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Does urban land-use increase risk of asthma symptoms?

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ABSTRACT

Background: Global urbanization is increasing rapidly, especially in Asian countries. The health impacts of this unprecedented rate of urbanization are not well understood. Prevalence of asthma is also increasing, especially in cities.

Methods: We explored the effects of urbanicity, based on urban land-use and traffic-related air pollutants (NO_2, PM_{10}), on asthma symptoms and diagnosis at a nationally representative level, using individual-level data from the 2008–2010 Community Health Survey data in Korea. We applied logistic regression, adjusting for sex, age, education, smoking status, and household income. To investigate whether different levels of urban intensity (i.e., degree of urbanization) affected the association, we stratified analysis by urban intensity for the subject's residential district: high ($\geq$30% urban), medium (10–30%), and low intensity ($<$10%).

Results: Increased urban land-use was significantly associated with increased risk of asthma symptoms and diagnosis. A 10% increase of urban land-use of a subject's residential district was associated with an odds ratio (OR) of 1.03 (95% CI: 1.02, 1.04) for self-reported physician-diagnosed asthma. However, increased urbanicity is associated with higher risk of asthma in areas with a baseline of low urbanicity, but not in areas with a baseline of high urbanicity. Significant positive associations were also observed for air pollution (PM_{10} and NO_2) with asthma symptoms and diagnosis.

Conclusions: Our findings suggest that increases in urbanicity or air pollution are associated with increased risk of asthma, and that the level of urban intensity affected the associations.

1. Introduction

Asthma is one of the most common chronic diseases, and its prevalence has increased in recent decades (Eder et al., 2006; WHO, 2008). Asthma has become a major health priority, especially in Asia, which is experiencing rapid economic development and urbanization (Wong et al., 2013). Previous studies suggest that several factors, such as traffic-related air pollution, residential proximity to roads and heavy traffic, and household characteristics, are associated with increased risk of asthma-related symptoms (Chauhan et al., 2003; Corburn et al., 2006; Gasana et al., 2012; Shirinde et al., 2014; Sinclair et al., 2014; Ware et al., 2014). Other studies found associations between asthma symptoms and family history such as genetics, similar environments, and Western lifestyle factors such as diet (Corbo et al., 2008; Selcuk et al., 2010).

Urbanization is another factor that could alter the prevalence of risk factors for chronic disease including asthma. Health may be affected by urbanization through environmental exposures including air pollution and noise. Further, urbanization may change the geographical distribution of chronic disease (e.g., obesity, hypertension, and diabetes mellitus) in developing countries due to changes in lifestyle risk factors such as dietary changes and reduced physical activity. Some studies have investigated how urbanization impacts health in developing countries (Allender et al., 2008; Eckert and Kohler, 2014). Some findings suggest that rapid urbanization may worsen health status (Bygbjerg, 2012; Koehlmoos et al., 2011; Moore et al., 2003) while others suggest that health improves with better access to health services and information (Kohler, 2013; Tatem et al., 2013). In some urban areas, such as New York City, U.S., the prevalence of asthma is severe, and children in poor urban neighborhoods are more likely to be hospitalized for asthma (Corburn et al., 2006).

Disparities in asthma prevalence by region (Wong et al., 2013) may, in part, relate to environmental exposures. Asthma symptoms occur more frequently in urban than rural areas, which may be influenced by urban environmental exposures such as vehicle emissions, house dust mites, and Western-style diets (Jie et al., 2013; Lawson et al., 2011; Solé et al., 2007; Van de Poel et al., 2009; Vlaski and Lawson, 2014). Some studies suggest that the higher asthma prevalence and morbidity in some poor inner-city

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residents and rural populations are related to socio-economic status (SES) and population characteristics such as lower education, lower income, larger fraction of older persons, lack of health insurance coverage, and less availability of healthcare service (Jie et al., 2013; Litonjua et al., 2001; Valet et al., 2009).

The impact of allergic respiratory diseases, including asthma, appears to be higher in urban than rural areas, with urban air pollution resulting from high levels of road traffic and vehicle emissions. Air pollutants may interact with pollen grains leading to increased release of allergens. Due to the damage of airway membranes caused by air pollution, inhaled allergens may more easily access the cells of the immune system (D'Amato et al., 2010). In addition, climate change has impacts on pollen quantity, pollen season, and the distribution of plants and pollen. Increased exposure to allergens due to climate change with high levels of pollutants may increase asthma symptoms in urban areas (Beggs, 2004; D'Amato et al., 2010).

The global urban population is increasing rapidly. The population of developing countries, particularly in Asia and Africa, will be over 80% of the world's urban population within the next two decades (Allender et al., 2011). Thus, understanding geographic differences in asthma prevalence and the pathways through which urbanization affects health is needed. This issue is particularly important for regions that may have the fastest urbanization and less ability to respond to environmental and health stressors.

