Environment International 66 (2014) 165–173

Contents lists available at ScienceDirect

Environment International

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

Health effects of ambient air pollution: Do different methods for estimating exposure lead to different results?

Yann Sellier [a,b], Julien Galineau [c], Agnes Hulin [d], Fabrice Caini [d], Nathalie Marquis [c], Vladislav Navel [d], Sebastien Bottagisi [a,b], Lise Giorgis-Allemand [a,b], Claire Jacquier [c], Remy Slama [a,b], Johanna Lepeule [a,b,e,*], the EDEN mother–child cohort study group

[a] Inserm, U823, Institut Albert Bonniot, Team of Environmental Epidemiology Applied to Reproduction and Respiratory Health, Grenoble, France
[b] Université Joseph Fourier, Grenoble, France
[c] Air Lorraine, Nancy, France
[d] ATMO Poitou-Charentes, La Rochelle, France
[e] Exposure, Epidemiology, and Risk Program, Department of Environmental Health, Harvard School of Public Health, Boston, MA 02115, USA

ARTICLE INFO

Article history:
Received 27 June 2013
Accepted 4 February 2014
Available online 2 March 2014

Keywords:
Exposure modeling
Measurement error
Spatial resolution

ABSTRACT

Background: Spatially resolved exposure models are increasingly used in epidemiology. We previously reported that, although exhibiting a moderate correlation, pregnancy nitrogen dioxide (NO_2) levels estimated by the nearest air quality monitoring station (AQMS) model and a geostatistical model, showed similar associations with infant birth weight.

Objectives: We extended this study by comparing a total of four exposure models, including two highly spatially resolved models: a land-use regression (LUR) model and a dispersion model. Comparisons were made in terms of predicted NO_2 and particle (aerodynamic diameter < 10 μm, PM_{10}) exposure and adjusted association with birth weight.

Methods: The four exposure models were implemented in two French metropolitan areas where 1026 pregnant women were followed as part of the EDEN mother–child cohort.

Results: Correlations between model predictions were high (≥0.70), except for NO_2 between the AQMS and both the LUR (r = 0.54) and dispersion models (r = 0.63). Spatial variations as estimated by the AQMS model were greater for NO_2 (95%) than for PM_{10} (22%). The direction of effect estimates of NO_2 on birth weight varied according to the exposure model, while PM_{10} effect estimates were more consistent across exposure models.

Conclusions: For PM_{10}, highly spatially resolved exposure model agreed with the poor spatial resolution AQMS model in terms of estimated pollutant levels and health effects. For more spatially heterogeneous pollutants like NO_2, although predicted levels from spatially resolved models (all but AQMS) agreed with each other, our results suggest that some may disagree with each other as well as with the AQMS regarding the direction of the estimated health effects.

1. Introduction

Great advances have been achieved over the past 5 years in improving the spatial resolution of air pollution exposure models used for studying its mid- and long-term health effects. Epidemiological studies have moved from an approach based on air-quality monitors, which provides temporally resolved estimates but is unlikely to capture the within-city spatial heterogeneity of air pollutant concentrations (Lebret et al., 2000), to more spatially resolved models based either on measured concentrations, combined with geographical information system data (land-use regression) and/or geostatistical techniques, or on dispersion modeling (Briggs, 2005). A few studies have compared the performance of such exposure models and concluded to the existence of substantial differences (Cyrys et al., 2005; Gulliver et al., 2011; Marshall et al., 2008; Rosenlund et al., 2008). For endpoints such as mortality and respiratory health, measurement error resulting from the use of poorly spatially resolved models may have a large impact on the exposure–response relationship (Jerrett et al., 2005; Pouliou et al., 2008). Although fine spatial scale land-use regression and dispersion models are increasingly used in reproductive epidemiology (Aguilera et al., 2010; Pereira et al., 2011; Rahmalia et al., 2012; Slama et al., 2007), few systematic comparisons have been undertaken in terms of exposure estimates (Marshall et al., 2008) or health effect estimates (Brauer et al., 2008; Lepeule et al., 2010; Wu et al., 2011). Since implementing such fine scale exposure models is costly, and since air

* Corresponding author at: Equipe 12, Centre de Recherche INSERM-UJF U823, Institut Albert Bonniot, UJF Site Santé, BP 170 La Tronche, 38042 GRENOBLE Cedex 9, France. Tel.: +33 476 549 466.
E-mail address: jlepeule@hsph.harvard.edu (J. Lepeule).

http://dx.doi.org/10.1016/j.envint.2014.02.001
0160-4120/

quality monitoring data are widely available, there is a critical need for understanding the implications of the use of such exposure models.

