# Long Trend of $PM_{2.5}$ Mass Concentration Variations and Its Related Cardiovascular and Respiratory Diseases in Ten Countries

Shunuan Xie

Guangzhou Alcanta International College Qingteng academy

3311428485@qq.com

**Abstract.** Numerous epidemiology studies indicated that exposure to fine particulate matter ($PM_{2.5}$) could cause chronic human health effects. However, long-term trends in $PM_{2.5}$-related health effects across countries remain unclear. Hence, we aimed to explore the differences in long trend variations for $PM_{2.5}$ mass concentration and $PM_{2.5}$-related health effects in different countries. The $PM_{2.5}$ data from AQLI (Air Quality Living Index) were selected to study the long-term trend of $PM_{2.5}$ mass concentration variations (from 2010 to 2019). Meanwhile, $PM_{2.5}$-related cardiovascular disease and $PM_{2.5}$-related respiratory disease data from GBD (Global Burden of Disease) were selected to analyze the potential health effects of $PM_{2.5}$ in different countries. The results indicated that the annual ambient $PM_{2.5}$ mass concentration decreased in most counties in the last ten years. Meanwhile, the $PM_{2.5}$-related cardiovascular and respiratory diseases rate (the number of deaths in hundred thousand people, data from GBD study) decreased in most countries except Japan and India. This inconsistent correlation between $PM_{2.5}$ concentration and adverse $PM_{2.5}$ health effects across countries deserves more attention.

**Keywords:** **c**ardiovascular disease, respiratory disease, $PM_{2.5}$, long trend, countries

## 1 Introduction

Air pollution always harms human health [1, 2], especially PM2.5 (particulate matter with aerodynamic diameters less than 2.5 μm) [3]. The Global Burden of Disease (GBD) study documented 4.5 million premature deaths due to outdoor air pollution and 2.3 million deaths due to indoor air pollution in 2019 (https://www.healthdata.org/). Ambient PM2.5 is a mixture of multiple pollutants, such as organic carbon (OC) and blank carbon (BC), ions, and elements, which account for roughly 70 – 110 percent of total ambient PM2.5 mass concentration in different regions [4]. Those chemical components showed higher associations to various health endpoints [5], especially cardiopulmonary and cardiovascular diseases [6, 7].


A. Holl et al. (Eds.): ICHESS 2022, ASSEHR 720, pp. 2857–2862, 2022.
https://doi.org/10.2991/978-2-494069-89-3_327

The substances of the different toxic components are from various sources [8]. The emission sources of PM2.5 can be roughly apportionment as industrial emissions, biomass burning, coal combustion, natural emissions, and transportation emissions. The toxicity of PM2.5 can vary from source to source, and the number of patients and premature mortality rates is inconsistent [9]. Most polluted sources could simultaneously impact PM2.5 mass concentrations and their related health effects. As for India, waste incineration will become one of the most contributing sources of air pollution [10]. In 2010, one of the higher sources of outdoor air pollution mortality in the United States was power generation, followed only by agriculture [9]. With human activities and the effects of global warming, the extent of wildfires on PM2.5 is becoming more evident, posing a severe risk to human health [11]. The results showed that a 10 μg/m3 increase in wildfire-specific PM2.5 was associated with a 1.3 - 10% increase in respiratory hospitalizations, compared with a 0.67 - 1.3% increase in non-wildfire PM2.5[12]. Reducing fossil fuel emissions is important for controlling PM2.5 mass concentration and reducing PM pollution health impacts [1, 3]. Agriculture also adds pollutants to the air, mainly from agricultural waste, farm-relative burning, tractor emissions, and other emissions [13]. In addition, PM2.5 can also vary over time, and differences in PM2.5 toxicity in different countries and regions can cause various health effects. For example, in China, the death rate of COPD decreased by 68.6% from 1990 to 2017[14]. However, few studies focus on the PM2.5 mass concentration and its related health effect on respiratory and cardiovascular disease mortality for a long trend variations worldwide. This study collected $PM_{2.5}$ mass concentrations in different countries from AQLI (https://aqli.epic.uchicago.edu). And the $PM_{2.5}$-related mortality data for cardiovascular and respiratory disease in the ten selected countries were collected from GBD studies. We aimed to (1) explore the long trend of ambient $PM_{2.5}$ mass concentrations in different countries and (2) analyze the potential health effect of $PM_{2.5}$ on respiratory and cardiovascular disease mortality in different countries.

