Global burden of diseases attributable to air pollution

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Abstract

Air pollution has remained a major issue of concern over the years with serious toxicological effects on human health. This paper evaluates the comparison of estimates and describes the global burden of diseases related to air pollution in the regions of WHO from 1990 to 2015. The study uses existing data from IHME on global burden of diseases (Mortality and Disability Adjusted Life Years) related to air pollution such as Trachea, Bronchus and Lung cancer, COPD, Ischemic heart disease and Stroke. This study shows that air pollution is one of the major environmental risk factors for the global burden of disease in 1990-2015 and has remained relatively stable for the past 25 years. By region, the largest burden of disease related to air pollution is found in Western Pacific and South-East Asia, reflecting the heavy industry and air pollution hotspots within the developing nations of these regions. Moreover, the rates of Disability Adjusted Life Years increased because of increase in pollution, especially in South-East Asia region, African region, and Eastern Mediterranean region where populations are both growing and ageing.

Introduction

Air pollution is the presence of toxic chemicals or compounds (including those of biological origin) in the air, at levels that pose a health risk.[1] In an even broader sense, air pollution means the presence of chemicals or compounds in the air which are usually not present, and which lower the quality of the air or cause detrimental changes to the quality of life.[2] Globally, it is estimated that air pollution is responsible for 3.1 million premature deaths worldwide every year and 3.2% of the global burden of disease.[3-6] Epidemiological studies revealed that there is a link between air pollution and diseases with public health importance such as cardiovascular diseases for instance stroke and ischemic heart disease, cancers, and respiratory diseases.[4] Respiratory diseases related to air pollution include acute respiratory infections, chronic obstructive pulmonary diseases and asthma.[3,5]

Regionally, low and middle-income countries in the WHO's South-East Asia and Western Pacific Regions had the largest air pollution related burden in 2012, with a total of 7.1 million deaths.[5] The South East Asian and Western Pacific regions bear most of the burden with 2.2 and 2.8 million deaths respectively.[5] More than 600,000 deaths occurred in Africa, 394,000 in the Eastern Mediterranean region, 287,000 in Europe and 131,000 in the region of Americas. The remaining 472,000 deaths occurred in high income countries.[5,6]

Materials and Methods

Data sources

I accessed official website of Institute for Health Metric and Evaluation (IHME) through the Global burden of disease project (*vizhub.healthdata.org/gbd-compare/*). IHME is an independent global health research center at the University of Washington that provides rigorous and comparable measurement of the world's most important health problems and evaluates the strategies used to address them. IHME makes this information freely available for students, researchers, and policymakers so that they can have the evidence they need to make decisions about how to allocate resources to best improve population health.

Previous epidemiological studies revealed that air pollution is a risk factor for diseases with public health importance such as cardiovascular diseases for instance stroke and ischemic heart disease, cancers, and respiratory diseases, hence these diseases were used as an indicator for search to generate the data from IHME database.

I downloaded data on burden of disease (Mortality and Disability Adjusted Life Years) on Trachea, Bronchus and Lung cancer, Chronic Obstructive Pulmonary Disease, Heart disease, and Stroke attributable to air pollution; the data were then organized and edited into a usable format. Data gotten from IHME was used for comparable estimates of exposure to air pollution and its associated health effects in the region of WHO from 1990 to 2015. The study used a variety of measures including Microsoft Excel 2013 to generate graphical presentation of the data. The data and methods have their origins with IHME's GBD project and, particularly, its major update in 2010, which substantially expanded the analyses.

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Database for literature search

Research articles were identified through five databases –World Health Organization (WHO) Environmental Protection Agency (EPA), Cochrane library, Friends of the Earth (FOE), and PubMed. The databases were sorted in order of relevance and key words such as *global disease burden related to air pollution* were used.

Results: disease burden attributable to air pollution in regions of WHO

Chronic obstructive pulmonary disease's disability adjusted life years related to air pollution

Figure 1 Shows the COPD DALYs attributable to air pollution in the regions of WHO from 1990 to 2015. Four regions—European region, African region, Eastern Mediterranean region, and region of the Americas experienced a decline in COPD DALYs per 100,000 population between 1990 to 2015. Western Pacific region had the highest rate of COPD DALYs as of 1990, however, the region experienced a significant decrease in COPD DALYs ever since, while South-East Asia had the highest rate from year 2000 to 2015.

