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INCREASING THE VISIBILITY AND KNOWLEDGE BASE ON AIR QUALITY WITH BIG DATA AND ITS IMPACT ON THE POPULATION HEALTH

Erasmus+ KA220 Cooperation Partnerships

# IMPACT OF AIR POLLUTION ON HUMAN HEALTH AND PUBLIC FINANCES


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## 1 INTRODUCTION

We live in an era that offers us countless opportunities for development in the field of industry and technology, which, however, also brings with it various pitfalls for the population and living organisms of planet Earth, such as the emergence of climate change or the impact on human health due to air pollution (Manisalidis, Stavropoulou, Stavropoulos & Bezirtzoglou, 2020). To clarify what air pollution means, it is the pollution of the surrounding atmosphere due to the presence of chemicals, gases, or particulate matter that cause discomfort, increase morbidity and mortality (Almetwally, ABin-Jumah & Allam, 2020). We can also talk about the destructive effect of any source that pollutes the atmosphere and/or degrades the environment through its activities (Ghorani-Azam et al., 2016). A large part of air pollutants come from so-called secondary sources which are formed by chemical reactions between different gases. The most common are gases emitted by industrial plants, power plants, automobile emissions, and high-rise buildings, which are dispersed into the atmosphere spreading over cities and surrounding villages (Mishra et al., 2023). Most of the global population is exposed to harmful levels of air pollution. Each year, this exposure leads to millions of premature deaths, and many more live with long-term health issues from inhaling polluted air. In 2021, air pollution contributed to 8.1 million deaths — more than 1 in 8 deaths worldwide. Air pollution was the second most significant risk factor for early mortality globally, surpassed only by high blood pressure (Health Effects Institute, 2024). The respiratory tract (from the nasal airways to the airways to the alveolar gas exchange units in the lungs) linking the immune system and the external environment are the first to be affected in air pollution (Glencross, Ho, Camina, Hawrylowicz & Pfeffer, 2020). During respiration, the aforementioned substances enter the respiratory system through inhalation, which later induce diseases of the respiratory tract, cardiovascular system (Karl et al., 2009), cause disorders of the reproductive and central nervous systems, as well as cancer (Manisalidis, Stavropoulou, Stavropoulos & Bezirtzoglou, 2020). Sometimes, pollution leads to immediate health issues, but most health effects develop gradually over time. For many decades, scientific research has highlighted various health effects linked to air pollution, as shown Figure 1. Short-term spikes in pollution levels can worsen asthma symptoms and temporarily increase hospital admissions for heart and lung issues. However, it is long-term exposure to polluted air that causes the most serious health impacts. Prolonged exposure over months or years can lead to illnesses and premature death due to heart and lung diseases, diabetes, and it also raises the risk of adverse birth outcomes, such as preterm births, stillbirths, and miscarriages (Health Effects Institute, 2024).

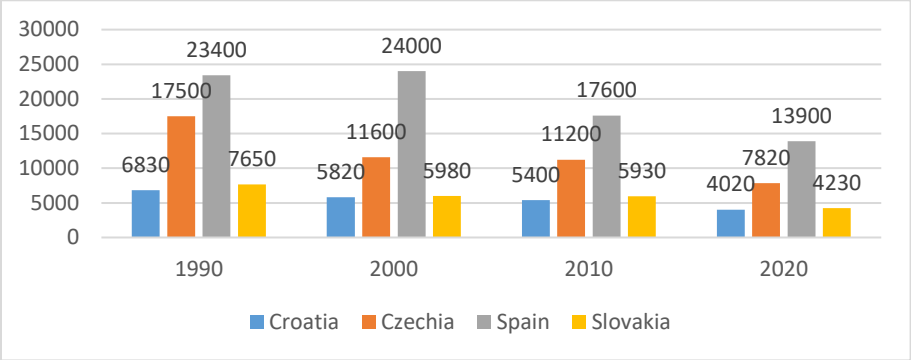


**Figure 1:** Number of deaths attributable to air pollution in selected countries

Source: Health Effects Institute. 2024. State of Global Air 2024.

