SOCIAL INEQUALITY IN HUMAN EXPOSURE TO POPs IN ADOLESCENTS? SOCIO-STRATIFYING RESULTS OF THE FIRST FLEMISH HUMAN BIOMONITORING CAMPAIGN (FLEHS I)

Morrens B[1], Bruckers L[2], Den Hond E[3], Nelen V[4], Schoeters G[3], Baeyens W[5], Van Larebeke N[6], Keune H[1], Loots I[1]

[1]Faculty of Political and Social Sciences, University of Antwerp, Sint-Jacobstraat 2, Antwerp, Belgium; [2]Interuniversity Institute for Biostatistics and statistical Bioinformatics, Hasselt University, Agoralaan - building D, Diepenbeek-Belgium; [3]Department of Environmental Toxicology, Flemish Institute for Technological Research, Boeretang 200, Mol, Belgium; [4]Provincial Institute of Hygiene, Kronenburgstraat 45, Antwerp, Belgium; [5]Department of Analytical and Environmental Chemistry, Brussels Free University, Pleinlaan 2, Brussels, Belgium; [6]Department of Radiotherapy and Nuclear Medicine, University Ghent, De Pintelaan 185, Ghent, Belgium

Introduction

Environmental justice research suggests that inequalities in the distribution of environmental exposure to chemical pollution systematically disadvantage the lower social strata of society. A vast amount of literature shows that hazards in the physical and chemical environment disproportionately affect those individuals, households and neighbourhoods that also face hazards in their social environment [1, 2]. The effects of these inequalities on the human exposure to pollution remain however to a large extend unknown, especially concerning concentrations of POPs [3]. The purpose of this study is to assess social gradients in human biomonitoring results of chlorinated persistent compounds in a representative sample of Flemish adolescents, and determine whether these gradients can be explained by specific underlying factors related to both exposure and social position. The hypothesis is to find negative social gradients in body concentrations: lower SES having higher exposure.

Materials and methods

We investigate the associations between individual socioeconomic status (SES), measured by parental educational attainments, and serum concentration of three chlorinated persistent compounds: polychlorinated biphenyls (PCBs) (sum of marker PCB 138, 153 and 180), hexachlorobenzene (HCB) and p,p'-dichlorodiphenyldichloroethylene (p,p'-DDE, a metabolite of DDT) of 1642 adolescents aged 14-15. We classified the highest parental educational attainment into three categories: primary, secondary and tertiary education, corresponding respectively to adolescents with a low, middle or high SES. The data come from the First Flemish human biomonitoring campaign (FLEHS I), conducted by the Flemish Centre for Environment and Health in Flanders, the northern part of Belgium. The toxicological procedures of the blood and urine analyses are described in detail elsewhere [4]. Social gradients in average exposure and prevalence in high exposure (>P90) to the three biomarkers were examined with geometric means and odds ratios (with 95% confidence intervals), using three consecutive linear and logistic regression models. The first model investigates social gradients in the unadjusted geometric mean exposure and in the probability to have high exposure. If significant social gradients are found, model 2 extends model 1 by including covariates to be known from literature to influence internal exposure: gender, age, body mass index, smoking status and living region.

Correcting for these covariates may explain the initially found relations with SES. If social gradients remain significant in model 2, a third model additionally includes biomarker specific covariates.

Results

Table 1 describes the social distribution of some characteristics of the study population that can be associated with exposure and susceptibility to environmental pollution. All indicators (except BMI and residential area) are self-reported by the adolescents or his/her parents in the questionnaires. Gender, age and BMI are well known personal factors that may influence the internal concentration of (particularly persistent) pollutants. These factors are significantly related to the SES of adolescents in our study sample. Age and BMI follow a negative social gradient (higher in lower SES category). More boys are present in the lower SES categories. Smoking behaviour follows a significant negative social gradient. Daily tobacco smoking is reported three times more often by low compared to high SES adolescents. Nutrition habits are also important factors, since dietary intake is a well-known exposure route for many pollutants. Our study sample however reveals no significant social gradients for the consumption of home grown products (such as vegetables, fruit or eggs) or fish consumption. Being breastfed as baby, is a main determinant of the internal concentration of chlorinated compounds in later life. Breastfeeding follows a positive social gradient: adolescents with high SES (tertiary educated parents) were significantly more breastfed than adolescents with lower SES. In our study sample, adolescents with lower SES more frequently live in industrial areas, adolescents with high SES live more in rural areas.

Table 1: characteristics of the study population, by socioeconomic status

	Total N=1642	Socioeconomic status (SES)			p-value
		Low N=254	Middle N=573	High N=815	
Sex (% boys)	53.2	57.9	55.7	50.1	0.032
Age (years) (mean)	14.9	15.0	14.9	14.8	<0.001
BMI (mean)	20.6	21.2	21.0	20.1	<0.001
Daily tobacco smoking (%)	8.0	14.3	10.4	4.3	<0.001
Consumption home grown products (%)	38.3	33.2	37.9	40.1	0.140
Fish consumption (mean g/day)	18.4	19.2	17.5	18.8	0.348
Breastfed as baby (%)	60.5	42.4	50.0	73.5	<0.001
Residential area (%)					<0.001
Industry	51	57.5	57.3	44.5	
Urban	24.6	25.9	20.6	26.9	
Rural	24.4	16.5	22.2	28.5	