## 2 Method

Ten countries were selected to analyze the potential associations between ambient PM2.5 mass concentration and PM2.5-related mortality rate in different regions. Ten countries were selected based on the location information, economic situation, population, and pollution levels. The selected countries include America, Britain, Brazil, Australia, Egypt, China, India, Canada, Japan, and Germany. The ambient annual PM2.5 mass concentration data of different countries comes from AQLI (Air quality life index). The yearly PM2.5 mass concentration data were selected from 2010 to 2019, which could cover the main variations in recent years.

The PM2.5-related mortality data for cardiovascular and respiratory were collected from the global burden of disease (https://www.healthdata.org/gbd/2019). This GBD study estimated 369 diseases and injuries related to 87 risk factors from 1990 to 2019. The basic information in the GBD studies selections include locations, age, sex, data sets, years, cause, and other influence factors. Measures available include deaths, years of life lost (YLLs), years lived with disability (YLDs), disability-adjusted life years

(DALs), incidence, prevalence, mental mortality ratio, life expectancy, healthy life expectancy (HALE), and other factors. This study selected the death rate (deaths, rate per 100k) of respiratory and cardiovascular diseases. The time range for respiratory and cardiovascular diseases was from 2010 to 2019. It included the full age range of the populations of the ten countries mentioned above, as well as all sex, to study the long trend variations of PM2.5 concentrations on human health.

# 3 Results and discussion

## 3.1 Long trend variations for annual ambient $PM_{2.5}$ in ten countries

India and China have shown higher annual PM2.5 mass concentrations in the past ten years, which is also very consistent with the findings of the previous studies [15]. PM2.5 mass concentrations in India and China extremely exceeded the new WHO standard threshold of 5 μg/m3 and the old WHO standard (10 μg/m3). At the same time, many countries have met or are close to the standard, e.g., the UK, the USA, Canada, Brazil, Japan, and Germany, and only Australia has met the standard for the new WHO PM2.5 standard.

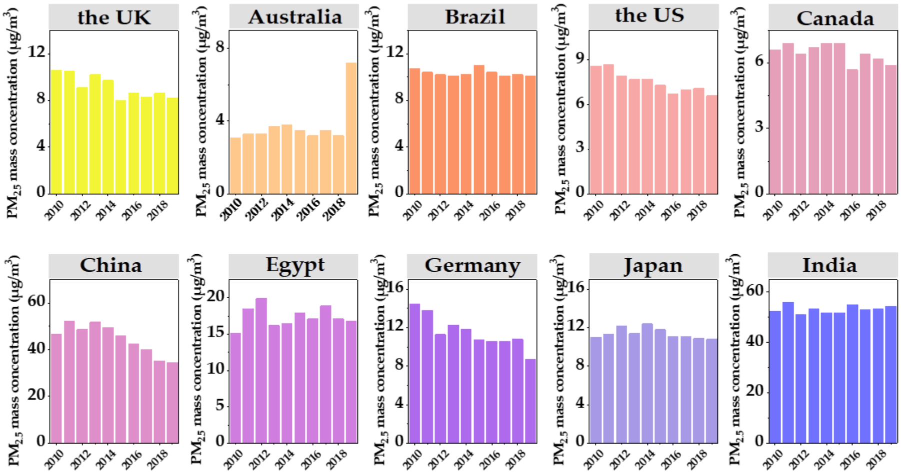


**Fig. 1.** Variations for annual ambient $PM_{2.5}$ mass concentration of ten counties from 2010 to 2019. (owner-drawing)

Figure1 shows the change in PM2.5 mass concentration from 2010 to 2019 in 10 countries. There are differences in PM2.5 trends among multiple countries. China showed an upward trend from 2010 to 2013 and decreased dramatically from 2013 to 2019. The reasons for the significant variation in China from 2013 to 2019 are due to the strong control by the Chinese government and the emergence of some policies, such as reducing energy consumption and replacing clean energy with traditional polluted energy [16]. The UK and the US also showed a gradual downward trend from 2013 to 2019. Similarly, Germany showed a significant decrease in PM2.5 mass concentration. And no significant trend is observed in Brazil, Canada, Egypt, India, and Japan. Interestingly, even though Australia met the new WHO standard, pollution events such as wildfires could also severely influence the ambient PM2.5 mass concentration.