If air quality is not improved, by mid-century, outdoor air pollution will cause one premature death every five seconds. Without stricter policies, annual premature deaths could rise to 9 million by 2060. The highest number of these deaths are expected to occur in densely populated areas with high levels of PM2.5 and ozone (notably in China and India) and in regions with aging populations, such as China and Eastern Europe (OECD, 2016). Currently, air pollution continues to have significant impacts on the health of Europeans as well, particularly in urban areas, where EU air quality standards for the protection of human health are regularly exceeded. Among the pollutants posing the greatest health risks are particulate matter, nitrogen dioxide, and ground-level ozone, all of which have been associated with serious long-term health consequences (European Environment Agency, 2023).

In addition, according to a Swedish cohort study, air pollution is also responsible for the development of diabetes if the human body is exposed to it for a long period of time (Hromadka, Korposh, Partridge, James, Davis, Crump & Tatam, 2017). Environmental pollution is a global problem that is not only related to public health, but also interferes with the social, economic, or legislative aspects of the population and their lifestyles (Glencross, Ho, Camina, Hawrylowicz & Pfeffer, 2020). It also has an impact on labour productivity, the number of hours worked by farmers or the cognitive performance of students in schools and universities. Pollutants that create smog and acid rain not only damage the respiratory tract but are also responsible for ozone depletion, which also contributes to global warming (Choe et al. 2018; Padula et al. 2019; Tofield 2017; Zhao et al., 2019a). Consequences caused by climate change or global warming bring serious risks such as ecosystem disruption, melting glaciers, extinction or damage to fauna and flora, or food security issues (Karl et al. 2009 & Marlon et al. 2019).

As Almetwally et al. (2020) state in their study, we can classify air pollution based on its source, origin, chemical composition, magnitude, and release from indoors or outdoors (Bernstein et al, 2004).The most common natural sources of pollution are forest fires, volcanic eruptions,

dust storms, pollen grains, radon gas produced by radioactive decay of the Earth's crust, microorganisms, natural radioactivity, fog, haze, or the aforementioned ozone (Appannagari, 2017).Pollutants caused by natural factors have less impact on the environment precisely because of their ability to regenerate rapidly. On the other hand, we have the so-called anthropogenic air pollution, which has become one of the biggest global risks through 9 million deaths per year (WHO, 2019).

## 2 BACKGROUND

In their research, Almetwally et al. (2020) divide man-made pollution into three groups of sources namely point, area and line sources. Oil refineries, power plants, paper mills or pulp and wood processors are examples of point sources that are significant polluters in combination with area sources. Examples of area sources include dry cleaners, paint shops, landfills, bakeries, or petrol stations, etc. (Kibble & Harrison, 2005). Another way we can classify air pollutants is into mobile pollutants such as trucks or cars, buses, planes, ships or trains and stationery (non-mobile) pollutants represented by chemical plants, industrial parks, power plants, and oil refineries (Fujita et al., 2014). Meireles et al. (2021) studied the transport sector, which has built its negative popularity by its carbon footprint in 11 Mediterranean countries. Based on their findings, they assess that fiscal instruments such as transport taxes and vehicle registration taxes on CO2 emissions actively contribute to CO2 emissions in the long run. According to Safi et al. (2021), the collective's research highlights the potential of using environmental taxes as an important instrument that could not only counteract ever-increasing emissions with its effects but could even lead to carbon neutrality. The fact is, however, that economic growth is an incentive mechanism for increasing car purchases, which in the long term has a negative impact on the environment. One of the most recent recommendations is to motivate the population to buy electric or more environmentally friendly vehicles, especially in Mediterranean countries (Dahmani, 2024). Even though cars are one of the most influential external emitters of pollutants (Tran, Park & Lee, 2020), research has shifted in the last decade to the knowledge of indoor factors, which tells us that there have been changes in the lifestyles and behaviours of the inhabitants and this is due to increased urbanisation as described by Ekmekcioglu & Keskin (2007). Hromadka et al. (2017) highlight the impact of reduced indoor environmental quality due to the emergence of diseases associated with buildings and interiors. The consequence of changes in the socio-economic sphere just in areas with high urbanization is created by the continuous process of globalization which is also facilitated by the growing trend of sustainable development (Yang et al., 2022). In addition, studies on the migration of populations to larger cities have been reported (Adger et al., 2020), which has also been predicted by the United Nations (2014). The problem of urbanization also contributes to significant climate change, both locally and globally (Koch, 2021). Cichowicz & Bochenek (2024) confirm, in conjunction with increased urbanization, the non-negligible influence of anthropogenic factors that add to the number of concentrated pollutants in the urban

