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Associations between maternal exposure to air pollution and traffic noise and newborn's size at birth: A cohort study☆

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ABSTRACT

Background: Maternal exposure to air pollution and traffic noise has been suggested to impair fetal growth, but studies have reported inconsistent findings.
Objective
To investigate associations between residential air pollution and traffic noise during pregnancy and newborn's size at birth.
Methods: From a national birth cohort we identified 75,166 live-born singletons born at term with information on the children's size at birth. Residential address history from conception until birth was collected and air pollution (NO_2 and NO_x) and road traffic noise was modeled at all addresses. Associations between exposures and indicators of newborn's size at birth: birth weight, placental weight and head and abdominal circumference were analyzed by linear and logistic regression, and adjusted for potential confounders.
Results: In mutually adjusted models we found a 10 μg/m^3 higher time-weighted mean exposure to NO_2 during pregnancy to be associated with a 0.35 mm smaller head circumference (95% confidence interval (CI): 95% CI: −0.57; −0.12); a 0.50 mm smaller abdominal circumference (95% CI: −0.80; −0.20) and a 5.02 g higher placental weight (95% CI: 2.93; 7.11). No associations were found between air pollution and birth weight. Exposure to residential road traffic noise was weakly associated with reduced head circumference, whereas none of the other newborn's size indicators were associated with noise, neither before nor after adjustment for air pollution.
Conclusions: This study indicates that air pollution may result in a small reduction in offspring's birth head and abdominal circumference, but not birth weight, whereas traffic noise seems not to affect newborn's size at birth.

1. Introduction

Long-term exposure to air pollution and traffic noise are both suspected of impairing fetal growth. A growing number of studies have found maternal exposure to air pollution to be associated with reduced offspring's size at birth, including lower birth weight (Bell et al., 2007; Dadvand et al., 2014; Estarlich et al., 2011; Gehring et al., 2014; Gouveia et al., 2004; Mannes et al., 2005; Pedersen et al., 2013), smaller head circumference at birth (Ballester et al., 2010; Pedersen et al., 2013; Slama et al., 2009) and lower placental weight (van den Hooven et al., 2012). Other studies have failed to find associations between air pollution and reduced size at birth (Estarlich et al., 2011; Gehring et al., 2011a; Gehring et al., 2011b; Hansen et al., 2007; Madsen et al., 2010; Salam et al., 2005). Although traffic noise is also suspected of decreasing birth size, and air pollution and road traffic noise are known to be correlated only two of the above studies have included both exposures and mutually adjusted for one another (Dadvand et al., 2014; Gehring et al., 2014). The largest of these studies, ($N = 68{,}238$) conducted in the greater metropolitan area of Vancouver, British Columbia, indicated independent adverse associations between both exposures and birth weight after mutual adjustment (Gehring et al., 2014). The second study ($N = 6438$) from the city of Barcelona, Spain, indicated an association between air pollution and term low birth weight both before and after adjustment for road traffic noise, whereas they found no associations for road traffic noise (Dadvand et al., 2014). Also, two studies have investigated associations between traffic noise and birth size

Abbreviations: DNBC, Danish National Birth Cohort; dB, decibel; CI, confidence interval.

☆ DH and MS conceived the study idea and DH analyzed the data. MK performed the air pollution modeling and AMNA participated in establishing the Danish National Birth Cohort. DH, MS, AMNA, MP and ORN contributed to the data analysis and data interpretation. DH drafted the paper, and all the authors critically revised it. All authors read and approved the final manuscript.

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without including air pollution. One of these studies reported airport noise to be associated with lower birth weight (Knipschild et al., 1981), whereas the other study found no associations between residential traffic noise exposure and birth weight (Wu et al., 1996).

The mechanisms behind the association between air pollution or traffic noise and fetal growth are still unclear. Systemic oxidative stress, inflammation, perturbed endothelial function and changes in blood viscosity and coagulation leading to alteration of placental growth and decreases in placental exchange of nutrients and gases have been suggested as mechanisms for air pollution (Kannan et al., 2006; van den Hooven et al., 2012). For traffic noise the suggested mechanisms are stress, which may adversely influence implantation, including a reduction in placental blood flow and oxygen deprivation (Ristovska et al., 2014) as well as sleep disturbance during pregnancy, which has been proposed to affect the neuroendocrine system (Okun et al., 2009).

We aimed to investigate associations between exposure to air pollution and traffic noise during pregnancy (including mutual adjustment) and newborn's size at birth, including indicators as placental weight and head and abdominal circumference among live-born term singletons using data from a large population based cohort.

2. Materials and methods

2.1. Study population

The study is based on the Danish National Birth Cohort (DNBC), which have been described in detail elsewhere (Olsen et al., 2001). Briefly, during 1996–2002, pregnant women, who intended to carry their pregnancy to term, who spoke Danish and who had a permanent address in Denmark, were invited to participate in the DNBC. The invitation took place at the first antenatal visit to the general practitioner, where the women received written information and an informed consent form to sign and forward to the study secretariat. Sixty-four percent of the general practitioners gave information about the DNBC and approximately 60% of all eligible pregnant women accepted to participate in the cohort, corresponding to around 30% of all births in Denmark during the enrolment period. All participating women provided informed consent.

