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Mortality attributable to fine particulate matter in Asia, 2000–2015: a cross-sectional cause-of-death analysis

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ABSTRACT

Objectives To investigate the effect that particulate matter with a diameter of 2.5 µg ($PM_{2.5}$) had on mortality in Asian populations in years 2000–2015.

Setting Mortality and level of $PM_{2.5}$ data from the United Nations, Global Burden of Disease and University of Chicago were used.

Outcome measures Age pattern of mortality and the number of life-years lost (LYL) attributable to $PM_{2.5}$ in years 2000–2015. LYL were further separated into causes of death to quantify the contribution of each cause.

Results Ischaemic heart disease (IHD) mortality increased to represent over 31% of the LYL attributable to $PM_{2.5}$ between 2005–2010 and 2010–2015 in Asia (females 31% and males 35%). However, great diversity in LYL attributable to $PM_{2.5}$ by causes-of-death were found across the region, with IHD proportions of LYL ranging from 25% to 63% for males from Eastern and Central Asia, respectively. Similar diversity was observed for mortality attributable to $PM_{2.5}$ for other causes of death across Asia: chronic obstructive pulmonary disease (LYL ranging from 6% to 28%), lung cancer (4% to 20%) and stroke (11% to 22%).

Conclusion $PM_{2.5}$ is a crucial component in the rising health effects in Asia. The diverse trends in cause-specific mortality attributable to $PM_{2.5}$ creates a further challenge for health systems in the region. These findings highlight that immediate interventions are needed to mitigate the increasing levels of air pollution and with that reduce its detrimental effect on the health and mortality of Asian populations.

Strengths and limitations of this study

- ► First study to estimate life-years lost by causes of death attributable to $PM_{2.5}$ for Asian countries.
- ► For each of the causes of death attributable to $PM_{2.5}$ comparison between countries and regions in Asia from 2000 to 2015 were assessed.
- ► This study lacked the number of deaths attributable to $PM_{2.5}$ for the age group 0–24 and ages above 85.
- ► Our findings only show an underestimate of the real impact that air pollution is causing in Asian populations.
- ► Existent heterogeneity in air pollution within countries, for example, between urban/rural areas, remains a challenge in the region

BACKGROUND

Air pollution is one of the most serious global issues today, given its short-term and long-term health effects. Reducing air pollution-related mortality has become one of the Sustainable Development Goals, that is, the guideline of global development by United Nations by 2030.[1–4] WHO estimated that the global number of deaths due to an unhealthy environment in 2012 was 12.6 million deaths.[1] Also, the number of hospital cases attributable to air pollution have increased; for example, in the Indian state of Uttar Pradesh, it changed from 14% to 28% between 2002 and 2014.[5] Although there are various types of air pollution such as sulphur dioxide, carbon monoxide, ozone and particulate matter (PM), many studies agree that PM_{10} and $PM_{2.5}$ (particles with a diameter of 10 and 2.5 µg/m^3 or smaller) have severe harmful impact on health outcomes.[6–8] Ambient PM and household air pollution reductions, for instance, have an important effect on life expectancy increases.[9]

PM arose from population growth and the development of urbanisation, vehicular emission in the city, industry and biomass burning in rural areas.[2 10–12] Changes in the long-term effects on the climate, environment and pollution have increased the number of deaths attributable to air pollution.[13–15] $PM_{2.5}$ became the fifth-ranking mortality risk factor and caused higher mortality (around 4.2 million deaths), compared with other risk factors such as alcohol use, unsafe water source and second-hand smoking in 2015.[1 5] The global premature deaths attributable to $PM_{2.5}$ were estimated at 16 million years of human life lost per year.[8 10]

In 2015, the number of deaths due to $PM_{2.5}$ in the world increased by 20% with respect to 1990 levels.[16] The absolute mortality numbers due to air pollution have increased over time concomitant with increasing levels of $PM_{2.5}$, leading to high mortality from non-communicable diseases (NCDs), particularly in Asia.[17–20] It is also in Asia, where the countries with the highest exposure to $PM_{2.5}$ are found, and few studies have addressed the effect of $PM_{2.5}$ on mortality. For example, the data from the Global Burden of Disease[21] showed that the number of all-cause deaths due to $PM_{2.5}$ for females in Thailand has increased by over 52% from 2000 to 2010 and by 77% to 2017, while the annual average level of $PM_{2.5}$ in the country increased by 7 µg/m^3.[21 22] As for age groups, $PM_{2.5}$ affects more young children and the elderly than adults; A study from China found that this pollutant impacts all age groups of people, but young children below age 15, and the elderly, above age 60, are more seriously affected.[23] Besides, daily deaths attributable to $PM_{2.5}$ during 2013 China recorded a mean of 11.26 deaths per day, whereby 4.92 were age 60–79, 4.13 above age 80 and about 2.22 under age 60.[24]