The results of the regression models for mean and high exposure to chlorinated compounds are presented in Table 2. Model 1 shows the unadjusted geometric mean and the probability of having a high concentration. For PCBs the mean exposure significantly increases with increasing SES. Also the odds for high exposure (>P90) follows a significant and positive gradient. Sex, age, smoking status and BMI are important determining factors in the internal concentration of PCBs and these factors are significantly associated with SES. However model 2 shows that controlling for these factors does not diminish the effect of SES. Further correction for breastfeeding in model 3 results in a non significant social gradient for high exposure. The OR for the low and middle SES category become closer to 1 (indicating no difference with the highest category) and are no longer statistically significant. The social gradient that is present in the distribution of high internal PCB levels in 14-15 year adolescents, can – at least partly – be explained by the social gradient in nursing with maternal milk when these adolescents were baby's. The positive social gradient in average exposure to PCBs however stays significant.

For HCB and DDE, the unadjusted geometric mean concentration in model 1 shows a significant positive gradient, but a non significant OR for high exposure. The positive gradient in geometric mean stays significant after correcting for sex, age, smoking status and BMI. Further correcting for breastfeeding explains the SES gradient in geometric mean for DDE but not for HCB.

Table 2: Social distribution of average and high exposure to chlorinated compounds (sum PCBs, DDE and HCB), unadjusted and adjusted regression models

	Sum PCBs (ng/g lipid)		**HCB (ng/g lipid)**		**p,p'-DDE (ng/g lipid)**	
	Geometric mean (95% CI)	OR for high exposure (95% CI)	geometric mean (95% CI)	OR for high exposure (95% CI)	geometric mean (95% CI)	OR for high exposure (95% CI)
Model 1[a]						
Low SES	56.94 (53.40; 60.71)	0.36 (0.20; 0.65)	19.47 (18.67; 20.31)	0.74 (0.45; 1.21)	99.86 (90.01; 110.78)	0.86 (0.53; 1.40)
Middle SES	61.36 (58.79; 64.05)	0.54 (0.38; 0.79)	20.06 (19.51; 20.63)	0.72 (0.50; 1.05)	100.83 (94.07; 108.07)	0.91 (0.63-1.30)
High SES	72.82 (70.26; 75.49)	1.00	21.31 (20.81; 21.83)	1.00	113.84 (107.42; 120.65)	1.00
p-value	<0.0001	<0.0001	0.0001	0.1680	0.0118	0.7872
Model 2[b]						
Low SES	52.15 (48.86; 55.66)	0.32 (0.17; 0.61)	18.89 (18.05; 19.77)	-	93.24 (83.04; 104.71)	-
Middle SES	57.41 (54.48; 60.51)	0.59 (0.39; 0.88)	19.72 (19.01; 20.44)	-	93.23 (84.91; 102.36)	-
High SES	65.31 (61.95; 68.86)	1.00	20.97 (20.22; 21.77)	-	108.77 (99.00; 119.51)	-
p-value	<0.0001	0.0005	<0.0001	-	0.0008	-
Model 3[c]						
Low SES	53.83 (50.53; 57.34)	0.49 (0.26; 0.95)	19.00 (18.16; 19.89)	-	96.34 (85.97; 107.97)	-
Middle SES	58.28 (55.40; 61.31)	0.75 (0.49; 1.13)	19.83 (19.13; 20.56)	-	95.33 (87.01; 104.43)	-
High SES	62.76 (59.62; 66.08)	1.00	20.69 (19.94; 21.46)	-	103.25 (94.11; 113.27)	-
p-value	<0.0001	0.0756	0.0008	-	0.1705	-

[a] unadjusted mean exposure and OR for high exposure
[b] adjusted for sex, age, smoking status, BMI and residential area
[c] additionally adjusted for breastfeeding
CI: confidently interval; OR: odds ratio

Discussion

In this study, we tested the general environmental justice hypothesis that people of lower socioeconomic strata are more exposed to environmental pollution than people of higher social strata. Our results show that the association between socioeconomic status (SES) and the internal body concentration of exposure to environmental pollutants in Flemish adolescents (aged 14-15) is more complex than can be assumed on the basis of the environmental justice hypothesis because chlorinated compounds (PCBs and pesticides HCB and DDE) are positively associated with SES. Our results show that socially constructed lifestyle factors and dietary habits play an important role in these relations. The positive relation between SES and PCBs (OR) or DDE (geometric mean) (higher SES have higher exposure) could not be explained by differences in sex, age, smoking, BMI or

residential area, but disappeared after additional adjustment for breastfeeding. This indicates that the nursing habit of the mother is a principal factor in the observed social differences in the body concentration of PCBs and DDE among adolescents.

Although our findings do not support the environmental justice hypothesis, the results are consistent with other available studies. Positive associations between indicators of SES and chlorinated compounds are also found in pregnant women in the US [5] and Spain [6], and in 4 year old children in the Michigan region (US) [7]. In the Czech adult population however, PCB concentrations were not significantly associated with individual educational attainment [8]. A higher fish consumption and more nursing with maternal milk are identified as main determinants explaining the social differences in serum concentrations of chlorinated compounds. Similar to our findings, the initially found relation between education and PCBs in US children (4 years) disappeared after adjustment was made for breastfeeding [7].

Our study suggests that more complex patterns of social stratification emerge when assessing the internal body concentration of environmental exposure. It therefore remains important to consider the chemical environment in relation to the social environment when monitoring environmental health risks.

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