Blood concentrations of metals, essential trace elements, rare earth elements and other chemicals in the general adult population of Barcelona: Distribution and associated sociodemographic factors

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Abbreviations: ATSDR, Agency for Toxic Substances and Disease Registry; BHS, Barcelona Health Survey; BEs, Biomonitoring Equivalents; BMI, body mass index; CI, confidence interval; CPS, counts per second; HB2GV, human biomonitoring health-based guidance values; HBM-GV, Human biomonitoring Guidance Values; ICP-MS, Inductively Coupled Plasma Mass Spectrometry; ISTD, internal standard; IUIBS, Research Institute of Biomedical and Health Sciences; LOD, limit of detection; LOQ, limit of quantification; POPs, persistent organic pollutants; REE, rare earth elements; RSD, relative standard deviations; ULPGC, University of Las Palmas de Gran Canaria; QC, quality control.

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A B S T R A C T

Background: Very little information is available on the population distribution and on sociodemographic predictors of body concentrations of rare earth elements (REE) and other chemicals used in the manufacturing of high-tech devices.

Objectives: To analyze the distribution and associated sociodemographic factors of blood concentrations of chemical elements (including some metals, essential trace elements, rare earth elements and other minority elements) in a representative sample of the general population of Barcelona (Spain).

Methods: A sample of participants in the Barcelona Health Survey of 2016 (N = 240) were interviewed face-to-face, gave blood, and underwent a physical exam. Concentrations of 50 chemical elements were analyzed by ICP-MS in whole blood samples.

Results: All 50 chemicals studied, including 26 REE and minority elements, were detected. Lead, silver, arsenic, cadmium, mercury, antimony, strontium, thallium and six essential trace elements were detected in more than 70% of the population. The most frequently detected REE and minority elements were europium (62%), thulium (56%), gold (41%), indium (31%), ruthenium (24%), and tantalum (20%). Less affluent occupational social classes had higher percentages of detection of some REE. Median concentrations of silver, arsenic, cadmium and mercury were: 0.091, 3.01, 0.309, and 3.33 ng/mL, respectively. Women had lower median concentrations than men of lead (1.47 vs. 2.04 µg/dL, respectively), iron and zinc, and higher concentrations of copper and manganese. The influence of sociodemographic characteristics on chemical concentrations differed by sex.

Conclusions: While well-known contaminants as lead, mercury, cadmium, or arsenic were detected in the majority of the population, numerous individuals had also detectable concentrations of chemicals as europium, indium, thulium, or gold. Sociodemographic and physical characteristics (sex, age, social class, weight change) influenced concentrations of some chemicals.

1. Introduction

Very little information is available on the distribution of human body concentrations of rare earth elements (REE) and other minority elements in the general population. Many of such chemicals, along with essential trace elements –and well-known contaminants as lead or cadmium– are used in computers, other high-tech devices, and other consumer goods. When these products are discarded, they often become electronic waste (e-waste) and environmental pollutants that may affect human health [1,2].

A major focus of the present study is the analysis of 50 elements used in the manufacturing of such electronic devices [1]. They include REE, precious metals and other scarce elements, essential trace elements for humans, such as iron, selenium or zinc, and well-known pollutants as lead, cadmium, mercury, or arsenic. The latter four are part of the Substance Priority List of the U.S. Agency for Toxic Substances and Disease Registry's (ATSDR) [3].

Human population-based biomonitoring studies on REE and other minority elements are yet scarce [4-9]. Monitoring population time trends in human contamination from some of the mentioned chemicals (e.g., lead, cadmium, other metals) is also necessary because of the relatively well-known adverse health effects that such chemicals contribute to cause, as cardiovascular and kidney diseases, some cancers, or neurocognitive disorders [10-12]. Although knowledge about health effects of chronic exposure to REE is more scarce, anemia (decreased hemoglobin concentration), severe breathlessness and pneumoconiosis (respiratory tract damage), brain tumors, and other adverse effects have been observed in experimental studies [13-17].

Better knowledge about sociodemographic, physical, and behavioural factors that influence human concentrations of REE and other mentioned chemicals is also needed [18-21]. For instance,

apart from studies on populations living near REE mining locations, there are only three reports worldwide on the influence of socioeconomic position on concentrations of REE and other minority elements [4,5,22], and there are no studies on the influence of weight change or having been breastfed in childhood.

Barcelona is one of the few cities that regularly conducts analyses of trends in body concentrations of environmental contaminants based on studies representative of the general adult population [23,24]. Moreover, such analyses are integrated within the Barcelona Health Survey (BHS) [25], which is a strength from scientific and policy standpoints [26,27]. In addition to previously published analyses of trends in levels of persistent organic pollutants (POPs) [23], our biobank of the 2016 BHS also enabled subsequent analyses of blood concentrations of metals, essential trace elements, REE and other chemicals, which we report in the present paper.

Therefore, the aim of the present study was to quantify the blood concentrations of 50 chemical elements in a representative sample of the general adult population of Barcelona city, and to analyze their associations with sociodemographic factors.

2. Methods

2.1. Design, study population and health interview survey

We performed a cross-sectional study in a sub-sample of the Barcelona Health Survey (BHS) for 2016. Methods of BHS have been described in detail [23,24,28,29]. Briefly, the BHS is a health survey that is representative of the adult non-institutionalized population of the city of Barcelona (Spain). At the end of the 2016 BHS interviews, participants ≥18 years old were offered the opportunity to take part in the study on environmental pollutants [30]. Subsequently, a nurse personally interviewed again each person who accepted to participate, measured the weight, height, and the hip and waist circumference, and collected blood and urine samples. Participants had been asked to fast for at least eight hours before blood extraction. Whole blood was collected in 4 mL EDTA tubes and stored at –80º until 2018-2019, when concentrations of chemicals were analyzed. The additional interview for the study included structured questions about recent and past changes in body weight (last 6 months), and on whether the person had been breastfed. Women were also asked about parity, breastfeeding their children, and miscarriages (spontaneous and induced) [23].

The Ethics Committee of the Parc de Salut Mar approved the study protocol, and all participants signed an informed consent before completing questionnaires at baseline.

