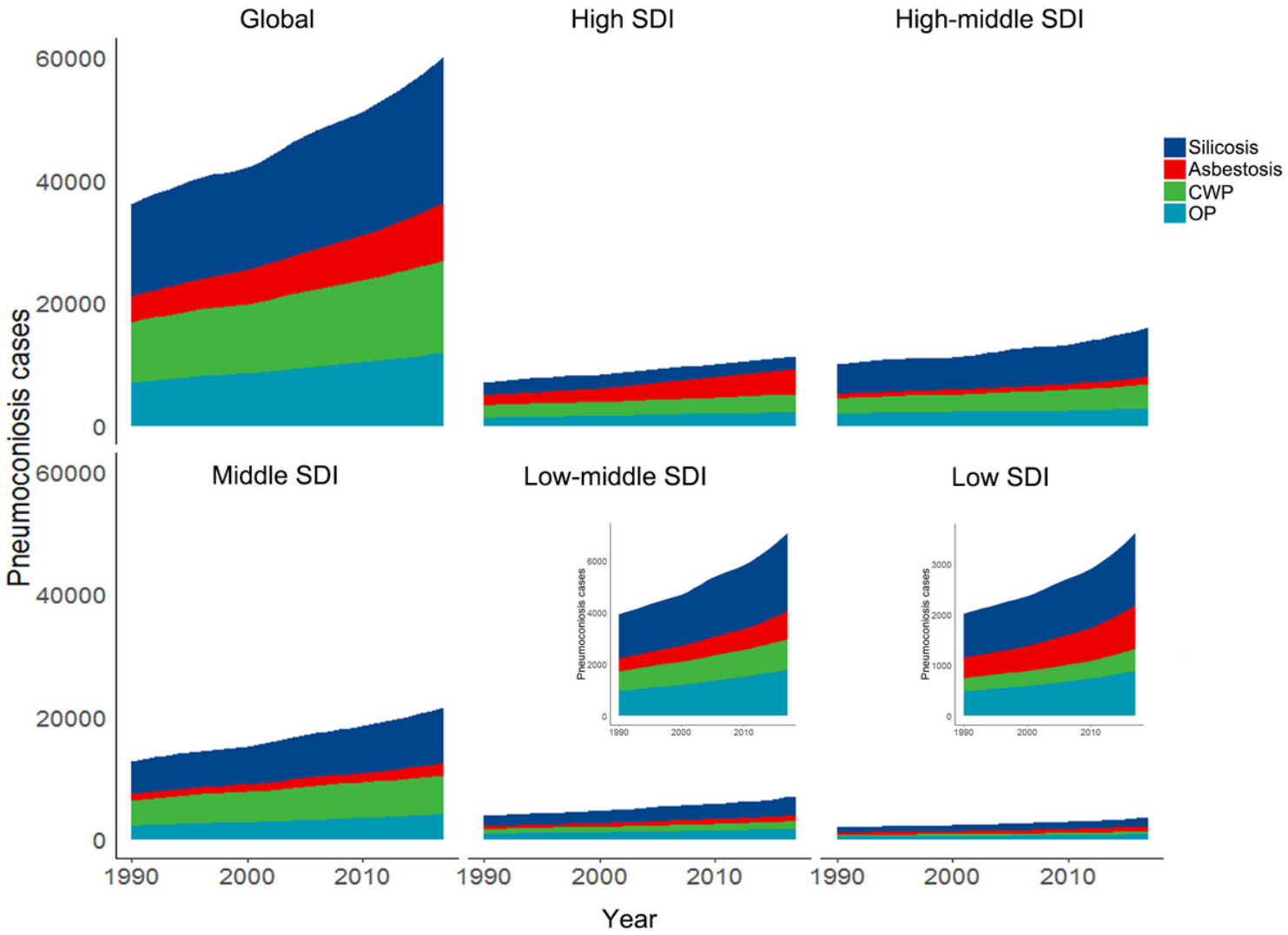

Figure 1

The pneumoconiosis cases caused by different etiologies, by SDI regions, from 1990 to 2017. Data from low-middle-SDI and low-SDI regions are presented in the top-right panel. CWP, coal workers' pneumoconiosis; OP, other pneumoconiosis; SDI, socio-demographic index.

