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Impact of Air Pollution on Global Burden of Disease in 2019

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Abstract: Air pollution consisting of ambient air pollution and household air pollution (HAP) threatens health globally. Air pollution aggravates the health of vulnerable people such as infants, children, women, and the elderly as well as people with chronic diseases such as cardiorespiratory illnesses, little social support, and poor access to medical services. This study is aimed to estimate the impact of air pollution on global burden of disease (GBD). We extracted data about mortality and disability adjusted life years (DALYs) attributable to air pollution from 1990 to 2019. The extracted data were then organized and edited into a usable format using STATA version 15. Furthermore, we also estimated the impacts for three categories based on their socio-demographic index (SDI) as calculated by GBD study. The impacts of air pollution on overall burden of disease by SDI, gender, type of pollution, and type of disease is estimated and their trends over the period of 1990 to 2019 are presented. The attributable burden of ambient air pollution is increasing over the years while attributable burden of HAP is declining over the years, globally. The findings of this study will be useful for evidence-based planning for prevention and control of air pollution and reduction of burden of disease from air pollution at global, regional, and national levels.

Keywords: air pollution; gender; burden of disease; non-communicable diseases; deaths; DALYs; policy; socio-demographic index

1. Introduction

Globally, air pollution is reported as a major environmental risk factor that poses a substantial threat to human health [1]. Approximately 90% of the global population is at risk of air pollution and the disease burden attributable to air pollution continues to grow, posing a serious threat to global health [2–5]. As per global estimates, air pollution, both ambient air pollution (AAP) and household air pollution (HAP), accounts for 7 million premature deaths worldwide [2]. Moreover, the burden of disease attributed to air pollution is considerably higher in low-and-middle-income countries (LMICs), where more than 90% of deaths occur, compared to high-income countries [1,6,7].

Particularly, the morbidity and mortality due to AAP have escalated steadily over time, with an estimated 4.2 million annual deaths [3,8,9]. For this reason, it is important to monitor pollution data clearly and actuate optimized solutions in order to establish a new equilibrium among sustainability and human productivity and wellness [10]. Particulate matter (PM), nitrogen oxides (NO and NO_2), sulfur dioxide (SO_2), and ozone (O_3) are the major established ambient air pollutants responsible for adverse health effects [2]. Albeit in a declining trend, household air pollution (HAP) accounts for around 3.8 million deaths per year [11]. About 3 billion people, particularly in developing countries, continue to rely on inefficient and polluting fuels for various purposes such as cooking, heating, and lighting [2,5,12]. Therefore, HAP remains a great environmental health threat in low-and middle-income countries [13].

Air pollution, both AAP and HAP, aggravates health problems and escalates the likelihood of severe health impacts. Respiratory diseases and conditions are the most known and established health effects of air pollution; nevertheless, cardiovascular, cerebrovascular, reproductive, neurologic, and carcinogenic effects have also been associated with air pollution [14–18]. Non-communicable diseases (NCDs) contribute most of the global disease burden (GBD) [5] and air pollution is one of the top-ranking risk factors of NCDs. Air pollution accounted for 16% of all NCD deaths among those aged 30 to 69 in 2016 [13,19].

Every year, around 7 million people die prematurely because of an increased number of deaths from stroke, chronic obstructive pulmonary disease (COPD), heart disease, lung cancer, and acute respiratory infections (ARIs) caused by air pollution [2]. As per the estimation of the World Health Organization (WHO), ischemic heart disease (IHD) and strokes accounted for 58% of AAP-related premature deaths in 2016, while COPD and ARIs accounted for 18% and lung cancer for 6%, respectively [2]. On the other hand, pneumonia and ischemic heart disease accounted for 27% of HAP-related deaths, while COPD, stroke, and lung cancer accounted for 20%, 18%, and 8% of deaths, respectively [11]. This descriptive study, which is based on secondary data drawn from the GBD study, aims to estimate the impact of air pollution on the GBD in 2019.

2. Materials and Methods

This descriptive study accessed the data from GBD Study 2019 led by the Institute for Health Metrics and Evaluation (IHME) at University of Washington and publicly available via the GBD compare website [20]. The GBD study is a systematic way to quantify the comparative amount of health loss due to diseases, injuries, and risk factors by age, sex, and geographies for specific points in time. IHME makes this information freely available so that appropriate decisions can be made based on available evidence.

