Chapter 1
Urgency to Assess the Health Impact of Ambient Air Pollution in China

Bo-Yi Yang, Yimin Liu, Li-Wen Hu, Xiao-Wen Zeng, and Guang-Hui Dong

Abstract As the world's second-largest economy, China is going on suffering from environmental pollution, especially for ambient air pollution, which has become a major threat to public health; public awareness of the detrimental effects of air pollution on health is increasing—particularly in relation to haze days. Considering the nonlinear relationship of ambient air pollution exposure and health impacts, and the differences in specific sources of air pollution with those in North America and Europe, conducting health impact assessments of ambient air pollution in China has thus become an urgent task for public health practitioners. Systematic review of the health effects of exposure to ambient air pollution from quantitative studies conducted in Chinese could provide vital information for epidemiology-based health impact assessments and the implementation of a national environmental protection policy.

Keywords Ambient air pollution • Health impact • China

With the rapid economic development, China has become the world's second-largest economy. However, behind this beautiful scene, environmental pollution induced by urbanization and industrialization has led to devastating health impacts in Chinese population [5]. According to the reports of the World Health Organization, the number of patients and deaths because of lungs, stomach, liver, and esophagus diseases accounted for 30%, 40%, 50%, and 50% of the global total, respectively

B.-Y. Yang • L.-W. Hu • X.-W. Zeng • G.-H. Dong (✉)
Guangzhou Key Laboratory of Environmental Pollution and Health Risk Assessment, Department of Preventive Medicine, School of Public Health, Sun Yat-sen University, 74 Zhongshan 2nd Road, Yuexiu District, Guangzhou 510080, Guangdong, China
e-mail: donggh5@mail.sysu.edu.cn; donggh512@hotmail.com

Y. Liu
Laboratory of Occupational Environment and Health Effects, Guangzhou Key Medical Discipline of Occupational Health Guardianship, Guangzhou Prevention and Treatment Center for Occupational Diseases, Guangzhou Twelfth People's Hospital, Guangzhou 510620, China

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[22]. One culprit behind these figures is the deteriorating environmental pollution. According to an authoritative estimate made by the World Bank, the annual losses caused by environmental pollution amounted to about 10% of total gross domestic product (GDP) [17, 21].

Compared with the pollution condition of other environmental media, air pollution in China is becoming more and more serious and has aroused great attention for the frequent haze events in recent years [18, 19]. For example, results of the Global Burden of Diseases, Injuries, and Risk Factors Study 2010 [9] indicated that ambient air pollution has ranked as the fourth in terms of the age-standardized disability-adjusted life years (DALYs) rate in 2010 [18]. In 2014–2015, the total DALYs simply caused by particles with an aerodynamic diameter of ≤ 2.5 μm ($PM_{2.5}$) and ≤ 10 μm (PM_{10}) in China was 7.2 and 20.66 million, and mortality and chronic bronchitis shared about 93% of the total DALYs for PM_{10} [16].

How dangerous is the ambient air pollution in China? It may be more vivid and meaningful to compare air pollution to cigarette smoking than just citing the numbers of yearly deaths. As shown in Fig. 1.1, we may have an idea of air pollution in terms of cigarettes equivalent based on the satellite monitoring data by applying