Coal and wood burning, motor vehicles, and dust emissions were primary sources of ambient PM2.5 in most countries [8]. Previous studies suggested that roughly 60% of PM2.5 mass concentrations were attributed to anthropogenic activities, including residential biomass burning, power plants, industrial coal combustion, and perceived dust. India is also the second most populous country in the world, with a total population of 1.366 billion. The dramatic increase in population has led to an increase in PM2.5 emissions in India. However, PM2.5 in Germany and Japan showed different patterns. Motor vehicle emission was the primary PM2.5 emission source in Germany. Besides vehicle emissions, biomass burning was also one of the primary PM2.5 sources in Japan.

## 3.2 Long trend variations for $PM_{2.5}$ -related cardiovascular and respiratory diseases death rate in ten countries

Numerous studies indicated that long terms PM2.5 exposure are linked to multiple health endpoints through different pathways. Consequently, the description of the long trend of PM2.5-related cardiovascular and respiratory disease deaths could reflect the potential health effects of ambient PM2.5 in different countries.

According to GBD studies, Figure 2 summarizes the death rate of PM2.5-related cardiovascular and respiratory diseases in ten countries. Figure 2 indicates that the highest mortality rate in respiratory diseases is in India, followed by China. As for PM2.5-related cardiovascular disease, the high mortality rate was in Egypt and Germany. India has the top mortality rates in respiratory and cardiovascular diseases among the ten countries. Australia and Canada are ranked in the bottom two. Most of the mortality rate among nations is due to pollution emissions. According to Figure 1, the higher the average annual PM2.5, the higher the mortality rate due to air pollution in that country, and there is a correlation.

China showed a dramatic decline in deaths from respiratory and cardiovascular diseases compared to other countries. However, Germany showed a rapid decrease in cardiopulmonary death rate but not so prompt in respiratory diseases. Therefore, it can be found that the change in $PM_{2.5}$ mass concentration in China significantly influences its health effect. In Brazil, although the annual mean concentration of $PM_{2.5}$ did not change significantly, there was a significant reduction in mortality rate in patients with cardiovascular rather than respiratory diseases. On the contrary, Japan has a slightly decreasing trend in annual mean concentrations of $PM_{2.5}$ and a significant increasing trend in attributable mortality rate, possibly because of the rising $PM_{2.5}$ toxicity. In addition, Egypt has the highest cardiovascular disease mortality rate, ranking first among the ten countries. The mortality rate has not substantially changed recently, but the average annual $PM_{2.5}$ mass concentration decreased. The UK has a decreasing trend for respiratory and cardiovascular diseases, and $PM_{2.5}$ decreases even at a low concentration level. The annual $PM_{2.5}$ concentrations were consistently lower between Australia and Canada, except for the sudden surge in PM emissions in 2019 in Australia, where there was also no significant change in mortality rate, with most mortality rates in both countries remaining at the horizontal level.

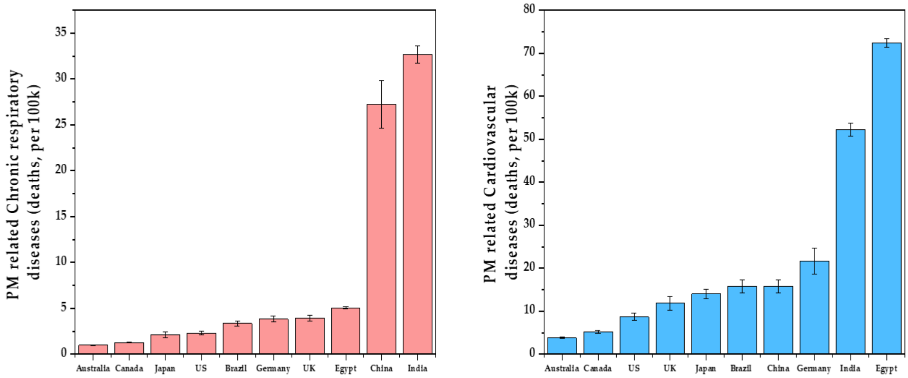


**Fig. 2.** Ranks for the ten years (2010-2019) average $PM_{2.5}$-related chronic respiratory diseases (deaths, per 100k) and cardiovascular diseases rate (deaths, per 100k) in ten counties （owner-drawing）

