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The health effects of individual characteristics and environmental factors in China: Evidence from the hierarchical linear model

Yue-Jun Zhang [a, b, *], Yan-Lin Jin [a, b], Tian-Tian Zhu [c, **]

[a] Business School, Hunan University, Changsha, 410082, China
[b] Center for Resource and Environmental Management, Hunan University, Changsha, 410082, China
[c] Education Science Research Institute, Hunan University, Changsha, 410082, China

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ABSTRACT

Environmental pollution and its health risks to human beings have been becoming increasingly serious in China, and the health status of the individuals is not only affected by their environment but also by their own characteristics and socio-economic status. Based on the survey data of China Family Panel Studies (2014), three hierarchical linear models at three levels of individual, family, and community were developed to investigate the influencing factors of individual health status. The results indicate that: (1) there exists significant difference among individual health status, of which 16% and 9.11% are caused by the family and community levels, respectively; (2) the average health status of men is better than that of women by 6.95%. As for the difference in health effects produced by gender, total household income can reduce this difference; (3) age has significant negative health effects, while the level of education has positive effect on individual health status; and (4) the health effects of pollution is mainly reflected by its interaction with gender; in particular, when men and women face the same level of pollution exposure, men are more susceptible.

1. Introduction

Pollution, especially air pollution, proves a major public health crisis in the world especially in China. In the past decades, millions of people have died every year from diseases caused by exposure to air pollution (Zhang et al., 2017; Wu et al., 2017), making it the world's fourth largest threat to human health, behind high blood pressure, dietary risks, and smoking. Although energy is the driving force of economic and social progress, the combustion of energy and fossil fuels caused by human activities is also the largest source of air pollution (Lott et al., 2017; Khan et al., 2016). Air pollution brings major costs to the economy and damage to the environment (Mi et al., 2015, 2017; Lu et al., 2016). Without changes to the mode of generation and use of energy, the ruinous toll from air pollution on human life is set to rise (Huang and McElroy, 2015; Lu et al., 2013).

In recent years, China has undergone a process of rapid industrialisation and urbanisation (Fan et al., 2017; Zhang et al., 2014). As a result, the scale and speed of China's economic growth has brought about the significant deterioration of air quality, with the total level of polluted air emissions well above that of other countries (Liu and Diamond, 2005). According to the data of International Energy Agency (IEA), only about 3% of the population in China enjoy a level of exposure to $PM_{2.5}$ concentrations that comply with the guidelines of World Health Organisation (WHO). Overall, the average life expectancy of Chinese residents is shortened by 25 months as a result of poor air quality.[1]

As air pollution, and the related health risks, become more severe, the Chinese Government is increasingly aware of the seriousness of the problem, and has been trying to alleviate its effects

* Corresponding author. Business School, Hunan University, Changsha, 410082, China.
** Corresponding author. Education Science Research Institute, Hunan University, Changsha, 410082, China.
E-mail addresses: zyjmis@126.com (Y.-J. Zhang), ztt_bnu@hnu.edu.cn (T.-T. Zhu).

[1] Source: IEA: Energy and air pollution, world energy outlook special report. http://www.iea.org/publications/freepublications/publication/WorldEnergyOutlookSpecialReport2016EnergyandAirPollution.pdf.

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since the 1970s. One landmark initiatives is the Action Plan on Air Pollution Prevention issued in September, 2013 (Cai et al., 2017). It is the provincial road map to improve air quality from 2013 to 2017 and its specific target is that: by 2017, the concentration of respirable particulate matter in the national prefecture level and above should be more than 10% lower than that in 2012, and the fine particulate concentration in the Beijing-Tianjin-Hebei region, Yangtze River Delta, and Pearl River Delta decreased by 25%, 20%, and 15%, respectively, of which the annual average concentration of fine particles in Beijing should be limited to 0.06 mg/m^3. Since the implementation of the Action Plan on Air Pollution Prevention, there has been an overall improvement in air quality, but many areas are still faced by a grim situation, *e.g.*, the annual average concentration of PM_{10} increased in many provinces instead .[2] As a result, the air quality in different regions still shows large differences, which in turn leads to different exposure risks to residents in different regions (Cai et al., 2017; Liang et al., 2016; Chan and Yao, 2008).

In addition, as for those living in the same region, there is ample evidence that socio-economic status has significant effect on the individual health status, which is mainly reflected by the different levels of access to health care (Picatoste et al., 2018; Dominici et al., 2014; Dye, 2008; Neidell, 2004). In all countries, whether low-, middle, or high-income, there are significant differences in the health status of different social groups. The lower an individual's socio-economic position, the higher their risk of poor health.[3] In particular, China has a multi-level social structure, such as individuals, families, work units, villages, and communities. In this complex nested structure, family is a prominent social organisation that directly affects individuals, not only with regard to an individual's initial social status, but also to the development of individuals by way of persistent impacts (McLanahan and Percheski, 2008; Thornton and Camburn, 1987).