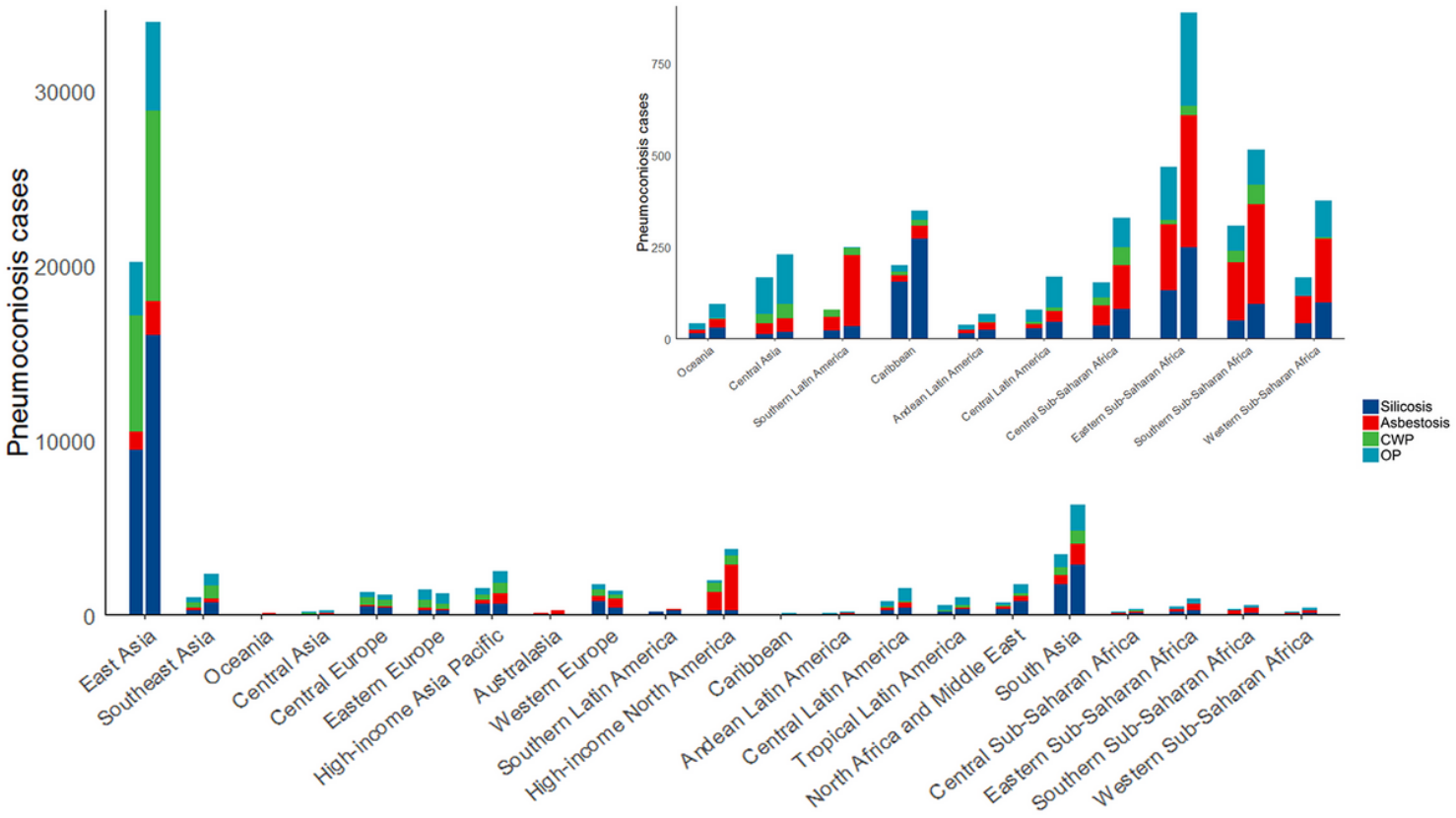

Figure 2

Incident cases of pneumoconiosis at a regional level. The left column in each group is case data in 1990 and the right column in 2017. Those data from certain regions can be viewed in the top-right of the panel. CWP, coal workers' pneumoconiosis; OP, other pneumoconiosis; SDI, socio-demographic index.