2.2. Sociodemographic and physical characteristics

Body mass index (BMI) was computed by measured weight [kg] divided by measured height squared [m^2]. Participants were asked for weight change in the 6 months prior to BHS blood draw, which was classified in three categories: lost 4-5 kg, little or no change, and gained 4-5

kg. Educational level was classified in three categories according to the highest completed level: University, completed secondary schooling, and completed primary schooling (finished 2nd stage) or less. Occupational social class 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. Five social class categories were created: I, managers of companies with 10 or more employees, senior technical staff, higher level professionals; II, managers of companies with less than 10 employees, intermediate level professionals; III, administrative and financial management supporting personnel, other self-employed professionals, supervisors of manual workers, other skilled non-manual workers; IV, skilled and partly skilled manual workers; V, unskilled manual workers [28,31].

The age of the 240 participants ranged from 19 to 80 years, the average age being 50 years old. Fifty-three percent of all participants were women. About 16% were obese (BMI ≥ 30 kg/m^2), 19% were current smokers and 35% former smokers, 85% were breastfed in childhood, 23% were born outside Spain, and 31% were from less affluent occupational social classes (IV or V). Further details of participants' characteristics were previously described [23].

2.3. Analytical chemical methods

2.3.1. Selection of elements and sample preparation

Analyses of blood samples of the 2016 BHS were carried out in the Research Institute of Biomedical and Health Sciences (IUIBS) in the University of Las Palmas de Gran Canaria (ULPGC), Canary Islands (Spain). Fifty chemical elements were analyzed, including 9 essential trace elements (iron, copper, selenium, zinc, cobalt, chromium, manganese, molybdenum, and nickel), 15 elements from the ATSDR's Substance Priority List of 2019

(lead, silver, aluminium, arsenic, barium, beryllium, cadmium, mercury, palladium, antimony, strontium, thorium, thallium, uranium, and vanadium) [3], 20 rare earth elements (REE) (cerium, dysprosium, erbium, europium, gallium, gadolinium, holmium, indium, lanthanum, lutetium, niobium, neodymium, praseodymium, samarium, tin, tantalum, terbium, thulium, yttrium, and ytterbium) and 6 other minority elements (gold, bismuth, osmium, platinum, ruthenium, and titanium) commonly used in the manufacture of high-tech devices (Suppl. Tables 1-4) [1,4,32].

One hundred mg of whole blood was weighed into quartz digestion tubes and then digested into 1 mL of acid solution (65% HNO_3) using a Milestone Ethos Up equipment (Milestone, Bologna, Italy). The digestion conditions were programmed as follows (power (W)–temperature (C)–time (min): step 1: 1800–100–5; step 2: 1800–150–5; step 3: 1800–200–8; and step 4: 1800–200–7. After cooling, the digested samples were transferred and diluted. An aliquot of each sample was taken and the internal standard (ISTD) was added for the analysis. The ISTD solution included scandium, germanium, rhodium and iridium (20 mg/mL each) and was introduced in the Inductively Coupled Plasma Mass Spectrometry (ICP-MS) at an approximate concentration of 38 ppb to assess the reproducibility of the counts per second of ions (CPS) and relative standard deviations (RSD) values, in addition to the recovery values of the four isotopes (45Sc, 72Ge, 103Rh, 193Ir) between 70 and 130% expressed in a stability graph. After each sequence is completed, Ge was removed as internal standard with rare earth elements calibration curve to avoid the interferences of doubly charge ions of Nd and Sm. Elements of standard purity (5% HNO3, 100 mg/L) were purchased from CPA Chem (Stara Zagora, Bulgaria). Two standard curves (range = 0 – 300 ng/mL) were made in order to avoid the interferences of doubly charge ions from some rare earth elements an reach the highest accuracy: (a) one used a commercial multi-element mixture (CPA Chem Catalog number E5B8·K1.5N.L1, 21 elements) containing the essential trace elements, the main heavy metals and elements stabilized in hydrochloric acid (Os, Pt, Au, Pd and Ru); (b) one containing the

other multi-element mixture included individual elements (CPA Chem) that contained the REEs and other elements used in electronic devices. To avoid the memory effect of elements, especially with Hg, a cleaning solution consisting of 2.0% HNO3 and 1% HCl was introduced between samples [13,15]. ISTD was added to each vial (calibration, blanks, quality controls) prior to its introduction in the ICP-MS.

2.3.2. Analytical Procedure

An Agilent 7900 ICP-MS (Agilent Technologies, Tokyo, Japan) was used for quantification. Instrument configuration and optimization were previously reported [15]. The elements were quantified in the MassHunter v.4.2. ICP-MS Data Analysis software (Agilent Technologies). The analytical method was previously in-house validated [32]. The complete procedure was validated prior to its use with the employment of a reference certified material (RCM, Seronorm™ Trace Elements Whole Blood) at three levels of concentration. The recoveries rates were 89–128% for REEs and other elements used in electronic devices, and 87–118% for ATSDR's toxic heavy elements and trace elements (regression coefficients > 0.998 for all elements). Instrumental limit of detection (LOD) and quantification (LOQ) were calculated as the concentration of the element produced a signal that was three and ten times higher than of the averaged blanks solution measured in the same day of the analysis of the samples, respectively. The calculated relative standard deviations (RSD) were generally lower than 5%, except for few elements (Cu, Ni, Se, As, Ba, Zn, Sm), as the RSD raised to 10-12% at the lowest level of fortification. LODs ranged from <0.001 ng/mL for some rare elements to 0.009 mg/dL (90 ng/mL) for Fe, and the LOQs from 0.003 ng/mL for U and Pt to 0.136 mg/dL (1360 ng/mL) for Fe (Suppl. Tables 1-4) [33]. When the assigned value of an analyte was below the LOD, it was assigned the mid-value of this limit; and when a concentration was between the LOD and the LOQ, the mid-value between LOD and LOQ was used. As quality control (QC) of the analysis, a reagent blank digested in the same conditions and two tailor-made mix to obtain a final concentration of 50 µg/L were included each 21 vials of the

sequence. Results were acceptable when the concentration of the analytes determined in the QCs was within 20% of the deviation of the theoretical value.

2.4. Statistical analyses

Main statistical analyses were performed for chemicals that were detected (i.e., were present at concentrations above the detection limit) in >70% of participants, including 6 essential trace elements and 8 elements from the ATSDR's Substance Priority List. No REE or minority element was detected in >70% of participants (Suppl. Tables 1-4).

