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Air pollution, health impacts, and new energy vehicles in China

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1 Introduction

Air pollution has long been a significant environmental and public health concern in China, driven by rapid industrialization, poor emission control, urbanization, and heavy reliance on fossil fuels (1). However, the country has made remarkable progress in combating air pollution through various policies and initiatives in recent years (2). Among those initiatives the promotion of new energy vehicles (NEVs), particularly electric vehicles, might hold promise for additional reducing emissions and improving air quality in China. Nevertheless, the potential impact of the introduction of NEVs on air pollution remains unclear (3, 4). In addition, the rise in NEVs may introduce potentially even new health concerns, revealing a complex and multifaceted impact on public health.

2 China's endeavors to reduce air pollution

Over the past decade, China has implemented a series of actions aimed at curbing air pollution and enhancing environmental quality. For instance, the Air Pollution Prevention and Control Action Plan, launched in 2013, set targets for reducing key pollutants, including particulate matter ($PM_{2.5}$ and PM_{10}). Through stringent regulations, industrial upgrades, and the promotion of cleaner energy sources, significant reductions in emissions of air pollutants have been achieved (1). A similar pollution control effect was observed with the implementation of the Atmospheric Environmental Policy for Autumn and Winter, first implemented in 2017 (5). Notably, the introduction of China's Policies and Actions on Carbon Peaking and Carbon Neutrality in 2020 further contributes to the improvement of air quality and mitigation of adverse impacts of pollution on public health in the country (6, 7). Data from monitoring stations across the country indicate a reduction in annual $PM_{2.5}$ levels in many regions, reflecting the effectiveness of pollution control measures (http://www.allaboutair.cn/a/reports/2023/1027/684.html). The effects of these measures in protecting public and individual health has been observed as well (8, 9). However, challenges remain, particularly in addressing ozone pollution, which has shown a relatively unchanged trend despite the efforts to reduce precursor emissions (10). These trends are illustrated in Figure 1 as well, showcasing four cities with equivalent gross domestic product (GDP) in 2023 as examples. These cities' GDPs ranged from Suzhou's 2.47 trillion Chinese Yuan to Wuhan's 2.00 trillion Chinese Yuan (0.34 trillion to 0.28 trillion United States dollar), according to the governmental statistics (https://data.stats.gov.cn/english/index.htm).

