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Sociodemographic factors influencing participation in the Barcelona Health Survey study on serum concentrations of persistent organic pollutants

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ABSTRACT

Background: Little is known about factors affecting participation in population-based biomonitoring studies. We analyzed socioeconomic factors influencing participation in the Barcelona Health Survey (BHS) study on the distribution of serum concentrations of persistent organic pollutants (POPs).
Methods: After completing the BHS personal interview at home participants aged $\geqslant$15 years were invited to donate blood. Conducted on a different date and location, the POPs study included additional questions, blood extraction, and a brief physical examination. Factors influencing participation were analyzed by logistic regression.
Results: Of 523 BHS participants that we contacted to participate in the study, 231 (44%) participated; they were broadly representative of the city population regarding sex, birth place, body mass index (BMI), employment status and occupational social class. Participants in the POPs study had higher educational level and family income. Controlling for confounders, participation was slightly higher among women than men (odds ratio [OR] = 1.38, $p = 0.02$), and lower among the youngest and oldest subjects ($p = 0.002$), with a strong and monotonic trend of increasing participation with increasing educational level ($p < 0.001$) (OR for university level *vs.* no studies = 4.58, 95% CI: 2.3–9.3).
Conclusions: Although participation was somewhat low, participants were similar to the city population regarding sex, BMI, birth place, employment, and occupational social class. Health surveys that integrate environmental biomarkers should invest specific resources to encourage participation of the youngest and oldest individuals, and of those with more disadvantaged socioeconomic position (particularly, citizens with lowest education).

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1. Introduction

Health surveys are central components of health monitoring systems (De Bruin et al., 1996; Hupkens et al., 1999; Aromaa et al., 2003), but when they include a physical examination and blood extraction they usually have lower participation rates (Porta et al., 2008b); non-participation hampers the study representativeness and, hence, the validity of inferences to the general population. Biases will occur, for instance, when sociodemographic and economic variables as sex, age, educational level, family income or other measures of socioeconomic position are associated both with participation in the study and with the blood or tissue concentration of the biomarkers. While biomonitoring studies often report the response rate (Department of Health and Human Services, 2001; Becker et al., 2002; Link et al., 2005; Zumbado et al., 2005), little is known about factors influencing participation in such studies (Pullen et al., 1992; Sala et al., 1999; Merzenich et al., 2001; Boshuizen et al., 2006). Of course, the characteristics, causes and implications of non-response have long been analyzed

Abbreviations: BHS, Barcelona Health Survey; BMI, body mass index; CI, confidence interval; GerES, German Environmental Survey; HES, health examination surveys; HIS, health interview surveys; IMIM, *Institut Municipal d'Investigació Médica*; NRHEEC, National Reports of Human Exposure to Environmental Chemicals (USA); OR, odds ratio; ORa, adjusted odds ratio; POPs, persistent organic pollutants; WHO, World Health Organization.

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in health interview surveys (HIS) and health examination surveys (HES) (De Bruin et al., 1996; Aromaa et al., 2003), but hardly ever in the context of surveys in the general population that included blood, urine or tissue collection (Merzenich et al., 2001; Porta et al., 2008b).

The design of the most recent HIS in Barcelona included selecting survey participants with the explicit objective of analyzing the distribution of concentrations of persistent organic pollutants (POPs) in the city inhabitants. This prospective integration of POPs biomonitoring within a HIS occurred for the first time in Spain, and is surprisingly uncommon worldwide (De Bruin et al., 1996; Hupkens et al., 1999; Ueda (1998); Buckland et al., 2001; Department of Health and Human Services, 2001; Becker et al., 2002; Aromaa et al., 2003; Bates et al., 2004; Harden et al., 2004; Link et al., 2005; Angerer et al., 2007; Needham et al., 2007; Porta et al., 2008b).

We therefore analyzed the recruitment process and factors influencing participation in the 2006 Barcelona Health Survey (BHS) study on the distribution of serum concentrations of POPs.

2. Methods

2.1. Recruitment process

The population of the city of Barcelona in 2006 was 1 605 602 inhabitants, with significant socioeconomic differences (Marí-Dell'Olmo et al., 2007; Rodríguez-Sanz et al., 2008). As part of its mission of evaluating the health needs of the general population, monitoring health determinants, developing policies for disease prevention and control, and contributing to the development of an environmental and social context that is sustainable for health, in 2006 the *Agència de Salut Pública de Barcelona* conducted the fifth Barcelona Health Survey (BHS). The main objective of the survey was to obtain information about subjective experiences related to health, morbidity, mental health, life styles, uses of health services and preventive practices. Detailed information on the survey is available elsewhere (Borrell and Rodríguez-Sanz, 2008; Rodríguez-Sanz et al., 2008). Briefly, a representative sample of the non-institutionalized population was selected by simple random sampling from the census; the sample comprised 3125 individuals, of whom 1644 were women. In order to obtain the sample 7933 individuals were contacted. On average, it was necessary to contact 2.5 persons to recruit one participant; this latter figure was higher for men (2.7) and for subjects between 30 and 39 years of age (3.4). The main factors that influenced non-participation were unwillingness to participate (33.5%), change of address (30.3%), and impossibility to get in touch with the potential participant (21.0%). Face to face interviews were conducted at home by trained monitors from May to November, 2006.

At the end of the BHS interview participants $\geqslant$15 years were informed and offered by the monitors to take part in a BHS study on POP levels in the city population. This study was conducted by our Unit at the *Institut Municipal d'Investigació Médica of Barcelona* (IMIM). Participants who consented in principle to participate were subsequently contacted by telephone; the call included a brief explanation of the aims, benefits and requirements of participation. No economic compensation in return of participation – except for travel expenses to IMIM – and no communication of individual POP results were offered. Participants were asked to fast for at least 4 h before blood extraction.