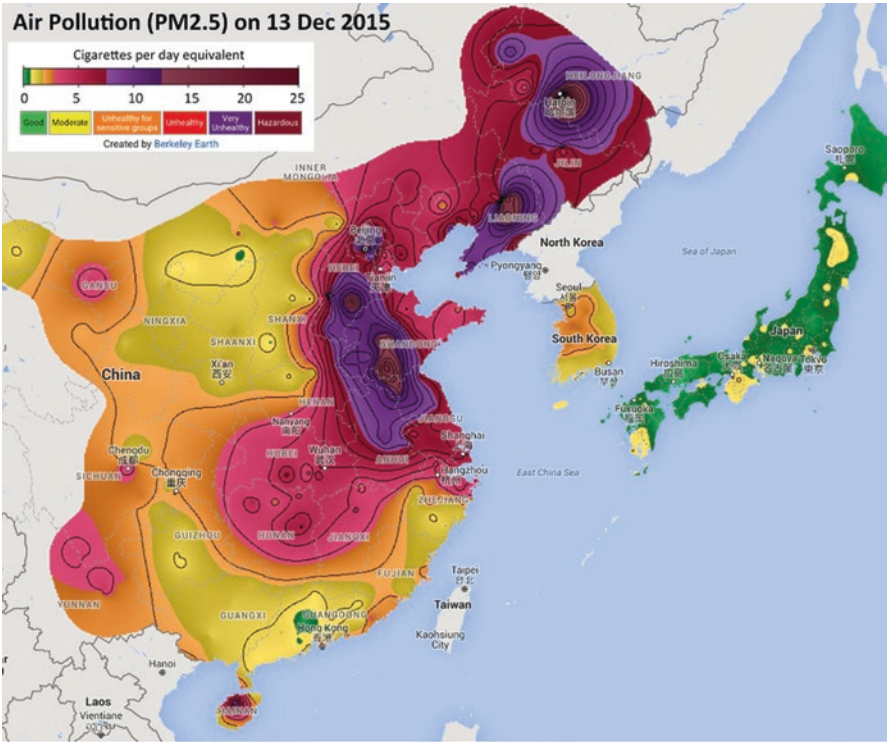

Fig. 1.1 Map of air pollution and cigarette equivalence in East China (Cited from Berkeley Earth: http://berkeleyearth.org/air-pollution-and-cigarette-equivalence/)

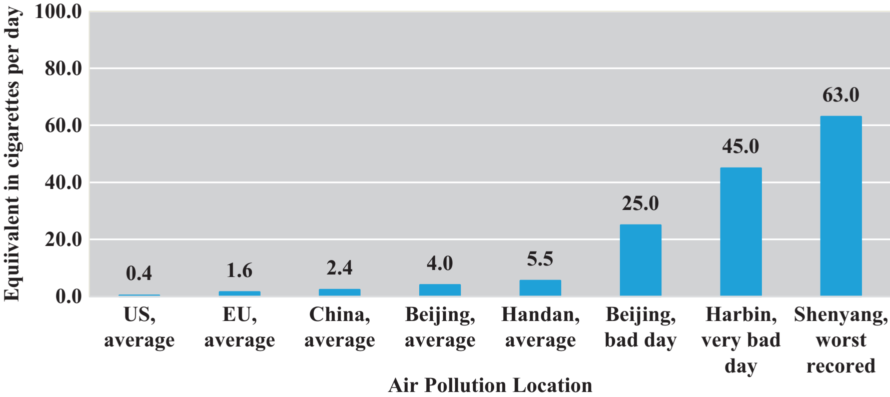

Fig. 1.2 Air pollution approximated as cigarettes equivalent in China with the United States and Europe (Cited from Berkeley Earth: http://berkeleyearth.org/air-pollution-and-cigarette-equivalence/)

kriging interpolation to derive pollution maps for China [15]. For example, in 2015, the average $PM_{2.5}$ in Beijing over the year was about 85 μg/m^3, equivalent to about four cigarettes per day. The average value in the industrial city of Handan, about 200 km south of Beijing, was about 120 μg/m^3, equivalent to 5.5 cigarettes/day. When in Beijing the level rose to 550 μg/m^3, it was equivalent to 25 cigarettes per day. In Harbin, the air pollution had reached the limit of the scale, 999 μg/m^3. That would be equivalent to 45 cigarettes per day.

According to the rule of thumb, one cigarette per day is the rough equivalent of a $PM_{2.5}$ level of 22 μg/m^3; the EPA estimates that the average air pollution in the United States in 2013 was 9.0 μg/m^3 indicating equivalent to 0.41 cigarettes per day for every person in the United States (Fig. 1.2). For Europe, air pollution is equivalent in detrimental health effects to smoking 1.6 cigarettes per day. In China, the numbers are far worse; on bad days, the health effects of air pollution are comparable to the harm done smoking two packs per day (40 cigarettes). Moreover, a recent peak reported in the city of Shenyang set a new record of 1,400 μg/m^3, equivalent to over three packs of cigarettes per day for every man, woman, and child living there.

