Science of the Total Environment 529 (2015) 243–248

Contents lists available at ScienceDirect

Science of the Total Environment

journal homepage: www.elsevier.com/locate/scitotenv

Gender-specific differences of interaction between obesity and air pollution on stroke and cardiovascular diseases in Chinese adults from a high pollution range area: A large population based cross sectional study

Xiao-Di Qin [a], Zhengmin Qian [b], Michael G. Vaughn [c], Edwin Trevathan [b], Brett Emo [d], Gunther Paul [e], Wan-Hui Ren [f], Yuan-Tao Hao [g], Guang-Hui Dong [a,*]

[a] Guangzhou Key Laboratory of Environmental Pollution and Health Risk Assessment, Department of Environmental and Occupational Health, School of Public Health, Sun Yat-sen University, Guangzhou 510080, PR China
[b] Department of Epidemiology, College for Public Health and Social Justice, Saint Louis University, Saint Louis, MO 63104, USA
[c] School of Social Work, College for Public Health and Social Justice, Saint Louis University, Saint Louis, MO 63104, USA
[d] Department of Environmental and Occupational Health, College for Public Health and Social Justice, Saint Louis University, Saint Louis, MO 63104, USA
[e] Facuty of Health, School of Public Health and Social Work, Queensland University of Technology, Kelvin Grove, QLD 4059, Australia
[f] Department of Ambient Air Pollution Monitor, Shenyang Environmental Monitoring Center, Shenyang 110004, China
[g] Department of Epidemiology and Biostatistics, School of Public Health, Sun Yat-sen University, Guangzhou 510080, PR China

HIGHLIGHTS

- Few studies assessed interactions of obesity and air pollution on CVDs in Chinese.
- We included a large population of 24,845 Chinese adults from three cities of China.
- Obesity enhanced the effects of air pollution on stoke and CVDs in Chinese adults.
- Modification of obesity was significant only in females.

ARTICLE INFO

Article history:
Received 20 December 2014
Received in revised form 4 May 2015
Accepted 12 May 2015
Available online xxxx

Editor: D. Barcelo

Keywords:
Obesity
Air pollution
Stroke
Cardiovascular diseases
Interaction effect

ABSTRACT

Background: Little information exists regarding the interaction effects of obesity with long-term air pollution exposure on cardiovascular diseases (CVDs) and stroke in areas of high pollution. The aim of the present study is to examine whether obesity modifies CVD-related associations among people living in an industrial province of northeast China.

Methods: We studied 24,845 Chinese adults, aged 18 to 74 years old, from three Northeastern Chinese cities in 2009 utilizing a cross-sectional study design. Body weight and height were measured by trained observers. Overweight and obesity were defined as a body mass index (BMI) between 25–29.9 and ≥30 kg/m^2, respectively. Prevalence rate and related risk factors of cardiovascular and cerebrovascular diseases were investigated by a questionnaire. Three-year (2006–2008) average concentrations of particulate matter (PM_{10}), sulfur dioxide (SO_2), nitrogen dioxides (NO_2), and ozone (O_3) were measured by fixed monitoring stations. All the participants lived within 1 km of air monitoring sites. Two-level logistic regression (personal level and district-specific pollutant level) was used to examine these effects, controlling for covariates.

Results: We observed significant interactions between exposure and obesity on CVDs and stroke. The associations between annual pollutant concentrations and CVDs and stroke were strongest in obese subjects (OR 1.15–1.47 for stroke, 1.33–1.59 for CVDs), less strong in overweight subjects (OR 1.22–1.35 for stroke, 1.07–1.13 for CVDs), and weakest in normal weight subjects (OR ranged from 0.98–1.01 for stroke, 0.93–1.15 for CVDs). When stratified by gender, these interactions were significant only in women.

Conclusions: Study findings indicate that being overweight and obese may enhance the effects of air pollution on the prevalence of CVDs and stroke in Northeastern metropolitan China. Further studies will be needed to investigate the temporality of BMI relative to exposure and onset of disease.

* Corresponding author at: Department of Preventive Medicine, School of Public Health, Sun Yat-sen University, 74 Zhongshan 2nd Road, Yuexiu District, Guangzhou 510080, PR China.
E-mail address: donggh5@mail.sysu.edu.cn (G.-H. Dong).

http://dx.doi.org/10.1016/j.scitotenv.2015.05.041
0048-9697/

1. Introduction

Cardiovascular diseases (CVDs) are the primary cause of death in the world, with 17.3 million deaths in 2008, including 6.2 million people who died of stroke (Mendis et al., 2011). China has a significant burden of cardiovascular diseases, with about 6 million deaths attributed to cardiovascular diseases in 2010, accounting for 41% of all deaths (Hu et al., 2012). Although many studies have focused on traditional risk factors for cardiovascular disease, such as smoking, obesity, diabetes, metabolic syndrome, and high blood pressure (Yusuf et al., 2001), there is growing evidence that air pollution may also be a risk factor for cardiovascular disease (Brook et al., 2010; Chen et al., 2013). The specific underlying etiology and pathogenesis behind this association remain unclear, but most authors agree that a possible pathway of air pollution acting on CVDs may include inflammation, autonomic dysfunction, and oxidative stress (Tsai et al., 2012).