The selection of a representative sample of the non-institutionalized population in each BHS followed a complex design [23-29]. In order to guarantee that the demographic structure of the population is preserved with respect to age and sex, and thus the representativeness of the study population with respect the general population of Barcelona, sampling weights were used in the statistical analyses of the present study.

Univariate statistics were computed as customary [34]. First, for all 50 chemicals, we describe the percentages of the population with concentrations of each chemical above the limit of detection by sex, age, BMI, place of birth, smoking history, educational level, occupational social class, if they were breastfed or not and, in the case of women, if they had breastfed their children, and parity. We used Fisher’s exact test to detect differences between groups.

Then, for chemicals detected in over 70% of the population we quantified blood concentrations and calculated median, 25th and 75th percentiles and geometric means adjusted for age. Kruskal–Wallis' test and Wald test were used to assess differences in concentrations of chemicals by sociodemographic, physical, and behavioural characteristics of

the participants (age, BMI, weight change in last 6 months, if they were breastfed or not, place of birth, occupational social class, smoking history, and in the case of women, if they had breastfed their children and parity). All analyses were stratified by sex. We also computed multivariate analyses to assess simultaneously the effect of various sociodemographic characteristics on chemical concentrations. For each chemical we selected models in which all predictors, mutually adjusted, showed statistically significant associations with the chemical concentrations. Finally, Spearman's rank correlation coefficients (ρ) were computed to evaluate correlations among pairs of chemicals. Density plots were used to chart the distributions of chemical concentrations [26,27]. Since most concentrations of elements did not follow a normal distribution, comparisons between groups were performed using non-parametric tests (Kruskal–Wallis and Mann–Whitney U-test), and log-transformed values were used in regression analyses. The normality of the data was assessed using the Kolmogorov–Smirnov test.

Statistical analyses were conducted using SPSS version 22.0.0.0 (IBM SPSS Statistics, Armonk, NY, USA, 2013), and R version 3.5.2 (2018).

3. Results

All 50 chemical elements studied were detected in the study population: the smallest number of chemicals detected in one person was 11, and the largest, 39 (median, 17). The corresponding figures when excluding the essential trace elements were 6 and 33, respectively (median, 11).

Among the nine essential trace elements studied (Figure 1 - panel A, Suppl. Table 1), iron, copper, selenium and zinc were detected and quantified in all the 240 participants, and manganese and molybdenum were detected and quantified in more than 70%. From the ATSDR's Priority List, lead, silver, arsenic, cadmium, mercury, antimony, strontium and thallium were also detected in more than 70% of the population (Figure 1 - panel B, Suppl. Table 2). Most of the 26 REE and other minority elements were detected and quantified in more than 5% of the participants (dysprosium, erbium, europium, gallium, holmium, indium, lutetium, niobium, neodymium, tin, tantalum, terbium, thulium, yttrium, ytterbium, gold, bismuth, platinum, ruthenium, titanium); however, only six of them were detected in ≥20% of the population: europium (62%), thulium (56%), gold (41%), indium (31%), ruthenium (24%), and tantalum (20%) (Figure 1 - panels C and D, Suppl. Tables 3 and 4).

Several sociodemographic characteristics influenced the percentage of detection of some chemicals (Table 1). Women had a higher percentage of detection than men of aluminum, cadmium, mercury and three essential elements (cobalt, chromium and manganese). Some elements were more frequently detected in participants ≥65 years old: chromium, silver, palladium, thallium, uranium, dysprosium, holmium, indium, lutetium, and tantalum (all p-values <0.05). The percentage of detection of cobalt decreased with increasing BMI; by contrast, overweight and obese participants had a higher percentage of detection of indium, gold and platinum, and to a lesser extent beryllium, uranium, cerium, and lanthanum. Mercury, europium, indium, lutetium, terbium, thulium, platinum, and ruthenium were detected more

frequently in participants from less affluent social classes (IV-V). Participants who had been breastfed in infancy had a significantly lower percentage of detection only of cobalt, nickel, and some REE and minority elements (gadolinium, lutetium, thulium, ytterbium, bismuth and ruthenium) (Table 1).

In models assessing simultaneously the effect of various sociodemographic characteristics for the six most frequently detected REE and minority elements, being of the less affluent social classes remained associated to an increased probability of having europium, indium and thulium detected (results not shown). A lower educational level was associated to an increased probability of detection of europium, gold and ruthenium. Not having been breastfed as a child was associated to a higher probability of having indium, thulium and ruthenium detected. Among women, having breastfed their children showed no associations.

Figure 2 shows the population distribution of concentrations of chemical elements detected in more than 70% of the population (i.e., six essential trace elements and eight elements from the ATSDR's List). While distributions for elements from the ATSDR's List were skewed towards the area of higher concentrations (Figure 2, panel B) –i.e., a certain minority of the population had much higher concentrations than the vast majority–, distributions for essential trace elements as selenium or zinc tended to follow a normal distribution (Figure 2, panel A).

Significant differences by sociodemographic characteristics were also found in concentrations of chemical elements detected in more than 70% of the population (Tables 2, 3 and 4). Women had lower median concentrations than men of lead and of some essential elements as iron and zinc ($p<0.001$), while copper and manganese levels were higher in women than men ($p<0.001$ and $p=0.021$, respectively) (Table 2). When geometric means adjusted for age were considered, the same findings by sex were observed.

Statistically significant differences across age categories were found in concentrations of lead, arsenic, cadmium and strontium in both men and women, of thallium in men, and of mercury, antimony and selenium in women (Tables 3 and 4). Although concentrations tended to increase with age, in some cases the highest concentrations were found in participants aged 45-64 years old: cadmium (in men and women), arsenic, mercury and selenium (in women).

BMI was positively associated with concentrations of arsenic, mercury, selenium, and zinc only in men (Table 4). Moreover, men who had gained 4-5 kg in the 6 months prior to BHS blood draw had higher concentrations of lead and lower concentrations of zinc than men who had little or no weight change; men and women who had lost 4-5 kg had higher concentrations of silver. In women, weight change (loss of 4-5 kg) also increased concentrations of strontium (Table 3).

