Relationship between Lung Cancer Mortality and Haze in Yangtze River Delta of China from 1961 to 2005

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Abstract. Since the reform and opening up in China, the occurrence frequency of hazy phenomena have yearly increased, particularly in the urban agglomeration such as the Yangtze River Delta (YRD), Beijing-Tianjin Area, and the Pearl River Delta Area. The exposure to extremely poor ambient air quality might result in harmful influence on human health, such as respiratory system and cardiovascular diseases and deterioration in lung function. Here, we selected a typical area of the Yangtze River Delta (Nanjing city for case). We statistically analyze 45-year historical surface observations data of haze in Nangjing city, Southeastern China to study the relationship between lung cancer mortality and haze. The results showed that the dramatic increasing trend of annual occurrence of hazy days between 1961 and 2005, and then the relative incidence of lung cancer increased.

Keywords: Lung cancer, Haze, Adenocarcinoma, Mortality

1. Introduction
The influence of air pollution on the death rate of heart and lung is a great threat to the health of urban residents. Every year, a large number of hospitalizations and deaths are related to exposure to outdoor air pollution, including increased mortality rate, increased hospitalization rates, and decreased lung function [1]. Several researchers have found that the large increases in sickness and death of preexisting cardiorespiratory that accompanied such episodes of air pollution [2]. Many researches pointed out the associations between exposure to poor ambient air quality and respiratory symptoms by previous cross-sectional studies [3]. Other studies also showed decrements of lung function with increase of air pollution [4]. People living in urban environments may face increasing risk of disease and death caused by exposure to environmental pollution, because typical urban areas are more polluted than surrounding suburban or rural areas (such as automobile exhaust and industrial waste gas) [5]. Therefore, several studies have been published on this association in USA, Canada, and Europe [6].

With population increasing quickly and economic development, the Chinese atmospheric pollution has turned into a principal question, due to the intensive emission, especially in urban agglomeration such as the Yangtze River Delta (YRD), Beijing-Tianjin region, and Pearl River Delta region [7]. Because of the dramatic growth of emissions of anthropogenic pollutants (e.g. SO2, NOx and O3) [8] has led to high aerosol concentrations in atmosphere [9]. Cheng et al. [10] found that mass extinction efficiency of PM10 is 2.25m2/g in the last decade, and it still increases year by year in YRD. The
extremely high concentrations of aerosols and gaseous pollutants in Central and Southern China have been reported by some investigators [11]. Last decade, more and more researchers have implemented the studies on air pollution and health in China [12], where atmospheric pollution furnishes a great risk for respiratory morbidity and cardio-pulmonary mortality [13].

Most of statistical evidence showed that particulate matter has harmful effect on the health [7]. However, atmospheric particles have the complex composition and have no even distribution [13]. Furthermore, there no trend evaluation on the health effect of haze in Nanjing was found. Therefore, the objective of our study is to study the association of haze day and lung cancer mortality in Nanjing, which is one of the typically polluted zones in YRD, China.

2. Material and Methods
Nanjing city (32º03’ N, 118º46’ E) is a typically polluted city of YRD. There is a population of 8.0 million by the end of 2010. Vehicular and industries emissions are main sources of local air pollution. The mortality data of Nanjing city were obtained from the Municipal Center for Disease Control and Prevention in Nanjing. The causes of death were extracted, using the International Classification of Diseases, Tenth Revision (ICD-10). The haze day data (from 1961 to 2005) were obtained from Nanjing Meteorological Station.

3. Results and Discussion
3.1. Temporal Changes of Haze Days and the Mortality of Cancer
As shown by figure 1, it is features of the evolution of the haze day during 1961 – 2005 timeframe. There are four successive periods: 1) between 1961 and 1974, the annual occurrence of haze days (AOHD) is few, generally less than 5 days; 2) between 1975 and 1995, the AOHD rapidly increases, with values reaching about 158 days in 1994; 3) between 1995 and 2000, the AOHD slightly decreases; 4) between 2001 and 2005, the AOHD values continue to increase, and are characterized by small annual variations.

![Figure 1](image-url)

**Figure 1.** Time series (1961–2005) of annual occurrence of haze days and mortality of cancer (deaths/100,000 people).

The lung cancer morbidity is small between 1961 and 1974 with 12 (deaths/100,000), subsequently, added up to 25 (deaths/100,000) between 1975 and 1994, and continue to increase to 35 (deaths/100,000) between 1975 and 1995, but decreases to 32 (deaths/100,000) between 2001 and
2005 (see figure 1).

3.2. Relationship of Haze Days and the Mortality of Cancer

Figure 1 also shows that the mortality of four kinds of cancer in Nanjing. Three kinds of cancers (gastric cancer, esophagus cancer, and intestinal cancer) do not exhibit any significant correlation with long-term trend of AOHD. Obviously, there is a significant difference in variation tendency of lung cancers compared with other three cancers (gastric cancer, esophagus cancer, and intestinal cancer).

Although the mortality of lung cancers was associated with AOHD, we found variation tendency value of the yearly average AOHD was absolutely inconsistent with variation trend value of cancer mortality in different time period. Tie [7] showed a statistical analysis of atmospheric aerosol particles resulted in lung cancer mortality in the city of Guangzhou, China. They pointed out that the highest correlation coefficient between atmospheric aerosol particles and lung cancer mortality will be found in a time lag of about 7-8 years. Because the occurrence of lung cancer needs to be exposed to fine particles for a long time, the incubation periods of lung cancers is caused by atmospheric particulate matter. The related coefficient between mortality and AOHD was not absolutely consistent. However, we didn’t get the quantitative time lag that is similar to the value derived by Tie [7], because of the lack of enough long-term data of lung cancer mortality in Nanjing.

