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# *Air Pollution and Respiratory Health: A Comparative Review of Beijing and London*

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***Abstract.*** Air pollution poses a significant threat to global public health, especially harmful to the respiratory system. Beijing and London, as two representative cities, have adopted different strategies to manage air pollution. This paper focuses on the differences between the two cities in terms of pollution structure, health impacts, policies, and outcomes. The study finds that Beijing mainly uses centralized control and total emission reduction, which has effectively lowered $PM_{2.5}$ levels in a short time. In contrast, London emphasizes system building, public participation, and social fairness, leading to a steady decline in $NO_2$ levels through long-term policies, with more attention to vulnerable groups. This paper compares the strengths and weaknesses of both approaches and points out that fairness, sustainability, and the complex sources of pollution remain key challenges. The study offers useful insights into how different policy models affect air pollution control and public health, and suggests future directions for research on multi-source pollution, long-term health effects, and policy equity.

***Keywords:*** Air pollution, respiratory health, Beijing, London, $PM_{2.5}$

## 1. Introduction

Air pollution refers to harmful substances in the air, caused by human activities or natural processes, that reach levels high enough to affect human health or the environment. As one of the most serious global environmental issues, it has become a major public health challenge. With fast urbanization, cities are facing increasing levels of air pollution. In large cities, pollutant concentrations often exceed safe limits and seriously affect residents' health. Beijing and London, as two major global cities, have long experienced different types and levels of air pollution. Due to variations in economic development, emission sources, and regulatory strategies, the nature and health effects of air pollution differ between the two cities. Studying their situations can provide useful insights for other cities facing similar problems.

Recent research has demonstrated that prolonged exposure to elevated air pollution levels significantly raises the risk of developing respiratory illnesses.$PM_{2.5}$, for example, is linked to lung function decline and respiratory infections. Some studies also suggest that in low-income and high-pollution areas, air pollution worsens childhood asthma and airway inflammation. However,

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comparative studies between Beijing and London are still limited. There is a lack of detailed research on the differences in pollutant types, sources, and health impacts between the two cities.

This study compares how air pollution affects respiratory health in Beijing and London, and examines the policy strategies adopted by each city.Specifically, it will first examine the trends of key pollutants like $PM_{2.5}$ and $NO_2$ in both cities over the past 20 years. Then, it will analyze how different pollution structures affect respiratory diseases. Finally, it will compare the air pollution policies of China and the UK, and evaluate their effectiveness. Through this comparison, the study hopes to offer useful ideas for cities developing air pollution control strategies that protect respiratory health, especially for vulnerable populations.

## 2. Air pollution levels and trends in Beijing and London

### 2.1. Air pollution in Beijing and its trends

Beijing is recognized as one of the most severely polluted cities worldwide in terms of air quality. Beijing has long suffered from heavy pollution caused by a combination of industrial emissions, vehicle exhaust, coal burning, and unfavorable weather conditions. The main pollutants include $PM_{2.5,}$ $PM_{10}$, $NO_2$, $SO_2$, CO, and $O_3$. Among them, $PM_{2.5}$ is considered one of the most harmful to health because it can enter deep into the lungs and even the bloodstream. It is also the most important pollutant in Beijing's air pollution.

Since the implementation of the Air Pollution Prevention and Control Action Plan in 2013, Significant improvements have been made in Beijing's air quality. The annual average concentration of $PM_{2.5}$ dropped from 89.5μg/m³ in 2013 to about 33μg/m³in 2021—a reduction of over 60% [1]. Despite improvements, the level still exceeds the WHO's revised 2021 standard of 5μg/m³by a large margin. Beijing's air pollution also shows clear seasonal patterns, with worse conditions in winter due to heating demands and poor air dispersion caused by cold weather.

Although the frequency and intensity of heavy pollution days have decreased over time, air pollution remains a serious public health problem in Beijing, especially during smog events and sandstorms, which continue to threaten respiratory health.