environment. Lin et al., (2018) in their research states that the rate at which air pollution has started to become an unpredictable global problem. According to a collective of authors, air pollution is a collective problem with its sources emanating from social, economic, and ecological systems (Mason et al., 2019; Sueyoshi & Yuan, 2015). By introducing strict laws, regulations or emission plans, countries are constantly trying to protect citizens and improve air quality, but this is still an insufficient measure to combat pollution and its impact on human lives (Khreis et al., 2016 & Vedrenne et al., 2015). Currently, there are strategies to significantly help improve air quality, but they are dependent on the estimation of the economic value of the benefits due to the proposed programs that have been developed under the guidance of public authorities, and which must be followed and respected (Manisalidis, Stavropoulou, Stavropoulos, & Bezirtzoglou, 2020). Similarly, Brauer et al. (2016) also describe that governments have begun to implement clean air policies, strategies, and plans across the board to eliminate air pollution emissions, thereby achieving improvements in the health status of the population (Yang, Teng & Wang, 2013). It is for this reason that air pollution is a matter of public concern for two main reasons, namely firstly, the protection of public health and secondly, the impact on the country's economy (Chen et al., 2017).

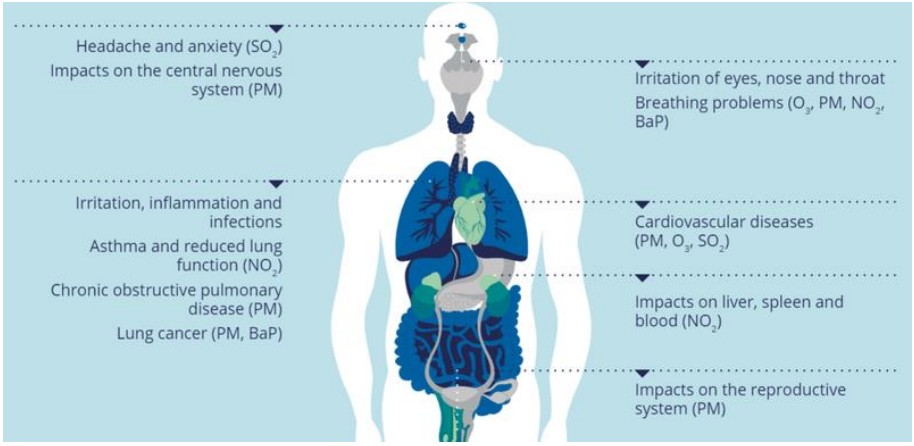


**Figure 2:** The impact of air pollution on human health

Note: Particulate matter with a diameter of 2.5 µm or less ($PM_{2.5}$), particulate matter with a diameter of 10 µm or less ($PM_{10}$), ozone ($O_3$), nitrogen dioxide ($NO_2$), benzo[a]pyrene (BaP) and sulphur dioxide ($SO_2$).

Source: European Environment Agency. 2024. How air pollution affects our health.

Sensitivity to air pollution, is not uniform across all individuals; it varies significantly based on factors including age, nutritional status, genetic predispositions, and overall health. Specific "sensitive groups"—such as children, pregnant women and their unborn children, individuals

with malnutrition, people with chronic health conditions, and older adults face an increased risk of negative health effects when exposed to poor air quality, see Figure 2 (Ministry of Environment of the Slovak Republic, 2023). Additionally, studies strongly associate lower socio-economic status with higher air pollution exposure, as many low-income populations in Europe live near busy roads or industrial sites, increasing their risk. Regions in Europe with lower GDP per capita, particularly in Eastern and Southeastern Europe, tend to have higher levels of PM2.5 pollution which correlates with more premature deaths linked to air pollution (European Environment Agency, 2024).

