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Relative effects of educational level and occupational social class on body concentrations of persistent organic pollutants in a representative sample of the general population of Catalonia, Spain

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ABSTRACT

Scant evidence is available worldwide on the relative influence of occupational social class and educational level on body concentrations of persistent organic pollutants (POPs) in the general population. The objective was to analyse such influence in a representative sample of the general population of Catalonia, Spain. Participants in the Catalan Health Interview Survey aged 18–74 were interviewed face-to-face, gave blood, and underwent a physical exam. The role of age, body mass index (BMI), and parity was analysed with General Linear Models, and adjusted geometric means (GMs) were obtained. Crude (unadjusted) concentrations were higher in women and men with lower education, and in women, but not men, in the less affluent social class. After adjusting for age, in women there were no associations between POP levels and social class or education. After adjusting for age and BMI, men in the less affluent class had higher *p,p′*-DDE concentrations than men in class I (p-value = 0.016), while men in class IV had lower HCB than men in the upper class (p-value < 0.03). Also in contrast with some expectations, positive associations between education and POP levels were observed after adjusting for age and BMI in men; e.g., men with university studies had higher HCB concentrations than men with first stage of primary schooling (adjusted GM 153.9 and 80.5 ng/g, respectively) (p-value < 0.001). When education and social class were co-adjusted for, some positive associations with education in men remained statistically significant, whereas class remained associated only with *p,p′*-DDE. Educational level influenced blood concentrations of POPs more than occupational social class, especially in men. In women, POP concentrations were mainly explained by age/birth cohort, parity and BMI. In men, while concentrations were also mainly explained by age/birth cohort and BMI, both social class and education showed positive associations. Important characteristics of socioeconomic groups as age and BMI may largely explain crude differences among such groups in internal contamination by POPs. The absence of clear patterns of relationships between blood concentrations of POPs and indicators of socioeconomic position may fundamentally be due to the widespread, lifelong, and generally invisible contamination of human food webs. Decreasing historical trends would also partly explain crude socioeconomic differences apparently due to birth cohort effects.

1. Introduction

POPs are highly lipophilic and degradation-resistant synthetic chemicals, which essentially originate from the production and use of organochlorine and other synthetic compounds. They bioaccumulate in the environment, food webs and living organisms, and contribute to cause severe health effects, even at concentrations traditionally deemed low (Alonso-Magdalena et al., 2011; Bergman et al., 2013; Department of Health and Human Services, 2009; Engel and Wolff, 2013; Henkler and Luch, 2011; NRC, National Research Council and Committee on Human Biomonitoring for Environmental Toxicants, 2006; Porta, 2012; Porta et al., 2008b, 2012b; Schug et al., 2013; Stein, 2012; Thayer and Kuzawa, 2011; Thornton et al., 2002; Vandenberg et al., 2012;

Abbreviations: DDT, dichlorodiphenyltrichloroethane; DDE, dichlorodiphenyldichloroethene; PCBs, polychlorinated biphenyls; HCB, hexachlorobenzene; HCH, hexachlorocyclohexane; PeCB, pentachlorobenzene; POPs, persistent organic pollutants; BMI, body mass index; GM, geometric mean; CI, confidence interval; WFE, without formal education; Primary (I), primary schooling (1st stage); Primary (II), primary schooling (2nd stage); CHIS, Catalan Health Interview Survey; IMIM, Hospital del Mar Research Institute.

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WHO, World Health Organization, 2003; Woodruff et al., 2010; Wu et al., 2012; Yang et al., 2012). Exposed to such agents throughout life, mostly from the ingestion of fatty parts of animal foods, virtually all humans store POP mixtures in fat tissues. Although some POPs were prohibited decades ago – and their concentrations thus decreased – human exposure, contamination and clinical effects remain relevant (Bergman et al., 2013; Department of Health and Human Services, 2009; Institute of Medicine, 2003; NRC, National Research Council and Committee on Human Biomonitoring for Environmental Toxicants, 2006; Porta et al., 2008b, 2012b; Quinn and Wania, 2012; Quinn et al., 2011). Body concentrations of POPs are known to often be associated with age, body mass index (BMI), and, in women, also with parity (Agudo et al., 2009; Porta et al., 2008b, 2010, 2012b; Quinn and Wania, 2012; Quinn et al., 2011; Wolff et al., 2005). Some relationships have also been observed between POP concentrations and socioeconomic variables (Chao et al., 2010; Freire et al., 2011; Morrens et al., 2012; Porta et al., 2008a, 2012a; Vrijheid et al., 2012).