The GBD study uses various sources of data such as censuses, household surveys, health service use, civil registration and vital statistics disease registries, air pollution monitors, satellite imaging, disease notifications, and other sources from 1990 to 2019 in making estimates of the burden of disease (BoD) [21]. Several studies have shown the attribution of air pollution on BOD especially affecting several NCDs such as cardiorespiratory diseases [1,14,19,22].

For this article, we extracted data about mortality and disability adjusted life years (DALYs) which are attributable to air pollution from 1990 to 2019. The extracted data were then organized and presented in a usable format using STATA version 15. Furthermore, we also display the results for three categories based on their Socio-demographic Index (SDI) as calculated by GBD. This SDI is a composite indicator of development status, which ranges from 0 to 1 which is calculated as a geometric mean of the values of the indices of lag-distributed per capita income, mean education in people aged 15 years or older, and total fertility rate in people younger than 25 years. Hence, the SDI is a summary measure of a certain geographic or administrative boundary' socio-economic development was developed by GBD researcher.

3. Results

The impacts of air pollution on overall BOD by SDI, gender, type of pollution, and type of disease is estimated and their trends over the period of 1990 to 2019 are presented. Figure 1 illustrates the DALYs rate over a population of 100,000 attributable to air pollution in various SDI regions including a global DALYs trend over 29 years from 1990 to 2019. The global trend in DALYS rate attributable to air pollution declined from 1990 to 2019.

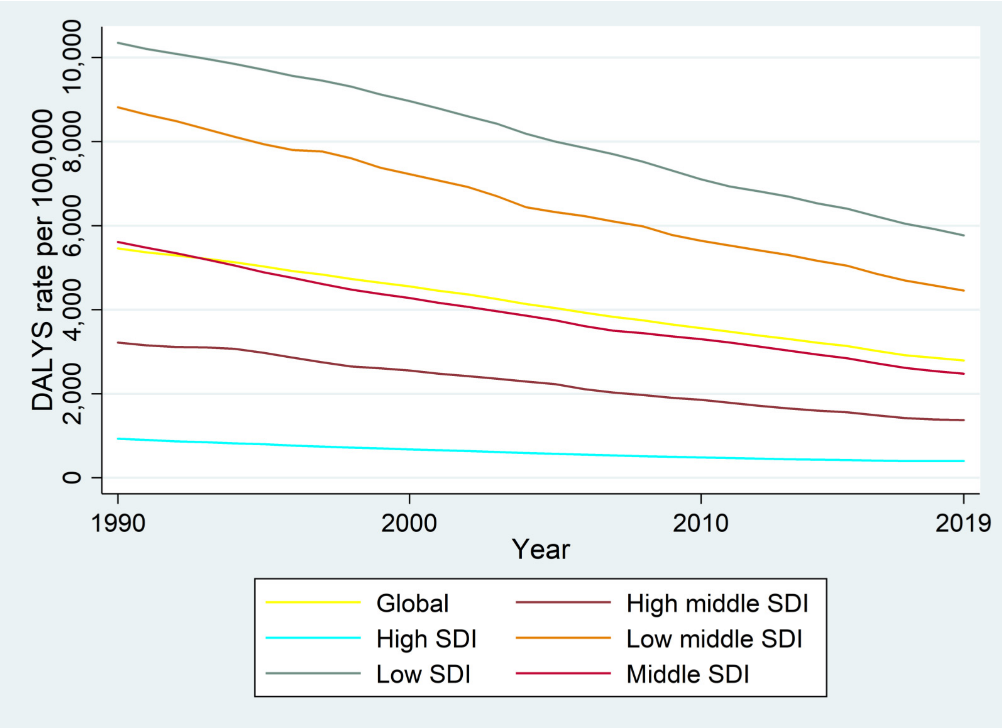

Figure 1. DALYs attributable to air pollution from 1990 to 2019.

Similarly, the DALYs rate in low SDI and low middle SDI regions fell gradually over time, albeit these regions continued to have the highest DALYs rates due to air pollution, respectively. From 1990 to 2019, the low SDI region accounted for most of the DALYs attributed to air pollution. In 1990, the middle SDI region had a greater rate of DALYs than the global average rate, but this rate began to decline slowly in the mid-1990s. Between 1990 and 2008, the high middle SDI region showed somewhat undulating trends, but the DALYs rate gradually declined between 2010 and 2019. From 1990 through 2019, the high SDI region experienced the lowest DALYs rate and remained considerably stable between 2008 and 2019.