Lower concentrations of silver, arsenic, mercury, and molybdenum were found in women and men born abroad of Spain (Tables 3 and 4). Women born abroad also had lower concentrations of lead, iron, and zinc, while the lowest concentrations of thallium were observed in women born in the rest of Spain. The country of birth did not influence concentrations of cadmium, manganese or selenium.

Men of the less affluent occupational social classes (IV-V) had higher concentrations of lead (Table 4 and Figure 3), while men of classes I-II had higher concentrations of molybdenum, and women of the most affluent classes higher concentrations of mercury (Table 3 and Figure 3). Higher concentrations of mercury and arsenic were observed in men with university educational level vs. men with secondary schooling.

Men who were current smokers had significantly higher concentrations of lead and cadmium, and lower concentrations of antimony, iron, selenium, and zinc (Table 4). Women who were current smokers had higher concentrations of cadmium (Table 3).

Nulliparous women had lower age-adjusted concentrations of cadmium (p=0.027) and mercury (p=0.070), while the highest concentrations of both chemicals were observed in women who had breastfed their children 6 or less months (Table 3). When adjusting for age, the observed crude associations for lead with parity and breastfeeding did not remain significant.

In models assessing simultaneously the effect of various sociodemographic characteristics, sex was associated with concentrations of seven out of the 14 chemicals detected above 70% of participants (results not shown): women had higher concentrations of arsenic, cadmium, copper and manganese, and lower concentrations of lead, iron and selenium than men. Increasing age was associated with higher concentrations of five elements (lead, cadmium, antimony, strontium, and copper). Smoking and birth place were associated with concentrations of four chemicals. Former and current smokers had higher concentrations of lead and cadmium than never smokers, and lower concentrations of antimony; current smokers also had lower concentrations of selenium than former and never-smokers. All such models included all sociodemographic characteristics that showed statistically significant associations with the chemical concentrations when mutually adjusted. Participants born abroad of Spain had lower concentrations of silver, arsenic, molybdenum and iron. BMI was associated with higher concentrations of arsenic and mercury, while loss of 4-5 kg in the 6 months prior to BHS blood draw was associated with higher concentrations of silver and strontium. In women, being nulliparous was associated with lower concentrations of cadmium and mercury, while no associations were observed with breastfeeding (again, adjusting for the relevant predictors for each chemical).

Among chemical elements detected in more than 70% of the population, the highest Spearman's correlation coefficients were observed between iron and zinc ($\rho = 0.69$), mercury and arsenic ($\rho = 0.65$), and mercury and selenium ($\rho = 0.61$) (all three $p < 0.001$) (Suppl. Figure 1). While almost all correlation coefficients were <0.6, some strong correlations were observed between some pairs of REE: cerium and lanthanum ($\rho = 0.84$), cerium and praseodymium ($\rho = 0.74$), lanthanum and praseodymium ($\rho = 0.79$), and dysprosium and holmium ($\rho = 0.77$) (all four p-values <0.001). Remarkably, virtually no correlations were found between 62 POPs previously analyzed in the same participants and the 50 chemical elements analyzed in the present study (Suppl. Figure 2) [23]; the highest coefficients were observed between lead and PCBs 138, 153 and 180 (ρ of 0.48 - 0.49, p-values <0.001).

4. Discussion

Well-known contaminants as lead, mercury, cadmium, or arsenic, were detected in the vast majority of the population. Numerous individuals had also detectable concentrations of chemicals as europium, indium, thulium, or gold. Actually, all 50 chemical elements analyzed in the present study, including 26 REE and minority elements, were detected. Fourteen chemicals were detected in more than 70% of the population, including lead (100%), arsenic (100%), antimony (100%), strontium (99%), cadmium (98%), mercury (96%), silver (86%), thallium (72%) and six essential trace elements. Except for some essential trace elements, population distributions of the chemical concentrations were highly skewed, with high interindividual differences, as also previously observed for POPs [23,24,35]. The most frequently detected REE and minority elements were europium (62%), thulium (56%), gold (41%), indium (31%), ruthenium (24%), and tantalum (20%).

The use of REE elements in human activities is increasing, and it can be assumed that human exposure and accumulation will consequently increase [1,2]. Very little information is available on sociodemographic and behavioural predictors of body concentrations of REE in the general population [4,5,22]. Contact with electronic waste, and lifestyle factors –such as active and passive smoking, use of electronic cigarettes– have also been suggested as influential factors [18-20,36]. Nevertheless, tobacco has a complex role as a source of chemicals [18]. In fact, tobacco smoking was not associated with REE in the present study, but it was with other chemicals: men who were current tobacco smokers had higher concentrations of cadmium and lead than never smokers –as previously observed [37]–, and lower concentrations of antimony, iron, selenium, and zinc. Lower concentrations of the latter three essential trace elements could be a result of increased excretion due to the high concentrations of cadmium, of inflammatory responses to tobacco smoking, or of a poorer quality of diet among smokers compared to non-smokers [38-41]. In the general adult population of Northern France, lower

blood concentrations of cobalt, manganese and mercury were found among current smokers [37].

Another possible exposure relevant at the population level is traffic volume, as cerium and other REE are used as additives in diesel fuels [42]. REE are also present in some foods, since REE are used in zootechnical and agricultural applications as feed additives and fertilizers to improve animal/plant production. REE are also used as contrast media in imaging tests as MRA and MRI [43]. Furthermore, some REE are naturally found in soils and taken up by plants [44].

The less affluent occupational social classes had higher percentages of detection of some REE as europium, indium or thulium. In a biomonitoring study conducted in southern Spain –which is the only other study worldwide measuring at least 20 REE in a representative sample of the general population–[4], higher values of some elements were observed in subjects with higher income levels. Both in such study and in the present one, higher concentrations of mercury were observed in the more affluent groups, perhaps related to higher fish consumption. In Germany higher urinary concentrations of gold and platinum were found in upper social classes; the authors of the study considered that a possible reason was a higher number of teeth with noble metal dental alloy restorations in upper social classes [22].