Although some mixed evidence exists, reasons for differences in internal body concentrations of persistent organic pollutants (POPs) across socioeconomic groups are largely unknown worldwide. In spite of the involvement in health disorders of both environmental pollutants and social factors, there are wide gaps in knowledge of the influence of socioeconomic position on human contamination by POPs and other pollutants (Bergman et al., 2013; Borrell et al., 2004a; Davey Smith et al., 1998; Martikainen et al., 2007; Morrens et al., 2012; NRC, National Research Council and Committee on Human Biomonitoring for Environmental Toxicants, 2006; Porta et al., 2008b, 2012a; Subramanyam et al., 2013; Thayer and Kuzawa, 2011). Some evidence from studies based on non-representative samples indicates that such contamination does not affect all social and educational groups homogeneously; rather, some compounds seem to contaminate more intensely the more disadvantaged groups, generating a potentially unfair and perhaps avoidable gradient of inequalities in health (Brown, 1995; Freire et al., 2011; Hoffmann et al., 2009; Porta et al., 2008a). Even so, it has seldom been assessed to what extent structural differences among social groups in age and body weight explain their differences in POP contamination. Evidence on the relationships between social factors and human concentrations of environmental pollutants can also lead to a better understanding of health patterns by social class and educational level (Davies et al., 1972; Morrens et al., 2012).

Socioeconomic position is often related to environmental and occupational exposures, other living conditions, diet and lifestyle (Freire et al., 2011; Glynn et al., 2007; Ibarluzea et al., 2011; León-Muñoz et al., 2012; López-Azpiazu et al., 2003; Mesas et al., 2012; Rothman et al., 2011). Though commonly related, the nature and health effects of education and social class are different, sometimes outcome specific, and they cannot be used interchangeably: they measure different phenomena and act through different mechanisms (Martikainen et al., 2007; Schnittker, 2004; Thayer and Kuzawa, 2011). In addition to their potential to explain part of the population variation in human contamination by POPs, social class and education are also common possible confounders of associations between POPs and epidemiologic factors.

It is thus somewhat surprising that the evidence on the possible relation between indicators of socioeconomic position and human POP concentrations is so scant in studies based on representative samples of the general healthy population. To date, only reports from the United States (NRHEEC) (Department of Health and Human Services, 2009) and Germany (GerEs) (Becker et al., 2002) have assessed the relationship between body POP concentrations and ethnicity or socioeconomic status, respectively, in such samples.

Therefore, the present study aimed to investigate the separate and combined effects of occupational social class and educational level on body concentrations of several POPs in a representative sample of the general population of Catalonia, Spain. Special attention was paid to assess to what extent important characteristics of social groups, as age and body mass index, explain differences in internal contamination by POPs.

2. Materials and methods

2.1. Study population

The study population has been described in detail elsewhere (Porta et al., 2010). Briefly, participants in the Catalan Health Interview Survey (CHIS 2002) aged 18–74 years old (N = 6243) were offered to take part in a health examination, which included a physical exam, a supplementary interview, and the collection of urine and blood samples. A total of 1374 individuals participated in the health examination during 2002. Trained nurses recorded the weight and height, and the corresponding body mass index (BMI) was computed (measured weight [kg] divided by measured height squared [m^2]). Participants were asked to fast for 12 h before blood extraction. Blood was first stored frozen at −20 °C to determine immunologic, biochemical and nutritional parameters. Once these initial analyses were completed, the remaining serum was kept frozen at −80 °C until 2006, when POP concentrations were analysed. Information on blood concentrations of lipids and at least 1 mL of serum (for POP analyses) was available from 919 participants (Porta et al., 2010).

There were no significant differences between the 919 participants with data on POP concentrations and the remaining participants in the health examination (1374–919) with respect to age, sex, BMI, social class and educational level. The present study included 902 (of the 919) individuals with information on both POP concentrations and social class, and 912 individuals with information of POP concentrations and educational level. Information on educational level was also available for 896 of the 902 individuals. The proportion of women and the mean age were slightly higher in the 902 individuals included in the study than in the remaining participants of CHIS (6243–902).

2.2. Socioeconomic variables

Sociodemographic variables (sex, age, occupational social class, educational level and, in women, parity) were obtained from the CHIS. People were asked for the highest completed level of education, and the different educational levels were classified in five categories (without formal education (WFE), primary schooling (1st stage), primary schooling (2nd stage), secondary, and university studies). WFE included the illiterate.

Occupational social class was based on the "dominant approach" (Borrell et al., 2004b; Krieger et al., 1997), that is, it was assigned through the current or last occupation of the participant or, if he/she had a less privileged social class than the head of the household, through the current or last occupation of the latter. In 69.6% of participants social class was the same in both persons, and in 19.2% the social class of the head of the household was more affluent. Occupations were coded using the four-digit Spanish 'Clasificación Nacional de Ocupaciones' (CNO94), which is closely related to the international ISCO88 coding system (INE, Instituto Nacional de Estadística, 2010). Variables from the CHIS considered to code the occupation of each participant or head of the household based on CNO94 were: current or last job, company activity, and job status. Six social class categories were then created following the methodology proposed by the Spanish Epidemiological Society (Domingo-Salvany et al., 2000): social class I: managers of companies with 10 or more employees, senior technical staff, higher level professionals (associated to a complete degree); social class II: managers of companies with less than 10 employees, intermediate level professionals; social class III: administrative and financial management supporting personnel, other self-employed professionals, supervisors of manual workers, other skilled non-manual workers; social class IV: skilled (IVa) and partly skilled (IVb) manual workers; and social class V: unskilled manual workers.

Parity was defined as the number of children born per women. Place of birth was not analysed because only 2.7% of women and 3.3% of men were born outside Spain. Moreover, individuals born abroad were