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Editorial: Air pollution as a risk factor affecting human health and economic costs

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Editorial on the Research Topic
Air pollution as a risk factor affecting human health and economic costs

This Research Topic focuses on the critical topic of air quality and its impact on public health, sustainable development, and economic growth. Air pollution is a significant global challenge, considered by the World Health Organization as a top environmental health risk. The Global Burden disease estimates that air pollution caused 6.7 million premature deaths worldwide (Fuller et al., 2022), ultimately leading to economic loss (World Bank, 2022). The 17 articles included in this Research Topic provide valuable insights into the inter disciplinary aspects of air pollution, offering innovative research, methodologies, and findings that contribute to the scientific understanding of this complex issue.

Air quality is of utmost importance as it directly influences human health, standards of living, healthcare costs, and the economies of nations. The World Health Organization (WHO) (Ambient outdoor air pollution, 2024) has recognized the detrimental effects of air pollution on public health, leading to millions of premature deaths each year (Babatola, 2018; Fuller et al., 2022; McDuffie et al., 2021). More specifically, air pollution has been linked to respiratory diseases, cardiovascular diseases, neurological disorders, and has a disproportionate impact on vulnerable populations such as children and the elderly (Yin et al., 2021). Therefore, understanding the sources and impacts of air pollution is crucial for developing effective strategies to mitigate its effects and improve public health and wellbeing (McDuffie et al., 2021; Reis et al., 2022). They have also been proven to be one of the potential causes of reduced intelligence and accelerated aging, as they promote neurodegenerative conditions (Zhang et al., 2018).

The 17 articles in this Research Topic cover a wide range of topics related to air quality, including the assessment of air pollution across European countries, the economic growth and pollutant emissions, the comparative risk assessment of behavioral, environmental, and occupational risks for various countries, and the spatial effects of economic growth, energy consumption, and environmental pollution in the provinces of China. Additionally, the articles explore the integration of the three dimensions of sustainable development, the evaluation of life-integrated bioelectrochemical-constructed wetland systems, and the

application of statistical methods in the construction of a model for identifying the combustion of waste in heating boilers (Liu et al.; Xiao et al.; Bielenia and Podolska; Liu et al.; Xiao et al.; Chou et al.; Colombo et al.; Enyew et al.; Jasińska-Biliczak and Ikwuwunna; Kim et al.; Sun et al.; Wang et al.; Xu et al.; Ye and Tao; Zhang et al.; Tsai et al.; Xia et al.).

Several articles focus on the specific challenges and initiatives in addressing air pollution in the European Union, particularly in the Po Valley, which is considered one of the most critical hotspots for pollution in Europe. The studies highlight the need for targeted policies, regional cooperation, and the reduction of emissions from industrial sources to improve air quality and public health. Furthermore, the articles emphasize the importance of aligning air quality standards with WHO recommendations and the development of progressive strategies to reduce air pollution and its impact on health and natural ecosystems.

The findings and methodologies presented in these articles contribute to a deeper understanding of the sources, impacts, and management of air pollution, providing valuable insights for policymakers, researchers, and practitioners. The research in this Research Topic offers innovative approaches, such as the use of decision support models, spatial econometrics models, and bioelectrochemical-constructed wetland systems, to assess air quality and its economic and health implications. The articles also highlight the importance of integrating scientific, educational, and production efforts to address air pollution and promote sustainable development.

The case in China illustrates a clear positive correlation between economic growth and industrial pollution. Industrial pollution accompanies the growth of foreign direct investment (FDI), which, in turn, promote economic growth, adversely affecting the environment. This aspect was extensively analyzed in the article: “Evaluation of the triangle-relationship of industrial pollution, foreign direct investment, and economic growth in China’s transformation”. While the peculiarities of China’s economy are different from other markets, they certainly illustrate a trend that can be replicated in other countries and should serve as a warning to other governments that are shaping environmental policies and the relationship between foreign investment and the consequences of industrial development on pollution emissions (Zhang et al.). Departing from traditional research, this study delves into the intricate interactions between industrial pollution, FDI, and economic growth in China. Using a dynamic simultaneous equation model, it reveals the dual role of FDI in promoting economic growth and contributing to environmental degradation. Policymakers are urged to optimize industrial structure for sustainable development.

