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Health and Economic Loss Assessment of Haze Pollution in "2+26" Cities in the Air Pollution Transmission Channel

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Abstract: Based on the annual average $PM_{2.5}$ concentration data, economic data and health data from 2017 to 2020 in 2+26 cities, we evaluated the health effects and health and economic losses attributable to $PM_{2.5}$ pollution in eight health end points (premature death, outpatient visit, hospitalization and illness). The results showed that the average annual $PM_{2.5}$ concentration, health effects of each disease, economic loss, total health effects and total economic loss in 2+26 cities gradually decreased from 2017 to 2020, but the health effects and economic loss in some cities increased in 2020. The health endpoints with the highest economic losses were chronic bronchitis and premature death, followed by acute bronchitis, asthma, asthma, and asthma, followed by acute bronchitis, asthma, cardiovascular disease, and respiratory hospitalizations, and finally pediatrics and internal medicine. Based on the above results, the reduction o $PM_{2.5}$f concentration was the main reason for the reduction of health effects and health economic effects attributed to $PM_{2.5}$ in 2+26 cities. There is still room for further reduction of $PM_{2.5}$ pollution in each city. Therefore, cities can still take corresponding measures to control $PM_{2.5}$ pollution in the future to reduce health benefits and health economic benefits caused by $PM_{2.5}$. However, we also found that the reduction of health effects and health economic effects and the magnitude of reduction differed greatly among cities with different levels of development. Therefore, for some cities with a low level of economic development, they are facing the pressure of economic development and the pressure of reducing pollution. How to achieve the effect of reducing haze pollution while developing the economy is the problem that these cities need to solve at present.

Keywords: $PM_{2.5}$; Economic losses; Atmospheric contamination; Transmission path.

1. Introduction

Some substances produced by human activities and natural processes, after entering the atmospheric environment, remain at a certain concentration level and exist in the atmosphere for a sufficient time, which will affect human life and cause certain harm to human health and the environment [1,2].

Air pollution is mainly caused by human activities. In the process of production activities and winter heating in secondary industry factories, the burning of fossil fuels will emit particulate matter into the atmosphere [3,4]. In addition, vehicle exhaust emissions are also an important source of air pollutants [5]. Once atmospheric pollutants enter the atmospheric environment, they may exist in the atmosphere for a long time due to natural meteorological conditions and natural geographical environment factors, thus causing harm to human health [6,7]. Studies have shown that air pollutants may cause cardiovascular diseases, respiratory diseases, and even death in severe cases [8,9,10].

In order to control air pollution, our country has issued a series of policies and taken a series of measures. In September 2013, The State Council issued the Action Plan for Air Pollution Prevention and Control, which adopted measures such as desulfurization, denitrification, and dust removal in key industries, promotion of new energy vehicles, and optimization of industrial structure and energy structure, aiming to improve the overall air quality of the country and reduce heavy pollution weather. In March 2016, the Standing Committee of the National People's Congress proposed in the Outline of the 13th Five-Year Plan for National Economic and Social Development that each city should designate a plan to meet air quality standards, reduce the number of days with moderate pollution, and have more than 80% of the days with good air quality. In March 2017, the Beijing-Tianjin-Hebei region and surrounding areas, including Beijing, Tianjin City, Hebei province, Shanxi Province, Shandong Province, and Henan province, were the air

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pollution transmission channel cities. In the 2017 Work Plan for the Prevention and Control of Air Pollution in Beijing-Tianjin-Hebei and Surrounding Areas issued by the Ministry of Environmental Protection, the above cities will be implemented with separate emission limits to further strengthen the rectification of these areas and gradually promote the adjustment of industrial structure. In the same year, the Action Plan for Comprehensive Air Pollution Control in Autumn and Winter of 2017-2018 proposed to ensure the full completion of the assessment criteria for the Air Pollution Prevention and Control Action Plan. The Three-year Action Plan to Win the Blue Sky Defense was released at the end of June 2018, which focused on continuing air pollution prevention and control in the Beijing-Tianjin-Hebei region and its surrounding areas, the Fenwei Plain, and the Yangtze River Delta, and proposed total emission limits for carbon dioxide and nitrogen oxides nationwide. In addition, under the instructions of the central government, local governments have also introduced relevant policies and documents to specify air pollution control measures.