Participation involved, among others, two prenatal computer-assisted telephone interviews, conducted by trained interviewers around gestational week 12 and 30. In these interviews the participating women were asked questions related to maternal characteristics, such as pre-pregnancy weight and height as well as questions related to maternal lifestyle factors during the pregnancy period, such as alcohol consumption and smoking habits. The DNBC was conducted in accordance with the Helsinki Declaration and approved by the Danish ethical committee.

Of the 88,374 term live-born singletons in the DNBC, we included first enrolled pregnancy, for whom information on home addresses of the mother during pregnancy and her child's size at birth (i.e. birth weight, placental weight, head and abdominal circumference and gestational age) were available.

2.2. Outcomes

Information on birth weight, placental weight, head and abdominal circumference was obtained from the Danish Medical Birth Registry using the child's personal identification number (Knudsen and Olsen, 1998). Birth weight was measured by a calibrated digital baby weight or by using a steelyard, according to standard methods at each place of birth. Placental weight was measured with a digital weight without trimming the placental disk of membranes or the umbilical cord and head and abdominal circumference were measured using standard measuring tape. All outcomes were measured within 2 h after delivery.

Information on gestational age was obtained from the Danish National Discharge Registry, recorded by midwifes at birth and based on a combination of the first day of the last menstrual period, menstrual pattern, ultrasound examination done before 24 weeks of gestation and a clinical assessment of the newborn. We used two estimates of low birth weight: 1) term low birth weight: birth weight below 2500 g among infants born at or after 37 weeks; and 2) low birth weight: birth weight below 2500 g among all infants (thus including children who were born <37 weeks of gestation into the study base).

2.3. Exposure

Residential address history during the pregnancy period was collected using the Danish civil registration system (Pedersen, 2011). Concentrations of nitrogen oxides (NO_2 and NO_x) were calculated using the Danish AirGIS dispersion modeling system at each address the mother had lived at during pregnancy. AirGIS (Jensen et al., 2001) performs the calculation of air pollution at a location as the sum of: 1) local air pollution from traffic in the nearest streets based on the Operational Street Pollution Model (OSPM); 2) the urban background contribution based on an area dispersion model; and 3) contributions from the regional background (Berkowicz et al., 2008). Input data for the AirGIS system included address points (geographical coordinates at each address), building height, street and building geometry, traffic data for individual road links, including yearly average daily traffic, vehicle distribution (light, heavy), traffic speed and road type (Jensen et al., 2009) emission factors for the Danish car fleet, and meteorological data. Traffic counts were obtained for all Danish roads with >1000 vehicles per day from a national road and traffic database (Jensen et al., 2009). The AirGIS system and the OSPM have been successfully validated and applied in several studies (Ketzel et al., 2011; Ketzel et al., 2012; Raaschou-Nielsen et al., 2011). As an example, AirGIS modeled and measured 1-month mean concentrations of NO_2 and NO_x over an 8-year period in a busy street in Copenhagen showed a correlation of 0.67 and 0.88, respectively (Ketzel et al., 2011). NO_2 and NO_x were used as indicators of traffic-related air pollution and calculated as the mean concentration of NO_2 (μg/m^3) and NO_x (μg/m^3) at each trimester as well as for the entire pregnancy period (including change of address).

Residential road traffic noise exposure was calculated for each pregnancy address using SoundPLAN (www.soundplan.dk), which calculates road traffic noise in accordance with the Nordic prediction method (Bendtsen, 1999). Input variables for the noise model included the geographical coordinates and height (floor) for each address, all Danish building polygons with building height and traffic data on road lines (same input data as described for the air pollution modeling). We assumed that the terrain was flat, which is a reasonable assumption in Denmark, and that urban areas, roads, and areas with water were hard surfaces, whereas all other areas were acoustically porous. No information was available on noise barriers or type of asphalt. Road traffic noise was calculated as the equivalent continuous A-weighted sound pressure level (L_{Aeq}), at the most exposed facade of the dwelling at each address for the day (L_d; 07:00–19:00 h), evening (L_e; 19:00–22:00 h) and night (L_n; 22:00–07:00 h), and expressed as L_{den}. All values below 40 dB were set to 40 dB, as this was considered the lower limit of road traffic noise. Residential exposure to railway traffic noise was calculated for each pregnancy address using SoundPLAN, which calculates railway traffic noise in accordance with NORD2000, a Nordic calculation method for prediction of noise propagating for railway traffic noise. Input variables were address coordinates (and height), railway lines, with information on annual average daily train lengths, train types and travel speed, building polygons and noise barriers along the railway. Railway traffic noise was expressed as L_{den} at the most exposed facade of the dwelling. The noise impact from all Danish airports and airfields was determined from information about noise zones (5 dB categories) obtained from local authorities. The curves for aircraft noise were transformed into digital maps and linked to each residential address history by geographical coordinates.