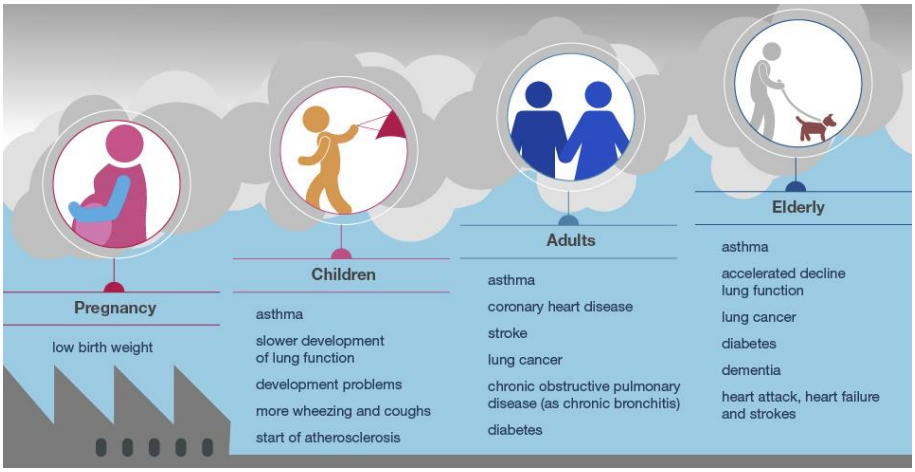


**Figure 3:** The impact of air pollution across different stages of life

Source: Office for Health Improvement and Disparities. 2022. Air pollution: applying All Our Health

## 3 CONCLUSION

Zhang et al. (2019) also describe the timeliness of addressing climate change and its green finance. The bridge between the state of environmental pollution and economic growth is most often the environmental Kuznets hypothesis (Feng et al., 2024), which has an inverted U-shaped curve called the EKC, which, in addition to Grossman & Kruger (1992), has also been confirmed by other scholars such as Xu, Luo & Lin (2016) or Sha & Ming (2020) , and points out that with economic development, air pollution (sulfur dioxide emissions, chemical oxygen demand, smoke and dust) will first increase and then decrease. According to Feng et al. (2024), the research results conclude by highlighting that investing in green finance has a very significant and positive impact on the development of the economy, while green finance also has a certain impact on the management of emerging pollutant emissions. We can confidently assert that as economies grow, the problems associated with air pollution are also increasing worldwide (Feng et al., 2019), therefore, the issue of environmental protection related to the

expansion of industrial zones is a crucial issue in policy discussions worldwide as well as in China (Li et al., 2017 & Kim et al., 2016), including the design of possible solutions to eliminate air pollution (Sueyoshi & Yuan, 2015). To better understand the air pollution situation in developing countries, an appropriate procedure should be developed to properly understand the sources, impacts and design appropriate measures as it is a complex problem (Khan et al., 2024). If we turn our eyes to the EU, to meet the climate targets under the EU Green Deal, additional public investments are projected at 0.5-1% of GDP per year during this decade (Darvas & Wolff, 2023), or 1-1.8% of GDP (Ferdinandusse, Nerlich & Téllez, 2022). The question that troubles the authors of the paper (Kantorowicz et al., 2024) concerns government spending financed by taxpayers' money and thus whether or under what conditions voters are willing to support so-called co-financing of this type of investment. Some of the more recent climate governance-oriented studies tend to focus on formal environmental regulation, with an emphasis on government-driven legal and administrative measures affecting microenterprises (Shi et al., 2023), whereas the most numerous studies deal with public concerns about the environment and their impact on environmental advances that push businesses to adopt greener strategies or introduce innovativeness in technological practices (Mousavi & Bossink (2020). The authors' collective Wang et al. (2024) highlight the positive effect of public concern for the environment that results in the mitigation of unwanted emissions, thereby strengthening government environmental regulation. Air pollution is one of the most serious global environmental challenges, with adverse effects not only on human health, well-being, and the environment but consequently also on the economy (Ostalé Valriberas et al., 2023). Air pollution negatively impacts workforce productivity and economic performance, leading to a global loss of 1.2 billion workdays annually—a number that could rise to 3.8 billion by 2060. According to the World Bank, health-related damages from air pollution cost $8.1 trillion each year, or about 6.1% of the global GDP (Clean Air Fund, n.d.). It is estimated that the economic costs of air pollution, resulting from decreased labor productivity, increased healthcare expenses, and losses in crop yields, will lead to 1% of global GDP annually by 2060 (OECD, 2016). Across the European Union air pollution leads to annual losses of €600 billion, amounting to 4% of its GDP. Between 2024 and 2030, the annual economic burden of air pollution in the EU is projected to be €490 billion, or 3% of GDP. This notable reduction likely reflects the effects of strong policy actions, such as stricter regulations and allocated funding (Mejino-López & Oliu-Barton, 2024).

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