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The effects of air pollution on mortality in South Korea

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Abstract

It is well known that air pollution has the negative effect on human health. This study is dealt with the relationship between air pollutant level and standardized mortality between 2005 and 2013 in Korea. The standardized mortality are collected by the 251 administrative districts using KOSIS (Korean Statistical Information Service) and the air pollutant data collected from air pollutant monitoring sites. The statistical interpolation technique is adapted to solve the problem of spatial misalignment between air pollutant and administrative districts. In addition, SaTScan is used to detecting the high relatively risk area based on spatial and temporal characteristics. It can help determining other external factors to mortality.

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Keywords: SaTSCan, Korea, Air pollution, Health effect, Spatio-temporal data

1. Introduction

It is well known that air pollution has the negative effect on human health from a number of previous studies. Continues to increase worldwide disease caused by air pollution, the World Health Organization has estimated that the number of mortality caused by air pollution close to about 7 million people (WHO,2014). For example, exposure to sulfur dioxide causes chronic lung disease and respiratory disorders. Exposure to ozone and particulate matter are associated with the occurrence of the respiratory and circulatory diseases and increase in mortality (Pope, 2002). Air pollution has spread rapidly due to industrialization and urbanization. This study has to look at the long-term effects of air pollution on cardiovascular disease and respiratory disease in South Korea. The area of high risk mortality and

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air pollution were calculated by SaTScan, which is software to detect spatial or space-time disease clusters and to evaluate the statistical significance of disease cluster. Visualization of cluster can help to understand the relationship between air pollution and mortality of each diseases.

2. Study Area and Data

The study area is the entire administrative area of South Korea in 2012. In 2012, the total population in Korea was 50,948,272. The focus in this study is a circulatory system disease (hypertensive disease, heart disease, ischemic heart disease, other heart disease, cerebrovascular disease) and diseases of the respiratory system (pneumonia, chronic airway disease). In addition, the air pollution is SO2, PM10, O3, NO2, CO.

The standardized mortality for diseases of the respiratory system, diseases of the circulatory system between 2005 and 2013 in Korea collected by the 251 administrative districts using KOSIS (Korean Statistical Information Service) and the air pollutant data for the same period collected from air pollutant monitoring sites for each area.

3. Methodology

3.1. Software for The Spatial and Space-Time Scan Statistic

In order to evaluate the overall spatial correlation, Moran's index I was calculated for distribution of cardiovascular diseases and respiratory diseases mortality. Moran's I ranges from -1 to +1, a positive/negative sign indicating positive/negative spatial autocorrelation. Cluster detection was performed in SaTScan with a Poisson model. Statistical cluster for concerned area are mapped according to the likelihood ratio of SaTScan. This study used likelihood ratio γ of the Poisson model and the Poisson model for SaTScan is as follows :

$$\gamma = \left(\frac{\mathrm{c}}{\mathrm{E[c]}}\right)^{\mathrm{c}} \left(\frac{\mathrm{C-c}}{\mathrm{C-E[c]}}\right)^{\mathrm{C-c}} I()$$

C is total value, c is the observed value and $\mathrm{E(c)}$ is the expected value and $\mathrm{I()}$ is an indicator function.

3.2. Geographically Weighted Regression

Geographic weighted regression (GWR) was performed to analyze the spatial correlation between air pollution and cardiovascular diseases, respiratory diseases. Compared to general regression analysis, which reflect the regression coefficients with study area, GWR is locally estimating the regression coefficients, whereby describe the change in the independent variables based on the location of the spatial unit. GWR uses the weighted matrix (W) between regions to compute β_{ij}, respective region's regression coefficients, with respect to the variable j, which depends on the geographical location i. GWR's regression analysis is as follows :

$$Y_i = \beta_{0i} + \sum_{j=1} \beta_{ji} X_{ji} + \epsilon_i$$

$$\widehat{\beta_{JI}} = (X^t W_i X)^{-1} (X^t W_i Y)$$

j is the location of the entire region, Y represents cardiovascular diseases, respiratory diseases mortality, the independent variable is the air pollution, and the regression coefficients and error term are represented as β and ϵ. The geographical weighted estimates of regression coefficient ($\hat{\beta}_{ij}$) is calculated by a weighted least-squares, and W_i is the degree of local neighborhood i.

4. Results

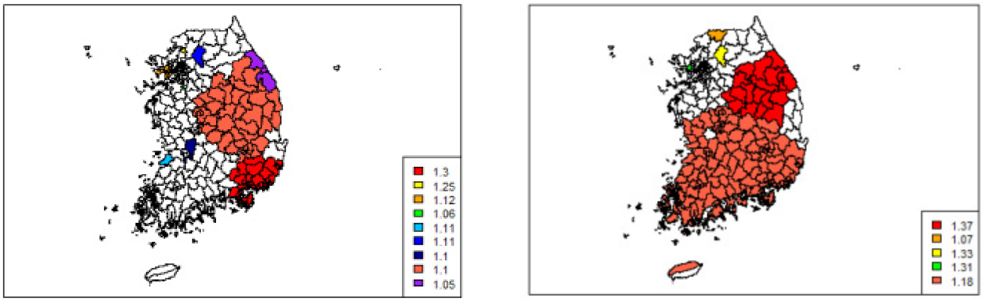

Fig. The regional clustering by SaTScan from diseases of the circulatory system (left) and diseases of the respiratory system(right). Color represents the relative risk.

Table1. Significant clusters by SaTScan from diseases of the circulatory system in South Korea, 2005-2013

Color of location	Population at risk	Number of case	Relative risk	Log likelihood ratio	P-value
Red	334,800,000	161,544	1.30	4766.45	<0.000
Yellow	9300,000	4,380	1.25	98.52	<0.000
Orange	74,400,000	31,504	1.12	197.61	<0.000
Green	427,800,000	170,148	1.06	233.83	<0.000
Sky blue	9,300,000	3,892	1.11	19.43	0.000058
Blue	9,300,000	3,892	1.11	19.43	0.000058
Dark blue	9,300,000	3,880	1.10	18.23	0.00016
Tomato	9,300,000	3,880	1.10	18.23	0.00016
Purple	27,900,000	11,080	1.05	13.23	0.011

Table2. Significant clusters by SaTScan from diseases of respiratory system in South Korea, 2005-2013

Color of location	Population at risk	Number of case	Relative risk	Log likelihood ratio	P-value
Red	176,700,000	28,168	1.37	1234.53	<0.000
Orange	1,162,500,000	143,760	1.07	240.23	<0.000
Yellow	9,300,000	1,452	1.33	53.65	<0.000
Green	9,300,000	1,428	1.31	47.01	0.0000
Tomato	9,300,000	1,248	1.18	15.90	0.0011

In the visualization result, relative risk of diseases of the circulatory system in near the Gyeongsangnam-do came highly, diseases of the respiratory system emerged highly in near the Gangwon-do. In addition, the relative risk was higher than the top of the area goes down. In general, in the south can be seen that the higher the risk for diseases of the respiratory system. The regulation may be necessary for the prevention of air pollution and disease.

Analysis of the disease is over, analysis of the air pollution monitoring site is in progress in the same way. After the air pollution analysis, using the Geographically Weighted Regression method will get the relationship between air pollution and mortality.

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