Upon arrival at IMIM, participants were offered a chance to ask further questions and then gave specific written informed consent to participate in the POPs study. There was no waiting time: the appointment was made for the time that suited each subject, and upon arrival the subject was immediately seen. A nurse interviewed each participant, measured the weight, height and the hip and waist circumference, and collected a blood sample. The interview included questions about recent and past changes in body weight, on whether the person had been breastfed, and on history of diabetes. Women were also asked about parity, breastfeeding and abortion histories. Thirty milliliters of blood were drawn by venipuncture to determine blood lipids and serum concentrations of POPs. Blood was collected in a vacuum system tube and centrifuged for 15 min × 3000 rpm at 4 °C to obtain serum. Right after centrifugation, serum was divided in 1–3 mL aliquots and stored at −80°. Written informed consent, blood sample, physical examination and questionnaire data were obtained for all the participants in the study. On average the visit took 19.3 min (median, 17).

The recruitment process and visits for the POPs study took place from July 2006 to January 2007, with a holiday break in August. Collection of information about phone calls evolved since the beginning of the study: complete information on when the phone call was placed, and on the number of calls made was registered from October 2006 to January 2007 (84.8% of total calls). Phone calls were performed at different times during the day (i.e., morning, afternoons, evenings) in order to increase the probability to contact possible participants. Information on sociodemographic factors was available for all subjects (participant and non-participant), during all months of study. A target of 230 participants was decided a priori based on scientific and budgetary factors. The scientific factors included: POP values expected on the basis of values observed in other studies (percentage of detection of each compound, mean concentration, variance), the desired precision of estimates (e.g., ±3% and ±4% were used), and the level of statistical confidence (90% and 95%). For common percentages of detection, the required number of subjects was 216 if the desired precision and confidence were 4% and 95%, and 271 if they were 3% and 90%, respectively.

For the remainder of this paper, the term "BHS participants" refers to all individuals who completed the BHS interview; those who at the end of the BHS interview agreed in principle to take part in the POPs study are referred to as "consenters", and subjects who declined, as "non-consenters". Finally, consenters are divided into subjects who underwent the physical examination and blood extraction (hereinafter, "study participants") and subjects who did not ("consenters who did not participate"). As we shall see in detail below, the term "non-participants" includes the latter and non-consenters.

To analyze the representativeness of study participants we compared them with a representative sample of the city population ($n = 5399$), which included all BHS participants aged $\geqslant$15 years (51%) and additional inhabitants of Barcelona aged $\geqslant$15 years interviewed for the 2006 Health Survey of Catalonia (49%). The two groups are similar because they were selected and interviewed using identical procedures; the final representative sample was obtained by weightening according to age, gender and city district (Rodríguez-Sanz et al., 2008; Borrell and Rodríguez-Sanz, 2008).

2.2. Socioeconomic variables affecting participation

For the purpose of this study, we analyzed the influence upon participation of the following socioeconomic variables collected in the BHS questionnaire: sex, age, place of birth, educational level, employment/occupational status, occupational social class, income, and body mass index (BMI) (self-reported weight [kg] divided by self-reported height squared [m^2]); individuals were grouped into four BMI categories as recommended by WHO (World Health Organization, 2008). The lower educational category of subjects without formal studies included the illiterate. To assign occu-

pational social class we used the Spanish classification, which is based on Goldthorpe's scheme; class was hence assigned through the current or last occupation of the interviewed or, if she/he had not worked, through the current or last occupation of the head of the household (Domingo-Salvany et al., 2000; Rodríguez-Sanz et al., 2008). The classification includes 5 well-established main social groups: I, Managers of companies with ⩾10 employees, senior technical staff, free professionals; II, Managers of companies with <10 employees, intermediate occupations; III, Administrative personnel and financial management supporting professionals, self employed professionals, supervisors of manual workers, other skilled non-manual workers; IV, Skilled and partly skilled manual workers; and V, Unskilled manual workers. The income variable refers to the family gross annual income according to the number of people living in the household (Rodríguez-Sanz et al., 2008).

2.3. Statistical analyses

Univariate statistics were computed as customary (Kleinbaum et al., 1998; Armitage et al., 2002). In contingency tables, Fisher's exact test for independence or homogeneity was applied to assess the relationship between two categorical variables; when this test could not be applied Pearson's Chi-square test was used. For comparisons between continuous variables, Student's *t*-test and Mann–Withney's *U* test were used (Kleinbaum et al., 1998). To analyze the socioeconomic factors influencing participation, multivariate-adjusted odds ratios (OR) and their corresponding 95% confidence intervals (CI) were calculated by unconditional logistic regression (Rothman et al., 2008). Age, sex and educational level were included in models as potential confounding factors. When a linear trend was apparent for a categorical ordinal variable it was assessed through the multivariate analogue of Mantel's extension test for linear trend. When such trend was not clearly apparent, Wald's test was used to assess statistical significance. The level of statistical significance was set at 0.05, and all tests are two-tailed. Statistical analyses were conducted using SPSS, version 12.0 (SPSS Inc., Chicago, IL).