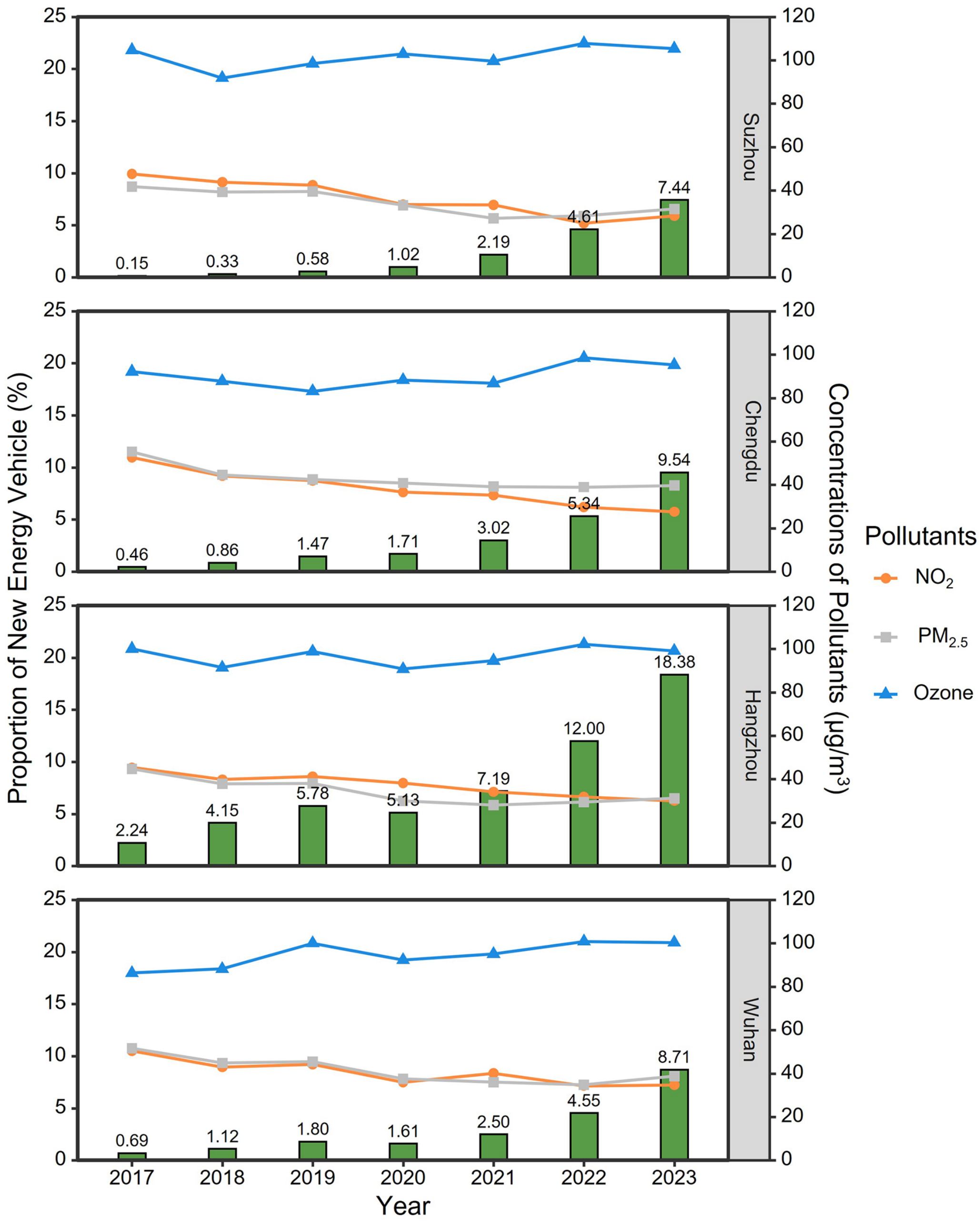

FIGURE 1
$PM_{2.5}$, NO_2, and ozone concentrations and changes in new energy vehicle (NEV) proportions from 2017 to 2023 in four cities. Annual average pollutant concentrations were adopted from monitoring stations, and the proportion of NEVs was extracted using information released by the China Ministry of Public Security Traffic Management Bureau (https://gab.122.gov.cn/m/index/).

3 Potential impact of NEVs on air pollution in China

In parallel with the endeavors to improve air quality, China has prioritized the development and promotion of NEVs as a key strategy to transition towards a low-carbon and pollution-reducing transportation system (11, 12). Consequently, China has emerged as a vast NEV market globally: In 2023, the total number of NEVs in Suzhou, Chengdu, Hangzhou, and Wuhan was around 0.390, 0.621, 0.748, and 0.388 million, respectively. Figure 1 also highlights the growing proportion of all types of NEVs in the four representative cities, with Hangzhou leading at 18% by 2023.

Theoretically, the introduction of NEVs may lead to reductions in traditional traffic-related air pollutants, such as PM and nitrogen oxides (NO_x), as combustion engine vehicles are gradually phased out. However, the real-world relationship between NEV adoption and air quality is complex and still difficult to evaluate fully at this moment. Some studies have reported that the increased numbers of NEVs might contribute to lower $PM_{2.5}$ and NO_2 concentrations (4, 13–16), while others present different views (3, 17). Recent comprehensive studies considering “well-to-wheel” air pollutant emissions highlighted that only NEV adoption combined with cleaner or renewable energy sources could significantly reduce air pollution and yield health benefits (3, 18).

While traditional pollutants, particularly PM, have gained strong research attention during China’s transition to NEVs, the potential changes in ambient ozone levels remain under investigation. As a secondary pollutant, ozone is highly sensitive to the balance of NOx and volatile organic compounds, whereas the increase in NEVs can further complicate ozone concentrations by affecting traffic-related pollutants like NOx (18–20). Moreover, ozone pollution in China is also driven by climate change and other meteorological influences (10). Overall, the potential interactions regarding NEVs, climate, and ozone are unclear.