Chronic obstructive pulmonary disease's mortality related to air pollution

Western Pacific and South-East Asia region each had the highest COPD deaths rate attributable to air pollution from 1990 to 2015 (Figure 2). However, much has been achieved over the years in Western Pacific region, and that has led to the decrease in the death rate from COPD in the region, while South-East Asia region experienced a slight increase from COPD deaths between 2010 and 2015. The trends in COPD attributable death rate were relatively stable in the Eastern Mediterranean region, European region, region of the Americas, and African region respectively.

Trachea, bronchus and lung cancer DALYs related to air pollution

Figure 3 demonstrates the Trachea, Bronchus and Lung cancer DALYs with the highest rate occurred in Western Pacific region. Western Pacific region and European region account for most of the air pollution attributable the Trachea, Bronchus and Lung cancer DALYs in the studied time period, and the Western Pacific region accounts for the highest rate of the global increase since 1990. South-East Asia region and Eastern Mediterranean region experienced a continued increase since 2010, while the rate in African region, and the region of the Americas remained relatively stable.

Trachea, bronchus lung cancer deaths related to air pollution

Western Pacific region experienced some of the largest increase in Trachea, Bronchus and Lung cancer deaths rate and has continued to increase over the years, however, the rate has become stable in 2015. The death rate in European region has decreased since the year 2005 as indicated in Figure 4. South-East Asia and Eastern Mediterranean region experienced a slight increase since 2000 in air pollution attributable to Trachea, Bronchus, Lung cancer deaths. The rate in the region of the Americas and African region remained relatively stable.

Ischemic stroke DALYs attributable to air pollution

Figure 5 shows the spatial pattern of change in DALYs from Ischemic stroke attributable to air pollution in the regions of WHO from 1990 to 2015. The Western Pacific region topped the list in 1990, the region experienced a rapid increase in 1995, stabled in 2005, then a slight fall in 2010, and the rate continued to decline ever since.

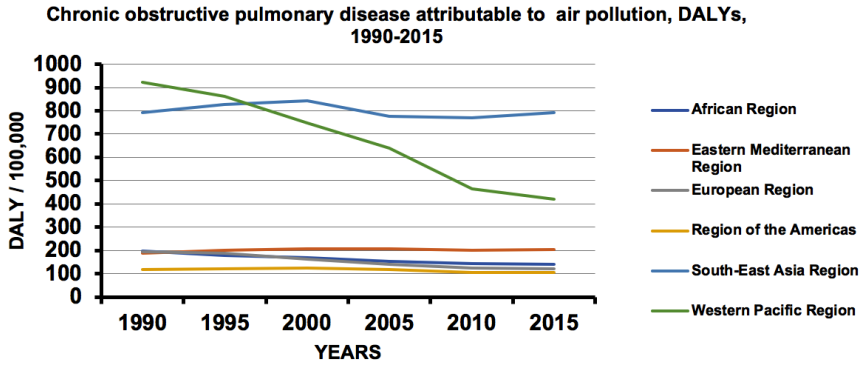

Figure 1. Chronic obstructive pulmonary disease attributable to air pollution, DALYs 1990-2015.