Differences in shaping the consequences of economic growth exist not only between countries, but even within countries, depending on the province. China, whose economy has grown rapidly in recent years and at the expense of high consumption of raw materials and energy, is experiencing economic stratification between the provinces. Provinces closer to the coast represent the more developed part of the country, which at the same time better combines economic development with public health development. Central and western provinces are less effective in shaping tools to control economic growth, health, and air quality to a lower degree. ‘These results are presented in the article The dynamic relationship among economic development, air pollution, and health production in China: the DNSBM efficiency model, which analyzed as many as 30 Chinese provinces over a 5-year period’. A mature mathematical model was created to analyze seemingly disparate parameters such as economic development, health quality and air quality (Ye and Tao). This study addresses the intricate relationships between economic development, air pollution, and health in China. The research spans from 2015 to 2020 across 30 Chinese provinces. The findings emphasize the need for improved efficiency in the transition from economic production to health outcomes, highlighting disparities among regions and the importance of tailored policies for sustainable development. The study is important in advancing the knowledge of the distributional effects of air quality, linking economic development and air quality issues to public health.

Although studies show a positive relationship between economic growth and air pollution (Ye and Tao; Zhang et al.), there is at the same time a legitimate concern that, as a further consequence, air pollution could have such far-reaching negative consequences that it would even threaten economic growth. The consequences of air pollution can affect many aspects of life on the planet, not only directly related to human health, but also the quality of life of other species, or the productivity of crops. While rapid and uncontrolled industrialization may be the cause of deteriorating air quality, in the aftermath, this reduction in quality can contribute to risks affecting the rate of economic growth. Lower population health can lead to reduced productivity, as well as more frequent absenteeism, due to deteriorating health (Jasińska-Biliczak and Ikwuwunna). A key challenge facing modern society, therefore, is to reduce harmful emissions in or-der to minimize the pressure of transportation on air pollution, as well as health. The impact of air pollutants, which are largely emitted by road transport, has been repeat-edly highlighted in the impact on the phenomenon under study. In particular, these are nitrogen oxides and particulate matter. In this regard, it would be necessary to expand the infrastructure that takes road traffic out of the agglomeration. An-other investment to improve the current situation should be to increase the green fleet of public transportation (Czechowski et al., 2022).

It is the health consequences for society that are the focus of this issue. Understanding the causes of the air pollution phenomenon is important for policies to manage it and find potential solutions. In order to implement appropriate measures, it is important to determine the consequences that result from the adverse composition of the air, including the presence of particulate matter. Determining the causality of air pollution on health is a very difficult issue and requires many years of cross-sectional studies. Such studies have been carried out in a number of geographic locations on different samples of study participants and have diagnosed a number of potential problems that are direct or indirect consequences of poor air quality.

Studies on the effects of particulate matter on the quality of respiratory function were conducted in China on a sample of men and women. Differences in impact were shown by gender and types of particulate matter, but indicated significant positive relationships between exposure to inhaled particulate matter and the development of certain respiratory abnormalities (Liu et al.). Examining the impact of different-sized particulate matter on pulmonary function, this study spans South and North China, encompassing

1,592 participants. The results underscore significant associations between ambient PM exposure and reduced lung function, emphasizing the need for region-specific considerations in air quality management and respiratory health promotion. Individual studies conducted in different scientific fields (social economics and medicine) can mutually reinforce each other's formulated conclusions, leading to unambiguous conclusions regarding the causes of health deterioration and its consequences, beyond biological measures.

Further research into the impact of air quality on health, lead to the discovery of numerous links between air conditions and the risk of developing diseases of civilization, including cardiovascular diseases (CVDs). The findings are described within the article Causality of Particulate Matter on Cardiovascular Diseases and Biomarkers (Wang et al.). Addressing the limitations of observational studies, this research employs Mendelian randomization to explore the causality between particulate matter (PM) and cardiovascular diseases (CVDs) and biomarkers. The findings suggest a significant causal relationship between PM2. 5 and myocardial infarction, heart failure, and lipid traits. The study emphasizes the necessity of ongoing efforts in air pollution abatement for preventing cardiovascular diseases.

Attention should be paid to additional non-environmental risk factors that may enhance the negative effects of poor air quality. The original research study on smoking cigarettes discusses a study conducted in Taiwan to investigate the potential joint effects of cigarette smoking and exposure to particulate matter (PM2.5) on the risk of metabolic syndrome (MS) in adults. The study included 126,366 Taiwanese adults between 30 and 70 years old with no history of cancer. The researchers analyzed data from the Taiwan Biobank and the Taiwan Environmental Protection Administration to assess the prevalence of MS based on PM2.5 exposure and cigarette smoking. The findings indicated a significant association between higher PM2.5 levels and an increased risk of MS, with odds ratios ranging from 1.058 to 1.185 for different PM2.5 quartiles. Additionally, the risk of MS was significantly higher among former and current smokers, with odds ratios of 1.062 and 1.531, respectively, suggesting a dose-dependent relationship. The interaction between PM2.5 and cigarette smoking regarding MS was also found to be significant. Stratified analyses revealed a higher risk of MS due to PM2.5 exposure among nonsmokers, and current smokers were observed to have a higher risk of MS regardless of PM2.5 levels. The study concluded that PM2.5 and cigarette smoking independently and jointly contribute to a higher risk of MS, with the combined exposure of both factors compounding the risk of MS.