Research on $PM_{2.5}$ air pollution-related mortality, suggests that $PM_{2.5}$ is positively correlated to both mortality and morbidity of NCDs, particularly on chronic obstructive pulmonary disease (COPD), lung cancer, stroke and heart diseases at all age groups.[1 2 6 7 9 25] From the number of cause-specific deaths at a global level, 26% of ischaemic heart disease (IHD) deaths were attributed to $PM_{2.5}$, 23% of stroke, 51% COPD and 43% of lung cancer deaths.[1] For example, there were positive relationships between $PM_{2.5}$ and all-cause mortality, as well as to respiratory, cerebrovascular and neuropsychology in Japanese cities from 2007 to 2011.[26] Similarly, in the Nanjing district in China, premature mortality achieved 50% reductions in COPD, IHD, lung cancer and stroke when $PM_{2.5}$ concentration decreased by 64%–80%.[27]

$PM_{2.5}$ is able to shorten life expectancy by augmenting premature deaths. Although life expectancy has increased since the early modern period,[28] exposure to air pollution has slowed down this increase. In 2016, $PM_{2.5}$ shortened global life expectancy at birth around 1 year and reduced it about 1.2–1.9 years for Asia and Africa.[9] Life expectancy in Indonesia was reduced by 1.2 years because of current higher $PM_{2.5}$ levels than the WHO air quality guidelines.[29]

To investigate the effect that $PM_{2.5}$ has had on mortality in Asia in the last decades, and particularly to study its impact on life expectancy, time trends of two mortality indicators are here examined, namely age-specific death rates (ASDR) and life-years lost (LYL). More specifically, the aims of this study are to investigate the impact of $PM_{2.5}$ in Asian mortality from 2000 to 2015 by studying: (1) the changes in the age pattern of mortality and (2) the number of cause-specific LYL in various countries with different levels of air pollution.

METHODS

Study data

Three types of data were used in this study: the age-specific and cause-specific number of deaths, death rates and the annual mean level of $PM_{2.5}$ in 2000–2015. Specifically, data used in this study derived from public databases at the Institute for Health Metrics and Evaluation (IHME),[21] United Nations[30] and the Energy Policy Institute, the University of Chicago (EPIC).[22]

The age-specific and cause-specific number of deaths were obtained from the IHME, which estimates the death counts attributable to ambient air pollution using an annual concentration of $PM_{2.5}$ from satellite remote sensing and chemical transport model,[21 31] and using the number of deaths from age 25 to 84.[32] From this source, the model estimated number of cause-specific death counts due to ambient PM air pollution and the number of all causes of death by sex and 5-year age groups from age 25 to 84 between 2000 and 2015 for each country, were obtained. The cause-specific mortality data due to $PM_{2.5}$ used in the analysis included the most affected five causes of death by $PM_{2.5}$: stroke, lung cancer, COPD, IHD and other causes (detailed population information and International Classification of Diseases revision 10 codes are found in online supplemental table A1 and A2), while the total mortality data uses all causes of death.

ASDRs by sex, for each population, were obtained from the abridged life tables elaborated by the United Nations for 5-calendar years (mid-year 2000 to mid-year 2005, or 2000–2005, as well as 2005–2010 and 2010–2015) and for 5-year age groups from age 0–84 and with an open age group 85 and more.[30] These data were used to calculate abridged life tables for those 5-calendar years from age 25 to 84 matching the cause-specific mortality data.

Annual mean concentrations of $PM_{2.5}$ data between 2000 and 2015 were derived from the Air Quality Life Index (AQLI) project from the EPIC. AQLI includes PM air pollution information, specifically average $PM_{2.5}$ data, from satellite measurement combining atmosphere parameters for climate change at the global and country level.[33]

To further interpret the findings, some countries in Asia were selected as examples of countries showing more or less progress in the concentration of $PM_{2.5}$, and in mortality attributable to $PM_{2.5}$ over time.

Methods

ASDR attributable to $PM_{2.5}$ and LYL due to $PM_{2.5}$ were calculated, and their change over time was analysed. This research uses the R Statistical software V.3.5.3 (Team RC., 2013)[34] to analyse and present the data; the approaches used in this analysis are: ASDR due to $PM_{2.5}$ air pollution and LYL by causes of death. First, ASDR due to $PM_{2.5}$ over the 2000–2015 period studied, by sex and for each country in Asia, were calculated from the original ASDR from the UN abridged life table and the proportions of deaths attributable to air pollution. Second, life expectancy and LYL between ages 25 and 85 were calculated. LYL is the complement of life expectancy and measures the number of years lost in the population before a fixed age τ, in this study $\tau = 85$. LYL will add to the life expectancy years short to 60 (equivalent to the life expectancy if nobody had died between ages 25 and 85). LYL can be further separated into causes of death to quantify the contribution of each cause to the overall LYL.[35 36] This research estimates the cause-specific LYL attributable to $PM_{2.5}$ by the most affected causes of death. LYL calculations were analysed between ages 25 and 85 due to the availability of the data attributable to air pollution in IHME.