To our knowledge, no other human biomonitoring study on the chemicals analyzed has assessed the association with weight change. Associations of weight change were found only with three elements: blood concentrations of lead were higher among men who had gained 4-5 kg in the 6 months prior to blood draw, while loss of 4-5 kg was associated with higher blood concentrations of silver and strontium. Indium, gold, platinum, beryllium, uranium, cerium, and lanthanum were more frequently detected in overweight and obese participants. BMI was also positively associated with concentrations of arsenic, mercury, selenium, and

zinc in men. Conversely, lower detection frequencies of cobalt were found in obese participants; this was similarly observed in a recent prospective study [45]. While most chemical elements are not highly lipid-soluble, some of them –mainly, metals like mercury, lead and arsenic– have an affinity for lipids and can accumulate in fatty tissue [46-48]. In a Spanish population, levels of nickel, lead, tin, and titanium were detected in 100% of adipose tissue samples from the 228 adults, while arsenic was found in 50% of them [49]. This might explain the associations we observed with weight loss and BMI.

Increasing age was associated with higher concentrations of lead, cadmium, antimony, strontium, and copper. Some elements were more frequently detected in participants ≥65 years old: chromium, silver, palladium, thallium, uranium, dysprosium, holmium, indium, lutetium, and tantalum. Thus, it is possible that exposure to many of the analyzed chemicals was more prolonged for the older birth cohorts, and, therefore, that there was not a common initial calendar or historic time of exposure for the three birth cohorts in which the study participants were subclassified. Similar results were recently reported, showing a positive correlation between age and plasma concentrations of arsenic, mercury, antimony and strontium [4]. Toxicokinetics (e.g., lower elimination rates among older participants) could also partly explain the age / birth cohort differences observed [11]. Formal age–cohort–period analyses [23,26,31,50,51] should be extended to REE and other chemical elements.

Differences in dietary habits might explain lower concentrations of mercury and cadmium observed in nulliparous women. Blood concentrations of mercury have been associated with fish intake among pregnant women [52,53]. Consumption of fish is advised to pregnant women because of its high content of some nutrients, such as omega-3 fatty acids [54]. Nonetheless, some types of fish may contain high concentrations of mercury [53]. Blood concentrations of cadmium are substantially elevated in persons with low body iron stores. Pregnant women are

reported to have lower iron stores than women at reproductive age [55]. Results are also consistent with other reports [56].

Some strong correlations were observed between concentrations of pairs of REE; for instance, between dysprosium and holmium or between cerium and lanthanum. These associations suggest potential common sources or pathways of exposure, which deserve further research. In fact, the addition of cerium and lanthanum-based catalytic additives in oil refining and diesel oil formulation is nowadays a common practice; thus, exposure to diesel exhaust may partly explain the observed correlation [17].

Patterns of exposure to REE might differ in populations near REE mining locations, industries, and general populations. Compared to results from the study in southern Spain [4], in the present study we found lower detection frequencies for most of REE and minority elements. Only for gold, ruthenium, mercury, cadmium, and silver, frequencies of detection were higher in the present study. As mentioned, many factors can influence human contamination by REE: the geochemical composition of the area, personal factors (e.g., age, sex or BMI), anthropogenic factors, daily diet and lifestyle, exposure from electronics, occupational or environmental exposure to industrial activities (diesel plants, technological devices), polluting activities (high traffic), or imaging tests [2,20].

Moreover, differences in the methodologies used in studies may also partly explain some differences in detection frequencies and concentrations observed (detection/quantification limits of the analytical methods and devices, sample matrix). While for chemicals as arsenic, cadmium, lead, mercury, and tin, whole blood is an appropriate matrix, this is less so for barium, nickel, and uranium [11].

According to the European Pollutant Release and Transfer Register (E-PRTR), the environmental pressure of heavy metals released in Barcelona is high, especially for arsenic, cadmium, chromium, copper, lead, mercury, nickel, and zinc [57]. This is because many industries now rely on urban waste water treatment plants to purify water effluent, but removing heavy metals from water is not a focus of these facilities [58]. There is a number of waste water treatment plants in Barcelona that receive polluted water effluents from chemical and food processing facilities. Such plants concentrate the pollution originated in the surrounding facilities and directly impact the concentration of chemical elements in the drinking water. However, for elements with regulatory limits, concentrations in tap water have not generally exceeded such limits in recent years, including 2016-2017 [59,60]. Moreover, for some heavy metals, as arsenic or mercury, exposure for the general population through diet is greater than through drinking water [61]. Exposure to lead may also be due to the fact that in Barcelona numerous old buildings still have lead pipes.

Data on the other metals included in the present study are not available from the European industrial emissions portal because they are not included in the 91-pollutant list of mandatory annual reporting [62].

In the general population blood concentrations of essential elements are generally maintained within a relatively constant range of levels, largely due to homeostatic compensatory mechanisms [63]. Despite exiting homeostatic mechanisms to keep essential elements within physiological limits, some of the essential metals have been reported to be carcinogenic (nickel, chromium) or neurotoxic (manganese) among humans, which provides an additional reason for their biomonitoring. Thus, the blood concentrations of the essential elements reported here should be interpreted with caution, or used to generate hypotheses on homeostatic mechanisms in different populations, or to identify factors that may influence homeostatic compensatory mechanisms. The article does not state or imply that the blood

concentration is reflective of the actual exposure, since biomarkers integrate exposures, toxicokinetics and other processes.

Human biomonitoring reference values estimate the upper margin of background exposure to a specific chemical at a given time in a specific population; thus, depending on the study time and population, reference values can be quite different for some metals and trace elements such as molybdenum, nickel, arsenic and mercury. Reference values are available mainly for cadmium, lead, mercury, copper, selenium, nickel and manganese; values are obtained from national-level biomonitoring studies conducted in different countries, including the United States, Canada, Germany, Italy and the Republic of Korea [8,9,22,64-68]. For some chemicals human biomonitoring health-based guidance values (HB2GV) are also available [69]. These values include Biomonitoring Equivalents (BEs), Human biomonitoring Guidance Values (HBM-GV) and HBM-I values. A formal analysis comparing concentrations found in the general population of Barcelona and the reference values or the HB2GV is beyond the scope of the present article. Future work focused on these comparisons should include formal analyses of the need for a reduction in the exposure to substances exceeding these values. Nevertheless, we observed that the 95th percentile concentration estimates found in the present study were below the guidance values for most of the chemicals with HB2GV available for blood. The maximum level found for these chemicals in our population (Suppl. Tables 1-4) was above the corresponding HB2GB for molybdenum, silver, aluminium, barium, cadmium, and titanium [69]. For mercury and zinc the 75th percentile concentrations were above the corresponding HB2GV. Results for zinc should be interpreted with caution, considering that urinary concentrations may be more reliable than blood concentrations due to homeostasis in blood [11,70].

