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Are current Chinese national ambient air quality standards on 24-hour averages for particulate matter sufficient to protect public health?

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ABSTRACT

With rapid economic development and urbanization in recent decades, China has experienced the worsening of ambient air quality. For better air quality management to protect human health, Chinese government revised national ambient air quality standards (NAAQS) for particulate matter (PM) in 2012 (GB3095-2012). To assess the effectiveness of current NAAQS for PM on public health in Chinese population, we conducted a meta-analysis on published studies examining the mortality risk of short-term exposure to PM with aerodynamic diameters less than 10 and 2.5 μm (PM_{10} and $PM_{2.5}$) in China. The reported 24-hour concentrations of PM_{10} and $PM_{2.5}$ in studies ranged from 43.5 to 150.1 μg/m^3 and 37.5 to 176.7 μg/m^3. In the pooled excess, mortality risk estimates of short-term exposure to PM. In specific, per 10 μg/m^3 increase in PM_{10}, we observed increases of 0.40% (95%CI: 0.33%, 0.47%), 0.57% (95%CI: 0.44%, 0.70%) and 0.49% (95%CI: 0.40%, 0.58%) in total, respiratory and cardiovascular mortality, per 10 μg/m^3 increase in $PM_{2.5}$, we observed increases of 0.51% (95% CI: 0.38%, 0.63%), 0.62% (95%CI: 0.52%, 0.73%) and 0.75% (95%CI: 0.54%, 0.95%) in total, respiratory and cardiovascular mortality. Finally, we derived 125 μg/m^3 for PM_{10} and 62.5 μg/m^3 for $PM_{2.5}$ as 24-hour recommendation values based on the pooled estimates. Our results indicated that current Chinese NAAQS for PM could be sufficient in mitigating the excess mortality risk from short-term exposure to ambient PM. However, future research on long-term exposure cohort studies in Chinese population is also essential in revising annual averages for PM in Chinese NAAQS.

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Contents

Introduction

Extensive epidemiological studies have reported associations between air pollution and elevated risks of mortality or morbidity for cardiovascular and respiratory diseases (Di et al., 2017; Dockery et al., 1993; Huang et al., 2012; Tao et al., 2012; Zanobetti and Schwartz, 2009). In addition, numerous systemic reviews and meta-analysis integrate evidence from epidemiologic studies and derive concentration response (C-R) functions for quantitative assessment of health effects attributed to air pollution (Anderson et al., 2012; Atkinson et al., 2015; WHO, 2004a). To promote human health protection, governmental agencies have been formulating and revising air quality standards largely based on the derived C-R functions, as well as quantitative reviews and meta-analysis (EEA, 2013; USEPA, 2012; WHO, 2006). With emerging evidence from global health research, the World Health Organization (WHO) released Air Quality Guidelines (AQGs) in 2005 for ambient particulate matter (PM) with aerodynamic diameter less than 10 μm (PM_{10}) and less than 2.5 μm ($PM_{2.5}$), sulfur dioxide (SO_2), nitrogen dioxide (NO_2), carbon monoxide (CO), and ozone (O_3) (WHO, 2006). The guidelines for 24-hour and annual averages, as well as staged interim target (IT) values for these pollutants are provided to encourage gradual improvement of air quality and to set up ultimate objective on health risk control at a global scale (Krzyzanowski and Cohen, 2008).

China has been experiencing the worsening of ambient air quality from rapid urbanization and industrialization, along with increasing coal consumption and fossil fuel combustion (Chen et al., 2012; Huang et al., 2012). As of 2015, the annual averages of PM_{10} and $PM_{2.5}$ in Beijing were 102 μg/m^3 and 81 μg/m^3 (National Bureau of Statistics of China, 2016), which were much higher than the annual AQG levels of 25 μg/m^3 for PM_{10} and 10 μg/m^3 for $PM_{2.5}$ recommended by WHO (WHO, 2006). For better air quality management practice on public health protection, the Chinese National Ambient Air Quality Standards (NAAQS) were revised in 2012 by adopting the IT-1 values in AQG, which were 150 μg/m^3 and 75 μg/m^3 for 24-hour averages of PM_{10} and $PM_{2.5}$, respectively (MEP, 2012). However, air quality standards formulation requires integrated assessment on the acceptable risk of air pollution attributable disease burden and accessibility of environmental management practice (Kan, 2012). Currently, Chinese government has adopted WHO AQG IT-1 values as the NAAQS values, which is expected to be updated when evidence from epidemiologic research conducted in Chinese populations become sufficiently available.

In this analysis, we conducted systematic literature review and quantitatively assessed the association between short-term exposure to ambient PM and mortality risk in Chinese population. Further, we derived 24-hour recommendation values for PM_{10} and $PM_{2.5}$ according to the pooled excess risk (ER) estimates of PM-mortality association from identified studies. Finally, we evaluated whether current Chinese NAAQS for PM are sufficient to protect public health. Our results highlighted the importance for health research of air pollution in setting up health risk management based air quality standards in China.

1. Methods

We used the meta-analysis method to assess the association between short-term exposure to PM_{10} and $PM_{2.5}$ and daily mortality, and evaluated whether the current Chinese NAAQS for PM are sufficient to protect public health in comparison with the 24-hour recommendation values derived from the identified studies. The synopsis was provided as follows.

1.1. *Literature search and data extraction*

We searched three online databases including PubMed, Web of Science and China National Knowledge Infrastructure (CNKI) on epidemiologic studies that reported the association between short-term exposure to PM_{10} and $PM_{2.5}$ and daily mortality, which were published in peer-reviewed journals that indexed from January 1990 to December 2016 *via* search stings.

The combinations of following key words for search stings were used: (1) air pollution, particulate matter, particle, PM_{10} or $PM_{2.5}$, (2) mortality, death or health effect, (3) China, Chinese or Hong Kong, (4) daily, time series, time-series or case-crossover. We also searched the relevant reference lists of identified studies as additional publications (Shang et al.,

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