To study time trends, the data between years 2000–2005 and 2010–2015 were compared for all Asian countries. Moreover, to investigate the change in LYL due to $PM_{2.5}$ over the period studied, the differences between 2000–2005 and 2010–2015 were calculated by subtracting the LYL in year 2010–2015 from year 2000–2005.

Details of the calculations are included in the online supplemental material and the analysis for each Asian country are provided in the online interactive application: https://airpollution.shinyapps.io/MortalityAsia/

RESULTS

As observed in figure 1, between 2000–2005 and 2010–2015, the average concentration of $PM_{2.5}$ increased in most Asian countries, with the exception of Japan, Mongolia and Timor-Leste where decreases were observed. The levels of $PM_{2.5}$ intensified in Eastern and Southern Asia,

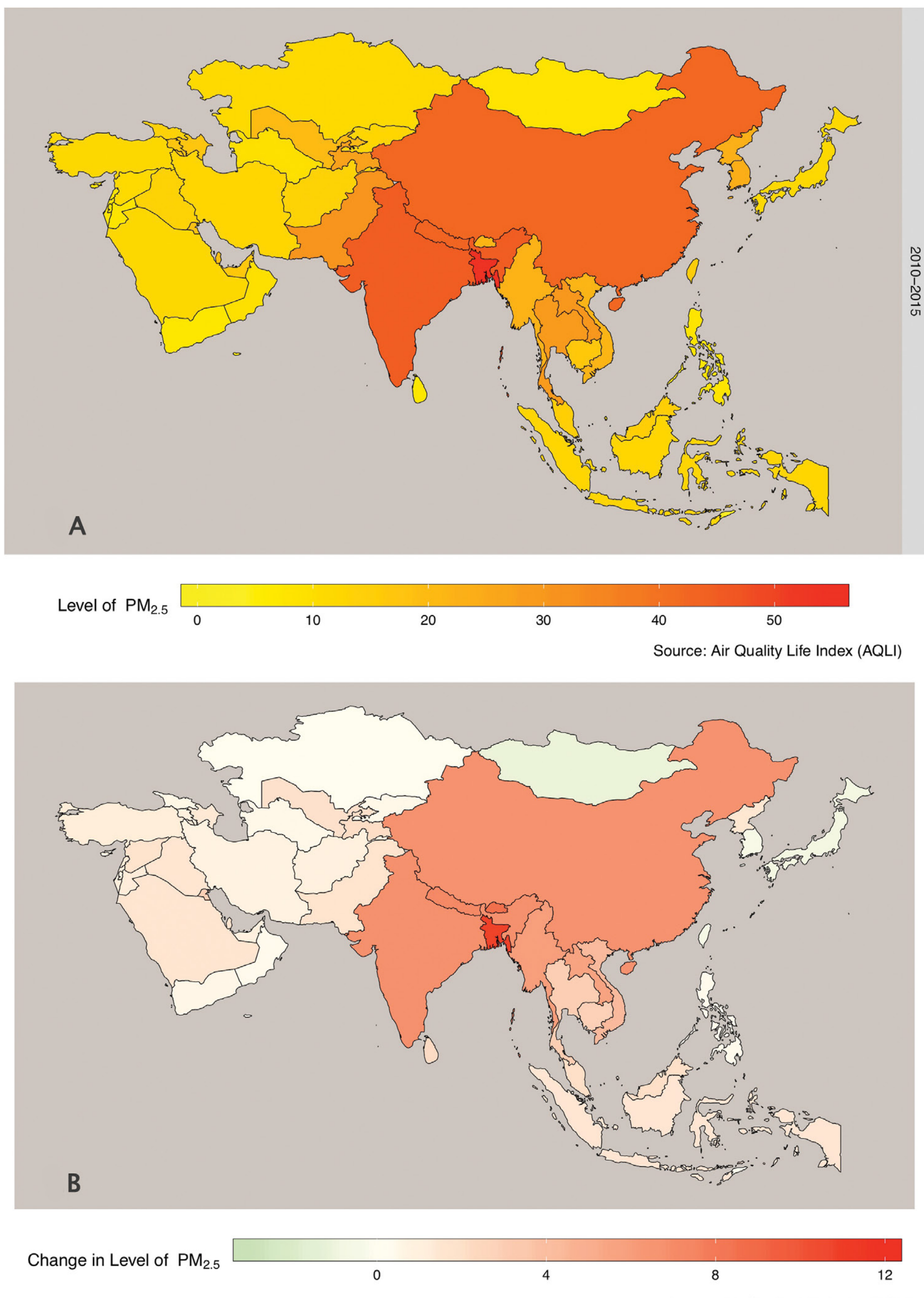

Figure 1 (A) Average level of $PM_{2.5}$ in Asia, by country between 2010 and 2015; (B) change in level of $PM_{2.5}$ in Asia by country between 2000 and 2015. The Asian map includes countries listed in table 1, except for Maldives without $PM_{2.5}$ data. $PM_{2.5}$, particulate matter with a diameter of 2.5 µg/m^3.