Most concentrations of trace elements and chemical elements in the ASTDR's list were below the reference values published from national-level biomonitoring studies [5,65]. Nevertheless,

arsenic, mercury and molybdenum exceed the reference values for the general Canadian population [65]. Eighty-six percent of participants had concentrations of molybdenum above the 1.6 ng/mL reference value of the Canadian Health Measures Survey, and 75% above a reported reference value for the Italian population [9,65]. Only 7% of participants in the present study had zinc concentrations above reference values from the Canadian Survey (670 ng/mL for women and 790 ng/mL for men) [64,65]. Nickel concentrations exceeded published reference values, but nickel was detected and quantified only in 5% of participants, even though it is a trace element. This low frequency of nickel detection was similar in the study in southern Spain [4]. Nevertheless, the interpretation of nickel measured in whole blood, instead of in other sample matrixes, is unclear [11]. Diet is the main source of exposure to nickel. Mean and median values for cobalt were below published reference values [9,65].

While our sample size was modest in general terms, many effect estimates were sufficiently precise. Also, such size may be attainable for local and regional governments with limited resources. Furthermore, our subjects were selected from a representative sample of the city, and sample weights were used to compensate for differences in age and sex between our study population and the actual city population. Therefore, the results here presented are representative of and generalizable to the adult non-institutionalized population of the city of Barcelona.

Moreover, other relevant indicators –which are usually not part of biomonitoring surveys– were collected in person (e.g., weight changes, lactation, and anthropometric data were registered by nurses). As usual in biomonitoring studies in the general population, no information was collected on occupational exposures or on history of living near potential sources of exposure.

5. Conclusions

While well-known contaminants, such as lead, mercury, cadmium, or arsenic, were still detected in the vast majority of the population, numerous individuals had also detectable concentrations of chemicals as europium, indium, thulium, or gold. Sociodemographic and physical characteristics (sex, age, social class, weight change) influenced blood concentrations of some chemicals. There are thus clear reasons to strengthen current projects on human biomonitoring in representative samples of the population, especially to assess time trends, sources, and health effects in different sectors of the general population, both of single pollutants and of mixtures of REE and related chemicals [71,72]. Finally, health risks linked to exposure to REE should be assessed, since their concentration in humans is expected to increase in the near future.

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The authors have no conflicts of interest in connection with the paper, and declare no competing financial interests.

Figure legends

Figure 1. Percentages of detection of chemical elements in blood samples in a representative sample of the general population of Barcelona (samples collected in 2016). Blue (B): detected and quantified. Purple (P): detected, non-quantified. White: non-detected. The figures above the bars refer to the percentage of detection (B+P). Details of chemical symbols are provided in Tables 1 and 2.

Figure 2. Population distributions of the 14 chemicals detected in >70% of the population.

Figure 3. Population distributions of blood concentrations of lead and mercury by occupational social class, and stratified by sex.

References

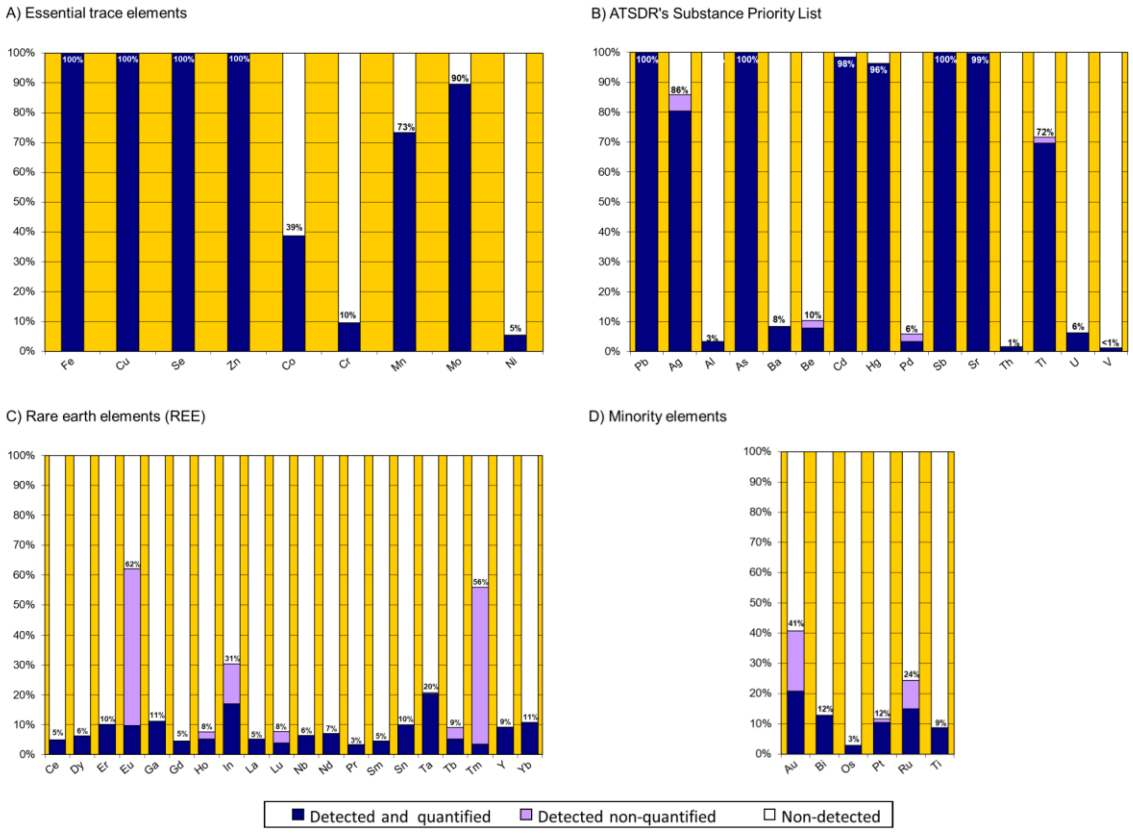
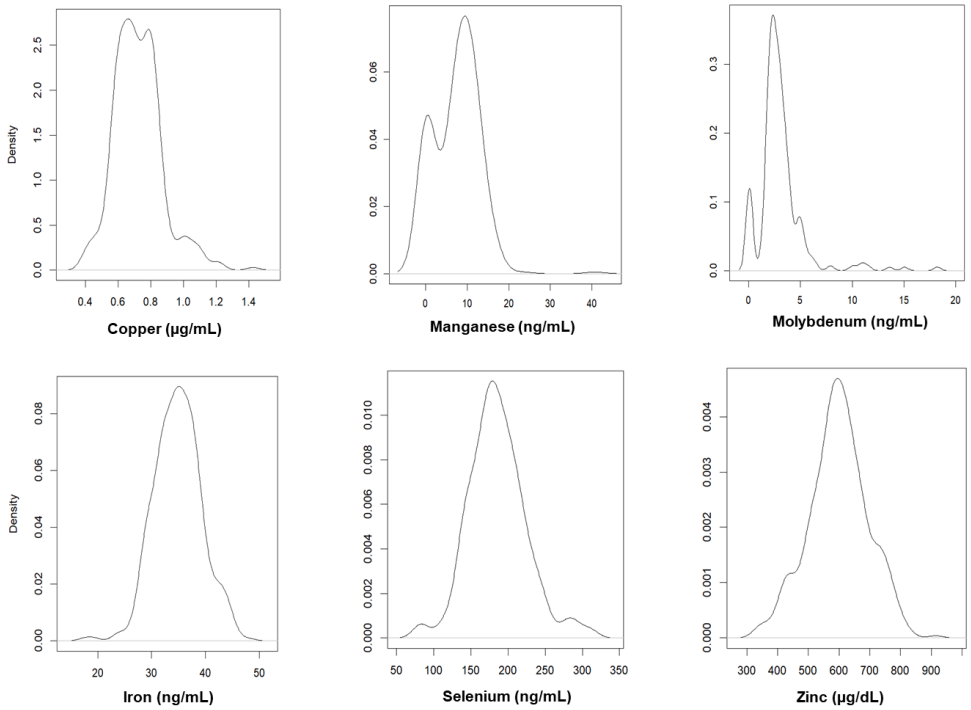