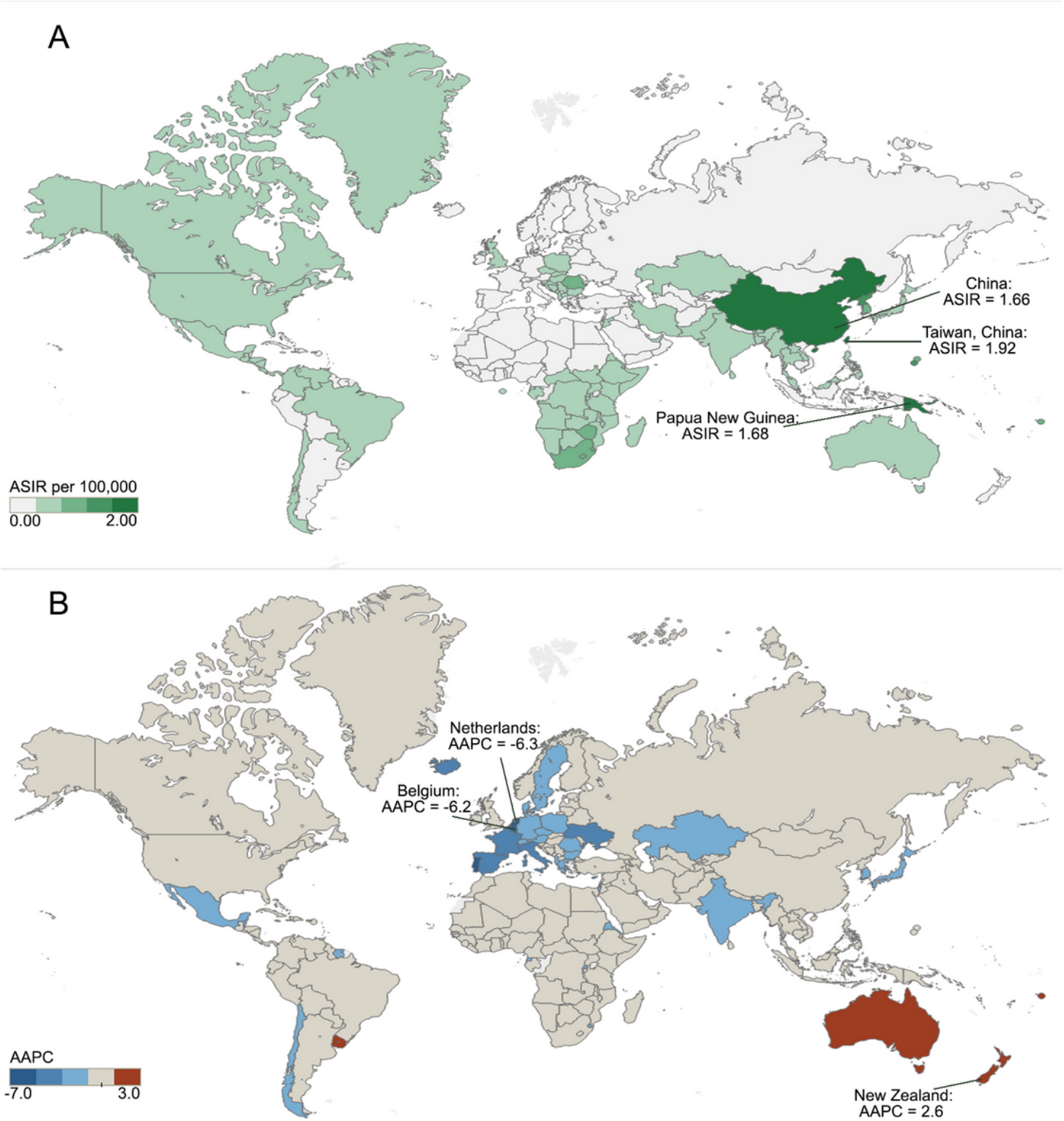

Figure 3

The global disease burden of pneumoconiosis for both sexes in 195 countries and territories. (A) The ASIR of pneumoconiosis in 2017; (B) The AAPC of pneumoconiosis ASIR from 1990 to 2017. Countries with an extreme number of cases/ evolution were annotated. ASIR, age standardized incidence rate; AAPC, average annual percentage change.