3. Results

From the 2755 participants in the Barcelona's Health Survey who were ⩾15 years old, 634 (23%) initially declared interest in participating in the POPs study. Of them, we attempted to contact 595 subjects, and were able to do so for 523, of whom 323 made an

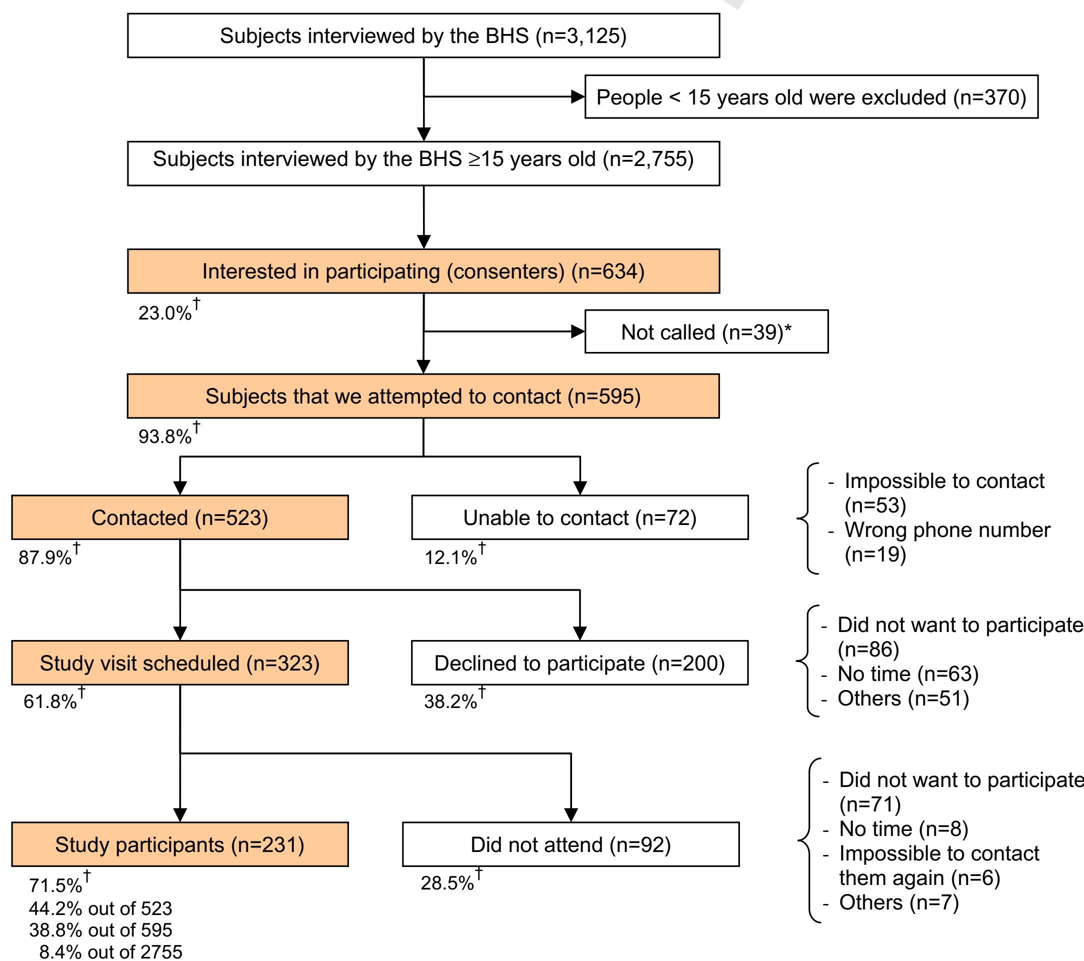

Fig. 1. Flow of participants through the recruitment process. †Percentage calculated with respect to the box immediately above (e.g., 23.0% = 634/2755 × 100). *These calls were not necessary because the target of 230 participants had been achieved. *Note:* Table 3 shows factors affecting participation in the POPs study by comparing participants in it (n = 231) and the other participants in the BHS (n = 2524 = 2755–231).

appointment to attend the POPs study visit for the interview, physical exam and blood draw (Fig. 1). The visit was actually attended by 231 subjects, which yields a response rate of 44% of the 523 individuals contacted, and of 39% of the 595. In spite of the initial interest, eventually unwillingness to participate was the most common reason why people failed to attend the visit.

The specific flow of individuals who made an appointment for the study visit is illustrated in Fig. 1S in Supplementary material. Of the 323 individuals, 199 (62%) attended the visit. Of the remaining 124, a new appointment could be scheduled for 50 individuals, of whom 27 (54%) showed up. Rescheduling was repeated up to four times, which yielded 5 additional participants.

The number of phone calls made to the 595 subjects to recruit the 231 participants was 2885 (includes non-answered calls). Thus, an average of 4.8 calls per subject was necessary to enroll a participant in the study (median: 3 calls). Only 5% of participants attended the visit after just one phone call; 3 calls were sufficient to recruit half of the 231 participants, and 5 calls to recruit 81% of them; the remaining 19% participants needed ⩾6 calls (Fig. 2). The maximum number of calls made to individuals that we attempted to contact was 17; to participants, the maximum number of calls made was 15.

Socioeconomic characteristics of the individuals who donated blood for the analysis of POPs (study participants) and from the representative sample of the population of the city of Barcelona are compared in Table 1. No statistically significant differences were found regarding sex and mean age, although among study participants there were more women and fewer individuals from the youngest and oldest age groups. No major differences were found either regarding autoreferred BMI, place of birth, and employment status. The distribution of social class was slightly more favorable among study participants, who also had a higher educational level ($p = 0.003$) and income ($p = 0.029$) (Table 1).

