Article:

Yu, B., Li, Y., Jia, P. et al. (2025) Reply to “Investigating the mechanisms of PM2.5's impact on blood pressure: establishing a three-tier response strategy” by Qiang et al. Journal of Hypertension, 43 (3). pp. 555-556. ISSN: 0263-6352

https://doi.org/10.1097/hjh.0000000000003928

Reply to “Investigating the mechanisms of $PM_{2.5}$'s impact on blood pressure: Establishing a three-tier response strategy” by Qiang *et al*.

Bin Yu[1,2], Yuchen Li[3], Peng Jia[4,5,6,7], Shujuan Yang[1,5*]
[1]West China School of Public Health and West China Fourth Hospital, Sichuan University, Chengdu, China
[2]Institute for Disaster Management and Reconstruction, Sichuan University-The Hongkong Polytechnic University, Chengdu, Sichuan, China
[3]School of Geography, University of Leeds, Leeds, UK
[4]School of Resource and Environmental Sciences, Wuhan University, Wuhan, China
[5]International Institute of Spatial Lifecourse Health (ISLE), Wuhan University, Wuhan, China
[6]Renmin Hospital, Wuhan University, Wuhan, China
[7]Hubei Luojia Laboratory, Wuhan, China

[*]Corresponding authors:
Shujuan Yang, PhD
Associate Professor, West China School of Public Health and West China Fourth Hospital, Sichuan University, Chengdu, China
Co-director, International Institute of Spatial Lifecourse Health (ISLE), Wuhan University, Wuhan, China
Email: rekiny@126.com; yangsj@scu.edu.cn

We appreciate the insightful comments provided by Qiang *et al*. (2024) regarding our recent publication, “Association of $PM_{2.5}$ and Its Chemical Constituents with Blood Pressure: A Cross-Sectional Study.” in *Journal of Hypertension*. We thank Dr. Zhang and colleagues for their recogniction of our work and for their constructive suggestions, which we address in detail below.

As noted by the authors, our study used 3-year average $PM_{2.5}$ exposure values without differentiating between short-term and long-term exposure effects. While we recognize that $PM_{2.5}$ concentrations are temporally dynamic, 3-year averages are commonly used to reflect stable, long-term exposure states in chronic disease research [1,2]. Our focus was on chronic exposure as a risk factor for hypertension, where long-term averages are likely more representative of sustained, cumulative effects. Nevertheless, we agree that incorporating short-term exposure analysis and seasonal stratification could yield additional insights, particularly given the transient nature of $PM_{2.5}$ levels. Notably, previous meta-analysis has linked short-term $PM_{2.5}$ exposure to hypertension risk [3], though no standardized definition of “short-term” in this context.

We concur with Qiang et al. that the examining interaction effects among $PM_{2.5}$ constituents could provide further understanding of their compound effects more fully.

Our choice of the Weighted Quantile Sum (WQS) approach instead of a logistic regression, was motivated by its efficacy in addressing overfitting and multicollinearity—challenges often encountered in environmental exposure research involving multiple correlated pollutants. To estimate interactions among $PM_{2.5}$ constituents, we recommend Bayesian kernel machine regression (BKMR) as a promising approach that handles multicollinearity and accomondates high dimensional interactions [4]. However, BKMR's computational demands limit its feasibility for large samples, underscoring the need for methodological advancements that can enable multi-pollutant analyses in extensive datasets.

Our study focused on the general population to establish findings applicable across a broad demographic, and subgroup analyses were not included in our initial design. We agree that targeted subgroup analyses could provide valuable insights for specific at-risk groups and enhance the representativeness of the results and ensures that observed differences reflect true effects rather than chance. Rather than pursuing subgroup analyses within the same dataset, we suggest dedicated studies focused on high-risk populations, such as elder adults or pregnant women, across multiple datasets to achieve more robust conclusion.

We recognize the importance of addressing diverse approaches to managing $PM_{2.5}$ exposure, as highlighted by the authors. We appreciate the authors' proposal of a "three-tier response strategy" and hope our findings contribute meaningfully toward this framework. Notably, our study revealed that associations between exposure to $PM_{2.5}$ constituents and elevated blood pressure were more pronounced at the 70^{th} to 90^{th} quantiles (systolic blood pressure exceeding 133 mmHg and diastolic blood pressure exceeding 82 mmHg). While further longitudinal research is warrented, these findings suggest that population-specific air quality standards could be beneficial in identifying and protecting individuals at heightened risk. High-risk groups, as identified by the authors, may benefit from targeted public health interventions to mitigate the adverse cardiovascular effects associated with $PM_{2.5}$ exposure..

Finally, we recognize the importance of precise exposure measurements, especially considering the variability in $PM_{2.5}$ concentrations due to seasonal changes, lifestyle factors, and regional socioeconomic differences. Although covariates and stratification can partially adjust for these variables, achieveing precision remains challenging when relying on aggregate data, whether at spatial resolutions of 10 kilometers or one kilometer. Encouragingly, some studies have begun to focus on real-time field data [5] and to meticulously account for individual mobility and variations in exposure. With advancements in monitoring technologies and methodologies, alongside improvements in cohort research, we anticipate that future studies will achieve more precise measurement and assessments.

Acknowledgement

Conflicts of interest

There are no conflicts of interest.

References

1. Cai C, Zhu S, Qin M, Li X, Feng C, Yu B, et al. Long-term exposure to PM(2.5) chemical constituents and diabesity: evidence from a multi-center cohort study in China. Lancet Reg Health West Pac 2024; 47:101100.
2. Yang S, Liang X, Dou Q, La Y, Cai J, Yang J, et al. Ethnic disparities in the association between ambient air pollution and risk for cardiometabolic abnormalities in China. Sci Total Environ 2022; 838:155940.
3. de Bont J, Jaganathan S, Dahlquist M, Persson Å, Stafoggia M, Ljungman P. Ambient air pollution and cardiovascular diseases: An umbrella review of systematic reviews and meta-analyses. Journal of Internal Medicine 2022; 291:779-800.
4. Yu L, Liu W, Wang X, Ye Z, Tan Q, Qiu W, et al. A review of practical statistical methods used in epidemiological studies to estimate the health effects of multi-pollutant mixture. Environmental Pollution 2022; 306:119356.
5. Geng G, Xiao Q, Liu S, Liu X, Cheng J, Zheng Y, et al. Tracking Air Pollution in China: Near Real-Time PM(2.5) Retrievals from Multisource Data Fusion. Environmental science & technology 2021; 55:12106-12115.