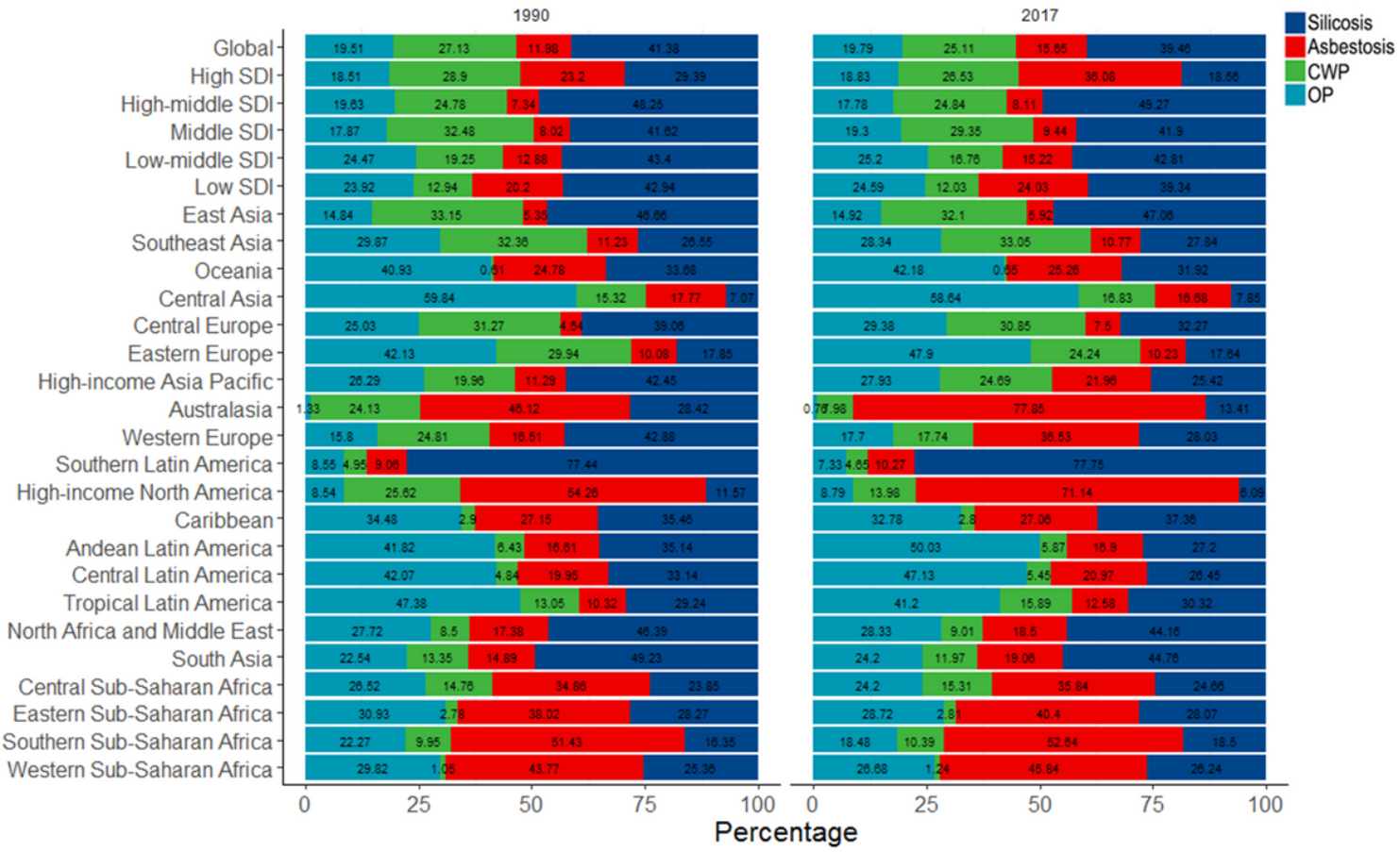

Figure 4

Contribution of different pneumoconiosis to absolute pneumoconiosis incident cases by region, in 1990 and 2017. CWP, coal workers' pneumoconiosis; OP, other pneumoconiosis; SDI, socio-demographic index.