Prior investigations have demonstrated an increased susceptibility to cardiovascular events due to poor air quality among persons with obesity (Baja et al., 2010). Moreover, obesity is associated with increased cardiovascular morbidity and mortality and increased inflammation and oxidative stress (Berrington de Gonzalez et al., 2010; Matsuda and Shimomura, 2014). Finally, the effects of inhaled ambient air pollution on adipose inflammation may be facilitated by obesity (Sun et al., 2009). Based on these findings, it is conceivable that obese individuals may be sensitive to the effects of ambient air pollutants, causing exacerbation of underlying cardiovascular disease. Given the paucity of research on these links, the objective of this investigation was to shed light on these relationships.

The authors hypothesized that, at the population level, air pollution exacerbates underlying CVDs and stroke in subjects with an obese or overweight BMI. This hypothesis was examined using data from the '33 Communities Chinese Health Study', a cross-sectional study of air pollutant exposure and health outcomes in a sizeable and well-characterized adult population sample in northeast China. Wide differences were observed both within and between cities and in ambient pollutant concentrations, providing a unique opportunity to examine underlying exposure–response relationships.

2. Materials and methods

2.1. Site selection and participant recruitment

The study sites and participant recruitment were reported elsewhere (Dong et al., 2013; Zhao et al., 2013). Briefly, Liaoning province is located in northeast China and is comprised of over 20 million people in 14 cities. In order to obtain the maximization of the pollution gradients of the pollutants of interest and minimize the correlation between pollutants in a district, three major provincial cities (Shenyang, Anshan, and Jinzhou) were selected based on the measured pollutants' concentrations between the years of 2006 and 2008.

Shenyang has five districts and both Anshan and Jinzhou have three districts, a total of 11 study districts. Each district contained a single fixed air monitoring station. A total of 33 locales were randomly selected, three locales within each district, among communities within 1 km of a monitoring station. Within each locale 700 to 1000 households were then randomly chosen and one participant, 18 to 74 years old, was selected from each household, without replacement. The study was limited to subjects who lived in the same location for 5 years or more. The design and conduct of this study were reviewed and approved by the Human Studies Committee of Sun Yat-sen University. Written informed consent was obtained from each participant prior to data collection. Data from this study have resulted in several publications and the study sites and participant recruitment were reported elsewhere (Dong et al., 2013; Zhao et al., 2013).

2.2. Definition of obesity and overweight

Body weight and body stature were measured using a standardized protocol (Dong et al., 2013; Zhao et al., 2013). Briefly, body mass index (BMI) was calculated as weight (in kilograms) divided by stature (in meters) squared (kg/m^2). According to the definitions proposed by the World Health Organization (1995), subjects with BMI ≥ 25 kg/m^2 and <30 kg/m^2 were classified as overweight and those with BMI ≥ 30 kg/m^2 were classified as obese.

2.3. Assessment of air pollution exposure

Ambient PM_{10}, SO_2, NO_2, and O_3 concentrations from 2006 to 2008 were obtained from municipal air monitoring stations sited within 1 km of each study household. The monitoring data was used to develop parameters of long-term exposure.

This study adhered to the methodological standards set by the State Environmental Protection Administration of China for air pollution measurements (State Environmental Protection Administration of China (SEPA), 1992). We measured pollution levels continuously for particulate matter of 10 μm or less in aerodynamic diameter (PM_{10}; β-ray absorption method), sulfur dioxide (SO_2; ultraviolet fluorescence), nitrogen dioxide (NO_2; chemiluminescence) and ozone (O_3; ultraviolet photometry). Daily average concentrations of PM_{10}, SO_2 and NO_2, and an 8-hour average of O_3 (10:00 AM to 6:00 PM) were calculated based on measurements from days in which at least 75% of the 1-hour values were available, after excluding outliers in the hourly measurements collected from each monitoring station. Estimated exposures were 3-year average (2006–2008) concentrations.

2.4. Cardiovascular diseases and stroke

Questionnaires were used to assess cardiovascular and cerebrovascular status (Dong et al., 2013; Zhao et al., 2013). Briefly, CVDs were classified by an affirmative response to the question "has a doctor ever diagnosed heart failure, coronary heart disease, or myocardial infarction to you." Stroke was determined by an affirmative response to the question "has a doctor ever diagnosed stroke including cerebral hemorrhage, cerebral embolism, cerebral thrombosis, or subarachnoid hemorrhage to you". Study participants who answered 'yes' to both cardiovascular diseases and stroke met the criteria for cardio-cerebrovascular disease.

2.5. Statistical analysis

Prior to hypothesis testing, data was assessed for normality (using Shapiro–Wilk W-test) and homogeneity (using Bartlett's test for unequal variances). For continuous variables, values of the mean ± SD were calculated for each group, however for categorical variables relative frequencies were calculated. Contingency tables and χ^2-tests were used to compute associations between categorical variables.

CVDs and stroke were set as the dependent variables (Y) with four air pollutants—PM_{10}, SO_2, NO_2 and O_3 as the environmental independent variables. Normal weight, overweight, and obese, defined by BMI, were established as a person-based independent variable. The following covariates (X) were also employed: age, sex, race, education, income, smoking, drinking, exercise, diet, sugar, family history of CVD, family history of stroke, and study district.

A two-level logistic regression model was used to analyze the effects of air pollution on CVD and stroke (Dong et al., 2013; Zhao et al., 2013). In the first level a logistic regression model was fitted to predict the probabilities of CVD and stroke for each participant using all covariates:

$$\mathrm{logit}\left[\Pr\left(y_{ij}\right)\right] = \alpha_j + \lambda \mathrm{Bodyweight}_{ij} + \beta' X \quad (1)$$