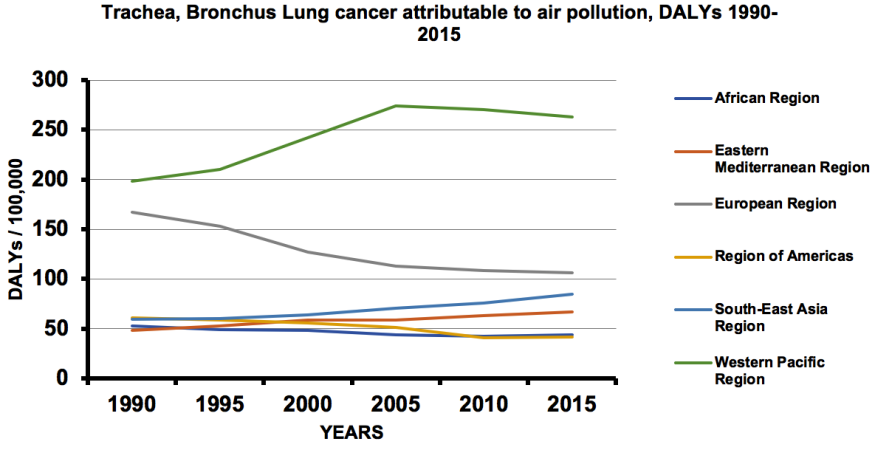

Figure 2. Chronic obstructive pulmonary disease attributable to air pollution, Deaths 1990-2015.

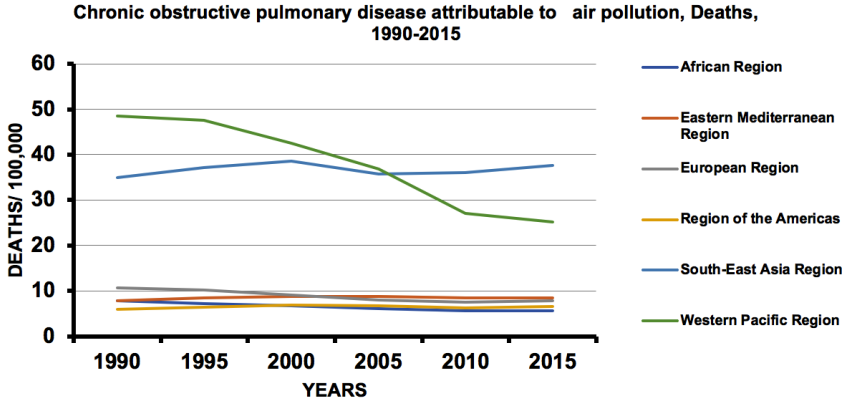

Figure 3. Trachea, Bronchus Lung cancer attributable to air pollution, DALYs 1990-2015.

The European region had the second highest Ischemic stroke DALYs rate in 1990, however, there was a notable decreased until 2005. Between 2010 and 2015, the rate was considerably stabled. Not all regions of WHO have seen this decrease. In South-East Asia, Ischemic stroke DALYs increased between 1990 and 2000, however, the rise was significant in 2005. In contrast, since 1995 Ischemic stroke DALYs rate is reduced in the region of the Americas, and African region. Particularly in African region, the rate has been relatively low during the studied period as compared to other regions.

Ischemic stroke deaths attributable to air pollution

Ischemic stroke deaths attributable to air pollution exposure from 1990 to 2015 varied considerably among the regions (Figure 6). In 1990 European region experienced the highest deaths rate from ischemic stroke but the rate has decreased significantly over the years. Western Pacific region experienced the second highest rate in 1990 and the trend have increased until 2005, however, the rate has continued to drop ever since. The death rate of ischemic stroke of the South-East Asia region has steadily increased since 1990. Region of the Americas experienced the lowest rate over the years.

Ischemic heart disease's disability adjusted life years attributable to air pollution

Progress is evident in the reduction of Ischemic heart disease DALYs since 1990 in European region though there is still much to be done (Figure 7). However, at the same time, highest rate of Ischemic heart disease burden was found in a geographic band including South-East Asia, and Eastern Mediterranean region. Western Pacific region experienced a rise since 2005 than the previous years, Africa region, and region of the Americas with the lowest rate.

Ischemic heart disease deaths attributable to air pollution

Ischemic heart disease death rate increased in the Eastern Mediterranean region, South-East Asia, and Western Pacific region from 1990 to 2010. However, the rate had been stabled in Eastern Mediterranean region in 2015. Western Pacific region experienced a decrease in the rate in 2015, unfortunately even as 2015, South-East Asia continued to experience the highest rate. In European region with the highest rate in 1990 experienced a significant decrease during the study period

