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Research article

Socioeconomic inequalities in exposure to environmental tobacco smoke in children in Israel

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ABSTRACT

Background: Environmental tobacco smoke (ETS) exposure in infants and children causes more frequent and severe asthma attacks, respiratory infections, ear infections, and sudden infant death syndrome. The aim of this study was to measure ETS exposure in children in Israel (ages 4–11 years) using urinary cotinine measurements, in order to compare exposure levels to other international populations, and to assess predictors of ETS exposure in children in Israel.

Methods: A subset of children who participated in the National Health and Nutrition Survey (RAV- MABAT) in 2015–2016 were invited to participate in the Second Israel Biomonitoring Survey. We analyzed urinary cotinine and creatinine concentrations in 103 children. Parents of study participants were interviewed in person on children's exposure to ETS at home and in other environments and on sociodemographic variables. We calculated creatinine-adjusted and unadjusted urinary cotinine geometric means in children and analyzed associations in univariable and multivariable analyses, between sociodemographic variables and parental – reported exposure, and urinary cotinine concentrations.

Results: Based on urinary creatinine measurement, over 60% of children are exposed to ETS (compared to < 40% based on parental report). Linear regression showed a positive association between urinary cotinine concentration and reported ETS exposure ($p = 0.001$). Mean cotinine concentration among children whose parents reported that they are exposed to ETS at home (5.1 μg/l) was significantly higher than the concentration among children whose parents reported they are not exposed to ETS at home (1.6 μg/l, $p < 0.001$). There was an inverse relationship between total family income and urinary cotinine concentration ($p < 0.05$). In a multivariable model adjusted for ethnicity and other factors, family income was a significant predictor of urinary cotinine level ($p = 0.04$, slope = -0.49). Geometric mean creatinine adjusted concentrations in children in the current study were higher than in children in Canada and selected European countries.

Conclusions: We found evidence of widespread exposure to ETS in children in the study. There is an urgent need to protect children in Israel from exposure to ETS.

1. Background

Forty percent of children worldwide are exposed to the harmful effects of tobacco smoke (WHO, 2009). Exposure to environmental tobacco smoke (ETS) in infants and children causes a wide range of respiratory and development adverse effects, including sudden infant death syndrome, asthma, middle ear infections, lifelong cardiovascular effects and problems with lung development (CDC, 2017; U.S. Department of Health and Human Services, 2006; Raghuveer et al., 2016). Accumulating evidence suggests that exposure to ETS increases the risk of leukemia, lymphoma, and brain tumors in children (U.S. Department of Health and Human Services, 2006). Moreover,

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childhood exposure to ETS, even at low levels of exposure, has been associated with cognitive deficits, such as lower achievements in reading and mathematics and lower verbal IQ (Yolton et al., 2005; Park et al., 2014) and with attention deficit/hyperactivity disorder (ADHD) and autism spectrum disorder (ASD) (Kim et al., 2018). Children exposed to ETS are more likely to become active smokers (Manzoli et al., 2005).

Smoking is prohibited in most closed public places and in schools in Israel. Following legislation approved in June 2018, the ban was extended to playgrounds, zoos, and other outdoor public areas, starting in September 2018 (State of Israel, 2018). However, the home environment, where children and adults spend much of their time, is unregulated. Recent national surveys indicate widespread exposure to ETS in children in Israel. Over 25% of middle school students reported that others smoke nearby at home while 40% reported that others smoke nearby at recreational areas (ICDC, 2018). Based on parental report, ~25% of Jewish infants and 52% of Arab infants are exposed to ETS at two months of age (MoH, 2014).

Human biomonitoring (HBM), the measurement of chemicals and their metabolites in biological samples, is an important tool for assessing exposure to ETS in non-smokers, including children (CDC, 2009). Urinary cotinine measurements is a reliable measure of ETS exposure (Benowitz, 1999) and is used in both the US and Canada to monitor ETS exposure in children (CDC, 2009; Health Canada, 2017). In Europe, the DEMOCOPHES (Demonstration of a study to Coordinate and Perform Human Biomonitoring on a European Scale) project included urinary cotinine measurements in children from 17 countries (Den Hond et al., 2015).

The aim of this study was to measure ETS exposure in children in Israel (ages 4–11 years) using urinary cotinine measurements, in order to compare exposure levels to other international populations, and to assess predictors of ETS exposure in children in Israel.

2. Materials and methods

The National Health and Nutrition Survey (RAV-MABAT) Survey, is a national survey conducted by the Israel Center for Disease Control (ICDC) and the Nutrition Division at the Israel Ministry of Health, in collaboration with the Central Bureau of Statistics, as part of a series of national health and nutritional surveys. The aim of the RAV- MABAT survey was to collect data on nutritional habits, anthropometric measurements, and health-related behaviors in the general Israeli population (adults and children).

