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URBAN ENVIRONMENT AND CHILDHOOD OBESITY IN CATALONIA (ECHOCAT)

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1. Summary of the project

Understanding the determinants of childhood obesity has never been more urgent given the high levels across the world and especially in Spain, which has one of the highest levels in Europe. It is increasingly recognized that urban environment may affect childhood growth and obesity and that it provides important opportunities for community-level intervention, but previous studies are scarce. The ECHOCAT project aimed to examine whether the urban environment influences childhood obesity across Catalonia in three unique and complementary study populations including data on 1.6 million Catalan children. Specific aims were:

1. To describe childhood obesity and related outcomes across Catalonia between 2006 and 2016 by different geographic levels from census tract to province, based on primary care data of 1.6 million children aged 0 to 14 years;
2. To evaluate the association between indicators of the urban environment (air pollution, green spaces, social environment, built environment, and unhealthy food environment) and childhood obesity:
 - a. at ecological level using data based on primary care data of 1.6 million children aged 0 to 14 years
 - b. at individual and longitudinal level in school children aged 10-12 years in the municipality of Sabadell
3. To evaluate potential mediators – diet, physical activity, and psychological well-being – in these associations;
4. To develop a health impact assessment to estimate the impact of potential urban environment interventions aimed at reducing and preventing childhood obesity in Catalonia.

The ECHOCAT project exploited three different data sources and study populations: the Information Systems for Research in Primary Care (SIDIAP) dataset, the BRain dEvelopment and Air polluTion ultrafine particles in sChool childrEn (BREATHE) project and the Sabadell school project. The SIDIAP data included ecological longitudinal data from primary care data of 1.6 million children (80% of the Catalan population) and was

used for studies I, II and III to answer objectives 1 and 2a. The BREATHE and Sabadell project were cross-sectional school studies with large amounts of individual data and were used for study IV (obj. 2b) and study V (obj. 2b and 3), respectively. The school studies combined anthropometric measurements with questionnaires to obtain data on obesity and important risk factors. Geographical information system technologies were used to estimate exposure to the different urban environment indicators at census tract level for the whole SIDIAP and at home and school address level for the school studies. Individual-level mediators including diet, physical activity, and psychological well-being were evaluated for their role in the association between urban environment indicators and childhood obesity. The health impact assessment will be developed during the next year (2021-2022)

2. Results of the ECHOCAT project

In the first study published in *Jama Network Open* (obj. 1), which included more than 1.1 million children and adolescents living in Catalonia, we observed that the prevalence levels of overweight and obesity remain alarmingly high. The incidence rate of overweight and obesity were the highest among children aged 6-7 years, and children with overweight (not including obesity) at baseline had 3 times more risk of developing obesity than children with normal weight at baseline. The prevalence and incidence levels of overweight and obesity were higher in boys, in children living in the most deprived areas, in urban areas, and among children from North, Central or South American nationality. Between 2006 and 2016, we observed a slight overall decrease in the prevalence trends of overweight and obesity, but disparities between socioeconomic groups increased substantially, especially during middle childhood (6-11 years). Further, we observed that children with non-Spanish nationality, especially among African and Asian nationalities, had lower prevalence levels of overweight and obesity in 2006, but during the next decade the levels were approaching those observed among children with Spanish nationality.

In the subsequent studies we focused on the association between the urban environment and childhood growth and obesity. In study two, published in *Environmental Pollution* (obj. 2a), we evaluated the urban exposures during early life and estimated body mass index (BMI) growth trajectories from birth until the age of 5

years in nearly 80,000 children. We observed that increased levels of NO₂, PM₁₀, PM_{2.5} and population density were associated with a small increase in BMI growth during follow-up, whereas increased levels of green spaces and land use mix were associated with a small reduction in BMI growth. We additionally observed that the associations were stronger during the first two months of life.

As we observed in study I that the highest incidence rates of obesity fell around 6-7 years, we used paper III, published in the *International Journal of Obesity* (obj. 2a), to evaluate longitudinally whether air pollution exposure in earlier stages before the age of 6 (before the incidence peak) was associated with the subsequent risk of developing overweight and obesity. In this study we followed 416,955 children who were between 2-5 years old at the baseline, and observed that increased levels of NO₂, PM₁₀ and PM_{coarse} were associated with a small increase in risk of developing overweight and obesity subsequently between ages 6 and 14 years. We also observed that increased levels of all air pollutants had stronger associations with developing overweight and obesity among children living in the most deprived areas compared to children living in the least deprived areas.

