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Retrospective health impact assessment for ozone pollution in Mexico City from 1991 to 2011

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RESUMEN

La contaminación atmosférica es el principal problema ambiental en la ciudad de México, donde el ozono es uno de los contaminantes que mayor daño causa a la salud humana. En este trabajo se presenta un análisis retrospectivo del impacto sanitario de las políticas regulatorias de contaminación por ozono desde 1991 hasta 2011 en la zona metropolitana del Valle de México. El estudio se divide en grupos etarios, ya que éstos presentan diferencias respecto a la vulnerabilidad. Dado que las personas se mueven de un lugar a otro durante el día, lo cual puede afectar su exposición potencial a los contaminantes, se consideran distribuciones espaciales de población variables durante el día. Los datos de ozono consisten en registros tomados con frecuencia horaria desde el 1 de enero de 1991 hasta el 31 de diciembre de 2011, en 22 estaciones de la red de monitoreo atmosférico de la ciudad de México. Sin embargo, considerar estos registros es insuficiente; también es necesario interpolar los valores para localizaciones no medidas. El análisis objetivo de Cressman fue el método utilizado para llevar a cabo la interpolación de concentraciones de ozono hacia retículas de resolución conveniente. Se demuestra que los diferentes grupos etarios presentan diferentes patrones espaciales de exposición, y que las personas en edad laboral (de 18 a 64 años) son las más beneficiadas. También se confirma la hipótesis de que en general las personas se mueven hacia regiones menos contaminadas durante el día.

ABSTRACT

Air pollution is the main environmental issue in Mexico City, where ozone is one of the most damaging pollutants for human health. In this work we present a retrospective health impact assessment (HIA) study split up by age groups for evaluating the benefits of ozone regulatory strategies from 1991 to 2011 in Mexico City. Since people move from one place to another during the day, which may affect their potential exposure to pollutants, we consider time-dependant spatial population distributions during the day. Ozone data is made up of observations taken with hourly frequency from January 1, 1991 to December 31, 2011, at approximately 22 stations of

the monitoring network of Mexico City. Interpolated values for unknown locations are also taken into account in the HIA. The Cressman objective analysis method is applied for interpolating the observed ozone concentrations from monitoring stations to grids of convenient resolution. We demonstrate that different age groups present different spatial patterns of exposure, being the working-age people (between 18 and 64 years) the most benefited. We also confirm the hypothesis that, in general, people move to less polluted regions during the day.

Keywords: Ozone exposure, health impact assessment, objective analysis, mobile population.

1. Introduction

Over the last two decades, several public health studies have confirmed the statistically significant associations between outdoor concentrations of tropospheric ozone and a wide range of adverse outcomes (Ostro *et al.*, 2006), including premature mortality, hospital admissions for respiratory disease, urgent care visits, asthma attacks and restrictions in activity.

In Mexico City, atmospheric pollution is the main environmental issue. According to the 2010 air quality report for Mexico City, published by the Sistema de Monitoreo Atmosférico (Air Quality Monitoring System) (SIMAT, 2010), air quality exhibits an important improvement for almost all the included pollutants, which is attributed to the application of different environmental prevention programs during the last 20 years. Nevertheless, in 2010 ozone and particulate matter concentrations exceeded the values established by the Mexican Official Standard in more than 40 and 28% of the days, respectively.

A research that evaluates potential and retrospective costs of pollution (or benefits of regulation strategies) is generally referred to as a health impact assessment (HIA) (Ostro *et al.*, 2006). In this work, a retrospective HIA is presented in order to evaluate the benefits of tropospheric ozone regulatory strategies from 1991 to 2011 in Mexico City. The analysis is split up into four population groups given by age: [0, 5), [5, 18), [18, 64), (64, ∞).

The main contribution of this study is acknowledging population mobility during the day, which affects their potential exposure to pollution. Therefore, considering a dynamical spatial population distribution that changes during the day instead of a static spatial population distribution given by home locations (i.e., assuming that people stay at home during the whole day) is a more realistic approach.

Interpolated values for unknown locations are also regarded in the HIA, in addition to records of ozone concentrations at monitoring stations. The Cressman objective analysis method is applied to interpolate the observed ozone concentrations from monitoring stations to grids of convenient resolution.

2. HIA components

An HIA for ozone pollution reduction involves four elements (Ostro *et al.*, 2006):

1. Estimation of changes in ozone concentration due to control strategies.
2. Estimation of the number of people exposed to the changes in ozone concentration.
3. Baseline incidence rate (BIR) of the adverse health outcomes associated with ozone pollution (i.e., number of health-related events per year per capita).
4. Concentration-response (CR) functions that link changes in ozone concentration with changes in the incidence of adverse health effects. These functions come from epidemiological studies and are expressed in terms of percentage of change in a given health outcome attributable to a unit change in ozone concentration.

The product of these four elements is considered as the expected number of avoided adverse health outcomes related to a control strategy. In order to generate estimates for the economic benefits, an economic valuation may be assigned to the health outcomes. Points 1 and 2 are explained in detail in the next two sections.

In this study, we focus on the following health outcomes:

Health endpoint	**Abbreviation**
Premature mortality	MORTALITY
Hospital admissions for respiratory diseases	RESP-HOSP
Emergency room visits due to asthma attacks	ASTHMA
School loss days	SCHOOL-LOSS
Minor restricted-activity days	MRAD