### 2.2. Air pollution in London and its trends

Although London is often seen as having better air quality than major Asian cities, its air pollution problem has become more complex in recent years. According to The Independent, on March 23, 2025, the concentration of particulate matter in London reached 197μg/m³—higher than Beijing's 190μg/m³ on the same day. This was the first time London had a higher value in this key indicator than Beijing. The main pollution sources include vehicle emissions (especially from diesel cars), construction activities, and residential heating systems [2].

Over the past 20 years, London has made progress in improving air quality by introducing measures such as Low Emission Zones (LEZ) and Ultra Low Emission Zones (ULEZ). However, $NO_2$ levels still exceed limits in areas with heavy traffic. In addition, air pollution exposure in London shows clear social inequality. Studies have found that the most polluted areas are often home to low-income and ethnic minority communities, increasing the health burden on the most vulnerable groups.

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### 2.3. Comparison and health impacts

Although Beijing and London differ in geography, energy structure, and urban development models, both cities face serious air pollution challenges. Overall, Beijing has higher pollution levels and a wider range of pollutant types than London. It is more likely to experience short-term, high-intensity pollution events due to complex causes such as industrial emissions, coal burning, and weather conditions. In contrast, London's pollution is mainly caused by traffic, especially $NO_2$ and $PM_{2.5}$, and shows a long-term, low-intensity exposure pattern.

In recent years, Beijing has reduced $PM_{2.5}$ significantly through measures like coal-to-electricity conversion and ultra-low emission upgrades. However, due to its complex pollution sources, it is still hard to solve completely. London, on the other hand, has improved air quality steadily through policies like ULEZ and cleaner transportation programs. Still, some areas, especially those with heavy traffic, continue to exceed pollution limits. In some years, London's average $PM_{2.5}$ level even surpassed Beijing's.

Both cities also show unequal pollution exposure. Vulnerable groups face higher health risks. In Beijing, pollution peaks are linked to acute respiratory problems, while in London,Chronic diseases are more likely to develop with prolonged exposure. Each city has followed a different path in pollution control—Beijing focuses on strong central actions, while London emphasizes systems and community-based efforts. Comparing their experiences can offer helpful strategies for other cities facing similar challenges.

## 3. The impact of different air pollution structures on diseases in Beijing and London

### 3.1. Relationship between pollutant structure and respiratory diseases

Air pollutants can be classified based on their physical and chemical properties into particulate matter ($PM_{2.5}$-$PM_{10}$), gaseous pollutants (e.g., $NO_2$, $SO_2$, $O_3$, CO), and toxic components Including compounds like polycyclic aromatic hydrocarbons and toxic metals. Different types of pollutants affect the human body through various mechanisms, triggering or worsening related diseases.

Particulate matter, due to its small particle size and large surface area, can penetrate the upper respiratory defenses and directly enter the lungs or bloodstream, causing chronic inflammation, oxidative stress, and reduced lung function [3]. $PM_{2.5}$ is one of the most widely confirmed risk factors for respiratory diseases. It is strongly associated with the worsening of asthma, a higher risk of chronic obstructive pulmonary disease (COPD), and lung cancer. Research indicates that exposure to $PM_{2.5}$ is strongly linked to a higher risk of hospitalization due to cardiopulmonary diseases, particularly hypertension. Each 0.1μg/m³increase in the 3-month average exposure increases the relative risk of hospitalization by about 0.51% [4].

Nitrogen oxides ($NO_2$), a major component of traffic pollution, strongly irritate the airway mucosa and are closely related to the incidence and acute attacks of asthma [5], particularly in children. Ozone ($O_3$) is generated under high temperature and strong sunlight. Studies show that exposure to ozone can cause inflammatory lung damage, worsen pre-existing diseases like asthma and COPD, and negatively impact neurological, metabolic, and reproductive health [6]. Additionally, sulfur dioxide ($SO_2$), mainly produced by coal burning, can cause acute respiratory irritation, throat pain, and breathing difficulties. Carbon monoxide (CO) affects the oxygen-carrying function of hemoglobin, and high concentrations can cause hypoxic damage.

Furthermore, the effect of air pollution on respiratory diseases is influenced by the type and concentration of pollutants, as well as exposure time, individual health, and genetic factors.

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Vulnerable groups include children, the elderly, and those with chronic illnesses.

