Environmental Research 160 (2018) 479–486

Contents lists available at ScienceDirect

Environmental Research

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

Traffic-related air pollution and childhood obesity in an Italian birth cohort

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A R T I C L E I N F O

Keywords:
Outdoor air pollution
Children
Body mass index
Obesity
Longitudinal study

A B S T R A C T

Background: Air pollution is associated with several adverse health outcomes in children, such as respiratory illnesses and cognitive development impairment. There are suggestions of an effect of traffic-related air pollution on the occurrence of childhood obesity, but the results are not consistent.

Objectives: The aim of the study is to analyse whether air pollution and vehicular traffic exposure, during the first four years of life, influence obesity- related measures among 4 and 8-year-old children from a prospective birth cohort in Rome.

Methods: A cohort of newborns, enrolled in 2003–2004 within the GASPII project, was followed at 4 and 8 years of age with parental interviews and clinical examinations. Air pollution was assessed at residential address using Land Use Regression models (for NO_2, NOx, PM_{10}, $PM_{2.5}$, PMcoarse, PM2.5 absorbance and one traffic variable (Total traffic load of all roads in a 100 m buffer)). The outcomes under study were body mass index (BMI Z-scores according to WHO recommendations, considered both categorical and continuous) measured at 4 and 8 years, and, waist circumference, waist-to-hip ratio, total and HDL cholesterol measured at 8 years. The associations were evaluated through both cross-sectional and longitudinal approaches, using logistic regression models, Generalized Estimating Equation models (GEE) and linear regression models, as appropriate. Moreover, Inverse Probability Weighting (IPW) methodology was used to account for selection bias at enrolment and at follow-up.

Results: A total of 719 infants were enrolled and 581 (80.8%) and 499 (69.4%) were followed at 4 and 8 years, respectively. The prevalence of overweight/obesity was 9.3% and 36.9% at 4 and 8 years. No evidence of an association was found between vehicular traffic and being overweight/obese. Similarly, there was no evidence of an association between exposure to air pollutants and all other ponderal excess parameters.

Conclusions: The study shows no association between exposure to vehicular traffic and exposure to pollutants on obesity related parameters such as BMI, blood lipids and abdominal adiposity during childhood. Overall evidence of air pollution being obesogenic remains limited.

1. Introduction

Over recent decades, the percentages of overweight and obese children have reached high levels all over the world. In 2013, the World Health Organization (WHO) estimated that around 42 million children under 5 years were overweight or obese (WHO, 2014).

Being overweight or obese during childhood can increase the risk of being overweight/obese, during adolescence or adulthood (Deckelbaum and Williams, 2001), and several complications and illnesses can arise from ponderal excess (Deckelbaum and Williams, 2001 Ebbeling et al., 2002; Lobstein et al., 2004). There are several complications and diseases that can follow excess fat accumulation (Ebbeling et al., 2002), and adiposity excess is associated with increased risk of developing type 2 diabetes (Deckelbaum and Williams, 2001) and cardiovascular diseases (Franks et al., 2010; Lobstein et al., 2004). An obese child who remains obese throughout adolescence and adulthood, will have during his life an increased risk of elevated blood pressure, chronic inflammation, stroke (Deckelbaum and Williams, 2001; Ebbeling et al., 2002), and eventually an early death (Ebbeling et al., 2002; Franks et al., 2010). There is increasing evidence that factors underlying childhood obesity may be related to exposures that occurred during pregnancy (Al Mamun et al., 2006; Evagelidou et al., 2006; Linabery et al., 2013; Whitaker, 2004), the neonatal period, and the first years of life (Ebbeling et al., 2002; Potter, 2006). Gestational

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http://dx.doi.org/10.1016/j.envres.2017.10.003
Received 23 May 2017; Received in revised form 3 October 2017; Accepted 3 October 2017

diabetes (Evagelidou et al., 2006), maternal weight gain (Linabery et al., 2013; Whitaker, 2004) or smoking (Al Mamun et al., 2006) during pregnancy can increase the risk of obesity in offspring. Moreover, factors like breastfeeding and growth after birth play an important role in childhood development; also lifestyle, physical activity, screen time, diet and duration of sleep are important factors for a child's ponderal status (Ebbeling et al., 2002; Potter, 2006).

One of the most concerning exposures considered in recent years is traffic-related air pollution: there are studies indicating that ambient air pollution reduces birth weight, affects growth after birth and increases risk of ponderal excess (i.e. being overweight or obese during childhood) (Dadvand et al., 2013; Fleisch et al., 2015; Lakshmanan et al., 2015). Some studies showed evidence of an association between air pollution and Body Mass Index (BMI) in children of different ages (Dong et al., 2014; Jerrett et al., 2010; Mao et al., 2016; Rundle et al., 2012). In 2014, Jerrett et al. proposed a conceptual framework (Jerrett et al., 2014) to clarify the possible pathways through which traffic-related air pollution may affect the risks of being obese or developing metabolic syndrome. The main pathways defined by the authors included: perceived safety (and reduced physical activity), an increase of stress levels due to noise (which affects sleep regulation and caloric intake) and the pathway related to systemic inflammation.

BMI level is the measure most often used to analyse the risk of being overweight or obese; few studies have used waist circumference as a measure of adiposity. This measure is a better estimate of visceral fat and given that it is easily reported and understood, seems to be a better measure than BMI (National Health Services, 2009). One study demonstrated that, using both BMI levels and waist circumference, the waist measurement was the best predictor in children of being overweight later (Maffeis et al., 2001). In addition, information on waist and hip circumference and the waist-to-hip ratio could be used as a further measure of body fat.

