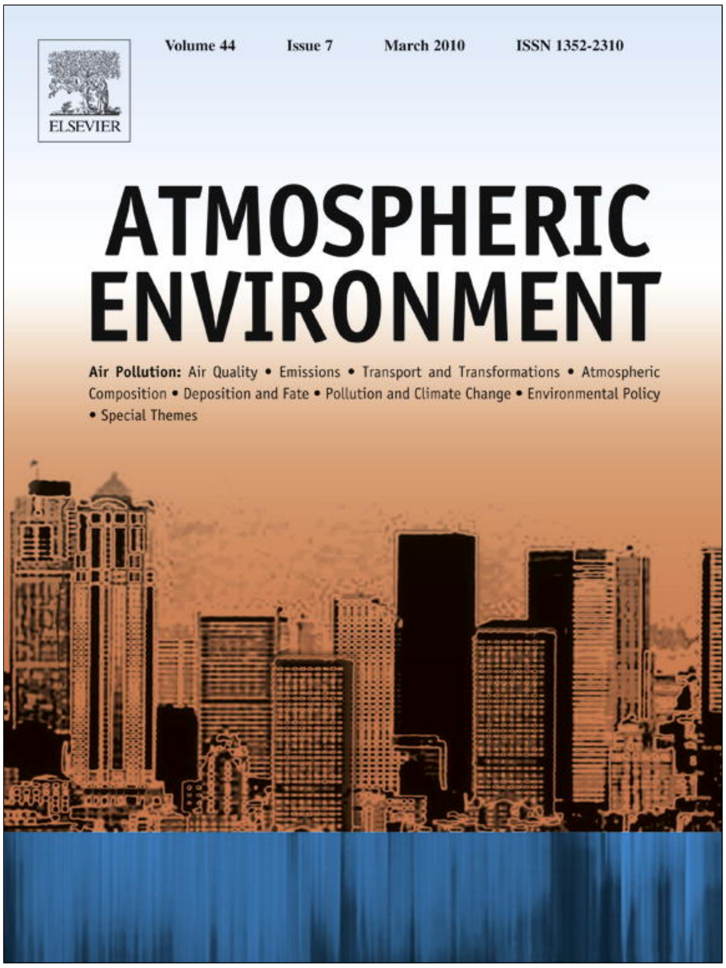
New Directions: Air quality epidemiology can benefit from activity based models

Peer-reviewed author version

INT PANIS, Luc (2010) New Directions: Air quality epidemiology can benefit from activity based models. In: ATMOSPHERIC ENVIRONMENT, 44(7). p. 1003-1004.

DOI: 10.1016/j.atmosenv.2009.10.047
Handle: http://hdl.handle.net/1942/11256


Volume 44 Issue 7 March 2010 ISSN 1352-2310
ELSEVIER
ATMOSPHERIC ENVIRONMENT
Air Pollution: Air Quality • Emissions • Transport and Transformations • Atmospheric Composition • Deposition and Fate • Pollution and Climate Change • Environmental Policy • Special Themes

Atmospheric Environment 44 (2010) 1003–1004

Contents lists available at ScienceDirect

Atmospheric Environment

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

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1. Main text

The link between air pollution and adverse health effects was established clearly and consistently 15 years ago. More recently, improved air quality in American cities was associated with increased life expectancy (Pope III et al., 2009). These observations spurred policy makers to devise air quality legislation and impose an increasing set of tightening emission standards aimed at reducing the anticipated health effects but at an increasing economic cost.

Over the last couple of years there was a growing consensus that vehicle related air pollution, may be more toxic or detrimental to public health than the general air pollution mixture. The hypothesis that emissions from mobile sources are a main culprit is based on the observation that tailpipe PM emissions generally fall within the Ultra Fine Particle (UFP $< 0.1\ \mu m$) and UFP may have health impacts which are additive to those attributed to PM (Knol et al., 2009). Also a number of studies have observed an association between health effects and the proximity to major roads (Gauderman et al., 2007). In addition there is continued concern over emissions of road traffic because suburban sprawl and increased vehicle miles traveled may in theory contribute to an increased exposure through an increase in the average intake fraction of pollutants from vehicle exhaust.

A thorough review of peer reviewed literature concluded that there was suggestive but insufficient evidence to decide on a causal link between vehicle emissions and most of the health endpoints except for the exacerbation of existing asthma although there was no unanimity (Health Effects Institute, 2009). Summarizing the situation in its critical review the Health Effects Institute panel concluded that most epidemiological studies lack accurate information on the true exposure of the test-persons involved (Health Effects Institute, 2009).

Nevertheless policy makers often refer to health effects to support specific policies, plans, projects and measures targeting the transport sector. Given the uncertainty about the causal link between *specific* vehicle emissions and health, policy makers should carefully devise no-regret measures or risk spending budget on measures that in retrospect may prove to be less effective.

Several recent epidemiological studies have used the proximity of the home to major roads as a surrogate for exposure and suggested that proximity of people to motorized road traffic partly explains observed health effects (Beelen et al., 2007). The use of simple proximity as a surrogate for exposure to mobile source emissions has its merits, but the HEI now recommends that exposure analysis should use more accurate methods such as land-use regression, or hybrid models including measurements. Unfortunately measuring exposure directly requires a large number of people and is therefore often not feasibly or prohibitively expensive.

In our opinion, exposure analysis could be improved by determining more accurately where people spend their time. People are only exposed to concentrations occurring in the areas where they are active at that time, which during the day is very often *not* at their home address (Beckx et al., 2008, 2009). We therefore suggest that exposure modelling takes advantage of the new possibilities offered by Activity-based models. This new class of models is able to predict for individuals where and when specific activities (e.g. work, leisure, shopping, ...) are conducted.

Both location, time of day and the microenvironment are essential parameters to accurately determine exposure to mobile source pollution with a high spatial variability such as NO_2 and Ultra Fine Particles. High resolution data on the temporal and spatial variation of the pollutant concentrations can be derived from measurements or dispersion models respectively. Similar high resolution data for the whereabouts of people can only be derived from Activity-based models. Although their obvious advantages for environmental purposes were recognized by Shiftan almost a decade ago (Shiftan, 2000), applications to exposure modelling remain scarce. Activity-based models have recently been used to provide a better total estimate of exposure while also enabling the disaggregation of individual exposure over activities (Beckx et al., 2008, 2009). They can therefore be used to reduce exposure misclassification and establish relationships between health impacts and air quality more precisely. Policy makers for their part can take advantage of the Activity-based paradigm to devise strategies that reduce exposure by changing time activity patterns. This will enable policies that reduce emissions from those sources that have the largest impact on exposure.

Acknowledgement

Discussions with several colleagues at VITO and UHasselt as well suggestions by anonymous reviewers and the editor helped to significantly improve this paper.

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