In studies II and III we evaluated levels of ambient air pollution at the home address, without accounting for the exposure levels at schools. In study IV, published in *Environment International* (obj. 2b), we assessed whether ambient air pollution at home and schools was associated with overweight and obesity in children aged 7-10 years. We observed that exposure to higher levels of ultrafine particles measured in the schoolyard was associated with higher odds of overweight and obesity compared with those exposed to lower levels. We also found that medium levels of exposure to NO₂, PM_{2.5}, and elemental carbon at schools were associated with higher odds of overweight and obesity. Exposures estimated at the home address, using land-use regression models, showed associations that were similar in direction but mostly they did not reach statistical significance, except for PM₁₀ exposure, which was associated with increased odds of overweight and obesity.

In study V, which is under review in *Environment International* (obj. 2b and 3), we found weight-related behaviours, such as consumption of fast food in restaurants, screen-time, and sleep duration, to be associated with childhood overweight/obesity. In single and multiple exposure models there were few associations between urban

environment exposures and the obesity outcomes or the weight-related behaviours. Exceptions were an association between higher PM coarse levels and higher zBMI in the single exposure model (which did not pass the multiple testing threshold), and associations between increased PM coarse, land use mix and denser unhealthy food environment and several obesity outcomes in multiple exposure models. On the other hand, cluster analyses showed that a pattern of urban exposures characterised by high levels of air pollution, road traffic, and road traffic noise, was associated with increased zBMI and higher odds of overweight and obesity.

In conclusion, the findings of this project suggest that the urban environment, especially ambient air pollution, may influence child's weight status from birth until mid-childhood. Urban exposures are widespread and the long-term health consequences of childhood obesity are clear, so even small effects of urban exposures on child's weight status are of global health importance. Socioeconomic status plays an important role in increasing inequalities of childhood obesity and in the association between the urban environment and childhood obesity.

3. Public health implications

Prevention and promotion programs aimed at reducing the levels of childhood obesity may be considered among the most important public health priorities worldwide. The impact of tackling the childhood obesity epidemic might be a cornerstone not only in improving child's health, but also in preventing obesity-related health problems during adulthood, such as type 2 diabetes or cardiovascular disorders, which represent a heavy burden on an individual level, but also for healthcare systems, for the efficiency of the workforce and on a societal level. The findings of this project suggest that time trends overall are showing only a moderate decline in obesity rates among children living in Catalonia. Importantly, time trends are not reversing in lower sociodemographic classes, giving rise to greater social inequalities.

Primary care professionals can play a key role in preventing childhood obesity in Catalonia, especially during early ages, as our results show that the highest incidence peak falls around 6-7 years. Our results also suggest that children with overweight (not including obesity) at early ages are more likely to develop obesity during childhood.

Thus, health professionals could intervene by identifying children with overweight at an early age, as well as providing families with information about the health consequences of childhood obesity, and promoting healthy lifestyles focused on the prevention of childhood obesity. The “childhood with health program” is a promotion and prevention health program in Spain that recommends visiting the paediatrician and the paediatric nurse several times through childhood, even if the child is healthy. Therefore, we recommend that the monitoring of children between 2-5 years who have overweight are included in health providers’ health programs according to the WHO guidelines; these children should be monitored and guided more often in order to prevent obesity. This may be an important step to reduce childhood obesity in Catalonia and in Spain. In addition, this project shows the importance of electronic health records (EHRs) as a useful monitoring and surveillance tool for childhood obesity. EHRs should continue to evaluate the annually trends of childhood obesity by sociodemographic factors and geographic areas, and could also be used to evaluate the effectiveness of public health interventions.

Socioeconomic status played an important role in this project; we have reported that inequalities of childhood obesity levels have increased and that more deprived children are more susceptible to the exposure of air pollution. Socioeconomic inequities are systematic differences between social groups that are avoidable and unfair (Marmot et al., 2012). Thus, these results reinforce that governments should focus on reducing inequities already from an early life. Reducing inequities would not only reduce the levels of childhood obesity, but would improve the general health of the population. Focusing on early life, governments should take action to provide good education and access to childcare systems, reducing poverty and promoting gender equality. Also, more efforts are needed for including children from minority groups in health promotion and prevention activities. We have shown that obesity trends seem to have increased substantially among immigrant children during the last decade, and this may play an important role in the observed socioeconomic inequalities of the trends of overweight and obesity.

