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Direct cost saving potential in medication costs due to a reduction in outdoor air pollution for the Brussels Capital Region

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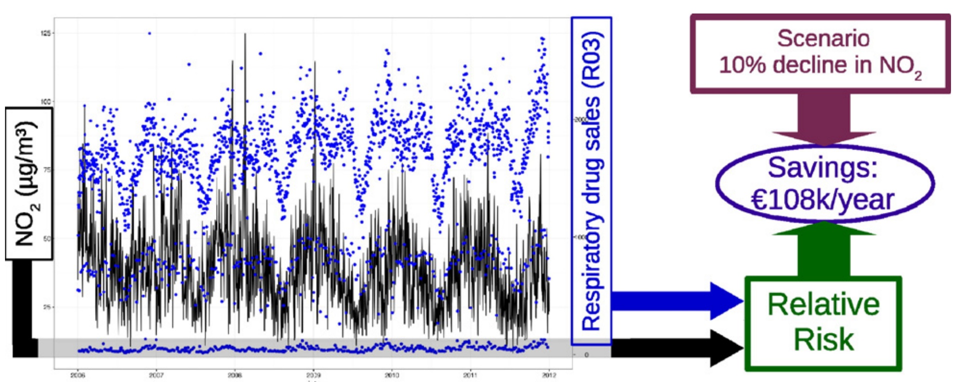
HIGHLIGHTS

- NO_2 is significantly associated with sales of anti-asthma/COPD medication.
- Both relative risks and annual expenditures are modified by age.
- 10% reduction in air pollution averts ~ €108 k/year in drug sales in Brussels.

GRAPHICAL ABSTRACT



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ABSTRACT

Introduction: The adverse health effects of exposure to air pollution have been well-established and include mortality, hospital admissions, emergency department visits, etc, but also less severe outcomes such as medication use and purchase. The economic impact, an additional motivator for policy, has been studied primarily for the more severe outcomes.

Methods: Purchase data of reimbursed medications typically prescribed for asthma and chronic obstructive pulmonary disease, were obtained through the mandatory Belgian health insurance system. A time series analyses approach was used to model daily sales on daily air pollution concentrations (NO_2, PM_{10} and $PM_{2.5}$) for residents of the Brussels Capital Region as a whole. In addition, a higher geographical resolution of both sales and pollutant concentrations allowed for a multi-sector approach. Annual savings were estimated for the scenario of a 10% reduction in each of the pollutants.

Results: Medication purchase was significantly associated with NO_2 concentrations, leading to an annual cost saving potential of € 107,845 [95%CI: € 71,483–€ 143,823] in R03 sales (WHO classification for drugs of obstructive airway diseases). Saving potentials of PM_{10} and $PM_{2.5}$ were not significant. Estimates were not sensitive to the geographical resolution, however, higher precision can be obtained with higher resolution data, subject to the condition that the number of sales is sufficiently large.

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1. Introduction

Many previous studies have confirmed the adverse effects of exposure to ambient air pollutants (Particulate Matter (PM), Nitrogen Dioxide (NO_2), Sulfur Dioxide (SO_2) and Ozon (O_3)) on respiratory public health (Sunyer, 2001; Laumbach and Kipen, 2012; WHO, 2013). The positive association between air pollution exposure and intermediate health indicators of respiratory morbidity such as emergency department visits (Arbex et al., 2009; Peel et al., 2005), hospital admissions (Medina-Ramón et al., 2006), and mortality has been widely described. Driven by these outcomes, policy making in Europe agreed on several measures to cut air pollution during the last forty years. However, more efforts should be made to implement stricter air quality standards as public health is affected even under the actual EU air quality standards (Devos et al., 2015). An extra stimulator is the economic impact. Economic data on the costs of air pollution is crucial information when priorities need to be defined and resources are scarce (Landrigan, 2012). Nevertheless, the spread of exposures across country borders, the extension of effects over different years, and many invisible effects and associated costs, make the precise estimation of the economic impact of air pollution very challenging. A limited amount of research has been conducted on the economic impact of the above described health indicators. Currently available health indicators such as hospital admissions, however, only reflect the most severe cases of patients with respiratory problems. This results in an incomplete picture of the (economic) health impact of air pollution.

Recently, research has been conducted on a less severe health indicator, namely respiratory drugs sales in community pharmacies. Zeghnoun et al. (1999) revealed in a time series study associations between black smoke (BS), NO_2, SO_2, and sales of mucolytic and anti-cough drugs. Similarly, Pitard et al. (2004) found associations with anti-asthma and chronic obstructive pulmonary disease (COPD) medication and with cough and cold medicine. Laurent et al. (2009) investigated the effect of NO_2, PM, and O_3 on beta-agonist sales, using a case-crossover design. Besides theme and methodology, these studies are characteristic in their relatively small populations (100,000 to 261,000). This is enabled by the larger frequency of medication use and purchase, compared to more traditional indicators such as hospital admissions and mortality. Conversely, for larger populations this indicator allows more specific subpopulations to be considered. Age is a primary candidate for defined subgroups as it is well-known that both asthma and chronic obstructive pulmonary disease (COPD) prevalence and incidence are age specific. For Belgium, estimated prevalence of asthma varies between 3.5% and 12.0%, according to age, time and study (Asher et al., 2006). COPD prevalence estimates range from 0.9% to 13.7% ('HISIA : Belgian Health Interview Survey – Interactive Analysis', 2015).