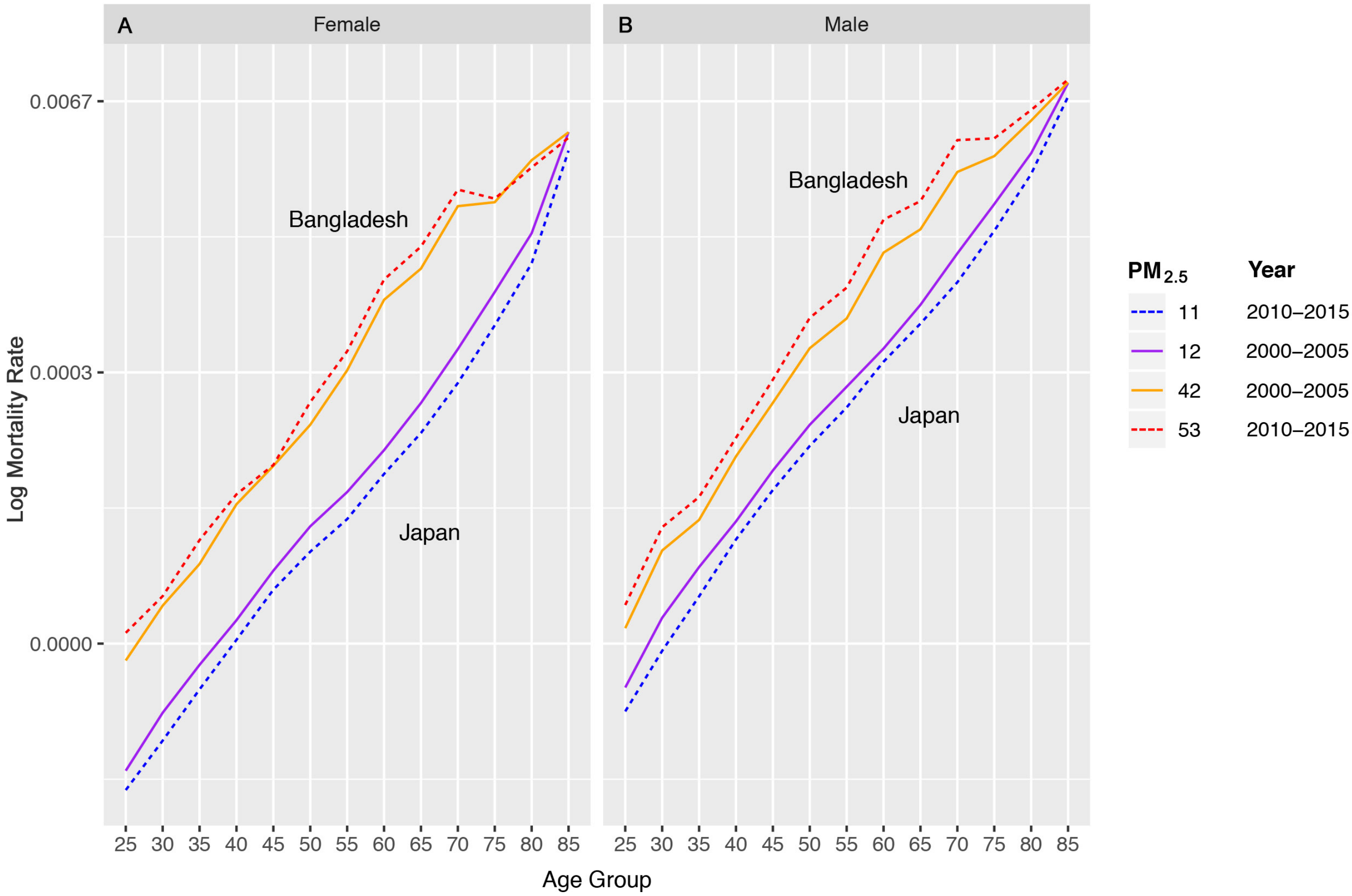

Figure 2 Age-specific and sex-specific death rates attributable to $PM_{2.5}$ by levels of $PM_{2.5}$ for Bangladesh and Japan, 2000–2015. The concentration of $PM_{2.5}$ for Bangladesh in 2000–2005 (solid orange line) was 42.0 μg/m^3 and Bangladesh in 2010–15 (dashed red line) was 52.8 μg/m^3, while that for Japan decreased from 12.1 μg/m^3 in 2000–2005 (solid purple line) to 11.4 μg/m^3 in 2010–2015 (dashed blue line). Source (A) age-specific death rates from IHME; and (B) annual level of $PM_{2.5}$ from AQLI. AQLI, Air Quality Life Index; IHME, Institute for Health Metrics and Evaluation; $PM_{2.5}$, particulate matter with a diameter of 2.5 μg/m^3.

particularly in Bangladesh, India, China and Nepal. In contrast, the levels of Western Asia were lower than in any other area in the continent.

Figure 2 presents the ASDR due to $PM_{2.5}$ increase in Bangladesh and $PM_{2.5}$ decrease in Japan. Figure 2 shows that in Bangladesh the death rates attributable to $PM_{2.5}$ increased while pollution also augmented from a level of $PM_{2.5}$ from 42.0 μg/m^3 in 2000–2005 to 52.8 μg/m^3 in 2010–2015. In the same period, the death rates in Japan decreased over time as the level of $PM_{2.5}$ reduced from 12.1 μg/m^3 in 2000–2005 to 11.4 μg/m^3 in 2010–2015. The information of LYL attributable to $PM_{2.5}$ for selected countries, for females and males, are presented in online supplemental figure A1 and A2.