Characteristics of non-consenters, consenters who did not participate and participants are summarized in Table 2. There were no significant differences among the three groups in employment status, occupational social class and income. The percentage of women was higher in participants than in non-consenters ($p = 0.044$). More consenters who did not participate were born in Central and South America than non-consenters ($p = 0.005$). Non-consenters and consenters who did not participate had a lower educational level than participants (both $p < 0.005$).

Finally, we analyzed factors affecting participation in the POPs study by comparing participants in it ($n = 231$) and the other participants in the BHS ($n = 2,524$) (Table 3). Age and educational level were associated with a higher participation; thus, individuals with university education were 3.76 times more likely to participate than individuals without formal studies. Age remained significant when adjusted by sex and education, and so did education when adjusted by age and sex (ORa for university level = 4.58). Crude and adjusted ORs show a strong and monotonic trend of increasing participation with increasing educational level ($p < 0.001$). Adjusting for age and education showed that overall women were 38% more likely to participate than men (Table 3, last columns); the higher participation of women was evident in all educational subgroups, and the difference with men was particularly strong in the group without formal studies, among whom the age-adjusted OR of women *vs.* men was 12.25 (95% CI: 1.29–116.68, $p = 0.029$). Although unadjusted models showed higher participation with increasing social class and with increasing income (p for trend = 0.007 and 0.015, respectively), when controlling for sex, age and educational level, class and income were no longer statistically significant. As compared to participation by inhabitants of the city district where IMIM (the POPs study centre) is located, participation was significantly higher only by inhabitants of one of the other 9 districts (ORa = 1.81, 95% CI: 1.02–3.21); i.e., participation was similar in 9 of the 10 districts.

When participation was analyzed by gender, the influence of age and education was similar as among the two sexes combined; e.g., as compared to women in the two lowest categories of education (now combined as one reference category in Table 4), the ORa for women of university level was 2.49, while the corresponding OR for men was 2.68 (Table 4). There was little or no effect of BMI and place of birth. If unadjusted by age and education, employment, class and income did influence participation among women: students and the unemployed were half as likely to participate than employed women; women of social classes I and II were twice as likely to participate than women of class V (p for trend = 0.012); and women in the two upper income categories were 46–74% more likely to participate than women with lowest income (p for trend = 0.045) (data not shown). While unemployed men were more likely to participate than those employed (ORa = 3.51), a null or weakly inverse association was observed in women (OR = 0.49) (p for interaction = 0.002) (Table 4). Among men, both employment status and income were significant when included in the same model along with age ($p = 0.004$ and p for trend = 0.030, respectively).

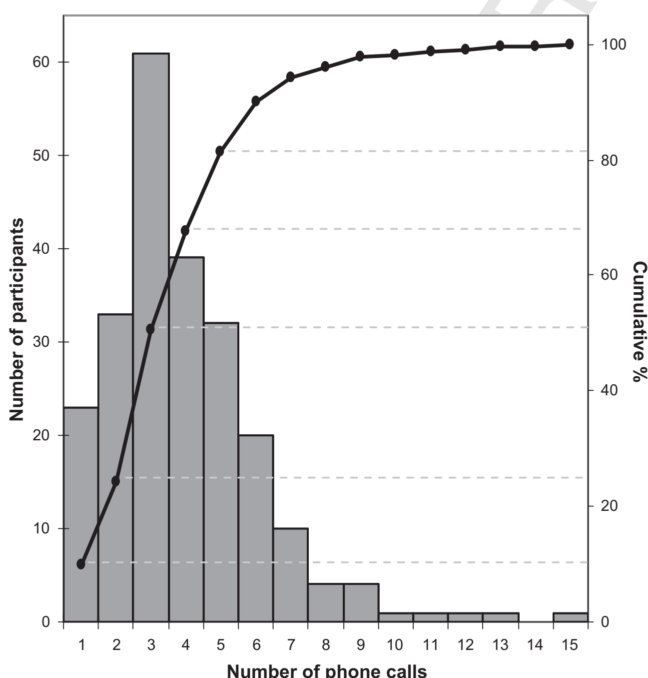

Fig. 2. Number of phone calls needed to achieve a visit among the 231 participants in the POPs study.

4. Discussion

Minimizing non-response in surveys is essential to make valid inferences to the target population. Common response rates for HIS range between 52% and 95%, whilst in HES they tend to be between 25% and 85% (Aromaa et al., 2003). The response rate achieved in the BHS POPs study among individuals with whom contact was attempted was 38.8% (231 of 595 individuals attempted to contact); the response among the 523 individuals actually contacted was 44.2%. There are several ways to report a study response rate (Sandler, 2002), especially when the recruitment process takes place within a relatively complex survey (Table 5) (Department of Health and Human Services, 2001, 2008a,b; Becker et al., 2002; Koppen et al., 2002; Bates et al., 2004; Link et al., 2005;

Table 1
Socioeconomic characteristics of individuals who donated blood for the analysis of POPs compared to a representative sample of the population of the city of Barcelona (all ⩾15 years old).