Mimilidis et al. (2014) observed that 45% of the people who reported having COPD in the national health interview survey of 2008, had filled prescriptions of related drugs (Anatomical Therapeutical Chemical classification R03: drugs for obstructive airway diseases, WHOCC ATC) in the same year. For asthma, no such reports are available for Belgium. Considering international results, a high likelihood of drug usage can be expected (Anarella et al., 2004). The high prevalence of drugs use also results in an economic cost for society. To the best of our knowledge, no research has been conducted on the economic impact of medication use associated with air pollution exposure. In this article we will use administrative data on medication sales to estimate the direct cost saving potential of a 10% decline in outdoor air pollution concentrations. Several variations on the analysis strategy will be considered, but all are limited to short- and medium-term effects.

2. Methods

2.1. Data

Prescription records on all drugs for obstructive airway diseases (ATC group R03), bought by residents of the Brussels Capital Region (BCR, circa one million inhabitants) between 01 January 2006 and 31 December 2011, were obtained from the Pharmanet database (Données Pharmanet, 2016). This administrative database is managed by the InterMutualistic Agency and contains all records of reimbursed drugs purchased in community pharmacies. In Belgium health insurance is mandatory and therefore the Pharmanet database is as good as complete. It incorporates information on the date and quantity of purchase, the price, the WHO Anatomical Therapeutical Classification of the product and a unique identifier of the recipient. The latter is linked to a population database with information on age, gender, and official place of residence. For approximately 90% of the population, residential address is known at the level of the statistical sector – average surface area of 1.54 km^2 – but for privacy reasons, these were regrouped into 4×4 km^2 sectors. For the remaining 10%, location is known at the level of the commune and for this article regrouped into in or out of the Brussels Capital Region, which is roughly 16×16 km^2.

Daily average PM_{10}, $PM_{2.5}$, and NO_2 concentrations were obtained from the Belgian Interregional Environment Agency. Data were derived from the RIO-CORINE model (Janssen et al., 2008), a nation-wide land-use regression model that combines data from monitoring stations with satellite image-based land cover data. The number of monitoring stations increased over time from 45 to 64 for PM_{10}, but were stable for NO_2, counting between 84 and 89. In the RIO-CORINE model, the 44 CORINE land cover classes are aggregated into 11 RIO land-use classes that are used for de- and re-trending local data with an ordinary Kriging interpolation step in between. The resulting interpolated air pollution concentrations were available on a 4×4 km^2 grid, matching the resolution of the health care utilization data, without missing values. However, the majority of $PM_{2.5}$ measurement stations have started only in 2008 and earlier data are based on back-extrapolation; in 2011, 37 stations were operational. Naturally, the number of stations and the type of pollutant influence the error of the interpolated values. A validation study by Maiheu et al. (2013) yielded temporal explained variances (R^2) between 0.7 and 0.9. These were calculated for the entire nation, however, the proximity to the nearest station(s) influences the local relative error and due to the placement of stations, this is favorable for the Brussels Capital Region.

Models were controlled for meteorological data and influenza epidemics, as these are known to be confounders for the association between air pollution and health outcomes. Meteorological data was provided by the Royal Meteorological Institute: daily mean relative humidity and maximum temperature as recorded in the station in Uccle (BCR). A binary indicator for influenza epidemics in Belgium (one per year), was provided by the National Influenza Centre (WIV-ISP).

Ethical approval for the study was obtained by the Belgian Privacy Comity, the sectoral comity of social security and health (Deliberation 12/091).

2.2. Statistical analyses

All records pertaining to medicines belonging to ATC group R03 were included in the analyses. Events wherein a single person bought more than five of the same product on a single day, were excluded. Such events are rare (<0.2%). They are atypical and may be errors.

We used a standard ecological time series approach: for each 4×4 km^2, pollutant, and age-group, we extracted time series of the

Table 1
Descriptive statistics of daily outdoor air pollutant concentrations for the Brussels Capital Region, 2006–2011.

	Minimum ($\mu g/m^3$)	Maximum ($\mu g/m^3$)	Mean ($\mu g/m^3$)	SD ($\mu g/m^3$)	Decline scenario ($\mu g/m^3$)
PM_{10}	6	120	29	15	−2.88
$PM_{2.5}$	3	92	19	13	−1.86
NO_2	8	125	39	15	−3.92