To further illustrate how cause-specific LYL attributable to $PM_{2.5}$ developed between 2000 and 2015, LYL were separated into five causes of death for each of the Asian regions (Figure 3). LYL due to $PM_{2.5}$ for Central and Western Asia decreased for all causes of death, while some causes of LYL for other regions increased over time. LYL by COPD decreased in Eastern Asia although the trend remained at the same level in South-Eastern and Southern Asia. LYL by IHD, lung cancer and stroke in Eastern Asia increased, while there was a decrease in LYL by other causes for this region. LYL by IHD in South-Eastern and Southern Asia also increased, whereas that by other causes declined from 2000–2005 to 2010–2015.

However, by combining low and high polluted countries in the results of LYL by region, the great existent diversity in each region is hidden. For example, Japan and Mongolia, which advanced in reducing $PM_{2.5}$ were included in the Eastern Asia with countries that did not experience similar improvements. Figure 4 presents the results of cause-specific LYL for selected countries: China, Mongolia and Thailand. LYL due to $PM_{2.5}$ for Mongolia, which was less exposed to $PM_{2.5}$ than the other two countries, decreased for all causes of death, except for stroke that increased and then declined. LYL due to COPD and stroke decreased or stagnated from 2000 to 2015 in the other two countries. LYL attributable to $PM_{2.5}$ by IHD and lung cancer were some of the causes of death which rose in China, a country that made small progress in reducing in $PM_{2.5}$ levels. Finally, LYL attributable to $PM_{2.5}$ by other causes increased in Thailand, where moderate progress in reducing $PM_{2.5}$ was observed, while in the other countries stagnating or decreasing trends were observed for these