	Barcelona representative sample N (%)	Study participants N (%)	p-Value[a]
Total	5399	231	
Sex			
Men	2533 (46.9)	94 (40.7)	0.069
Women	2866 (53.1)	137 (59.3)	
Age (years)			
Mean ± SD	47.4 ± 19.4	47.7 ± 16.2	0.833[b]
Median	45.0	45.0	0.360[c]
15–24	625 (11.6)	12 (5.2)	<0.001[d]
25–34	1060 (19.6)	41 (17.8)	0.229[e]
35–44	1011 (18.7)	61 (26.4)	
45–54	791 (14.7)	43 (18.6)	
55–64	700 (13.0)	31 (13.4)	
65–74	594 (11.0)	27 (11.7)	
>74	618 (11.4)	16 (6.9)	
Body mass index (autoreferred)			
Mean ± SD	24.97 ± 4.24	25.30 ± 4.40	0.246[b]
Median	24.57	24.46	0.270[c]
Underweight (<18.5)	166 (3.1)	8 (3.5)	0.906
Normal (18.5–24.9)	2763 (51.6)	121 (52.8)	
Overweight (25.0–29.9)	1835 (34.3)	74 (32.3)	
Obese (⩾30.0)	592 (11.0)	26 (11.4)	
Place of birth			
Catalonia	3340 (62.3)	155 (67.1)	0.385
Rest of Spain	1158 (21.6)	48 (20.8)	
Central and South America	534 (10.0)	19 (8.2)	
Other	325 (6.1)	9 (3.9)	
Educational level			
Without formal studies	579 (10.7)	10 (4.3)	0.003
Elementary not completed	830 (15.4)	31 (13.4)	
Elementary completed	1166 (21.6)	45 (19.5)	
Secondary	1363 (25.3)	63 (27.3)	
University	1430 (26.5)	81 (35.1)	
Other	26 (0.5)	1 (0.4)	
Employment status			
Employed	3098 (57.5)	141 (61.0)	0.304
Housewife	571 (10.6)	20 (8.7)	
Unemployed	262 (4.9)	15 (6.5)	
Retired	897 (16.6)	40 (17.3)	
Student	343 (6.4)	8 (3.5)	
Other	215 (4.0)	7 (3.0)	
Occupational social class			
V	632 (12.0)	21 (9.2)	0.077
IV	1921 (36.6)	71 (31.3)	
III	1304 (24.8)	56 (24.7)	
II	579 (11.0)	34 (15.0)	
I	822 (15.6)	45 (19.8)	
Income[f]			
<6000 €/person	1309 (24.2)	53 (22.9)	0.029[g]
6000–11 999 €/person	1128 (20.9)	52 (22.5)	
12 000–18 000 €/person	911 (16.9)	54 (23.4)	
>18 000 €/person	485 (9.0)	36 (15.6)	
Not recorded	1566 (29.0)	36 (15.6)	

[a] Unless otherwise specified, p-value derived from Fisher's exact test (two-tail).
[b] Student's t-test (two-tail).
[c] Mann–Whitney's U test (two-tail).
[d] Pearson's chi-square test (two-tail).
[e] Chi-square test (two-tail), youngest and oldest age groups not considered.
[f] Family gross annual income according to number of people living in the household.
[g] Excluding not recorded.

Masuda et al., 2005; Zumbado et al., 2005; Schulz et al., 2007). Some authors prefer to detail the recruitment process instead of reporting a specific percentage (Glynn et al., 2000; Koppen et al., 2002; Bates et al., 2004). In the German Environmental Survey (GerES) of 1998, for instance, the response rate was 55% (4822 out of a subsample of 8,845 subjects interviewed in the National Health Survey who where asked to participate in the examinations of GerES III) (Becker et al., 2002). A 45% response was achieved in the biochemical part of the Canary Islands Nutrition Survey (783 individuals out of 1747 participants in the entire survey) (Zumbado et al., 2005; Luzardo et al., 2006). In the US National Reports of Human Exposure to Environmental Chemicals (NRHEEC), the response rate ranged between 71% and 80% (e.g., in the NRHEEC I there were 3812 participants from 5325 individuals selected to

Table 2
Comparison of socioeconomic characteristics of the individuals interviewed on the BHS according to their interest in participating in the analysis of POPs.