The well-characterized EDEN mother–child cohort provides unique opportunities to study up to four exposure models to nitrogen dioxide (NO_2) and particles with aerodynamic diameter less than 10 μm (PM_{10}) in two metropolitan areas: the nearest air quality monitoring station (AQMS) model, a temporally-adjusted geostatistical (TAG) model, a land-use regression (LUR) model and a dispersion model. We previously showed that NO_2 levels during pregnancy estimated by the nearest AQMS and by the TAG were moderately correlated; nevertheless they exhibited similar associations with infant birth weight (Lepeule et al., 2010). In the present study, we extended our work by considering the LUR and dispersion models, aiming at capturing fine spatial contrasts in air pollutant concentrations and by considering PM_{10} estimated by the nearest AQMS and dispersion models. We compared these four NO_2 exposure models and two PM_{10} exposure models in terms of exposure estimates during pregnancy and we investigated how the relationship with birth weight varied according to the exposure model used.

2. Methods

2.1. Study population and data collection

The EDEN mother–child cohort consists in 2002 women enrolled before 26 gestational weeks at maternity wards of Nancy and Poitiers

Table 1
Characteristics of the study population, EDEN mother–child cohort.

Characteristic	NO_2 study area (n = 776)	PM_{10} study area (n = 1026)
Birth weight, g, mean (sd)	3284 (512)	3278 (505)
Sex of the offspring, n (%)		
Male	395 (50.9)	531 (51.7)
Female	381 (49.1)	495 (48.3)
Gestational duration (weeks), n (%)		
30–36	47 (6.1)	60 (5.9)
37–38	128 (16.5)	176 (17.1)
39–40	440 (56.7)	580 (56.5)
≥41	161 (20.7)	210 (20.5)
Birth order, n (%)		
First	367 (47.3)	477 (46.5)
Second	263 (33.9)	365 (35.6)
Third or more	145 (18.7)	182 (17.7)
Missing	1 (0.1)	2 (0.2)
Month of conception of the child, n (%)		
January–March	167 (21.5)	216 (21.1)
April–June	184 (23.7)	233 (22.7)
July–September	226 (29.1)	302 (29.4)
October–December	199 (25.7)	275 (26.8)
Maternal age at conception (years), n (%)		
<25	187 (24.1)	231 (22.5)
25–29	289 (37.2)	380 (37.0)
30–34	203 (26.2)	290 (28.3)
≥35	97 (12.5)	125 (12.2)
Maternal height (cm), n (%)		
<160	188 (24.2)	255 (24.9)
160–169	460 (59.3)	607 (59.1)
≥170	121 (15.6)	153 (14.9)
Missing	7 (0.9)	11 (1.1)
Maternal pre-pregnancy weight (kg), n (%)		
<50	83 (10.7)	112 (10.9)
50–59	333 (42.9)	433 (42.2)
60–69	211 (27.2)	282 (27.5)
70–79	87 (11.2)	120 (11.7)
≥80	60 (7.7)	76 (7.4)
Missing	2 (0.3)	3 (0.3)
Center, n (%)		
Poitiers	316 (40.7)	436 (42.5)
Nancy	460 (59.3)	590 (57.5)
Urbanization, n (%)		
Urban	414 (53.4)	424 (41.3)
Suburban	320 (41.2)	377 (37.0)
Rural	42 (5.4)	225 (21.9)
Maternal age at end of education (years), n (%)		
≤16	52 (6.7)	59 (5.7)
17–18	104 (13.4)	128 (12.5)
19–20	124 (16.0)	166 (16.2)
21–22	165 (21.3)	231 (22.5)
23–24	174 (22.4)	234 (22.8)
≥25	157 (20.2)	208 (20.3)
Maternal active smoking (2nd trimester), n (%)		
No	507 (65.3)	703 (68.4)
Yes	264 (34.1)	317 (31.0)
Missing	5 (0.6)	6 (0.6)
Maternal passive smoking (2nd trimester), n (%)		
No	641 (82.6)	845 (82.3)
Yes	133 (17.1)	178 (17.4)
Missing	2 (0.3)	3 (0.3)