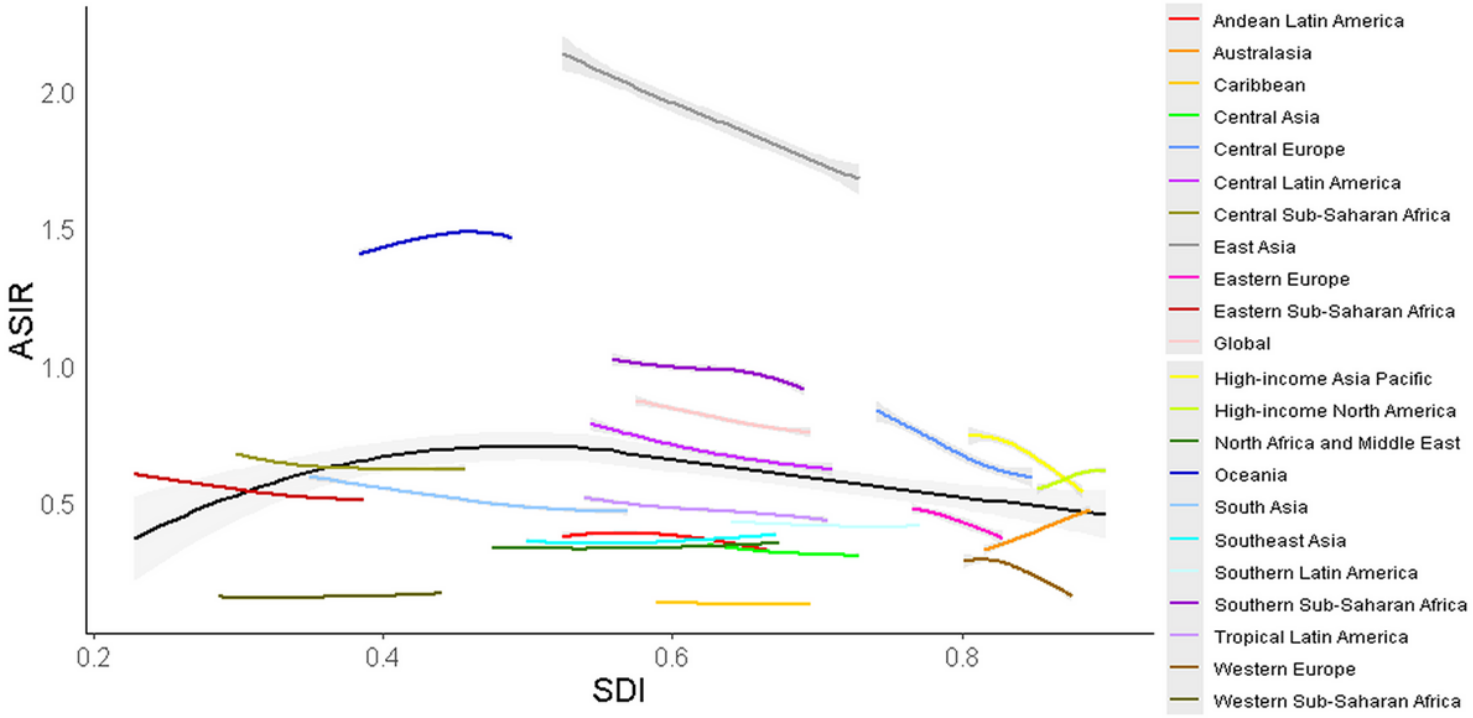

Figure 5

ASIR and the expected value based on the SDI, by regions from 1990 to 2017. The black line represents the expected value of an incidence rate based on a LOESS regression of all years of estimates by GBD locations and their SDI value. ASIR, age standardized incidence rate; GBD, global burden of disease; SDI, socio-demographic index; LOESS, locally weighted regression and smoothing scatterplots.