Figure 2 shows the mortality rate per 100,000 population attributable to air pollution in various SDI regions of the word from 1990 to 2019. During a 29-year timeframe, death rate due to air pollution decreased in all five regions. However, three regions—middle SDI, low middle SDI, and low SDI—had higher death rates in comparison to the global average deaths rate, with the low SDI region having the highest death rates since 1990. In the low middle SDI region, the falling mortality trend rate showed a slight increase in the late 1990s, followed by an undulating trend from 1997 to 2015, and then a modest decline since then. On the other hand, the high SDI region had the lowest death rate per 100,000 attributable to air pollution from 1990 to 2019; nonetheless, the declining trend remained steady from 2009 to 2019.

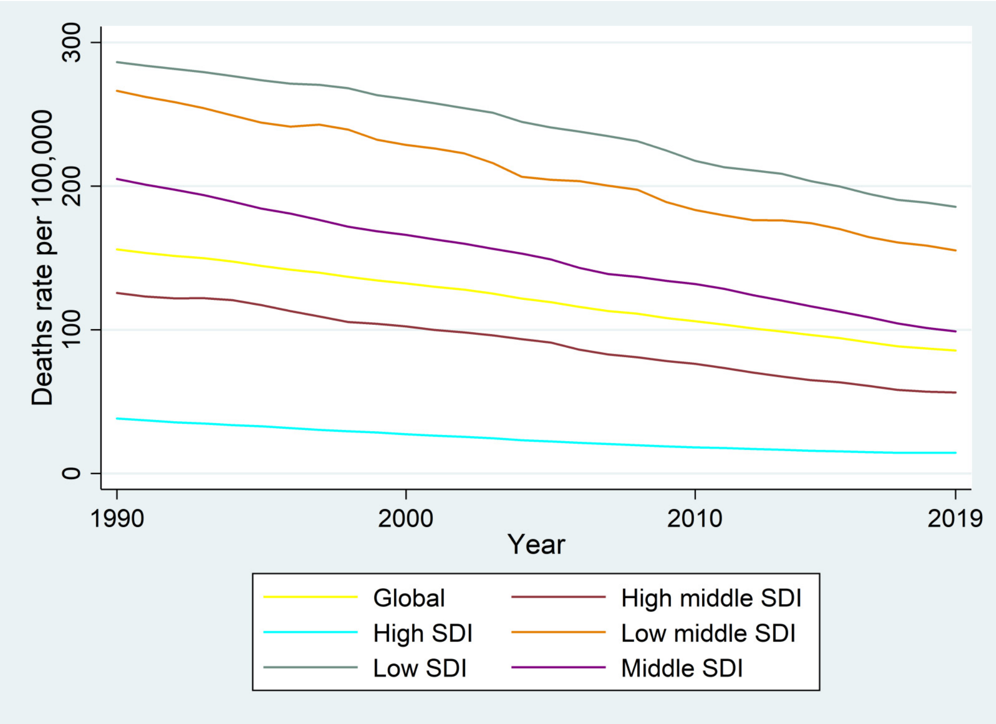

Figure 2. Deaths attributable to air pollution from 1990 to 2019.

The Figure 3 shows the gender-wise death rate attributable to air pollution from 1990 to 2019. Air pollution attributable death rate per 100,000 decreased considerably in both gender groups in the 29-year timeframe. However, in comparison to the female population, males were characterized by a greater mortality rate from 1990 to 2019. For the female population, the death rate attributed to air pollution was 135 per 100,000 in 1990, and the rate fell to 70 in 2019. For males, the mortality rate dropped from 185 in 1990 to 110 in 2019.