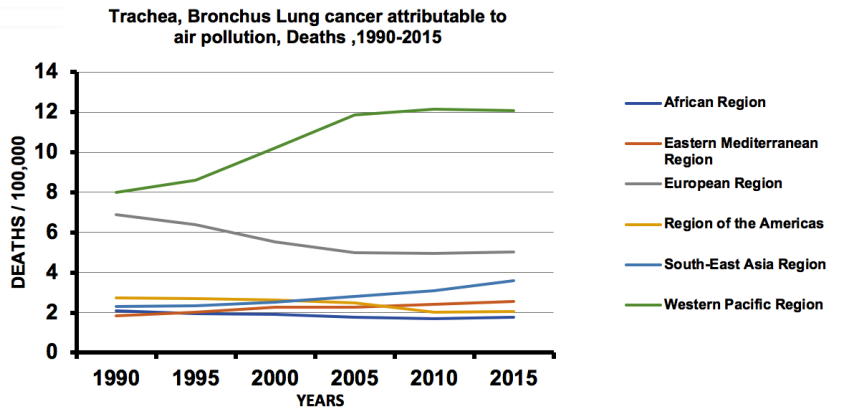

Figure 4. Trachea, Bronchus Lung cancer attributable to air pollution, Deaths 1990-2015.

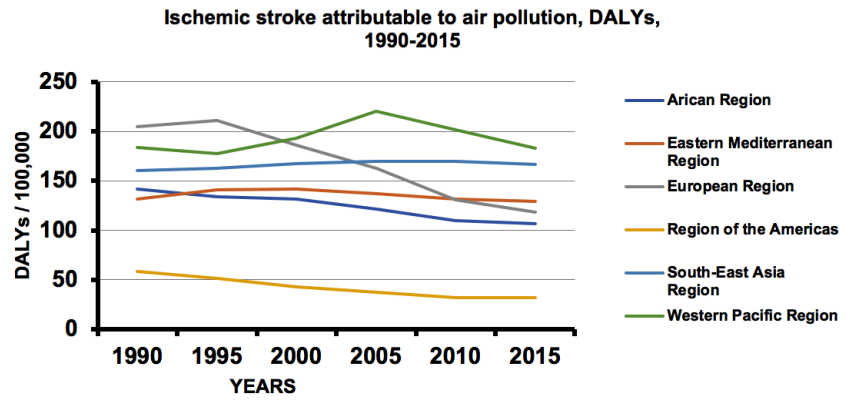

Figure 5. Ischemic stroke attributable to air pollution, DALYs 1990-2015.

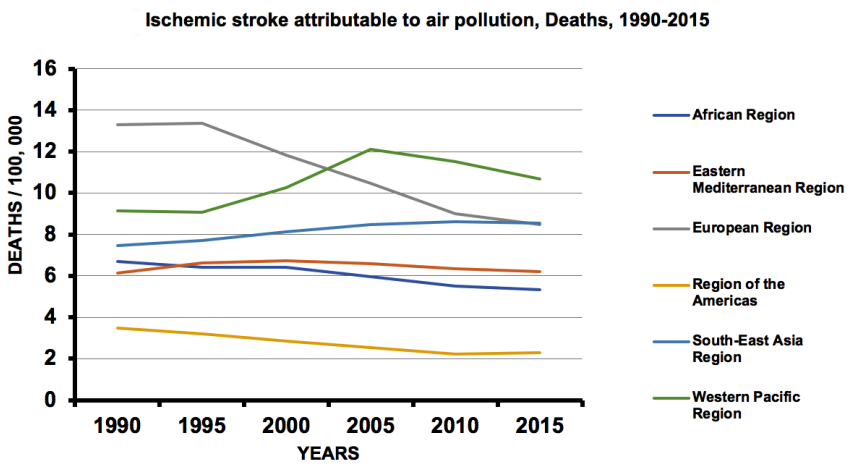

Figure 6. Ischemic stroke attributable to air pollution, Deaths, 1990-2015.

(Figure 8). In African region and region of the Americas had experienced a decrease in deaths rate of Ischemic Heart Disease in the previous years, however, the rate has been stable since the beginning of 2015.

Discussion and Conclusions

This study described the global burden of disease related to air pollution and compared the estimates of the burden among the WHO regions of the world. This study shows that air pollution is one of the major environmental risk factors for the global burden of disease in 1990-2015 and has remained relatively stable for the past 25 years.