Blood lipids levels are also considered related to ponderal excess. The effects of air pollution on blood lipids (total cholesterol and high-density lipoprotein cholesterol) have been studied without conclusive results. Few studies assessed the effects of air pollution on total cholesterol or on high-density lipoprotein (HDL cholesterol) in adult populations, with scarce evidence of an association (Jiang et al., 2016; Maiseyeu et al., 2015; Shanley et al., 2016; Sørensen et al., 2015; Wallwork et al., 2017). There are no studies that have analysed air pollution exposure during pregnancy, or in the first years of life, on the likelihood of having high blood lipid levels during childhood.

The aim of this study is to evaluate the effect of traffic-related air pollution on the risk of being overweight or obese among children enrolled in a birth cohort in Rome. Body mass index, waist circumference and waist-to-hip ratio were used in the analyses as measures of overweight/obese status. In addition, the relationship between exposure to traffic-related air pollution and blood lipids (total cholesterol and HDL cholesterol) was evaluated in the same prospective birth cohort.

2. Material and methods

2.1. Study population

The study population consisted of mother-infant pairs enrolled in the Gene and Environment Prospective Study on Infancy in Italy (GASPII, a prospective birth cohort study which has been fully described elsewhere (Porta et al., 2006; Porta et al., 2007)). Newborns were enrolled at birth in two obstetric hospitals in Rome from June 2003 until October 2004. The mothers were eligible if Italian, older than 18 years, and resident in the area of the Local Health Unit Rome E, total population about 500,000 inhabitants. There were 1290 mothers contacted, 55% responded; a total of 704 mothers and 719 infants (13 pair of twins and 1 triplet) were enrolled.

2.2. Data collection

Parents were first interviewed face to face at their child's birth. Two separate questionnaires were administered to fathers and mothers in order to collect information regarding pregnancy, parent's health and lifestyles, family social conditions, demographic characteristics, previous pregnancies, and maternal emotional status during pregnancy. Information about delivery was recorded by obstetricians. Follow-up of the children was conducted at 6 months, 15 months, 4, 7 and 8 years. Measures of BMI were collected at 4 and 8 years during clinical examinations, while data on abdominal fat and blood lipids were collected only at the 8 year follow-up.

2.3. Exposure assessment

We considered six pollutants (NO_2, NOx, PM_{10}, $PM_{2.5}$, PM_{coarse} and $PM_{2.5}$ absorbance), and one traffic variable, estimated at individual residential address. Exposure values were estimated between birth and the first four years of life, reflecting all the address changes during the period, and were calculated as time-weighted average exposure. The traffic variable was estimated only at birth. In order to assess exposure at each participant's residential address, all the addresses recorded at each interview were geo-coded using TeleAtlas, the Italian road network. 99.17% of addresses were geocoded, with an accuracy of the geocoding scores greater than 80%.

The estimates of NO_2, NOx, PM_{10}, $PM_{2.5}$, PM_{coarse} and $PM_{2.5}$ absorbance concentrations were assessed using Land Use Regression models (LUR) developed within the European Study of Cohorts for Air Pollution Effects (ESCAPE) (Beelen et al., 2013; Eeftens et al., 2012a) project. The measurements and the models are described elsewhere (Beelen et al., 2013; Cyrys et al., 2012; Eeftens et al., 2012a, 2012b). In brief, different fractions of particulate matter (PM_{10}, $PM_{2.5}$, PM_{coarse} and $PM_{2.5}$ absorbance) were measured at 20 sites, and nitrogen dioxide and oxides (NO_2 and NOx) at 40 sites. PM was monitored with Harvard impactors, and NO_2 and NOx with Ogawa badges. Measurements (Cyrys et al., 2012; Eeftens et al., 2012a) were collected between January 2010 and April 2011, in three 2-week periods accounting for different seasons. Annual average concentrations of the pollutants were calculated for each site, adjusting for temporal variations (using measurements from the whole year taken by a centrally located background reference site). GIS predictor variables were used to model spatial variation of annual average concentrations. The variables included traffic intensity, road density, urban green, and population density (Beelen et al., 2013; Eeftens et al., 2012a). The R^2 of the models ranged from 0.70 (PM_{coarse}) to 0.87 (NO_2). The models were validated using the leave-one-out cross-validation method, with R^2 that ranged from 0.57 (PM_{coarse}) to 0.79 ($PM_{2.5}$ absorbance). In addition, one traffic variable (traffic load of all roads in a 100 m buffer) was used to assess exposure to vehicular traffic. The variable, already included in the set of variables used to develop the ESCAPE LUR models, measured the total traffic load of all roads in a 100-meter buffer (vehicles × meters/day).

2.4. Overweight and obesity

At 4 years and 8 years of age, children underwent clinical follow-up during which measures of weight and height were recorded. Weight and height were measured in light clothing and barefoot. Height was measured standing. Anthropometric measures at 4 years of age were collected during a home visit by trained personnel following standardized procedures, while clinical follow-up at age 8 was performed by hospital personnel following standardized procedures. BMI was calculated as weight (in kilograms) divided by height squared (in meters). The age- and sex- specific BMI Z-score (standard deviations) was calculated using the World Health Organization (WHO) 2007 Growth Charts (Borghi et al., 2006; Onis et al., 2007). We decided to consider the overweight and obese children together, because of the very low