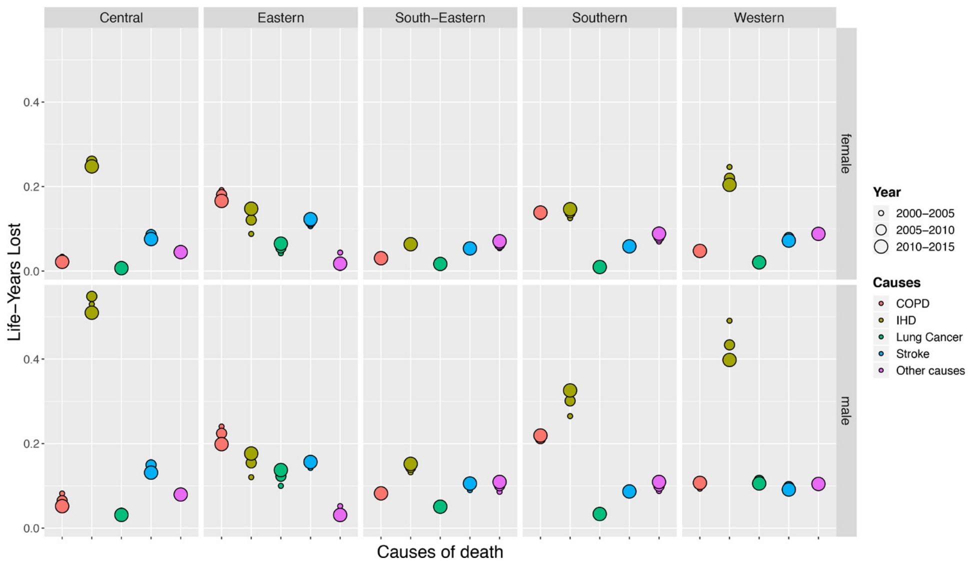

Figure 3 Life-years lost by causes of death attributable to $PM_{2.5}$ in Asia, by sex and region 2000–2015 (red dot) is COPD; (gold dot) is IHD; lung cancer (green dot); stroke (blue dot) and other causes (purple dot). COPD, chronic obstructive pulmonary disease; IHD, ischaemic heart disease; $PM_{2.5}$, particulate matter with a diameter of 2.5 µg/m^3.

causes. Generally, while the trend of LYL due to $PM_{2.5}$ by causes of death was different in every country, the general pattern was for people living in high polluted countries to experience greater loss of life-years in almost all diseases (detail numbers of LYL by causes of death attributable to $PM_{2.5}$ by Region and selected countries are found in online supplemental table A3 and A4).

Table 1 presents the life expectancy, LYL due to $PM_{2.5}$ and for all causes between ages 25 and 85, and their differences between 2000 and 2015, by sex for the selected Asian countries. While life expectancy increased, the number of life-years for all causes decreased over time in all countries. However, LYL due to $PM_{2.5}$ increased among the countries where the concentration of $PM_{2.5}$ augmented, such as Bangladesh, China, India and Thailand. On the contrary, among the countries with a decline in the average level of $PM_{2.5}$ from 2000 to 2015, such as Japan and Mongolia, LYL due to $PM_{2.5}$ also decreased. This positive correlation can also be seen in online supplemental figure A3 contrasting the changes in LYL attributable to $PM_{2.5}$ with the changes in the pollutant (Pearson correlation of R=0.35 for change in years 2000–2005 and 2005–2010, and R=0.36 for change in years 2005–2010 and 2010–2015). For countries with an increase in LYL attributable to $PM_{2.5}$ greater deterioration was seen for males than females. While, for the two countries with a decrease in air pollution, LYL for Mongolian females decreased more substantially than

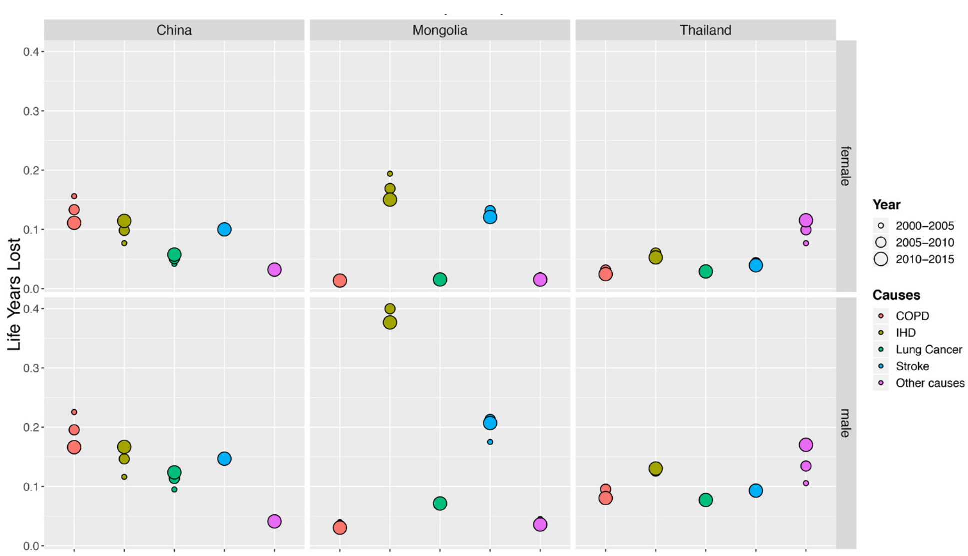

Figure 4 Life-Years lost by causes of death attributable to $PM_{2.5}$ in China, Mongolia and Thailand, by sex 2000–2015. (red dot) is COPD; (gold dot) is IHD; lung cancer (green dot); stroke (blue dot) and other causes (purple dot). COPD, chronic obstructive pulmonary disease; IHD, ischaemic heart disease; $PM_{2.5}$, particulate matter with a diameter of 2.5 µg/m^3.