	Non-consenters	Consenters		p-Value[a,e]	p-Value[a,f]	p-Value[a,g]
		Did not participate	Participants			
	N (%)	N (%)	N (%)			
Total	2121	403	231			
Sex						
Men	1014 (47.8)	176 (43.7)	94 (40.7)	0.142	0.044	0.505
Women	1107 (52.2)	227 (56.3)	137 (59.3)			
Age (years)						
Mean ± SD	48.9 ± 20.0	46.57 ± 19.8	47.67 ± 16.2	0.029[c]	0.272[c]	0.447[c]
Median	47.0	44.0	45.0	0.029[d]	0.642[d]	0.211[d]
15–24	236 (11.1)	60 (14.9)	12 (5.2)	0.280[b]	<0.001[b]	<0.001[b]
25–34	393 (18.5)	77 (19.1)	41 (17.8)			
35–44	357 (16.8)	66 (16.4)	61 (26.4)			
45–54	305 (14.4)	63 (15.6)	43 (18.6)			
55–64	286 (13.5)	52 (12.9)	31 (13.4)			
65–74	244 (11.5)	38 (9.4)	27 (11.7)			
>74	300 (14.2)	47 (11.7)	16 (6.9)			
Body mass index (autoreferred)						
Mean ± SD	24.93 ± 4.04	25.16 ± 4.39	25.31 ± 4.40	0.310[c]	0.191[c]	0.692[c]
Median	24.66	24.61	24.46	0.961[d]	0.449[d]	0.514[d]
Underweight (<18.50)	64 (3.1)	8 (2.0)	8 (3.5)	0.051	0.623	0.544
Normal (18.5–24.9)	1066 (51.0)	204 (51.2)	121 (52.8)			
Overweight (25.0–29.9)	754 (36.1)	130 (32.7)	74 (32.3)			
Obese (⩾30.0)	205 (9.8)	56 (14.1)	26 (11.4)			
Place of birth						
Catalonia	1361 (64.6)	243 (60.6)	155 (67.1)	0.005	0.365	0.398
Rest of Spain	469 (22.2)	97 (24.2)	48 (20.8)			
Central and South America	143 (6.8)	45 (11.2)	19 (8.2)			
Other	135 (6.4)	16 (4.0)	9 (3.9)			
Educational level						
Without formal studies	261 (12.3)	43 (10.7)	10 (4.3)	0.483	<0.001	0.004
Elementary not completed	365 (17.3)	66 (16.4)	31 (13.4)			
Elementary completed	420 (19.8)	95 (23.6)	45 (19.5)			
Secondary	497 (23.5)	96 (23.8)	63 (27.3)			
University	557 (26.3)	98 (24.3)	81 (35.1)			
Other	18 (0.8)	5 (1.2)	1 (0.4)			
Employment status						
Employed	1160 (54.7)	244 (60.5)	141 (61.0)	0.324	0.153	0.446
Housewife	220 (10.4)	36 (8.9)	20 (8.7)			
Unemployed	93 (4.4)	16 (4.0)	15 (6.5)			
Retired	427 (20.1)	68 (16.9)	40 (17.3)			
Student	132 (6.2)	27 (6.7)	8 (3.5)			
Other	88 (4.2)	12 (3.0)	7 (3.0)			
Occupational social class						
V	238 (11.5)	57 (14.3)	21 (9.2)	0.223	0.070	0.073
IV	773 (37.4)	151 (37.9)	71 (31.3)			
III	507 (24.6)	81 (20.3)	56 (24.7)			
II	214 (10.4)	48 (12.0)	34 (15.0)			
I	332 (16.1)	62 (15.5)	45 (19.8)			
Income[h]						
<6000 €/person	512 (24.1)	120 (29.8)	53 (22.9)	0.290[i]	0.095[i]	0.065[i]
6000–11 999 €/person	522 (24.6)	96 (23.8)	52 (22.5)			
12 000–18 000 €/person	398 (18.8)	71 (17.6)	54 (23.4)			
>18 000 €/person	220 (10.4)	45 (11.2)	36 (15.6)			
Not recorded	469 (22.1)	71 (17.6)	36 (15.6)			

[a] Unless otherwise specified, p-value derived from Fisher's exact test (two-tail).
[b] Pearson's chi-square test (two-tail).
[c] Student's t-test (two-tail).
[d] Mann–Whitney's U test (two-tail).
[e] Non consenters vs. consenters who did not participate.
[f] Non consenters vs. participants.
[g] Consenters who did not participate vs. participants.
[h] Family gross annual income according to number of people living in the household.
[i] Excluding "not recorded".

participate in the National Health and Nutrition Examination Survey) (Department of Health and Human Services, 2001, 2008a,b). In studies that do not report response rates the design complexity makes it difficult to estimate participation; e.g., in the Flanders Environmental and Health Study of women 50–65 years old, we estimated a 78% response, although this figure corresponds to 200 out of 255 women selected from those who accepted to participate when they were contacted (Koppen et al., 2002).

Table 3
Factors affecting participation in the POPs study of the 2006 Barcelona Health Survey.[a]