A) Essential trace elements
B) ATSDR's Substance Priority List
C) Rare earth elements (REE)
D) Minority elements
Detected and quantified
Detected non-quantified
Non-detected

Fig. 1

A) Essential trace elements



B) ATSDR's Substance Priority List

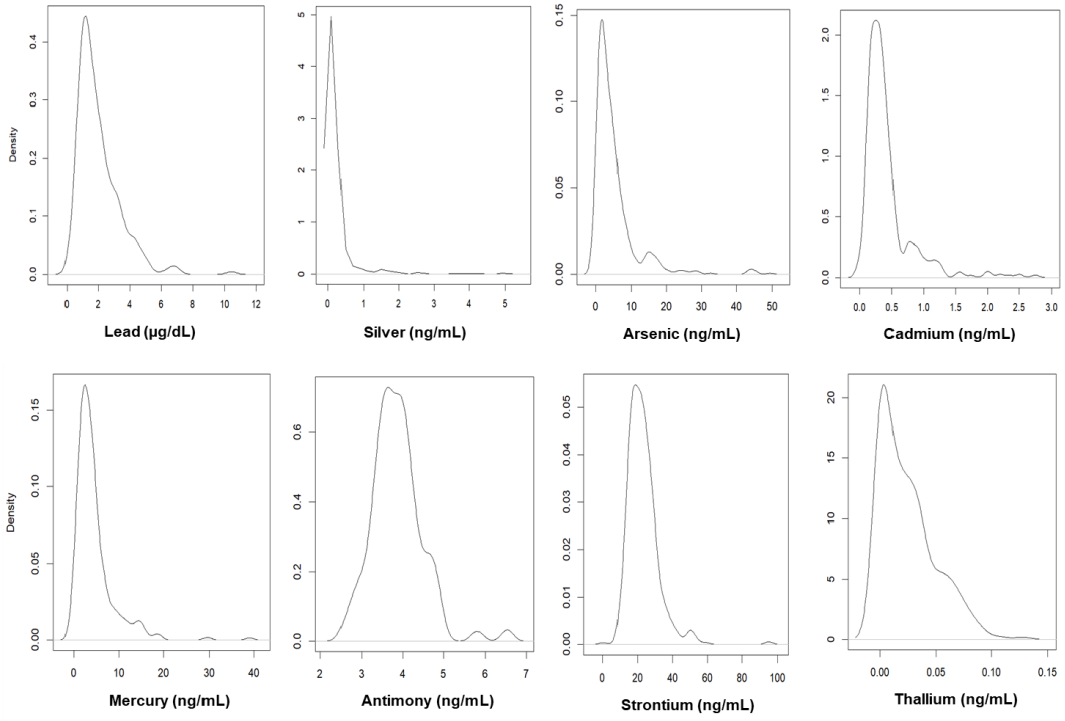


Fig. 2

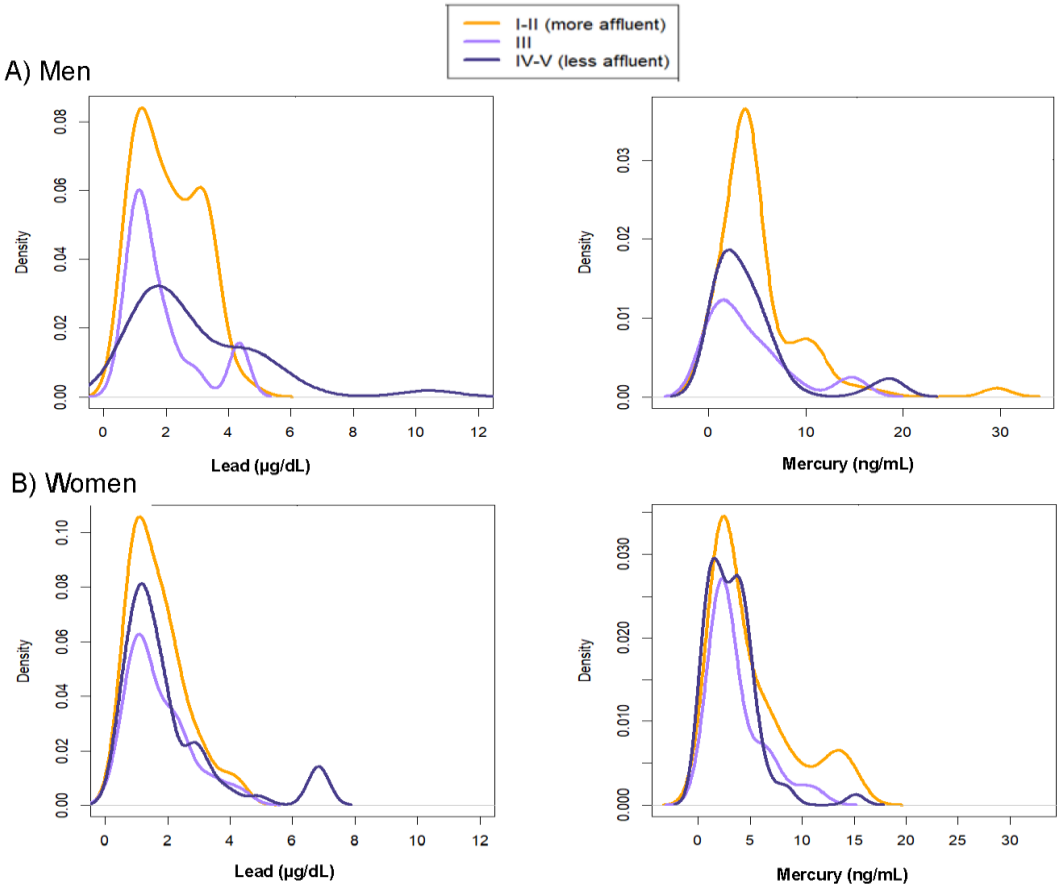

I-II (more affluent)
III
IV-V (less affluent)
A) Men
Density
Lead (µg/dL)
Mercury (ng/mL)
B) Women
Density
Lead (µg/dL)
Mercury (ng/mL)

Fig. 3

Table 1. Frequency of detection (% of participants with concentrations above the detection limit) of chemicals analysed in the population of Barcelona, by sociodemographic characteristics.*

Chemical	Sex			Age				BMI[a]			
	Male	Female	p-value	18-44 years	45-64 years	≥65 years	p-value	Normal	Over-weight	Obese	p-value
Essential trace elements											
Cobalt (Co)	30.0	**46.6**	0.011	40.1	33.0	44.8	–	**44.7**	38.5	18.2	0.013
Chromium (Cr)	1.4	**17.0**	<0.001	6.5	6.9	**19.8**	0.023	4.3	**14.9**	5.9	0.031
Manganese (Mn)	67.3	**78.8**	0.041	74.0	69.8	77.5	–	66.1	80.5	72.9	0.076
Molybdenum (Mo)	90.0	89.5	–	84.3	91.8	97.1	0.063	85.5	92.9	92.6	0.201
Nickel (Ni)	8.8	2.6	0.042	8.5	4.2	1.9	0.168	6.7	3.2	8.5	–
ATSDR's priority list											
Silver (Ag)	83.2	88.1	–	85.8	79.8	**94.3**	0.047	82.1	88.5	87.7	–
Aluminium (Al)	0.5	6.0	0.039	1.0	3.2	8.2	0.031	1.7	2.2	3.8	–
Barium (Ba)	6.3	10.1	–	9.2	5.6	10.6	–	8.1	9.0	8.3	–