### 3.2. Air pollution structure and health impacts in Beijing

Beijing's air pollution structure is quite complex, consisting mainly of primary pollutants (such as $PM_{2.5}$, $PM_{10}$, $NO_2$, $SO_2$, CO) and secondary pollutants (such as ozone, nitrate, sulfate, and organic aerosols). The sources of pollution include industrial emissions, traffic, construction dust, and residential coal burning for heating.

Pollutants vary significantly with different seasons and weather conditions. In winter, coal burning for heating leads to $PM_{2.5}$ and $SO_2$ dominance. In summer, secondary pollutants like ozone form under strong sunlight. During spring, sandstorms cause a significant increase in $PM_{10}$ levels, while in autumn, traffic and industrial emissions have a relatively balanced effect. Seasonal variations in the boundary layer processes directly influence the pollution levels in Beijing. In spring and summer, the boundary layer process is more favorable for near-ground pollutant dispersion, whereas in autumn and winter, typical boundary layer conditions hinder pollution dispersion, leading to severe pollution episodes.

In recent years, the proportion of nitrates, sulfates, and organic carbon in Beijing's pollutants has increased, indicating that secondary pollution has become an important health threat. Additionally, the combined pollution effect has gained increasing attention. For example, the combination of $PM_{2.5}$ and $NO_2$ is more likely to trigger acute respiratory attacks and even increase the risk of lung cancer.

### 3.3. Air pollution structure and health impacts in London

London's air pollution structure is primarily driven by traffic sources, especially nitrogen oxides (NOx), fine particulate matter ($PM_{2.5}$), ultrafine particles (UFP), and ozone ($O_3$) [7]. Diesel vehicles are the main source of $NO_2$ and UFP, while construction, residential heating, and cross-border pollution are important supplementary sources. Research has shown that a gasoline car, which accounted for only 0.15% of total driving distance, contributed 7.4% of the $PM_{2.5}$ exceedance in roadside testing, and construction activities were identified as a source of coarse particles ($PM_{10}$) [8].

Pollutants in London's urban areas are unevenly distributed, with significantly higher concentrations near major roads and industrial zones. These pollutants have a broad impact on respiratory health. $NO_2$ can cause airway inflammation, increasing the risk of acute asthma and bronchitis attacks, especially in children and adolescents [8]. PM2.5 and UFP can penetrate the deep respiratory tract, leading to lung function decline and exacerbating COPD. Chronic exposure is linked to a higher risk of death from lung cancer and cardiovascular diseases. $O_3$, which increases in summer, can cause bronchospasm, airway allergic reactions, and symptoms such as chest tightness and coughing.

Studies have shown that air pollution exposure in London has a "chronic accumulation" characteristic. Although the daily concentrations are not high, long-term exposure increases the risk of chronic respiratory diseases, such as asthma and COPD, and exacerbates their progression. This is especially evident in low-income and multi-ethnic communities. A study analyzing the long-term exposure model in London (2003–2010) found a relationship between traffic pollution ($PM_{2.5}$) and respiratory/cardiovascular mortality. In low-exposure areas, a 0.15μg/m³ increase in $PM_{2.5}$ was associated with a relative risk (RR) of 1.07 for all-cause mortality, whereas in high-exposure areas, the RR was slightly lower [9].

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### 3.4. Comparison of air pollution structures and health impacts in Beijing and London

Beijing and London have significantly different air pollution structures. Beijing is primarily affected by composite pollution, with high $PM_{2.5}$ concentrations and diverse sources, while London's pollution is mainly driven by traffic exhaust, with $NO_2$ and UFP being more prominent. Beijing frequently experiences high-concentration particulate pollution in autumn and winter, with acute respiratory responses being the primary health hazard. In contrast, London's pollution is more persistent, with chronic health effects being more common.

Additionally, Beijing's pollutants often involve synergistic exposure (e.g., $PM_{2.5}$ + $SO_2$ + $NO_2$), leading to acute irritation in vulnerable groups, while London's pollution is primarily characterized by local high concentrations of $NO_2$ and $O_3$, which have long-term effects on children with asthma and elderly individuals'lung function. Although the pollution components differ, both cities have been shown to have significant adverse effects on respiratory health.