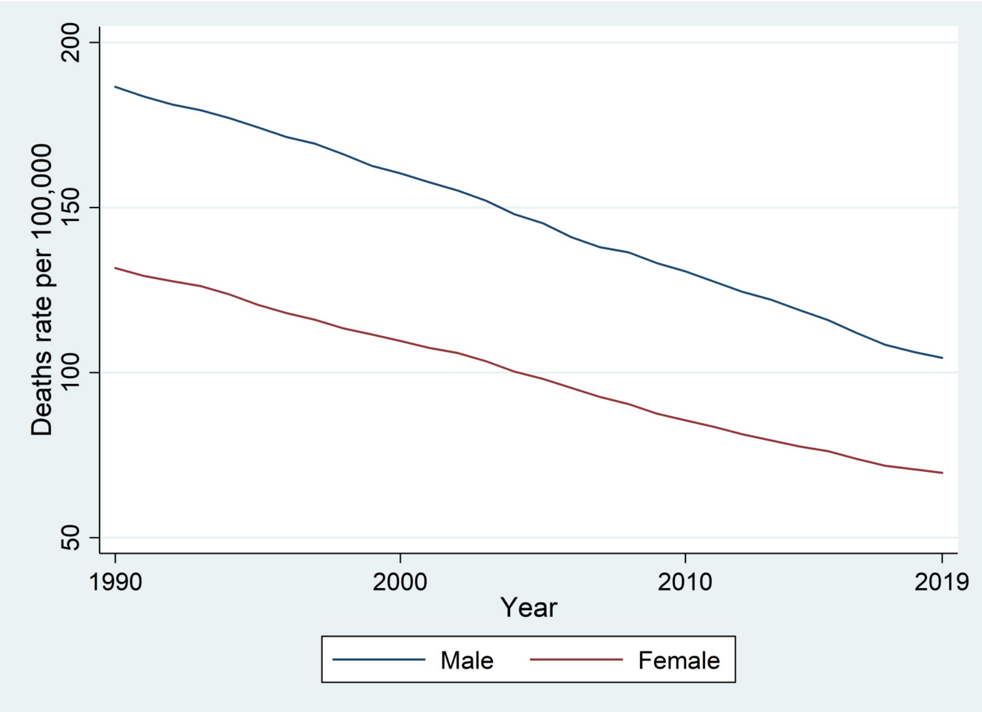

Figure 3. Gender-wise death rate attributable to air pollution from 1990 to 2019.

Figure 4 shows the death rate per 100,000 population attributable to ambient air pollution and HAP from 1990 to 2019. The graph illustrates that the death rate attributable to HAP plummeted from 81 per 100,000 population in 1990 to 30 in 2019; meanwhile, death rate attributable to AAP was just 39 per 100,000 population in 1990 but increased over the last 20 years. The death rate attributable to AAP somewhat fluctuated in between and reached a peak of 52 per 100,000 in 2015 and 54 per 100,000 in 2019.

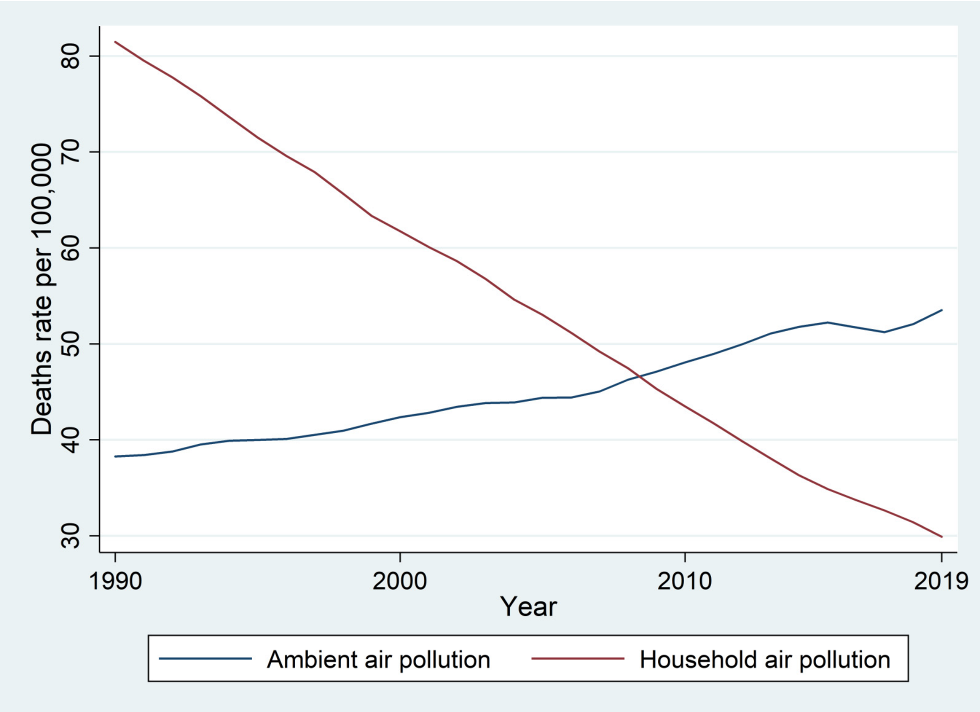

Figure 4. Different types of air pollution and attributable deaths.