	Participation			Unadjusted OR			Adjusted OR[b]		
	No *N* (%)	Yes *N* (%)	*p*-Value[c]	OR	(95% CI)	*p*-Value[e]	OR[b]	(95% CI)	*p*-Value[e]
Total	2524 (91.6)	231 (8.4)							
Sex									
Men	1190 (92.7)	94 (7.3)	0.063	1		0.06	1		0.023
Women	1334 (90.7)	137 (9.3)		1.3	(0.99–1.71)		1.38	(1.04–1.81)	
Age (years)									
15–24	296 (96.1)	12 (3.9)	<0.001[d]	1		<0.001	1		0.002
25–34	470 (92.0)	41 (8.0)		2.15	(1.11–4.16)		1.98	(1.01–3.87)	
35–44	423 (87.4)	61 (12.6)		3.56	(1.88–6.72)		3.35	(1.76–6.40)	
45–54	368 (89.5)	43 (10.5)		2.88	(1.49–5.57)		2.82	(1.46–5.49)	
55–64	338 (91.6)	31 (8.4)		2.26	(1.14–4.49)		2.47	(1.24–4.94)	
65–74	282 (91.3)	27 (8.7)		2.36	(1.74–4.75)		3.01	(1.46–6.19)	
⩾74	347 (95.6)	16 (4.4)		1.14	(0.53–2.44)		1.6	(0.72–3.54)	
Body Mass Index (autoreferred)									
Underweight or normal (<24.9)	1342 (91.2)	129 (8.8)	0.602	1		0.612	1		0.598
Overweight (25.0–29.9)	884 (92.3)	74 (7.7)		0.87	(0.65–1.17)	0.746[f]	1.01	(0.73–1.39)	0.439[f]
Obese (⩾30.0)	261 (90.9)	26 (9.1)		1.04	(0.67–1.61)		1.26	(0.80–1.99)	
Place of birth									
Catalonia	1604 (91.2)	155 (8.8)	0.508	1		0.497	1		0.771
Rest of Spain	566 (92.2)	48 (7.8)		0.88	(0.63–1.23)		1.06	(0.73–1.52)	
Central and South America	188 (90.8)	19 (9.2)		1.05	(0.63–1.72)		1.03	(0.62–1.71)	
Other	151 (94.4)	9 (5.6)		0.62	(0.31–1.23)		0.71	(0.35–1.42)	
Educational level									
Without formal studies	304 (96.8)	10 (3.2)	0.001	1		<0.001[g]	1		<0.001[g]
Elementary not completed	431 (93.3)	31 (6.7)		2.19	(1.06–4.53)	0.001	2.36	(1.14–4.91)	0.001
Elementary completed	515 (92.0)	45 (8.0)		2.66	(1.32–5.35)		3.16	(1.53–6.52)	
Secondary	593 (90.4)	63 (9.6)		3.23	(1.63–6.38)		3.98	(1.94–8.14)	
University	655 (89.0)	81 (11.0)		3.76	(1.92–7.35)		4.58	(2.27–9.27)	
Other	23 (95.8)	1 (4.2)		1.32	(0.16–10.78)		1.5	(0.18–12.27)	
Employment status									
Employed	1404 (90.9)	141 (9.1)	0.188	1		0.187	1		0.581
Housewife	256 (92.8)	20 (7.2)		0.78	(0.48–1.27)		0.91	(0.51–1.62)	
Unemployed	109 (87.9)	15 (12.1)		1.37	(0.78–2.42)		1.39	(0.78–2.46)	
Retired	495 (92.5)	40 (7.5)		0.81	(0.56–1.16)		1.04	(0.61–1.78)	
Student	159 (95.2)	8 (4.8)		0.5	(0.24–1.04)		0.57	(0.26–1.24)	
Other	100 (93.5)	7 (6.5)		0.7	(0.32–1.53)		0.97	(0.42–2.25)	
Occupational social class									
V	295 (93.4)	21 (6.6)	0.063	1		0.065	1		0.741
IV	924 (92.9)	71 (7.1)		1.08	(0.65–1.79)	0.007[f]	1.01	(0.60–1.68)	0.341[f]
III	588 (91.3)	56 (8.7)		1.34	(0.79–2.25)		1.01	(0.59–1.76)	
II	262 (88.5)	34 (11.5)		1.82	(1.03–3.22)		1.36	(0.73–2.53)	
I	394 (89.7)	45 (10.3)		1.6	(0.94–2.75)		1.2	(0.65–2.23)	
Income[h]									
<6000 €/person	632 (92.3)	53 (7.7)	0.022	1		0.015[g]	1		0.362[g]
6000–11 999 €/person	618 (92.2)	52 (7.8)		1	(0.67–1.49)	0.022	0.92	(0.61–1.37)	0.139
12 000–18 000 €/person	469 (89.7)	54 (10.3)		1.37	(0.92–2.04)		1.14	(0.76–1.73)	
>18 000 €/person	265 (88.0)	36 (12.0)		1.62	(1.04–2.53)		1.25	(0.77–2.03)	
Not recorded	540 (93.8)	36 (6.2)		0.79	(0.51–1.23)		0.69	(0.44–1.08)	

OR: odds ratio (OR = 1.00 denotes the reference category).
[a] Factors affecting participation in the POPs study are analyzed by comparing participants in it ($n = 231$) and the other participants in the BHS ($n = 2524 = 2755 - 231$, see Fig. 1).
[b] Odds ratio adjusted by sex, age and educational level.
[c] Fisher's exact test (two-tail).
[d] Pearson's chi-square test (two-tail).
[e] *p*-Value derived from Wald's test.
[f] *p*-Trend.
[g] *p*-Trend without "other" or "not recorded".
[h] Family gross annual income according to number of people living in the household.

Despite the fact that the participation achieved in the present study is not high, participants were similar to the population of Barcelona regarding sex, BMI, birth place, employment status, and occupational social class; their mean age was also similar to that of the city population, but there were less participants from the youngest and oldest age groups, and participants had a higher educational level and family income.

Variables positively influencing participation in the present study were female sex, age 35–74, and higher educational level; in the simpler analyses and in some multivariate analyses, social class and income, two other measures of socioeconomic position, were influential as well. Importantly, these sociodemographic factors have been found associated with human concentrations of POPs (Davies et al., 1972; Department of Health and Human Services, 2001; Borrell et al., 2004; Porta et al., 2008a; Umweltbundesamt, 2008). The higher participation of women was observed in all educational subgroups, and the difference with men was particularly strong among those with no formal studies. Some analyses

Table 4
Main results of multivariate analyses, by gender.

	Women			Men		
	OR	(95% CI)	*p*-Value[a]	OR	(95% CI)	*p*-Value[a]
Educational level						
Without formal studies or elementary not completed	1		0.001[c]	1		0.008[c]
Elementary completed	1.5	(0.82–2.73)	0.017	2.24	(1.06–4.76)	0.082
Secondary	2.36	(1.31–4.23)		2.07	(1.01–4.22)	
University	2.49	(1.41–4.39)		2.68	(1.36–5.27)	
Other	–			2.63	(0.31–22.33)	
Employment status						
Employed	1		0.638	1		0.012
Housewife	0.96	(0.51–1.79)		n.a.	n.a.	
Unemployed	0.49	(0.17–1.40)		3.51	(1.70–7.24)	
Retired	1.25	(0.60–2.57)		0.92	(0.40–2.10)	
Student	0.59	(0.22–1.60)		0.54	(0.15–1.88)	
Other	1.29	(0.49–3.42)		0.44	(0.06–3.31)	
Occupational social class						
V	1		0.58	1		0.696
IV	1.37	(0.70–2.67)	0.265[b]	0.6	(0.27–1.32)	0.803[b]
III	1.38	(0.67–2.82)		0.61	(0.25–1.44)	
II	2.02	(0.88–4.68)		0.75	(0.29–1.93)	
I	1.58	(0.68–3.69)		0.77	(0.31–1.91)	
Income[d]						
<6000 €/person	1		0.396[c]	1		0.710[c]
6000–11 999 €/person	0.93	(0.55–1.56)	0.695	0.86	(0.45–1.64)	0.184
12 000–18 000 €/person	1.18	(0.68–2.04)		1.04	(0.55–1.96)	
>18 000 €/person	1.28	(0.65–2.53)		1.14	(0.56–2.33)	
Not recorded	0.85	(0.50–1.46)		0.41	(0.18–0.96)	

OR: odds ratio adjusted by age and educational level (OR = 1.00 denotes the reference category).
n.a.: not applicable.
[a] *p*-Value derived from Wald's test.
[b] *p*-Trend.
[c] *p*-Trend without "other" or "not recorded".
[d] Family gross annual income according to number of people living in the household.