South Korea has experienced expansive urbanization along with rapid economic growth and industrialization. Urbanization increased sharply from 21.4% of the population residing in urban areas in 1950 to 82.7% in 2009 (UN, 2010). However, the impacts of urbanicity on health are poorly understood. Asthma in Korea is increasing steadily (Cho et al., 2006), with a prevalence of 2–13% in the general population, and 12.7% in the elderly. Most earlier studies on asthma and urbanization focused on potential differences in effects in urban areas versus rural areas (Cheong et al., 2012; Lin and Lin, 2014; Ro et al., 2013). Only a few, limited studies have investigated whether this relationship differed by the level of urban intensity (i.e., the degree of urbanization), although public health would be best served by identifying which aspects of urbanicity are most associated with health.

We explored the effects of urbanicity on asthma at a nationally representative level, using the 2008–2010 Community Health Survey data in Korea. The Survey data provides individual-level information on health status and its determinants. We investigated whether different levels of urban intensity are associated with risk of asthma symptoms and diagnosis. For this work, we view urban land-use as a summary measure of complex environmental factors related to urban environments that may include noise, traffic pollutants, and other factors. We also evaluated the associations between traffic-related air pollutants (nitrogen dioxide: NO_2, particulate matter with aerodynamic diameter $\leq$ 10μm: PM_{10}) and asthma, to distinguish the impacts of urban-related traffic from that of other urban factors.

2. Material and methods

2.1. Data

We obtained data for three years (2008–2010) of the Community Health Survey. These nationwide surveys have been conducted periodically since 2008 by the Korea Center for Disease Control and Prevention and public health centers. The goal of the Survey is to assess the health status and its determinants of the Korean population and to produce community-based comparable health statistics at various spatial scales (Kim et al., 2012; Ryu et al., 2011).

South Korea is divided into 8 provinces (e.g., Gyeonggi), 1 special autonomous province (Jeju), 6 metropolitan cities (e.g., Busan, Incheon), and 1 special city (Seoul). These divisions are further subdivided into smaller levels such as cities, counties, and districts. The large cities (population $>$500,000) are divided by *gu* (district). *Gus* are similar to boroughs in some Western countries. Provinces are further divided into a *si* (city) or *gun* (county). A *gun* (county) has population $<$150,000 and once a *gun* attains $>$150,000 residents, it becomes a *si* (city). A *gun* is less densely populated than a *gu* and more rural in character than the divisions *si* (city) or *gu* (district). For each study participant, data include the district of residence for those living in major cities, or the city, county, or district for those living in provinces. Hereafter, we refer to these areas as the "district-level."

The Community Health Survey uses a complex, stratified, multistage, probability-cluster sampling of a representative sample of the adults ($\geq$19 years) living in each community. The Survey was conducted by trained interviewers as face-to-face interviews based on a protocol and questionnaires. We used Survey data collected September–November in 2008 and 2009 and August–October in 2010. The questionnaires consist of a personal survey including socio-demographic characteristics, health behavior, chronic disease, injury, quality of life, immunizations and screening, and utilization of health services, and a family survey including type of house and household income. The Survey provides the location of residence at the district level for each subject. Analysis included 680,202 subjects.

Asthma was defined as presence of asthma symptoms during breathing/exercise within 1 year and/or self-reported physician diagnosis of asthma. The Survey asked: "Have you ever experienced asthma symptoms (wheezing sound) during breathing within 1 year?", "Have you ever experienced asthma symptoms (wheezing sound) during exercise within 1 year?", and "Have you ever been diagnosed with asthma by a physician?". The answer (Yes/No) of each question was used as the dependent variable in analysis of separate asthma-related health outcomes: presence of asthma symptom during breathing within the past year, presence of asthma symptom during exercise within the past year, and self-reported physician-diagnosed asthma.

For each study subject, Survey data included sex, age, education, smoking status, and household income. Age was categorized by the Survey as 19–44, 45–64, 65–74, and $\geq$75 years. Highest attained level of education was classified as none, elementary school (6 years), middle school (3 years beyond elementary school), high school (3 years beyond middle school), and university (e.g., undergraduate degree or graduate school). Smoking status was categorized as smoker and "non-smoker", which includes never smokers and light smokers ($<$5 packs of cigarettes during their lifetime). Average yearly household income was categorized as $<$30,000,000, 30,000,000–50,000,000 and $\geq$50,000,000 (1000 is approximately $1).

We obtained 2007 national land-use data from the National Geographic Information Institute (2014). Across the nation, 247 districts were included. The average area of a district was 403.3 km^2 (range 2.8–1818.0 km^2). For each district, the database provides the fraction of land-use for each of the 28 land-use categories (e.g., road, forest, farm), which were aggregated into 4 categories: urban, farm, forest/park, and water. We defined "urban" land-use as housing units, commercial/industrial areas, parking lot, school, and road. We estimated the risk of asthma symptoms and diagnosis associated with the fraction of land-use classified as urban within each district. Further, each district was classified by urban intensity (i.e., the degree of urbanization) as (a) high ($\geq$30% urban land-use of total cover), (b) medium (10–30%), and (c) low urban intensity ($<$10%).

We applied 2007 land-use data for our study period (2008–