Figure 5 shows the communicable maternal neonatal and nutritional diseases (CMNNDs) and NCD-related deaths rate attributable to HAP from 1990 to 2019. Both CMNNDs and NCD-related deaths per 100,000 due to HAP plummeted in the 29-year period. In this period, the death rates from CMNNDs and NCDs attributable to HAP lowered by 28%. Household air pollution accounted for a greater number of deaths from NCDs in comparison to CMNNDs diseases.

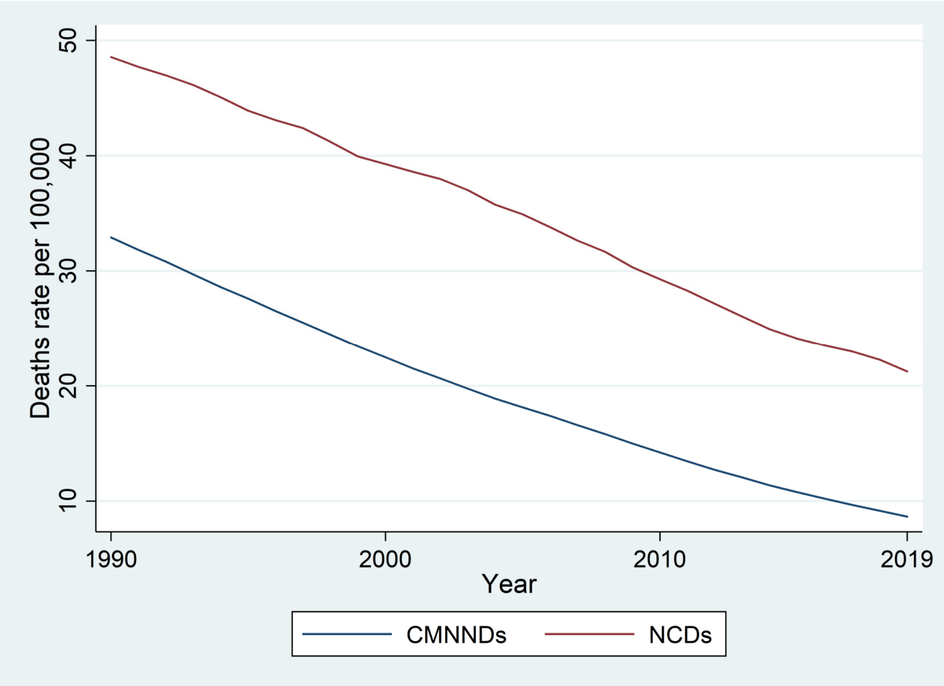

Figure 5. Deaths attributable to household air pollution from 1990 to 2019.

The Figure 6 illustrates CMNNDs and NCD-related deaths per 100,000 population attributable to AAP from 1990 to 2019. In comparison to CMNNDs , AAP significantly accounted for a higher death rate from NCDs. In 1990, AAP attributed to the death rate from NCDs was around 30 per 100,000 population, but by 2019 it surged up to 48. Meanwhile, the death rate from CMNNDs remained considerably low and stable in the same period.