Table 1 Life expectancy between ages 25 and 85, life-years lost due to $PM_{2.5}$ and for all causes, and their differences between 2000 and 2015, by sex and country

Country	Sex	${}_{60}e_{25}$ t_1	${}_{60}e_{25}$ t_2	$\Delta_{60}e_{25}$	LYL t_1	LYL t_2	ΔLYL	LYL^{AP} t_1	LYL^{AP} t_2	ΔLYL^{AP}	$\Delta PM_{2.5}$ ($\mu g/m^3$)
Bangladesh	Male	50.3	50.8	0.5	9.7	9.2	−0.5	0.5	0.6	0.2	10.83
	Female	50.9	52.4	1.5	9.1	7.6	−1.5	0.3	0.3	0.1	
China	Male	52.2	52.9	0.7	7.8	7.1	−0.7	0.6	0.6	0.0	6.61
	Female	53.9	54.7	0.7	6.1	5.3	−0.7	0.4	0.4	0.0	
India	Male	47.3	48.4	1.1	12.7	11.6	−1.1	0.7	0.8	0.1	6.74
	Female	49.6	51.2	1.6	10.4	8.8	−1.6	0.4	0.5	0.1	
Japan	Male	54.3	55.1	0.9	5.7	4.9	−0.9	0.2	0.2	−0.1	−0.71
	Female	57.2	57.6	0.3	2.8	2.4	−0.3	0.1	0.1	0.0	
Mongolia	Male	43.8	45.7	1.8	16.2	14.3	−1.8	0.7	0.7	0.0	−1.12
	Female	49.5	52.1	2.5	10.5	7.9	−2.5	0.4	0.3	−0.1	
Thailand	Male	47.3	49.5	2.2	12.7	10.1	−2.2	0.5	0.6	0.1	3.04
	Female	52.3	54.3	2.0	7.7	5.7	−2.0	0.2	0.3	0.0	

t_1, year 2000–2005; t_2, year 2010–2015; $\Delta_{60}e_{25}$ = difference in number of years lived from ages 25–85 between 2000–2005 and 2010–2015; ΔLYL= difference in life-years lost between 2000–2005 and 2010–2015; ΔLYL^{AP} = difference in life-years lost due to air pollution ($PM_{2.5}$) between 2000–2005 and 2010–2015; and $\Delta PM_{2.5}$ = difference in level of average $PM_{2.5}$ between 2000–2005 and 2010–2015. Positive numbers in the table represent an increase in life expectancy, LYL and $PM_{2.5}$, while negative numbers represent a decline in these measures. $PM_{2.5}$, particulate matter with a diameter of 2.5 $\mu g/m^3$.

for males and LYL for Japanese males decreased more than for females.

DISCUSSION

The concentration of $PM_{2.5}$ increased in most Asian countries between 2000 and 2015 affecting population health and mortality as cause-specific death rates attributable to $PM_{2.5}$ increase during the spread of the unhealthy environment. Evidence shows that more than half of the number of deaths due to air pollution occurred in India and China in 2015.[1 14]

Mortality is positively correlated to air pollution level and change in environment which influences the number of deaths[1 6 13 37 38]; in other words, the number of deaths increases if the pollutants increase. From 2000 to 2015, ASDR and LYL due to $PM_{2.5}$ increased in Asian countries experiencing a rise in the average level of $PM_{2.5}$, while they decreased among the countries with a decline in the level of air pollution. Further, life expectancy improvements related to the reduction of $PM_{2.5}$ could be achieved if Asian countries reached WHO guideline levels of $PM_{2.5}$ air pollution of 10 $\mu g/m^3$.[3 6 29 39] The changes in LYL due to $PM_{2.5}$ seem to have a small effect on overall life expectancy which has increased over time, meaning that most people still live longer, although the levels of $PM_{2.5}$ have increased. Risk factors such as smoking, alcohol use and unhealthy diet have greater impact on mortality than $PM_{2.5}$.[40–43] Nevertheless, additional gains in life expectancy would have been observed if $PM_{2.5}$ mortality was averted, for example up to 0.8 and 0.5 years for Indian males and females in years 2010–2015.

Results of this study show that LYL by causes of death due to $PM_{2.5}$ differed between countries and regions. Cause-specific LYL in countries with a high pollution level were more likely to increase, while in countries with low and middle pollution the LYL stagnated or decreased over time. The number of deaths attributable to $PM_{2.5}$ is estimated to rise more than 50% in the cities of Eastern and Southern Asia over the next 30 years if there is no improvement or control of air pollution.[1 18] Pollution-related health effects and causes of death are also associated with the countries' economy with 89% of mortality due to $PM_{2.5}$ emerging in low- and middle-income countries in 2015.[1] This is explained partially by the fact that upper-middle-income and high-income countries prioritise their investment in fighting diseases attributable to ambient air pollution, while low-income countries focus on reducing the burden of diseases emerging from a lack of ability to get clean water and sanitation.[1] A further source of uncertainty has been experienced recently with estimates associating the increase in the risk of getting infected by COVID-19 in places with greater exposure to air pollution, particularly higher levels of $PM_{2.5}$.[44] At the same time, averted pollution during lockdown has also increased.[45]