By region, the largest burden of disease related to air pollution is found in Western Pacific and South-East Asia (Figures 1-8), reflecting the heavy industry and air pollution hotspots within the developing nations of these regions. However, the problem is very much a global one. Focusing on European region, air pollution is again the biggest environment risk factor behind premature death.[6-10]

Deaths and DALYs attributable to air pollution differed widely by region of the world. Figure 1 shows that the highest COPD mortality rates and DALYs were observed in South-East Asia region with 39 deaths per 100,000 people and 791 DALYs per 100,000 people in 2015, followed by Western Pacific region with 25 deaths per 100,000 people and 421 DALYs per 100,000. Rates were 4 to 8-fold lower in European region having 7 deaths per 100,000 people and, 121 DALYs per 100,000 respectively. The highest rate of Lung cancer deaths and DALYs were observed in Western Pacific region over the years. There were an estimated 263.33 DALYs per 100, 000 people and 12.09 deaths per 100,000 people in Western Pacific region in 2015, while European region experienced the lowest DALYs and death rate from Trachea, Bronchus, and Lung cancer with 106 DALYs per 100,000 and 5 deaths per 100,000. Western Pacific region had the highest rate of ischemic stroke deaths and DALYs in 2015, followed by South-East Asia and region of Americas. Compared to COPD, Ischemic stroke, Trachea, Bronchus and Lung cancer, Ischemic heart disease's DALYs and death rate was generally higher in all the regions, mainly reflecting different historical exposure to tobacco smoking. Thus, the highest estimated rates were in South-East Asia having 943 DALYs per 100,000 people and 38 deaths per 100, 000, the lowest was observed in the region of the Americas with 271 DALYs per 100,000 people and 14 deaths per 100, 000 respectively.

Exposure to air pollution caused over 7.0 million deaths and 103.1 million lost years of healthy life in 2015, caused an estimated 7.6% of total global mortality in 2015.[3,5,10] However, between the studied period, mortality rate due to air pollution decreased slightly in region of the America and European region respectively. This decrease is because of improved air quality in high-income countries and declining mortality rates for cardiovascular diseases. In contrast, the rates of DALYs increased because of increase in pollution, especially in South-East Asia region, African region, and Eastern Mediterranean region where populations are both growing and ageing (Figures 1-8).

Emission of particles and chemicals into the atmosphere by industrial processes is one of the biggest causes of air pollution in developing countries.[6,7] Especially impacted by these pollutants are poor communities and countries since lower income regions tend to attract polluting industries, either by not having the political power to stop it, providing a cheap source of labour for the industry, or by having inadequate environmental laws than wealthier countries.

Environmental Kuznets curve (EKC) can be used to study the relationship between economic development and air pollution levels in developing countries.[6,8] During the early stage of economic development, air pollution level is generally low. However, when economic development reaches an intermediate stage, air pollution concentration levels tend to increase appreciably or even rise sharply if no effective ameliorating measures are taken. It might then reach an inflection point later at a higher development stage due to better environmental awareness and relevant control measures taken in protecting the environment. As zero risk is neither practical nor necessary, it is crucial to set appropriate air pollutants guidelines for air pollution management to meet. According to the EKC

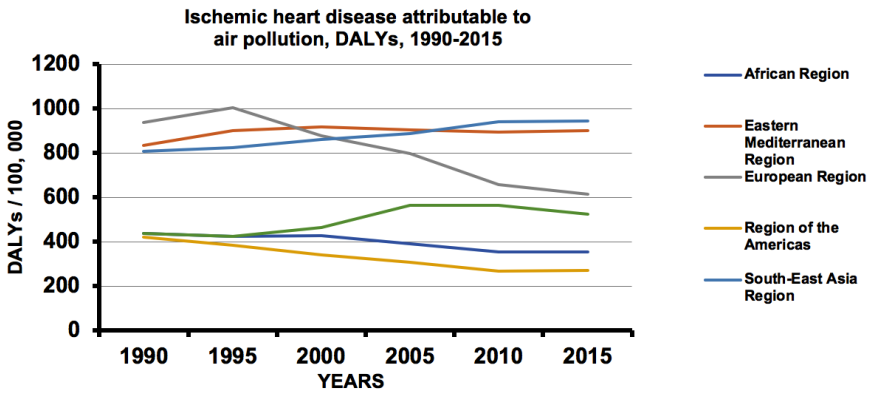

Figure 7. Ischemic heart disease attributable to air pollution, DALYs 1990-2015.