The study also provides essential background information on metabolic syndrome (MS), emphasizing its public health impact and association with various chronic diseases, including cancer, stroke, diabetes, and cardiovascular diseases. It highlights the contributing factors to MS, including age, unhealthy diet, obesity, alcohol consumption, physical inactivity, cigarette smoking, and exposure to PM2.5. Moreover, it discusses the significant role of cigarette smoking as a preventable promoter of global cardiovascular mortality and morbidity and its controversial association with MS. Similarly, it underscores the urgent global public health concern of air pollution, particularly PM2.5, and its significant impact on neurological and cardiovascular morbidity and mortality. The paper mentions conflicting findings regarding the relationship between PM2.5 and MS in various studies, emphasizing the need for robust investigations on the combined effect of PM2.5 and cigarette smoking on MS.

The significant findings of the study were presented, including the prevalence of MS based on PM2.5 exposure and cigarette smoking, as well as the interaction between these factors regarding MS. Additionally, the demographic characteristics of the study participants were summarized, highlighting the differences in PM2.5 exposure, cigarette smoking status, and other variables between individuals with and without MS.

In summary, the study provides crucial insights into the independent and joint associations of PM2.5 and cigarette smoking with the risk of metabolic syndrome in Taiwanese adults, contributing valuable evidence to the understanding of the health effects of air pollution and smoking on metabolic health. The findings underscore the importance of considering both environmental and behavioral factors in public health interventions targeting metabolic syndrome and related chronic diseases.

Many correlations have been detected between health and air pollution. Potentially dangerous observations were made not only on organs, directly related to the respiratory system, but also on semen quality. There have also been studies of correlations between air quality and liver cancer risk.

There is some controversy surrounding the impact of air pollution on semen quality. The meta-analysis of Chinese men explores the potential effects of six pollutants on semen quality. The study identifies associations between PM2.5, PM10, NO2, SO2 exposure and reduced total sperm number and motility. The findings emphasize the necessity of limiting air pollution exposure to protect semen quality (Liu et al.).

Using Mendelian randomization, (Sun et al.) investigates the causal relationship between air pollution and primary liver cancer in European and East Asian populations. While no statistical association is found between air pollution and primary liver cancer, nitrogen oxides show a causal relationship with the biomarker Arginase-1. The study provides valuable insights into the complex interactions between air pollution and liver cancer (Sun et al.). The study conducted a Mendelian randomization (MR) analysis to investigate the causal relationship between air pollution and primary liver cancer in both European and East Asian populations. The study focused on the effects of air pollution, including particulate matter (PM2.5, PM2.5–10, PM10), nitrogen dioxide, and nitrogen oxides, on the risk of primary liver cancer. The results of the MR analysis in both populations did not show any evidence of a causal relationship between air pollution and primary liver cancer risk. This was consistent across multiple methods used in the analysis, and no significant heterogeneity or pleiotropy was found. Additionally, the study examined the association between air pollution and primary liver cancer biomarkers, including Alpha-fetoprotein, Osteopontin, Glypican-3, and Arginase-1. Similarly, the results did not show any causal association between air pollution and these biomarkers. The findings of the study contribute to the understanding of the lack of statistical causality between air pollution and primary liver cancer. The study's conclusions reduce the possibility of clinical relevance and refute the role of air pollution in the etiology of primary liver cancer. These findings complement and update the methodology of several cohort studies that have reached similar conclusions. In

summary, the study provides evidence that air pollution is not statistically causally related to primary liver cancer, and it emphasizes the importance of considering genetic factors and conducting MR analyses to improve the reliability and credibility of research conclusions.

The importance of this issue is that it allows a broad understanding of the causes of the phenomenon, generally described as environmental pollution, and its consequences, especially in terms of the many health implications for society. Studies conducted in various geographic areas, allow far-reaching conclusions to be drawn regarding the consequences of air pollution on the health of society.

Negative health effects resulting from poor air quality do not go unaddressed by relevant decision-making institutions. Numerous actions are being carried out in the context of air pollution management and control, which are analyzed in this Research Topic.