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of participation in studies that included blood extraction found women to participate more than men (Department of Health and Human Services, 2008a), while others found the opposite (Merzenich et al., 2001; Boshuizen et al., 2006). In some studies (Pullen et al., 1992; Boshuizen et al., 2006) – but not all (Sala et al., 1999; Merzenich et al., 2001) – participants were more likely to be from the more affluent social classes or more educated. In our study occupational social class was not related to participation as strongly as education. The latter may have enabled individuals to understand better what POPs are and the relevance of the POPs study when BHS interviewers informed BHS participants and asked whether they would donate blood. The finding does not rule out that social class might be related to concentrations of POPs among participants (Porta et al., 2008a). Participation was similar in 9 of the 10 city districts; the only district with a significantly higher participation is not particularly near or far away from the POPs study centre.

Additional factors that may have favored non-participation in our study include: apprehension to blood draw, the request to be fasting, lack of time, difficulties to travel to the POPs study centre

Table 5
Response rates in studies on POP levels in the general population.

Country (region)	Reference	Year of study conduct	Study population	Age of study population (range, years)	Response rate (%)
West Germany (GerES I)	Schulz et al. (2007)	1985–1986	General population	25–69	73
West Germany (GerES IIa)	Schulz et al. (2007)	1990–1991	General population	25–69	63
East Germany (GerES IIb)	Schulz et al. (2007)	1991–1992	General population	18–79	69
Germany (Baden-Wuerttemberg)	Link et al. (2005)	1993–2003	Children from general population	10	68–89
New Zealand	Bates et al. (2004)	1996–1997	General population	>15	62[a]
Germany (GerES III)	Becker et al. (2002)	1997–1999	General population	18–69	55
Spain (Canary Islands)	Zumbado et al. (2005)	1997–1998	General population	6–75	45
Belgium (Flanders)	Koppen et al. (2002)	1999	Women from general population	50–65	78[a]
Japan	Masuda et al. (2005)	1999	General population	20–60	58
USA	CDC (2001)	1999	General population	>1	71
USA	CDC (1999–00)	1999–2000	General population	>1	76
USA	CDC (2001–02)	2001–2002	General population	>1	80
Germany (GerES IV)	Schulz et al. (2007)	2003–2006	Children from general population	3–14	77

GerES, German Environmental Survey; CDC, Centers for Disease Control and Prevention.
[a] Response rate calculated from the recruitment process reported by the authors.

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and the nature of the institution (IMIM is a research centre, not a hospital), and our decisions to not communicate individual POP results to participants and to not provide payment other than for travel (Pullen et al., 1992; Becker et al., 2002; Boshuizen et al., 2006; Schulz et al., 2007; Reis et al., 2008). Due to budgetary constraints, it was not feasible to apply a structured questionnaire (e.g., to the 2121 non-consenters and to the 403 consenters who did not participate) to elicit why they were not participating; this is another limitation of the study.

Health interview surveys (HIS) and combinations of health interview and health examination surveys (HIS/HES) are central components of health surveillance systems (De Bruin et al., 1996; Aromaa et al., 2003). They are also an important framework for biomonitoring studies because of their representativeness (i.e., they enable to extrapolate results to the target population), their collection of information on self-perceived health status and health determinants (which can be linked to data on POPs and other environmental factors) (Lee et al., 2007), and their potential to inform health policies (De Bruin et al., 1996; Hupkens et al., 1999; Aromaa et al., 2003; Porta et al., 2008b; Rodríguez-Sanz et al., 2008). However, traditionally HES have rarely included biomarkers of environmental agents from inception (De Bruin et al., 1996; Aromaa et al., 2003). The relevance of studies on POPs embedded in HES is also supported by the Stockholm convention on POPs, whose Article 11 refers to the responsibility that countries signatories of the treaty have to conduct research and monitoring on the presence, levels and trends of POPs in humans, and on POP effects on human health (Porta and Zumeta, 2002).

Thus, the prospective integration of POPs biomonitoring within the most recent HIS in Barcelona is innovative and relevant. Results may also help plan other surveys with biomarkers; for instance, in the present study, more than five telephone calls did not significantly improve response, an issue that few other biomarker studies have reported (Becker et al., 2002; Angerer et al., 2007; Needham et al., 2007). Naturally, different results may be observed in other sociocultural settings and research designs.

Health surveys that integrate biomarkers should invest specific resources to encourage participation of youngest and oldest individuals, and of those with more disadvantaged socioeconomic position (particularly, citizens with lowest education). Since this paper is one of few comprehensively reporting participation rates and factors affecting participation in a population-based biomonitoring public health survey, further studies are needed to refute or replicate the findings.

Conflict of Interest

None declared.

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Appendix A. Supplementary material

Supplementary data associated with this article can be found, in the online version, at doi:10.1016/j.chemosphere.2009.03.030.

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