Our results suggest that air pollution may influence child weight status through infancy and mid-childhood. Air pollution exposure is widespread worldwide and the long-term health consequences of childhood obesity are clear; therefore, even small increases in risk of childhood obesity associated with air pollution exposures would be important for

global health. And not to forget, air pollution has also been associated with many other adverse health outcomes in children and adulthood. Thus, the reduction of air pollution may not only prevent excess weight gain in children, but would improve general health worldwide. In addition, our evidence emphasizes the need to focus air pollution reduction policies on early life stages and on the most disadvantaged populations.

Moreover, this project suggests that there could be specific patterns of urban exposures in cities that are more likely to affect childhood obesity, such as areas with high air pollution, noise, and traffic. Thus, long-term solutions to the childhood obesity epidemic may be achieved by modifying multiple aspects of the urban environment. Reshaping the urban environment from a holistic approach will make cities healthier and more liveable for everyone. Hence, to make cities healthier there is a need to reduce air pollution and noise levels, increase green spaces, and improve physical activity levels, among other actions. To do this, governments should facilitate community social life, increase public and green spaces, and reduce cars in the cities. Increasing green spaces will facilitate contact with nature, which has shown to be valuable for health and may reduce the levels of obesity, and reduce levels of air pollution and noise. Further, governments should facilitate independent mobility to increase active commuting in the cities, which is related with increased physical activity and may reduce childhood obesity (Nieuwenhuijsen and Khreis, 2018). Independent mobility is related with increasing cycling networks, safer sidewalks and an improvement in public transportation.

4. Scientific activities of ECHOCAT

Published

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de Bont J.*, Bennet M.*, de León L., Duarte-Salles T. The prevalence and incidence rate of overweight and obesity among 2.5 million children and adolescents in Spain (In review in Revista española de cardiología).

Manuscripts in preparation

Bennet M., de Bont J., Díaz Y., Recalde M., Nieuwenhuijsen MJ., Duarte-Salles T. Urban built environment and the development of adult obesity: a mega-longitudinal study (expected to submit to Environmental Research in June).

Abellan, A., Méndez-Boo, L., Díaz, Y., Hermosilla, E., Aragón, M., Fina, F., Prieto-Alhambra, D., Medina-Peralta, M., Bolibar, B., García-Gil, M., and Duarte-Salles, T.* Linkage of mother and child pairs in the information system for research in primary care (SIDIAP) in Catalonia (expected to submit to BMJ open in June)

Abellán A., Díaz Y, de Castro M., Nieuwenhuijsen MJ., Sunyer J., Casas M.* and Duarte-Salles T.* Urban environment and respiratory outcomes during childhood behaviours (expected to submit to Environmental Health Perspectives in June).

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Duarte-Salles T, Méndez-Boo L, Díaz Y, Hermosilla E, Aragón M, Fina F, Prieto-Alhambra D, Medina-Peralta M, Bolívar B, Garcia-Gil M. Linkage of Mother and Child Pairs in the Information System for Research in Primary Care (SIDIAP) in Catalonia. 35th International Society for Pharmacoepidemiology (ISPE). Prague, Czech Republic, August, 2018.

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Bachelor/master thesis

Espuny-Planelles, J "La influència del aliments ultra processats sobre el sobrepès i l'obesitat en infants de 9-12 anys a Sabadell" supervised by de Bont J. and Fernández-Barrés S. Bachelor thesis of biomedical sciences at the Universitat de Barcelona. September 2019.

Bennett, M. "Urban built environment and the development of adult obesity: a mega-longitudinal study" supervised by de Bont J. and Duarte-Salles T. Final master thesis of Public Health master at the Universitat Pompeu Fabra. June 2020.

Terré-Torras. "Air pollution, green spaces and cancer risk in pre and post-menopausal women of Catalonia: a mega cohort" Supervised by Recalde M. and Duarte-Salles T. Final master thesis of Public Health master at the Universitat Pompeu Fabra. June 2020.

Arador, A. "Urban built environment and the development of adult obesity: a mega-longitudinal study" Supervised by Puente D. and Duarte-Salles T. Final master thesis of Public Health master at the Universitat Pompeu Fabra. June 2020.

Doctoral thesis

Jeroen de Bont "Urban environment and childhood growth and childhood obesity" supervised by Vrijheid M. i Duarte-Salles T. Doctoral thesis in Biomedicine at the Universitat Pompeu Fabra. 11 de December 2020. Final grade: Excellent Cum laude.