It is well known that the relationship of air pollution with health effect is nonlinear [4, 13, 14]. As shown in Fig. 1.3, at low pollution levels, we can find a greater rake ratio for the relationship of air pollution with health effects; however, at a high pollution level, the slope is becoming a little flat. For example, based on the data from a global analysis, it showed that dose–response relationships between air pollution and chronic obstructive pulmonary disease (COPD) mortality are nonlinear, with mortality risks increasing rapidly at low $PM_{2.5}$ levels (<100 μg/m^3) and reaching a plateau at higher levels (>300 μg/m^3) [4]. This plateau level can be applied to the Chinese population with regard to air pollutant levels throughout China. So, it is not surprising that the results from the low air pollution levels are inconsistent with

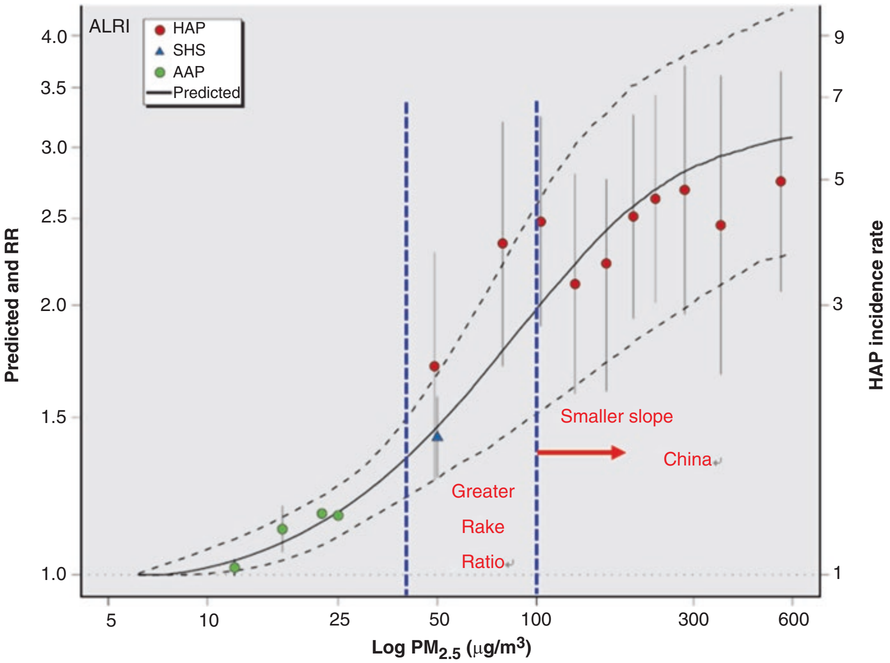

Fig. 1.3 Nonlinear relationship of air pollution with health effects (Cited from Burnett et al. [4])

the results from the high pollution levels. Although, many studies have assessed the effects of ambient air pollution on human health, most of these studies were from the developed countries where ambient air pollution levels were usually below 40 μg/m^3. Furthermore, the nonlinear relationship indicates that the associations from the developed countries may be not suitable for Chinese population.

With the transformation of traditional ideas that ambient air pollution and the associated health effects have typically been regarded as local or regional problems, with local or regional solutions, it is increasingly recognized that air quality in a given location can be substantially affected by atmospheric transport from distant sources, including sources from other continents [1, 6, 7, 10–12, 20], and this transport of pollution indicates that health impacts of air pollution are not only a local issue [2, 3, 8, 23]. For example, recently, Zhang et al. [24] estimated premature mortality caused by $PM_{2.5}$ pollution as a result of atmospheric transport and the production and consumption of goods and services in different world regions. They found that, of the 3.45 million premature deaths related to $PM_{2.5}$ pollution in 2007 worldwide, about 12% (411,100 deaths) were related to air pollutants emitted in a region of the world other than that in which the death occurred, and about 22% (762,400 deaths) were associated with goods and services produced in one region for consumption in another. For example, $PM_{2.5}$ pollution produced in China in 2007 is linked to more than 64,800 premature deaths in regions other than China, including more than 3,100 premature deaths in Western Europe and the United States. On the other hand, consumption in Western Europe and the United States is linked to more than 108,600 premature deaths in China.

Considering the above contents, and the fact that air pollution in China is mainly different from that in developed countries in terms of its magnitude, it will be very meaningful to show the health impact of air pollution in Chinese population. So, the aim of this book is to provide up-to-date review of the magnitude of adverse health effects of ambient air pollution in Chinese population. To the end, epidemiological evidence dating back to the 1990s, including data on mortality, morbidity, and hospital utilization for all non-accidental causes, cardiovascular diseases, stroke, respiratory diseases, mental health, and birth deficit caused by ambient PM_{10}, $PM_{2.5}$, sulfur dioxide, nitrogen dioxide, ozone, and carbon monoxide pollution in all age groups, was systematically assessed.

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