Overall, given China’s pivotal role as the largest domestic NEV market and its persistent air pollution challenges, understanding the implications of the NEV transition on air quality and health is imperative, and this chance is unique. Insights gleaned from China are invaluable for informing global policymakers and stakeholders, especially as NEV strategies face potential deceleration worldwide. For example, Europe’s largest party might be prepping to delay the EU’s internal combustion engine ban in January 2024 (https://www.motor1.com/news/705837/eep-leaked-election-manifesto-ice-ban/), and meanwhile, the American tech company Apple has decided to scrap plans to enter the automotive industry in February 2024 (https://www.theguardian.com/technology/2024/feb/27/apple-cancels-electric-car-layoffs).

4 Potential adverse impacts of NEVs on health

While NEVs might offer promising environmental benefits, especially in carbon neutrality and pollution reduction, addressing potentially associated health-related challenges and concerns is crucial for sustainable development. First of all, currently available studies cannot definitively testify to the role of NEVs in reducing air pollution concentration. Although some local or temporal decreases in common traffic-related pollutants could be attributed to NEVs (21), the increased electricity demand could lead to even higher emissions of fossil fuels if not met with clean or renewable energy sources. Thus, the potential environmental and health benefits of NEVs need to be carefully evaluated with a comprehensive view of the current energy supply infrastructure (3, 17). Moreover, the relationship between the increase in NEVs and ambient ozone is still less-investigated and unclear. Although the health effects of ozone are not fully understood (22), elevated ozone levels are already a major air quality concern in China (10). Therefore, prioritizing studies on ozone can be crucial in this new era of NEV adoption.

Additionally, NEVs, e.g., electric vehicles, may adopt regenerative braking systems that contribute to reducing the formation of brake wear particles (23); however, electric vehicles are structurally heavier because of their battery system and may increase the non-exhaust emissions from tires and roads (24). These issues warrant further comprehensive research together with advanced monitoring and mitigation strategies.

Without combustion engines, NEVs help reduce traffic noise (25), thus additionally mitigating noise-related adverse health effects. However, researchers also indicated that the quietness of electric motors may lead to increased risk to road users because the vehicles *per se* do not provide enough acoustic warnings (26). Injury epidemiological studies on this point are currently lacking, but health education on road traffic safety to the users, along with improvements in traffic infrastructure, legal frameworks, and post-crash pre-hospital care (27), could help mitigate the side effects of NEVs’ quietness before the introduction of engineering measures on NEVs.

Furthermore, some studies have explored the electromagnetic fields (EMF) generated by electric vehicles (28–30). Although current EMF exposure levels meet safety standards, researchers highlight potential long-term exposure risks (29) and the possibility of increased exposure following vehicles’ major repairs or accidents (30). Additionally, the production and disposal of lithium-ion batteries have long raised concerns about resource depletion, environmental pollution, and health risks (31, 32). The positive aspect is that increasing studies focus on the reuse of these retired batteries (33). For example, a recent study from China proposed reusing retired batteries for rural electrification, a relatively novel solution with substantial economic, environmental, and health gains (34).

5 Conclusions

China’s efforts to combat air pollution and promote NEVs represent a significant step towards environmental sustainability and public health improvement. While progress may be achieved in reducing conventional pollutants, challenges remain, particularly regarding emerging issues like ozone pollution. In addition, the potential environmental and health impacts associated with NEVs require greater attention. A holistic approach that integrates NEVs with renewable energy deployment, urban planning, comprehensive emissions reduction measures, and health education to raise awareness about the safe use of NEVs shall be essential to navigate the complex nexus of pollution and health in the new era. Additionally, further research should be conducted to fully understand the long-term health implications and develop guidelines for NEV usage. Leveraging China’s experiences and insights would be instrumental in paving a path towards cleaner, healthier environments worldwide.

Author contributions

TZ: Conceptualization, Data curation, Investigation, Methodology, Software, Visualization, Writing – original draft, Writing – review & editing. JH: Conceptualization, Methodology, Writing – review & editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

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