In general, individual health status is not only relevant to their own characteristics and socio-economic status, but is also influenced by the environment in which the person is located (Chen et al., 2017; Lu et al., 2017; Blalock, 1984), leading to unequal health effects; however, researchers often conduct their investigations at a single level, focusing on one aspect and paying less attention to the interactive effects. Under this circumstance, this research attempts to use the nested data of three levels of individual, family, and community, and comprehensively discuss the health effects of individual characteristics and environment by considering the factors from both micro- and macro-perspectives. Moreover, it should be noted that the traditional or ordinary linear models are generally aimed at a single level of data, and they also need to satisfy the basic assumptions for linearity, normal distribution, variance homogeneity, and independence. However, for the multi-level nested data, which are used in this research, the latter two assumptions often cannot be satisfied. Therefore, we consider developing the hierarchical linear model which can analyse the intra-group and inter-group effects of microscopic and macroscopic variables.

The main contribution of this research consists of four aspects: first, we conduct a systematic study of the two mechanisms that contribute to health inequality by taking pollution exposure from a macro-perspective and socio-economic status factors from a micro-perspective into the same analytical framework, no longer being limited to the fact that most of the existing studies investigate the health effects of pollution from a single perspective. Second, we make full use of micro-data at the individual level and macro-data at the regional level, thus completely reflecting the fact that the individual is the direct undertaker of pollution. Third, due to the complex social structure prevalent in China, we assess the unequal effects of pollution on individual health status from multiple perspectives. Fourth, we attempt to provide an empirical support for policymakers to develop more effective environmental health policies and build a more effective public health management system, thus seeking a sustainable path to environmental health.

The rest of this paper is arranged as follows. Section 2 reviews relevant literature. Section 3 describes the data and research methods. Section 4 analyses and discusses the empirical results of the model. And Section 5 concludes the paper with the main conclusions and some important policy suggestions.

2. Relevant literature review

Literature pertaining to pollution and its health effects is abundant. This review covers the related literature from three aspects of the definition of unequal health effects, the impacting mechanism, and the research methods.

There are two different interpretations of health inequality, which reflect the two mechanisms underpinning the unequal health effects caused by pollution. First, the effect of pollution on health depends on the level of exposure to pollution: the more serious the pollution, the higher the level of exposure thereto, and the greater the health risks and hazards (Coneus and Spiess, 2012; Brooks and Sethi, 1997). In particular, different regions focus on different industries, resulting in the level of pollution differing among regions (Cole et al., 2005; Copeland and Taylor, 2004). Therefore, from the macro-perspective, there are healthy inequities among regions. Second, because of different socio-economic statuses, some groups of people are more likely to be exposed to a more polluted environment, resulting in a greater risk of contamination (Charafeddine and Boden, 2008). Therefore, from the micro-perspective, there exist healthy disparities among individuals.

With respect to these two mechanisms, most researchers have explored the relationship between pollution and human health from the perspective of only a single level. Some typical studies are summarised in Table 1.

As can be seen from Table 1, first, from a macro-perspective, some researchers evaluated the health effects of air pollution on the mortality or life expectancy of some special groups, *e.g.*, infants, children, or the elderly, and they concluded that air pollution could increase mortality among, and reduce the life expectancy of, these groups. By further comparison, we can find that the degree of this kind of influence differs among countries and among regions, proving that such health inequalities are widespread, both worldwide and nationwide. Second, from a micro-perspective, some researchers have paid more attention to the health disparities caused by individual socio-economic statuses, especially by the effects of ethnicity or race, but these studies often focus on the cases in USA, UK, Germany and other developed countries. In addition, most of the existing studies develop their statistical models at a single level, which makes it hard to reflect the complex social structures of China, *e.g.*, individuals are nested in the family, while the family is nested in the community. As a result, it is difficult to completely assess the significance of any interactive effects between different levels.

In summary, although more researchers have paid attention to the unequal health effects caused by air pollution, there is still lack of comprehensive and systematic analysis. This is mainly reflected

[2] Source: Chinese Academy of Engineering: The mid-term assessment report of the air pollution control action plan. http://www.cae.cn/cae/html/main/col36/2016-07/05/20160705161134200910514_1.html.

[3] Source: WHO: 10 facts on health inequities and their causes. http://www.who.int/features/factfiles/health_inequities/en/.