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A GIS-based spatial correlation analysis for ambient air pollution and AECOPD hospitalizations in Jinan, China

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KEYWORDS
AECOPD hospitalization;
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Summary
Background: Acute exacerbations of COPD (AECOPD) are important events during disease procedure. AECOPD have negative effect on patients' quality of life, symptoms and lung function, and result in high socioeconomic costs. Though previous studies have demonstrated the significant association between outdoor air pollution and AECOPD hospitalizations, little is known about the spatial relationship utilized a spatial analyzing technique- Geographical Information System (GIS).
Objective: Using GIS to investigate the spatial association between ambient air pollution and AECOPD hospitalizations in Jinan City, 2009.
Methods: 414 AECOPD hospitalization cases in Jinan, 2009 were enrolled in our analysis. Monthly concentrations of five monitored air pollutants (NO_2, SO_2, PM10, O_3, CO) during January 2009–December 2009 were provided by Environmental Protection Agency of Shandong Province. Each individual was geocoded in ArcGIS10.0 software. The spatial distribution of five pollutants and the temporal-spatial specific air pollutants exposure level for each individual was estimated by ordinary Kriging model. Spatial autocorrelation (Global Moran's I) was employed to explore the spatial association between ambient air pollutants and AECOPD hospitalizations. A generalized linear model (GLM) using a Poisson distribution with log-link function was used to construct a core model.

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Results: At residence, concentrations of SO_2, PM10, NO_2, CO, O_3 and AECOPD hospitalization cases showed statistical significant spatially clustered. The Z-score of SO_2, PM10, CO, O_3, NO_2 at residence is 15.88, 13.93, 12.60, 4.02, 2.44 respectively, while at workplace, concentrations of PM10, SO_2, O_3, CO and AECOPD hospitalization cases showed statistical significant spatially clustered. The Z-score of PM10, SO_2, O_3, CO at workplace is 11.39, 8.07, 6.10, and 5.08 respectively. After adjusting for potential confounders in the model, only the PM10 concentrations at workplace showed statistical significance, with a 10 $\mu g/m^3$ increase of PM10 at workplace associated with a 7% (95%CI: [3.3%, 10%]) increase of hospitalizations due to AECOPD.
Conclusions: Ambient air pollution is correlated with AECOPD hospitalizations spatially. A 10 $\mu g/m^3$ increase of PM10 at workplace was associated with a 7% (95%CI: [3.3%, 10%]) increase of hospitalizations due to AECOPD in Jinan, 2009.

As a spatial data processing tool, GIS has novel and great potential on air pollutants exposure assessment and spatial analysis in AECOPD research.

Background

Acute exacerbations of Chronic Obstructive Pulmonary Disease (AECOPD) are important events during disease procedure. AECOPD have negative effect on patients' quality of life [1,2], symptoms and lung function [3], and result in high socioeconomic costs [4]. It is estimated that AECOPD would lead to 110,000 deaths and over 500,000 hospitalizations per year, the direct cost due to AECOPD was over 18 billion dollars [5]. The acute exacerbations accelerate the rate of decline of lung function [6,7], correlated with significant mortality, particularly in those requiring hospitalizations (Figs. 1 and 2).

Exacerbations of COPD can be triggered by various factors. Though respiratory tract infections appear to be the most common causes, not all patients suffering AECOPD have the evidence of infection. Growing evidence support that ambient air pollution is an environmental triggering factor for acute exacerbation of COPD [8—10].

Geographical information system (GIS) aims to integrate the digital capture, management, analysis and visualization of geographically referenced data spatially. Better interpretation of the patterns, trends and relationships between disease and demography, environment, space and time could be obtained through GIS. Thus GIS has important application in medical and health area, especially in the application of etiological research [11,12].

To our knowledge, few studies employed GIS technique to assess spatio-temporal specific exposure to air pollutants in the spatial association analysis between admissions for AECOPD and air pollution. There is no similar study in East China. We aim to assess the spatial association between ambient air pollution exposure and AECOPD hospitalizations in Jinan City through GIS.

Methods

Study area & study period

We set the study in Jinan City, 2009. Jinan is the capital of Shandong Province in Eastern China. It is located in the north-western part of Shandong province at 36° 01′—37° 32′ northern latitude and 116° 11′—117° 44′ east of Greenwich.

Target population

All cases enrolled in our study were from five large-scale hospitals interspersed in Jinan City.

COPD hospitalization cases met with the following inclusion criteria were included in our study:

(1) Hospitalization due to acute exacerbations of COPD, identified by International Statistical Classification of Diseases, 10th Revision (ICD-10) codes, J40-J44;
(2) Resided and worked in study area (Jinan City) during study period (Jan 2009—Dec 2009);
(3) Adults patients (age $>$ 18 years).

Exclusion criteria:

(1) Patients who did not reside or work in Jinan City during 2009.
(2) In order to avoid the impact of occupational exposure to air pollutants, patients who worked at high-polluting environment were excluded.

Written informed consent was obtained prior to data collection. The study and consent procedure was approved by the Ethics Committee of Qilu Hospital of Shandong University (No. KYLL-2014-4).

Exposure assessment

Subjects were geocoded using home residence and working site respectively in a Geographical Information System. We applied addresses geocoding techniques using ArcGIS 10.0 software. Each subject was shown on a map as a precise mark in correspondence with his/her home residence or working site respectively. For each marking site, concentrations of air pollutants were estimated using ordinary Kriging method to assess spatiotemporal-specific air pollution exposure. The monthly average concentrations of air pollutants from