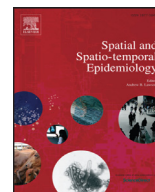


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Spatial and Spatio-temporal Epidemiology

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

Air pollution is associated with primary health care visits for asthma in Sweden: A case-crossover design with a distributed lag non-linear model

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ARTICLE INFO

Article history:

Received 15 December 2015

Revised 18 April 2016

Accepted 27 April 2016

Available online 29 April 2016

Keywords:

Asthma

Primary Health Care

Air pollution

ABSTRACT

Background: Air pollution can increase the symptoms of asthma and has an acute effect on the number of emergency room visits and hospital admissions because of asthma, but little is known about the effect of air pollution on the number of primary health care (PHC) visits for asthma.

Objective: To investigate the association between air pollution and the number of PHC visits for asthma in Scania, southern Sweden.

Methods: Data on daily PHC visits for asthma were obtained from a regional healthcare database in Scania, which covers approximately half a million people. Air pollution data from 2005 to 2010 were obtained from six urban background stations. We used a case-crossover study design and a distributed lag non-linear model in the analysis.

Results: The air pollution levels were generally within the EU air quality guidelines. The mean number of daily PHC visits for asthma was 34. The number of PHC visits increased by 5% (95% confidence interval (CI): 3.91–6.25%) with every $10 \mu\text{g m}^{-3}$ increase in daily mean NO_2 lag (0–15), suggesting that daily air pollution levels are associated with PHC visits for asthma.

Conclusion: Even though the air quality in Scania between 2005 and 2010 was within EU's guidelines, the number of PHC visits for asthma increased with increasing levels of air pollution. This suggests that as well as increasing hospital and emergency room visits, air pollution increases the burden on PHC due to milder symptoms of asthma.

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1. Introduction

Asthma is a chronic, inflammatory disease in the airways, characterized by respiratory symptoms such as wheezing, coughing, dyspnea, chest tightness and impaired lung function (Bruton et al., 2011; Myers et al., 2011). It is estimated that 235 million people suffer from asthma worldwide (WHO, 2013). The World Health Survey in 2011 reported a 9.4% prevalence of diagnosed asthma cases

among adults in high-income countries and 8.2% in low-income countries (ISAAC, 2011). The prevalence of asthma in Western Europe, including the Scandinavian countries, has remained stable during the past two decades following a rapid increase between 1990 and 2000 (Hansen et al., 2000). According to a population-based study conducted in western Sweden, approximately 8.5% of the adult population suffer from asthma; the highest prevalence, (about 10%) was among young adults (Lotvall et al., 2009). The aetiology of asthma is largely unknown, but varying prevalence within and between countries suggests that genetic as well as environmental factors play a major role. A

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review by UK's Committee on the Medical Effects of Air Pollutants (2012) came to the conclusion that exposure to outdoor air pollution, particularly among those living close to high traffic area, may cause asthma (Gowers et al., 2012). Evidence on acute respiratory effects from ambient outdoor air pollution has been well documented in a large number of population based studies, mostly using inpatient and emergency room data (Halonen et al., 2008; Petroschevsky et al., 2001; Villeneuve et al., 2007; Wong et al., 2001), or in smaller panel studies (Johnson et al., 2013; Karakatsani et al., 2012; Li et al., 2012). Interestingly, acute effects of air pollution on asthma has recently been documented in a few studies using prescribed or dispensed medications as an indicator of asthma symptoms (Bechtold et al., 2013; Belanger et al., 2013; Naureckas et al., 2005) which would typically describe both mild and severe symptoms.