When studying the assessment of economic losses caused by haze pollution, domestic and foreign researchers often use methods such as human capital method, willingness to pay method, disease cost method, statistical life value method and scenario analysis method. Burtraw et al. [11] used the power market equilibrium model named Haiku and the Model Tracking and Analysis Framework (TAF) of the Comprehensive assessment of Atmospheric Transport and Environmental impact to study the auxiliary benefits of greenhouse gas emission reduction policies in the power sector of the United States from 2000 to 2010. Shi[12] used Cox equivalent Poisson models and parallel computing to estimate the hazard ratio (HR) for first hospitalization for Parkinson's disease or Alzheimer's disease and related dementia, and found that exposure to annual average $PM_{2.5}$ was significantly associated with increased risk of Parkinson's disease, Alzheimer's disease, etc., in the United States. Domestic scholars have evaluated different regions of the country [13,14]. Most of the assessment focused on the Beijing-Tianjin-Hebei region, but there are other areas as well.Wang et al. [15] used the exposure response model to quantify the negative health effects of $PM_{2.5}$ pollution in Beijing in 2013, established a CGE model to simulate the exogenous impact of $PM_{2.5}$ pollution on the national economic system, and calculated that the GDP loss was 901 million CNY. Han[16] evaluated the health benefits of prevention and control of PM_{10} and $PM_{2.5}$ pollution in Zhengzhou from 2014 to 2016.Wu[17] evaluated the number of deaths attributed to long-term $PM_{2.5}$ exposure and its corresponding health and economic losses in the Beijing-Tianjin-Hebei region in 2015. Chen[18] used Poisson regression model to estimate the public health impact and economic loss of $PM_{2.5}$ pollution caused by coal consumption by using the data of 2015, and predicted the public health impact and economic loss of $PM_{2.5}$ pollution caused by coal consumption in 2020 and 2030. Dong[19] used the exposure response model to measure the health loss, and used the revised human capital method, willingness-to-pay method and disease cost method to calculate the economic loss, and found that $PM_{2.5}$ pollution had a significant impact on the health effect and economic loss of the Fenwei Plain. Fan[20] used a log-linear expose-response function to estimate the health impacts of PM_{10} in the Beijing-Tianjin-Hebei region in 2016, and found that the health economic losses caused by air pollution accounted for 1.32%, 0.97% and 1.74% of the local GDP in Beijing, Tianjin and Hebei. Wang[21] proposed a health-related economic loss assessment system, simulated the $PM_{2.5}$ concentration characteristics of three cities in the Beijing-Tianjin-Hebei region, and estimated the economic loss of the Beijing-Tianjin-Hebei region. Chen[22] discussed the establishment of ecological compensation mechanism and constructed a model to measure the economic loss of residents. Li[23] estimated the health effects and health economic losses caused by $PM_{2.5}$ in 297 cities at the prefecture level and above in China from 2015 to 2018, and found that the health economic loss decreased from 15790.39 billion CNY to 838.416 billion CNY, and the proportion of health economic loss in GDP decreased from 2.31% to 0.99%. Xu[24] evaluated the health economic loss caused by $PM_{2.5}$ pollution in the Beijing-Tianjin-Hebei region from 2013 to 2018 and found that the health economic loss caused by $PM_{2.5}$ pollution in the Beijing-Tianjin-Hebei region showed a downward trend year by year from 2013 to 2018. Wang[25] evaluated the health economic loss of "2+26" cities in 2020, and found that the economic loss showed a spatial distribution characteristics of high in the east and low in the west, and put forward corresponding policy recommendations on this basis. Zhao[26] evaluated the effect of "2+26" cities after adopting corresponding emission reduction policies from 2015 to 2018, and concluded that the concentration of each pollutant had decreased, and the health and economic losses caused by air pollution had been reduced.

The existing research results mainly focus on the Beijing-Tianjin-Hebei region, and there are few studies on 2+26 cities. The loss assessment in a period of time has not been updated. Therefore, this paper based on the existing research, Based on the air pollution transmission channel cities in Beijing-Tianjin-Hebei region identified in the 2017 Work Plan for Air Pollution Prevention and Control in Beijing-Tianjin-