It is supported possible causal relationship between the mortality of lung cancer and haze day occurrence. A number of medical authors have reported that the possibility of developing lung cancers will be increased as individuals were exposed to high concentration of particles produced by vehicles, industry and power plants. In the haze day (with relative humidity <80%, by visibility less than 10 km), it is generally considered to be related to atmospheric particles. Many studies have been published concerning significant correlation between haze day and high concentrations of particle matter (PM). Recently, several researchers have found that major particles are the radius of less than 1.0 μm in haze day of Nanjing [14]. Forastiere [15] believed that fine particles more easily generate lung cancer tumors, because it is easier for fine particles than the larger particles to penetrate into the lungs.

Tobacco smoking is by far the leading cause of lung cancer. It is known that lung cancer was a leading cause of deaths. Several researchers have reported that lung cancers are associate with tobacco smoke. We have not obtained data of the rate of cigarette smoking in Nanjing from 1961 to 2005. However, the different kinds of lung cancer cases in Nanjing city (1961-2005) were reported by Zeng et al [16].

Figure 2 showed a statistically significant increased risk (from 32.4% to 45.2%) for adenocarcinoma in Nanjing during ten years. A lot of study results indicated that air pollution appears to be more strongly associated with adenocarcinoma than with other types of lung cancer. Therefore, there is the better relationship between the AOHD and lung cancer mortality in Nanjing.

![Figure 2. Transform of pathology of lung cancer in ten years * data source in Zeng et al. [16].](image-url)
4. Summary
To conclude, we found that valuable statistical evidence of the association between AOHD and the mortality of lung cancers in YRD, such as Nanjing of China. Note that quick modifications in economic and healthcare systems may lead to major errors related to the data collected during periods. Due to the lack of data for other risk factors (e.g., age, education level, occupational groups, smoking influence, etc.) and no enough reliable information to affect our conclusions, our research cannot completely draw conclusions. Additionally, there is multifaceted analyses to complement pollution of the atmosphere and medical reports for obtained key evidence between haze day and lung cancers mortality in future.

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References
[1] Schwartz J 1994 Air pollution and daily mortality: a review and meta analysis Environmental Research 64(1): 36-52.
[2] POPE III C A 2000 What do epidemiologic findings tell us about health effects of environmental aerosols? Journal of Aerosol Medicine 13(4): 335-354.
[3] Zemp E, Elsasser S, Schindler C, et al. 1999 Long-term ambient air pollution and respiratory symptoms in adults (SAPALDIA study) American Journal of Respiratory and Critical Care Medicine 159(4): 1257-1266.
[4] Detels R, Tashkin D P, Sayre J W, et al. 1991 The UCLA population studies of CORD: X. A cohort study of changes in respiratory function associated with chronic exposure to SOx, NOx, and hydrocarbons American Journal of Public Health 81(3): 350-359.
[5] Lighty J S, Veranth J M, Sarofim A F 2000 Combustion aerosols: factors governing their size and composition and implications to human health Journal of the Air & Waste Management Association 50(9): 1565-1618.
[6] Moolgavkar S H, McClellan R O, Dewanji A, et al. 2013 Time-series analyses of air pollution and mortality in the United States: a subsampling approach Environmental Health Perspectives 121(1): 73.
[7] Tie X, Wu D, Brasseur G 2009 Lung cancer mortality and exposure to atmospheric aerosol particles in Guangzhou, China Atmospheric Environment 43(14): 2375-2377.
[8] Su S, Li B, Cui S, et al. 2011 Sulfur dioxide emissions from combustion in China: from 1990 to 2007 Environmental Science & Technology 45(19): 8403-8410.
[9] Kang H, Zhu B, Su J, et al. 2013 Analysis of a long-lasting haze episode in Nanjing, China Atmospheric Research 120: 78-87.
[10] Cheng Z, Wang S, Jiang J, et al. 2013 Long-term trend of haze pollution and impact of particulate matter in the Yangtze River Delta, China Environmental Pollution 182: 101-110.
[11] Wang S, Zhang Q, Streets D, et al. 2012 Growth in NO x emissions from power plants in China: bottom-up estimates and satellite observations Atmospheric Chemistry and Physics 12(10): 4429-4447.
[12] Zhang Z, Wang J, Chen L, et al. 2014 Impact of haze and air pollution-related hazards on hospital admissions in Guangzhou, China [J] Environmental Science and Pollution Research 21(6): 4236-4244.
[13] Karthikeyan S, Balasubramanian R, Iouri K 2006 Particulate air pollution from bushfires: Human exposure and possible health effects Journal of Toxicology and Environmental Health-Part a-Current Issues 69(21): 1895-1908.
[14] Parent M E, Rousseau M C, Boffetta P, et al. 2007 Exposure to diesel and gasoline engine emissions and the risk of lung cancer American Journal of Epidemiology 165(1): 53-62.
[15] Forastiere F 2004 Fine particles and lung cancer *Occupational and Environmental Medicine* **61**(10): 797-798.

[16] Zeng Y, Liang J, Shen H 2008 The characteristics of lung cancer cases in 1996-2005 in Nanjing, China *Chinese Journal of Lung Cancer* **11**(3): 406-409.