## 4 Conclusion

This study focus on the differences in ten-year-long trend variations for PM2.5 mass concentration and PM2.5-related health effects in different countries. A low PM2.5 mass concentration reflects better health effects in most countries. However, the health effects of long-trend variations of PM2.5 were unequal in specific countries, such as Brazil and Japan. As for Japan, with a slight decrease in PM2.5 mass concentration, an increasing trend in PM2.5-related cardiovascular and respiratory mortality rates was found, emphasizing the importance of the unequal toxicity of PM2.5, especially in lower PM2.5 mass concentrations. Although limitations were still in this study, PM2.5 pollution is still one of the topics of global concern, especially for human health.

## 5 Reference

1. Huang, R.J., et al., High secondary aerosol contribution to particulate pollution during haze events in China. Nature, 2014. **514**(7521): p. 218-22.
2. Burnett, R., et al., Global estimates of mortality associated with long-term exposure to outdoor fine particulate matter. Proc Natl Acad Sci U S A, 2018. **115**(38): p. 9592-9597.
3. McDuffie, E.E., et al., Source sector and fuel contributions to ambient PM2.5 and attributable mortality across multiple spatial scales. Nat Commun, 2021. **12**(1): p. 3594.
4. Zhang, Y., et al., Review of receptor-based source apportionment research of fine particulate matter and its challenges in China. Sci Total Environ, 2017. **586**: p. 917-929.
5. Kelly, F.J. and J.C. Fussell, Size, source and chemical composition as determinants of toxicity attributable to ambient particulate matter. Atmospheric Environment, 2012. **60**: p. 504-526.

6. Cohen, A.J., et al., Estimates and 25-year trends of the global burden of disease attributable to ambient air pollution: an analysis of data from the Global Burden of Diseases Study 2015. The Lancet, 2017. **389**(10082): p. 1907-1918.
7. Brook, R.D., et al., Particulate matter air pollution and cardiovascular disease: An update to the scientific statement from the American Heart Association. Circulation, 2010. **121**(21): p. 2331-78.
8. Hopke, P.K., et al., Global review of recent source apportionments for airborne particulate matter. Sci Total Environ, 2020. **740**: p. 140091.
9. Lelieveld, J., et al., The contribution of outdoor air pollution sources to premature mortality on a global scale. Nature, 2015. **525**(7569): p. 367-71.
10. Sharma, G., S. Annadate, and B. Sinha, *Will open waste burning become India's largest air pollution source?* Environ Pollut, 2022. **292**(Pt A): p. 118310.
11. Simpkins, G., *Wildfire threats.* Nature Climate Change, 2017. **7**(9): p. 624-624.
12. Aguilera, R., et al., Wildfire smoke impacts respiratory health more than fine particles from other sources: observational evidence from Southern California. Nat Commun, 2021. **12**(1): p. 1493.
13. Giannadaki, D., et al., Estimating health and economic benefits of reductions in air pollution from agriculture. Sci Total Environ, 2018. **622-623**: p. 1304-1316.
14. Zhou, M., et al., Mortality, morbidity, and risk factors in China and its provinces, 1990–2017: a systematic analysis for the Global Burden of Disease Study 2017. The Lancet, 2019. **394**(10204): p. 1145-1158.
15. Gupta, I., A. Salunkhe, and R. Kumar, Source apportionment of PM10 by positive matrix factorization in urban area of Mumbai, India. ScientificWorldJournal, 2012. **2012**: p. 585791.
16. Huang, X., et al., Characteristics of PM2.5 pollution in Beijing after the improvement of air quality. Journal of Environmental Sciences, 2021. **100**: p. 1-10.