## 4. Policies in Beijing and London for addressing the impact of air pollution on respiratory health

### 4.1. Air pollution control policies in Beijing

Beijing's air pollution control policies are characterized by government leadership, centralized actions, and high-intensity enforcement. Since the implementation of the "Air Pollution Prevention and Control Action Plan" in 2013[1]. Beijing has introduced several policies, which include policies like the "Clean Air Action Plan" and the "Three-Year Action Plan for the Blue Sky Campaign," which target coal reduction, industrial improvements, and vehicle emissions. Measures such as "coal-to-electricity" initiatives, alternating odd-even traffic restrictions, the elimination of old vehicles, and strengthening regional joint defense have significantly reduced the annual average concentration of $PM_{2.5}$.From 2013 to 2017, $PM_{2.5}$ levels decreased by 35% in Beijing and 25% in surrounding areas, providing valuable insights for long-term pollution control strategies [10]. Additionally, Beijing has built a comprehensive air quality monitoring network and included air pollution and health risks in its public governance agenda.

### 4.2. Air pollution control policies in London

London's air pollution control policies focus on institutional regulations and policy innovations, with strong systemic and public participation elements. In 2008, London implemented the "Low Emission Zone (LEZ)" policy, which was further upgraded to the "Ultra-Low Emission Zone (ULEZ)" in 2019. This policy imposes entry restrictions and charges on high-polluting vehicles, significantly reducing $NO_2$ concentrations [11]. London also promotes electric buses and encourages cycling and walking, aiming to reduce private car use and increase public transportation. The results of these policies have had significant impacts on health, education, and the socio-economic environment. Research by the Grantham Institute shows that after the introduction of LEZ, primary school performance improved, with vulnerable groups benefiting the most [12]. The London City Environmental Strategy Assessment Report predicts that by 2050, policies such as ULEZ will prevent approximately 300,000 related diseases and save around £5 billion in NHS and social costs.

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### 4.3. Comparison of policies in China and the UK and their effectiveness

In terms of policy focus, Beijing emphasizes centralized governance and total pollution control, achieving significant results in a short period. London, on the other hand, focuses more on market mechanisms, public participation, and sustainable development, with an emphasis on social equity. In terms of effectiveness, Beijing has made a remarkable reduction in $PM_{2.5}$ levels in a short time, demonstrating strong mobilization ability. In contrast, London has continuously reduced $NO_2$ levels through long-term institutional measures, thus lowering long-term health risks. It is important to note that London places greater emphasis on addressing health inequalities related to air pollution and considers the exposure risks of vulnerable groups in its policy design, whereas Beijing still has room for improvement in this area. However, London's policies have had limited control over particulate matter ($PM_{2.5}$) and ozone ($O_3$), and the implementation of these policies has imposed an economic burden on low-income groups.

## 5. Conclusion

This paper systematically compares the air pollution control policies and their impact on respiratory health in Beijing and London. By analyzing the main characteristics of air pollution, the structure of pollutants, and their effects on different populations, it is found that Beijing's focus on centralized governance significantly reduced $PM_{2.5}$ levels in the short term, demonstrating strong policy mobilization. In contrast, London’s public participation-oriented approach has led to a continuous reduction in $NO_2$ levels through long-term institutional design, with a stronger focus on health risks for vulnerable groups. Both cities’ policies have their advantages but also some shortcomings.

The findings of this study offer valuable insights for public health policymakers and contribute to the promotion of diversified and inclusive environmental governance strategies. Additionally, this study provides a theoretical basis and reference for further research on the specific health impacts of air pollution on vulnerable groups and the evaluation of policy interventions.

However, there are certain limitations in this study. First, it mainly relies on publicly available data and literature, lacking field monitoring, which may impact the details of the conclusions. Second, the sources of air pollution are complex and involve multiple factors, which were not fully covered in this study. Future research should strengthen interdisciplinary integration, utilize more monitoring and health data, and explore pollution mechanisms and health impacts in greater depth. Additionally, attention should be given to the social aspects of policy, particularly the fairness for vulnerable groups, to promote more effective and equitable air pollution governance.

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