Mortality attributable to $PM_{2.5}$ shows disparities by sex. ASDR and LYL due to $PM_{2.5}$ in most Asian countries were lower for females than males. However, exceptions exist like the equal female and male $PM_{2.5}$ LYL found in Japan. Among the possible explanations of these differential trends is the fact that for Japanese women the number of health effects due to air pollution has increased since they started imitating men's lifestyle such as smoking and working outdoors.[46 47] The different $PM_{2.5}$ mortality pattern by sex also results from different biological factors between females and males. For example, in a Canadian study on respiratory disease due to $PM_{2.5}$, girls developed fewer diseases than boys, explained by their smaller airways in connection to the lung functions.[48 49] Another factor that contributes to mortality disparities by sex is differences in respiratory anatomy between females and males. Findings from Southern California noted that, although males and females do outdoor activities in the same duration, females still have higher risk to be impacted by air pollution.[48]

The product of the population size by the LYL due to the $PM_{2.5}$ provides an estimate of the impact of the pollutant in each population. Between 2010 and 2015, Bangladesh lost 47.5 and 23.1 million years of life due to $PM_{2.5}$, while China lost 433.5 and 273.7 million years for males and females, respectively. The number of LYL for India was greater than in any other country, accounting for 545 and 314.5 million years lost due to $PM_{2.5}$ for males and females respectively. The comparable numbers of LYL for Japan and Mongolia, which had decreasing $PM_{2.5}$ trends, were 12.5 and 6.5 million years lost in Japan, while Mongolia lost 1 and 0.5 million years due to $PM_{2.5}$ for males and females, respectively.

Limitations of the study should be mentioned. Mortality due to $PM_{2.5}$ is more likely to influence children and older individuals than adults. This study lacked the number of deaths attributable to $PM_{2.5}$ for the age group 0–24 and ages above 85. Thus, our findings only show an underestimate of the real impact that air pollution is causing in Asian populations. Other models of the impact of air pollution in mortality,[50] different from the model estimates from IHME,[21] could also be used to obtain further estimates of the levels of $PM_{2.5}$ in the health of Asian populations. Although, some populations are advancing in the process of gathering the right information to obtain better estimates of the effects of air pollutants in populations' health,[2] the majority of countries will still depend on modelled data. As such, our results are a call for strong international efforts to collect better air pollution information. The results presented here correspond to averages at the country level, without differentiating the great regional heterogeneity in air pollution and its effects existent within countries. A comparative study including specific information on the economy of countries as well as the share of their economy invested in fighting mortality attributable to $PM_{2.5}$ should be further explored. Also, a deeper analysis of the reason for the cause-specific death due to $PM_{2.5}$ in different countries could enrich our knowledge on how to prevent mortality caused by air pollution. Finally, air pollution has both short- and long-term effects on health.[51] The impact on LYL on specific causes of death in our results, combined the historical exposure and the current levels of $PM_{2.5}$.[51] To study the effect of $PM_{2.5}$ on health outcomes, and disaggregate the short-term and long-term effects,[15 40] individual information (including smoking, alcohol use, weight, etc.) might be an alternative way to fully quantify the adverse effects of air pollution.[52 53]

CONCLUSION

In conclusion, LYL for all-causes mortality declined from 2000 to 2015 in all Asian countries. However, LYL due to $PM_{2.5}$ increased in countries experiencing rise in annual mean level of $PM_{2.5}$. LYL by causes of death including COPD, IHD, lung cancer, stroke and other causes due to $PM_{2.5}$ differ in time trends in various nations. Similarly, females LYL attributable to $PM_{2.5}$ had different trends than males in most countries.

The findings of this research emphasise the important role that air pollution is having on the health of Asian populations and the need for public health efforts to collect better air pollution information and reduce the years of life lost due to environmental deterioration.

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Contributors PS and VC-R conceived the idea, designed the framework and developed the project. PS and VC-R performed the analysis and wrote the manuscript together.

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Competing interests None declared.

Patient consent for publication Not required.

Ethics approval This study involved secondary data analysis of public sources, which did not have any individual identifiers, therefore, ethics approval from our respective Institutional Review Board (IRB) was not required.

Provenance and peer review Not commissioned; externally peer reviewed.

Data availability statement Data are available in a public, open access repository. We have included links to the data sources, which are all free available resources. This study used secondary data analysis. We derived the data from public sources and then analysed the data by following to the aims of the study. The results of the data (eg, figure of age-specific death rates, life-years lost and life-years lost by causes of death for all Asian countries) were provided in the online application: https://airpollution.shinyapps.io/MortalityAsia/

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