The article "New directions for the realization of SDG given the economic and welfare costs incurred by air pollution" by Jasinska-Biliczak and Ikwuwunna is a valuable addition to the Research Topic of the scientific journal. The subject of the article is particularly relevant to the Research Topic as it addresses the economic and welfare costs associated with air pollution, which is a critical aspect of air quality research. The findings of the study shed light on the impact of air pollution on human health, standards of living, health treatment, and the economies of states, emphasizing the need for new directions in the implementation of Sustainable Development Goals (SDG).

The research employs a comparative and statistical approach, focusing on the particulate matter factor and its implications for workforce productivity, absence from work, mortality, and crop yields. The study also contributes to the knowledge base of factors affecting human development and expands the statistical data based on a comparison between Poland and Germany in air quality tests. The methods used in the study provide a novel approach to understanding air pollution as a focus of research for the realization of SDG.

The main findings of the article highlight the significant impact of air pollution on both economic growth and public health, particularly in emerging economies. The study emphasizes the need for targeted actions to address air pollution and enhance population health, providing valuable insights for policymakers and researchers in the field of air quality research. The research also underscores the importance of aligning air quality standards with the recommendations of the World Health Organization (WHO) to reduce air pollution to levels that are no longer harmful to health and natural ecosystems.

In conclusion, the article presents a comprehensive analysis of the economic and welfare costs incurred by air pollution, offering valuable insights into the complex relationship between air quality, economic growth, and public health. The study's findings and conclusions provide a solid foundation for future research and policy development in the field of air quality and sustainable development.

The Research Topic prefaces as many as two articles that clearly demonstrate the possibilities of reducing emissions and the positive impact of pollution reduction.

An attempt to reduce emissions was made in the Po Valley area of Italy, which can be considered as one of the most polluted areas in europe. The work, "Assessing the Impacts and Feasibility of Emissions Reduction Scenarios in the Po Valley," investigates the feasibility of reducing Pm2.5 precursor emissions by 80% in order to achieve air quality compliance with WHO guidelines in the Po Valley region (Colombo et al.). Despite notable emission reductions of 50% and 80%, the study reveals that recommended pollutant levels are unlikely to be met across most areas of the Po Valley region. Implementing the finest available technologies across various sectors, particularly within the Lombardy region, is insufficient without simultaneous reductions in activity levels such as vehicle miles traveled, energy consumption for heating, and industrial, agricultural, and livestock production. The article also discusses the use of chemical transport models (CTMs) to understand the transport and transformation of air pollutants, providing insight into the sources atubution for pollution and their impact on public health. The study concludes that achieving improved air quality in the Po Valley requires a multifaceted endeavor involving numerous stakeholders and diverse strategies.

Moreover, achieving an 80% reduction in emissions within the Lombardy Region, would necessitate drastic reductions in activities such as vehicle usage, energy consumption for domestic heating, industrial activities, and livestock production. The study emphasizes the challenges of achieving an 80% reduction solely through technical measures and highlights the complexity of meeting air quality limits, which requires the adoption of source-specific emissions standards and the development of comprehensive air quality plans at the national, regional, and local levels.

The article "China's air quality improvement strategy may already be having a positive effect: evidence based on health risk assessment" presents a comprehensive analysis of the impact of PM2.5 pollution on public health in Shandong Province, China (Xu et al.). The study utilized exposure response functions, the cost of illness (COI) method, and the value of statistical life (VSL) method to estimate the health risks and economic losses associated with PM2.5 pollution. The findings revealed that despite a 30 μg/m3 reduction in PM2.5 baseline concentration, there was no significant increase in health risks and economic losses. The study also highlighted the potential positive effects of China's air quality improvement strategies. The authors emphasized the importance of regional difference analysis and long-term assessment for evaluating air quality prevention and control strategies in China. The ultimate goal of reducing population health risks through improved air quality was underscored as a key conclusion of the study. This article provides valuable insights into the effectiveness of air quality improvement strategies and their impact on public health, making it a significant contribution to the field of environmental health research.

All in all, this Research Topic highlights the importance of studying air pollution at local to regional scales across the globe. It adds to the ever-growing body of scientific evidence on the adverse health impacts of air pollution. It demonstrates both the causal effects on human health and the critical need for effective policies to mitigate these effects. Additionally, it emphasizes the importance of incorporating health risks and the impacts of air pollution into the evaluation of environmental policies. This issue speaks directly to decision-makers who are committed to making science-informed decisions.

Author contributions

EC: Conceptualization, Methodology, Writing–original draft, Writing–review and editing. AO-J: Data curation, Visualization, Writing–original draft, Writing–review and editing. TL: Writing–original draft, Writing–review and editing. AB: Writing–original draft, Writing–review and editing. LR: Writing–original draft, Writing–review and editing. CT: Writing–original draft, Writing–review and editing.

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