Perspectives

From Evaluation to Practice: Bridging the Gap Between Air Pollution Health Risk Assessment and Policy-Making in China

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ABSTRACT

This article systematically reviews the significant progress China has made in the field of air pollution health risk assessment since 2013, including the establishment of the national monitoring network, the improvement of relevant laws and formulation of technical guidelines. The paper focuses on an in-depth discussion of the current core challenges: the disconnection between health risk and decision-making, the lack of a multi-sectoral coordination mechanism, the imperfection of the technical system (particularly for mixed exposures and emerging pollutants), and the novel risks posed by global climate change. Based on this analysis, we prospectively propose fundamental pathways to advance the field: 1) constructing a robust management mechanism and coordination framework; 2) promoting the integration of the full environmental health risk assessment process into the decision-making pipeline (an "assessment-management interaction" paradigm); and 3) strengthening interdisciplinary collaboration and leveraging innovative technologies to refine the technical assessment system.

A prolonged and extensive haze episode that engulfed China in January 2013 sparked widespread public concern about air pollution's health impacts and prompted urgent government action. Conducting comprehensive health risk assessments can effectively guide air pollution control decision-making by establishing robust monitoring systems, conducting thorough investigations, and performing systematic risk assessment of air pollution and its health impacts. Following this pivotal event, China established the National Air Pollution (Haze) and Health Impact Monitoring Network in 2013 (*1*). Subsequently, both the revised Environmental Protection Law of the People's Republic of China in 2014 and the Basic Law on Medical and Health Care and Health Promotion of the People's Republic of China promulgated in 2019 mandated that the state establish and continuously improve comprehensive environmental and health risk assessment systems. Regarding the development of technical frameworks for environmental health risk assessment, China has formulated several key guidelines: the "Technical Guidelines for Exposure Assessment of Environmental Pollutants", "Technical Guidelines for Environmental Health Risk Assessment of Chemical Substances", "Framework Guidelines for Technical Methods of Environmental Risk Assessment of Chemical Substances", "Technical Specifications for Health Risk Assessment of Ambient Air Pollution", "Technical Guidelines for Environmental and Health Exposure Assessment of Chemical Substances (Trial)" and "Technical Guidelines for Environmental and Health Risk Characterization of Chemical Substances (Trial)." These comprehensive initiatives have advanced health risk assessment capabilities for air pollution through the implementation of monitoring networks of air pollution and health impact, pilot projects of appropriate risk assessment technologies. In recent years, researchers have published a substantial body of literatures on air pollution health risk assessment. However, the integration of air pollution health risk assessment findings into air pollution control decision-making processes remains significantly inadequate.

The primary purpose of health risk assessment is to provide a scientific basis for air quality supervision and health promotion decision-making. However, a significant disconnect exists between available scientific data and the information needs of decision-makers. Current air pollution health risk assessments are not integrated into the decision-making process, resulting in assessment results that fail to inform air pollution control policies effectively. Decision-makers and stakeholders-including community groups,

environmental organizations, industry representatives, and consumers-remain disengaged from the risk assessment process. This lack of interaction between risk assessment and decision-making creates substantial barriers. Furthermore, assessment transparency remains insufficient, limiting decision-makers and stakeholders understanding and engagement. The health impacts of air pollution span multiple departments and disciplines, yet an effective multi-sector coordination mechanism or clearly defined operational and management framework has not been established. The technical system for air pollution health risk assessment remains incomplete, lacking methodologies for assessing mixed and cumulative exposure to multiple pollutants, as well as risk assessment guidelines for different health hazard outcomes. Additionally, risk assessment techniques for airborne pathogenic microorganisms are absent. These existing problems collectively hinder the effective utilization of risk assessment as a decision-making tool.

Conversely, as the number of chemical substances continues to increase exponentially (currently, the Chemical Abstracts Service (CAS) REGISTRY of the American Chemical Society has registered over 279 million chemical substances)(*2*), emerging pollutants will coexist with traditional pollutants for the foreseeable future. Global climate change has intensified the frequency of extreme weather and climate events in China, creating additional complexity. The superimposition of air pollution with extreme weather conditions, combined with the delayed and complex health effects, makes scientific and accurate assessment of cumulative air pollution health risks increasingly challenging. The diverse nature of emerging pollutants renders traditional assessment methods inadequate for effectively evaluating their exposure pathways and health effects. Critical gaps exist in epidemiological and toxicological data necessary for conducting comprehensive health risk assessments of emerging pollutants. These emerging challenges represent significant obstacles that the field must address moving forward.

Scientific and effective management is essential for advancing air pollution health risk assessment to support air pollution control decision-making. China urgently needs to establish and enhance both its management mechanisms and technical systems for air pollution health risk assessment. By developing management specifications for environmental health risk assessment, we can clarify management goals, principles, and requirements while strengthening comprehensive process management of environmental health risk assessment. Air pollution demonstrates significant regional variations across the country. Related legislation has established the responsibilities of different governmental levels and departments, and local governments should implement hierarchical management of air pollution health risk assessment according to their legal responsibilities, national strategic priorities, management requirements, and regional air pollution challenges. Relevant departments must establish effective coordination mechanisms to achieve data resource sharing and information exchange.