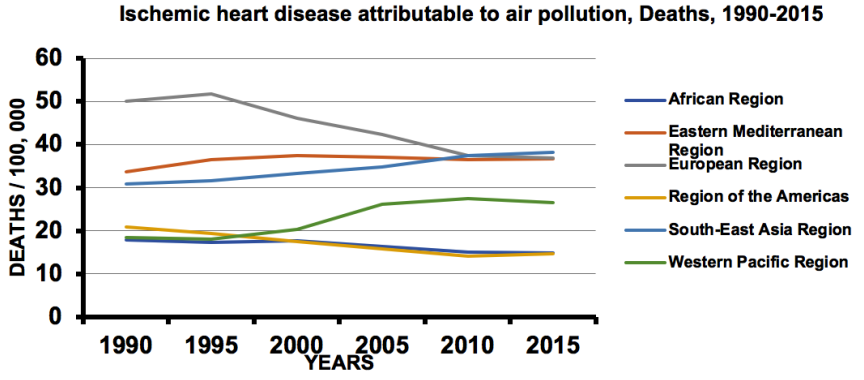

Figure 8. Ischemic heart disease attributable to air pollution, Deaths 1990-2015.

proposition, developing countries are on the rising part of the EKC (early stage of economic development) and developed countries are in the falling part of the EKC (advanced stage of economic development).[6,8] Many scientists noted that developing countries are at that stage of economic development, where Japan was 50 years ago, USA was 100 years ago, and the UK was 150 years ago.[7,8] Income growth in these advanced countries also led to rapid growth of pollution but, this does not imply that developing countries would also be able to follow the same growth path of advanced countries.

It has been advocated many times, interventions to reduce levels of air pollution require a concerted action by a host of sectors with a vested interest in air quality management (environment, transport, energy, health, and housing) at regional, national and international levels. The significant toll of ill health brought about by traffic-related pollutants means that integrated transport policies are critical for the improvement of urban environments.[6,9,10] Traffic must be reduced, and we must ensure a cleaner and greener element to what remains on the road. This can be achieved through an expansion of low emission zones, investment in clean and affordable public transport and incentives for its use, a move back from diesel to petrol or at least a ban on all highly polluting diesel vehicles, lowering speed limits and enhancing cycle routes.

Another intervention in moving towards a cleaner and healthier environment necessitates behavioural changes by the public, which in turn requires continued education and optimal communication.[6,7,9]

In an ideal world, people, and especially susceptible individuals should be aware of their air quality by regularly checking the air quality or targeted notifications for real-time data before going to work, school or to pursue leisure activities, enabling them to act in the event of increased pollution. Translating the correct scientific evidence into bold, realistic and effective policies undisputedly has the potential to reduce air pollution so that it no longer poses a damaging and costly toll on public health.[6-9]

As a result, the challenges for future reductions in the burden of disease attributable to air pollution are substantial. Exposure to ambient air pollution and its associated burden of disease can potentially be lowered for entire populations via policy action at the national and subnational levels. As the experience in the USA and EU emission standard suggests, changes in ambient $PM_{2.5}$ associated with aggressive air quality management programs, focused on major sources of air pollution including coal combustion, household burning of solid fuels, and road transport can lead to increased life expectancy over short timeframes.

In summary, air pollution contributes substantially to the global burden of disease, which has increased over the past 25 years. This increase is because of both demographic and epidemiological trends and increasing levels of air pollution in low-income and middle-income countries. Should these trends continue, major reductions in pollution levels will be needed to avoid increase in disease burden. Moreover, there might not be a modest reduction in burden in the most polluted countries unless exposure to $PM_{2.5}$ and other air pollutants decline markedly.

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