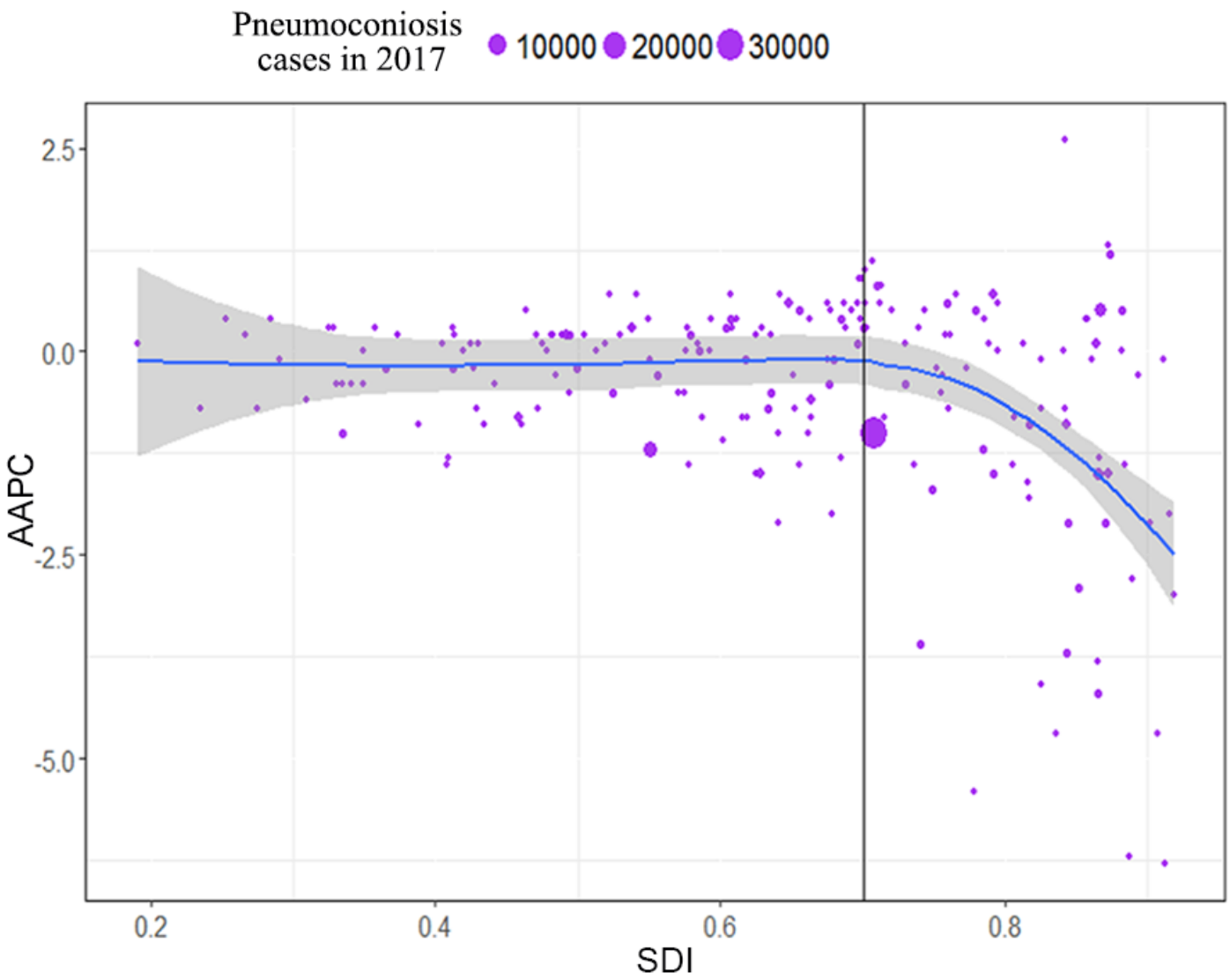

Figure 6

The correlation between AAPC and SDI in 2017. The circles represent countries and territories that were available on GBD data. The size of circle is increased with the cases of pneumoconiosis in 2017. The blue line represents the expected value of AAPC based on a LOESS regression of all years of estimates by SDI value in 2017. AAPC, average annual percentage change; GBD, global burden of disease; SDI, socio-demographic index; LOESS, locally weighted regression and smoothing scatterplots.

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- Supplementarymaterial.docx