Air pollution control measures should be grounded in risk assessment to optimize decision-making, thereby maximizing the utility of risk assessment (*3*). Drawing from the experience of the US Environmental Protection Agency, risk assessments should target specific problems and decisions to most effectively guide the decision-making process (*4*). During the early stages of health risk assessment, the interaction between risk assessment and management should be integrated into the risk assessment paradigm, establishing participation mechanisms for risk managers, decision-makers, and stakeholders in key assessment phases. Decision-makers, risk assessors, and other interested parties should participate in planning and scoping activities. At this stage, they collaboratively discuss the options under consideration and factors that may influence policies in the risk assessment, determine the assessment scope and appropriate evaluation level to meet decision-makers' needs, and establish the role of risk information in decision-making. During problem formulation, it is essential to establish an effective decision-maker participation mechanism involving discussions among risk management personnel, decision-makers, and risk assessors to develop detailed technical plans, conceptual models, and analysis frameworks for the assessment. At this stage, risk assessors must ensure that risk management personnel and decision-makers fully comprehend uncertainties and their implications (*5*). Risk assessors need to conduct dynamic evaluations, regularly update assessment results, and provide feedback to decision-makers, enabling informed decision-making through careful consideration while enhancing the transparency of environmental health risk assessments.

The technical system for assessing air pollution health risks requires continuous improvement through strengthened multidisciplinary cooperation and

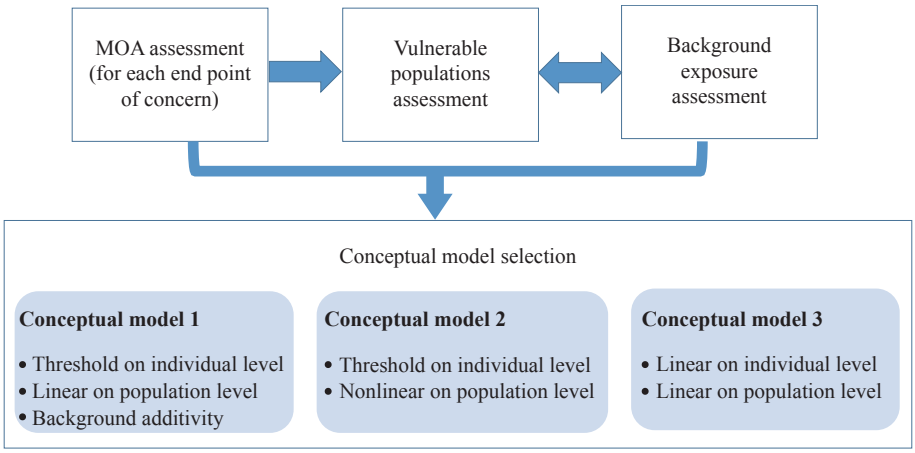

FIGURE 1. Three conceptual models in the unified framework.

innovative technology integration. Given the significant limitations in traditional carcinogenic and non-carcinogenic risk assessment methods — particularly regarding core concepts, uncertainty and variability treatment, and risk quantification — the "Conceptual Model in the Unified Framework (Figure 1)" was developed to assess exposure (dose)-response relationships more effectively (4).

Guidelines for exposure assessment should be developed that cover composite exposure, cumulative exposure, and different media and exposure scenarios. Guidelines for environmental health risk assessment that cover different populations (such as children, pregnant women, the elderly and other susceptible population) and different health outcomes should be developed. The combination of hazard information and toxicity data to describe and characterize the potential risks of emerging pollutants in the air should be expanded continuously by using quantitative structure-activity relationship (QSAR), adverse outcome path (AOP), computational toxicology, bio-informatics, and different machine learning models (*6*–*9*).

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REFERENCES

1. Disease Prevention and Control Bureau, National Health Commission, People's Republic of China. The Work plan for national air pollution (haze) and health impact monitoring network, in 2013. 2013. https://www.nhc.gov.cn/jkj/c100062/201310/ba06615ceeb349bf9cb72b32f4211c15.shtml. [2013-10-15]. (In Chinese).
2. Chemical Abstracts Service (CAS) REGISTRY®. https://www.cas.org/cas-data/cas-registry.
3. United States Environmental Protection Agency (USEPA). Guidance on cumulative risk assessment. Part 1. Planning and scoping. 1997. https://www.epa.gov/sites/default/files/2015-01/documents/cumrisk2_0.pdf.
4. National Research Council (US) Committee on Improving Risk Analysis Approaches Used by the U.S. EPA. Science and decisions: advancing risk assessment. Washington, DC: National Academies Press. 2009. http://dx.doi.org/10.17226/12209.
5. Fitzpatrick J, Schoeny R, Gallagher K, Deener K, Dockins C, Firestone M, et al. US Environmental Protection Agency's framework for human health risk assessment to inform decision making. Int J Risk Assess Manage 2017;20(1-3):3 – 20. https://doi.org/10.1504/IJRAM.2017.082558.
6. Yang YJ. Application of microbial electrochemical sensors in biotoxicity detection of environmental pollutants [dissertation]. Beijing: University of Chinese Academy of Sciences; 2021. https://d.wanfangdata.com.cn/thesis/Y3861042. (In Chinese).
7. Hines DE, Edwards SW, Conolly RB, Jarabek AM. A case study application of the aggregate exposure pathway (AEP) and adverse outcome pathway (AOP) frameworks to facilitate the integration of human health and ecological end points for cumulative risk assessment (CRA). Environ Sci Technol 2018;52(2):839 – 49. https://doi.org/10.1021/acs.est.7b04940.
8. Ma DH. Prenatal mother-to-infant transfer and metabolic degradation behavior of per- and polyfluoroalkyl substances [dissertation]. Beijing: University of Chinese Academy of Sciences; 2021. https://d.wanfangdata.com.cn/thesis/CiBUaGVzaXNOZXdTMjAyNTA2MTMyMDI1MDYxMzE2MTkxNhIIWTM4NjAyNDUaCGk3ejN2Y2Q0. (In Chinese).
9. Outeiral C, Strahm M, Shi JY, Morris GM, Benjamin SC, Deane CM. The prospects of quantum computing in computational molecular biology. WIREs Comput Mol Sci 2021;11:e1481. https://doi.org/10.1002/wcms.1481.