The sample of children was based on a random sample of children ages 2–11 years, from the population register. 1792 children participated in the 2015/6 RAV-MABAT Survey. Response rate (in the population of children) was 78.9%.

The First Israel Biomonitoring Survey was conducted in the adult general population in Israel in 2011, in order to evaluate exposure to environmental chemicals including ETS (Berman et al., 2013). For the Second Israel Biomonitoring Survey, a subset of children and adults who participated in the RAV-MABAT survey were asked to participate in a study on exposure to environmental contaminants (ETS and organophosphate pesticides). For the study on children, a sample of 100 children ages 4–11 years was designed to include children from different ethnic and geographic subgroups (girls/boys; urban/rural; Jewish/Arab). We purposely over-sampled Arab children in the current study in order to examine ethnic predictors of ETS exposure in children in Israel. A total of 103 children provided urine samples for the current study.

The study was conducted in accordance with the ethical principles of the Declaration of Helsinki. The study protocol was reviewed and approved by the Sheba Tel Hashomer Helsinki Committee. Participation in the study was voluntary. Parents were provided with an information brochure on the study (in Hebrew and Arabic) and with contact details to obtain individual results on their children's urinary level of environmental contaminants. Written informed consent was obtained from parents of all children in the study.

The participants' parents were interviewed using a structured questionnaire. The interviews were administered by trained interviewers. The interview consisted of a dietary and lifestyle questionnaire, demographic questionnaire, and questions regarding exposure to ETS. Parents were asked: “In the past month, to what extent was your child exposed to smoking of others (other people who smoked near your child)”. Possible answers were to a very great extent, great extent, slightly, or not at all. Parents who answered that their child was exposed to smoking of others, were asked whether the child was exposed to smoking of others at home, school, and other places (for example friends' house, events, public areas). All questions on ETS exposure in children have been validated and used previously by the Central Bureau of Statistics.

On the day of the interview, parents who agreed that their child participate in the study were provided with 120 ml urine specimen containers. On the day of sample collection, urine spot samples were collected in the containers and maintained at below 4 °C for a maximum of 12 h until they were transported to the Asaf Harofeh Medical Center. Urine samples were aliquoted and frozen at −20 °C. Frozen urine samples were transferred to Sheba Medical Center at Tel Hashomer and then were shipped to the University of Erlangen–Nuremberg in Germany on dry ice (−70 °C), where they were analyzed. Researchers at the University of Erlangen–Nuremberg had no access to details on participant's identification.

Laboratory analyses of cotinine and creatinine were performed at the Institute and Outpatient Clinic of Occupational, Social and Environmental Medicine, University Erlangen-Nuremberg in Germany. Cotinine in urine was determined using a gas chromatography mass spectrometry procedure validated and published by the German Research Foundation (DFG) working group “Analyses in biological materials” (Müller et al., 2003). In brief, cotinine was extracted from the urine using dichloromethane and quantified after gas chromatographic separation by mass spectrometry in single ion monitoring mode. Deuterated cotinine was used as an internal standard. Limit of detection (LOD) was 0.5 μg/l and limit of quantification (LOQ) was 1 μg/l. Creatinine in urine was determined by photometric detection as picrate according to the Jaffé method (Larsen, 1972). Quality control was performed by analyzing aliquots of control material in each series and accuracy was validated by the successful participation in G-EQUAS for both parameters (Göen et al., 2012).

Urinary analyte concentrations were provided in units of μg/l. In order to correct for variable dilutions among spot samples, these concentrations were divided by urinary creatinine concentrations (g creatinine/l urine) to generate creatinine-adjusted analyte concentrations.

3. Statistical methods

Concentrations below the LOQ for cotinine were imputed using a β-substitution for left censored data (Huynh et al., 2014; Ganser and Hewett, 2010). We calculated percent of participants with urinary cotinine above the LOQ, and geometric mean and median of cotinine in all participants. We conducted all calculations using both unadjusted (μg/l) and creatinine adjusted (μg/g) values. We calculated population weighted geometric mean using the following equation:

$$\overline{x} = \left(\prod_{i=1}^{n} x_i^{w_i} \right)^{1/\sum_{i=1}^{n} w_i}$$

in which: x_i = cotinine concentration in subject I; w_i = the weight in the population of subject x_i (0.74 for Jews, 0.26 for Arabs).

We compared data from our study to available data on urinary cotinine concentrations in children in national studies. We chose the 2014–2015 Canadian Health Measures Survey (Health Canada, 2017) and the 2011 DEMOCOPHES study which included children from