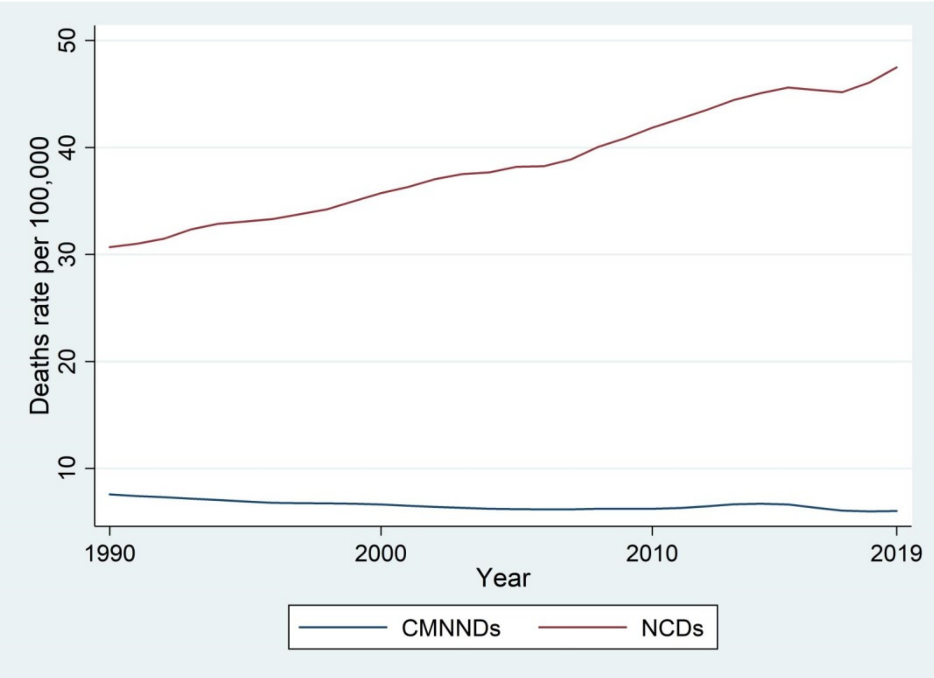

Figure 6. Deaths attributable to ambient air pollution from 1990 to 2019.

4. Discussion

Findings from this study revealed that air pollution declined between 1990 and 2019. The decline in air pollution could be due to two reasons. First, the millennium signalled increased awareness of unintended health outcomes due to air pollution. Rapid urbanization and globalization were ongoing that could increase air pollution. However, efforts towards reducing the risk of humans to air pollution secondary to energy generation were strengthened [23]. Although increased waste generation due to overcrowding in industrialized and commercial centres was a risk factor for the increased rate of waste generation, several studies investigated the measures through which air pollution could be minimized [24–26]. These measures, therefore, helped to identify that the combustion of fossil fuels and the generation of air pollutants due to industrial activities resulted in a trade-off of global health with financial sustainability. As a result, a large portion of the government's budgetary plan was channeled towards curative and preventive health costs since many productive hours were lost while seeking treatment for disability [27]. Thus, overall, air pollution was indeed contradictory to the government's aim of promoting the wellbeing of its citizens. As a result, increased involvement of experts in the medical and allied professions helped to understand the strategies for reducing ambient and household air production. The replacement of kerosene lamps and stoves with chargeable fluorescent lamps and gas cylinders for cooking alludes to this fact in many settings. Although a drastic change may be unattainable at the same point globally, all regions recorded a decline in DALYs due to air pollution.

We identified a decline in death rates due to air pollution across the five regions, with the low SDI region recording the highest death rates. Given the ongoing rapid commercialization, it is likely that environmental policy stringency measures such as the Clean Air Act contributed significantly to the reported decline in death rates due to air pollution between 1990 and 2019 [28]. The Clean Air Act is a comprehensive federal law under the auspices of the Environmental Protection Agency to establish National Air quality standards to promote environmental and public health [29]. As a result, the release of common air pollutants such as nitrogen oxides, particulate matter (PM2.5 and PM10) and ozone are placed under regular checks [30]. Agriculture, forestry, and land-use laws have helped to regulate ambient air pollution in many countries in the low SDI region whose economy primarily thrives on agriculture. Since ambient air pollution caused many NCD-related deaths, this elucidates that ambient air pollution is one of the drivers of the development of NCDs. If left unchecked, there is a high likelihood to record a surge in DALYs due to NCDs. To ensure that a steady decline in death rates and development of NCDs due to air pollution, policymakers are required to have high stringency regarding indiscriminate air pollution.

This study found that males had a higher mortality rate due to air pollution between 1990 and 2019. This finding shows that males are more likely to be users of technologies that emit air pollutants than females. Literature has reported that females are more likely to die due to CVDs than primarily from air pollution compared to males. This was confirmed from a study conducted in Poland where it was found that the effect of SO_2 inhalation was more pronounced in males [31,32]. As a result, the inhalation of this pollutant could cause pulmonary inflammation, resulting in thrombosis, endothelial dysfunction, imbalance of the autonomic nervous system, increased arterial pressure, and ultimately death [32–36]. The exact pathophysiologic mechanisms that underlay gender differences in the death rate due to air pollution are unknown. Pollution control measures should be considered and implemented promptly to avert preventable deaths.

5. Conclusions

Globally, air pollution is still a major risk factor which continues to pose a significant threat to environmental safety and public health. If the drivers and sources of air pollution are not immediately controlled, more air pollution-related deaths are likely to result.

In addition, higher DALYs and NCDs are bound to occur frequently. Despite the decline of DALYS attributable to HAP, the attributable burden of AAP is increasing over the years globally. Hence, air pollution prevention and control policies are urgently required to reduce burden of diseases attributable to air pollution at the global, regional, and national level.

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Conflicts of Interest: The authors declare no conflict of interest.

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