Acute effects of air pollution on asthma symptoms have thus mostly been studied with emergency room visits or using in-patient admissions, where symptoms can be assumed to be quite severe and acute, or in smaller panel studies. Less acute effects of air pollution on mild and moderate symptoms of asthma are usually treated in the primary health care (PHC), but PHC data is expensive and time consuming to collect, and have, to our knowledge, only been used in two prior studies. One of these studies was very small, with only 112 night time asthma visits (Yamazaki et al., 2013) and the other study investigated associations on a monthly basis, which is a rather crude time resolution (Sofianopoulou et al., 2013) Therefore there is a knowledge gap regarding less acute or mild and moderate symptoms of asthma in association with daily levels of outdoor air pollution.

The aim of the present study was to investigate the association between PHC visits and daily levels of air pollution in Scania, Southern Sweden, where PHC visits have been maintained in a centralized health registry since 2005, and where air pollution levels are rather low in an international perspective.

2. Methods

2.1. Study area and population

Sweden is the third largest country in Europe by area and with a population of 9.6 million in (2013). The present study was conducted in Scania, which is the southernmost county of Sweden (Fig. 1), with a population of over 1.2 million (So., 2012). More than 90% of the population in Scania lives in urban and semi-urban areas. As study area, we selected six municipalities in the vicinity of a meteorological measurement station (Fig. 1). These municipalities were Malmö, Lund, Vellinge, Burlöv, Staffanstorps and Lomma. The combined area of the municipalities is around 1000 km² and the population over half a million.

2.2. Air pollution and weather data

Air pollution data were obtained from the Swedish Environmental Research Institute (SMHI), six urban background monitoring stations were included in the study,

three in Malmö at Rådhuset, Rosengård and Hemparken station, one in Burlöv and two in Lund (Fig. 1). Hourly values of PM₁₀, PM_{2.5}, Ozone (O₃), Nitrogen dioxide (NO₂) and Sulphur dioxide (SO₂) were obtained for the period January 1st 2005 to December 31st 2010. The proportion of missing values ranged from 1.2% for O₃ to 2.2% for NO₂. Missing values were replaced by the mean value of three closest hours before and after in time. Information on daily levels of temperature, humidity, precipitation, wind speed, wind direction and barometric pressure were obtained from Swedish Meteorological and Hydrological Institute (SMHI) for the entire study period.

2.3. Primary health care (PHC) visits data

Fig. 2 explains the primary health care data selection procedure. Information on all PHC visits between 2005 and 2010 came from 19 PHC centers in Malmö, six in Lund, and one each in Lomma, Staffanstorps, Vellinge, and Burlöv. Health care in Sweden is decentralized and funded by taxes, the upper annual ceiling for an individual to pay is SEK 900–1100 (around 150 US\$) for hospital health care, and SEK 2000 (around 300 US\$) for dispensed prescribed medications. The cost for a visit to primary health care varies between 100 and 300 SEK (13–40 US\$) depending on the county council. The state government makes payments to private clinics once the upper ceiling is reached. Residents register to a health center, often near their residential area, and if needed are referred to specialized care by their physician. For children, all kind of health care including dental care is completely free of charge.

The county of Scania maintains a centralized database in which comprehensive information on all primary health care consultations are recorded. First, we identified all patients currently resident in one of the six municipalities included in the study, then, using a Swedish translation of the International Classification of Diseases, Revision 10 (ICD-10), all health care consultations for patients diagnosed as having any respiratory illness (all J-codes) in the study area were identified. Those with a main diagnosis of asthma were then separated using the ICD-10 codes J-45 and J45-P (Swedish translation of ICD Codes) and used in the final analysis.

Visits to private health care centers comprises around 17% (603,921) of the total number of PHC visits, and were excluded since the private health providers did not report the diagnosis to the centralized health care register database. The remaining PHC visits were at state owned primary health care clinics. The prevalence of missing diagnosis for public health care centers was high; overall, 59% of the PHC visits were without any diagnosis for the whole time period.

2.4. Ethical consideration

Members of ethical board were consulted and no ethical permit was necessary for the study as authors did not have access to any personal information and no personal identification was used for analysis, further data was analyzed at aggregate level i.e. total number of visits per day.

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