Beryllium (Be)	12.1	8.7	–	9.2	13.0	8.7	–	5.5	13.8	16.3	0.066
Cadmium (Cd)	96.0	100	0.045	95.8	100	100	0.155	95.8	100	100	0.169
Mercury (Hg)	92.3	100	0.001	95.1	99.3	94.7		92.3	99.4	100	0.031
Palladium (Pd)	7.6	4.2	–	4.2	2.3	**13.5**	0.015	3.2	5.3	6.9	–
Strontium (Sr)	99.5	100	–	100	99.3	100	–	100	100	98.6	0.166
Thorium (Th)	0.5	1.7	–	0.0	1.7	2.4		1.3	0.0	3.5	–
Thallium (Tl)	73.5	70.0	–	69.5	65.9	**83.7**	0.047	69.9	78.1	62.7	0.163
Uranium (U)	6.2	6.4	–	1.8	4.9	**16.8**	0.002	1.3	7.5	10.4	0.014
Vanadium (V)	0.5	1.2	–	1.5	0.0	1.0	–	1.5	0.6	0.0	–
Rare earth elements											
Cerium (Ce)	5.0	4.9	–	3.4	6.2	6.2		3.7	3.6	12.3	0.073
Dysprosium (Dy)	5.4	7.1	–	3.9	2.4	**16.4**	0.006	4.3	5.4	6.9	–
Erbium (Er)	8.8	11.2		7.6	8.3	17.3	0.134	7.1	11.3	9.0	–
Europium (Eu)	62.1	62.1	–	59.1	63.2	66.4		59.9	62.4	65.4	–
Gallium (Ga)	6.8	15.0	0.067	9.3	11.1	14.8		10.9	9.0	10.9	–
Gadolinium (Gd)	5.8	3.9	–	2.9	3.9	9.6	0.262	3.9	5.4	6.2	–
Holmium (Ho)	7.2	8.1	–	5.3	4.0	**17.3**	0.012	5.7	5.4	11.8	–
Indium (In)	30.2	30.7	–	24.5	26.5	**47.3**	0.011	19.5	39.1	**44.1**	0.001
Lanthanum (La)	5.9	4.6	–	2.9	6.9	7.1	–	3.3	4.1	13.7	0.056
Lutetium (Lu)	6.2	8.9	–	3.4	4.2	**20.7**	<0.001	3.7	8.7	9.3	0.221
Niobium (Nb)	5.4	7.2	–	7.3	6.8	3.8		9.2	3.7	5.5	0.232
Neodymium (Nd)	4.9	8.8	–	5.8	10.7	3.8	–	9.4	4.3	7.6	–
Praseodymium (Pr)	1.9	4.6	–	2.0	3.0	6.2	–	3.3	1.4	8.3	0.101
Samarium (Sm)	3.6	5.4	–	4.8	3.0	6.2	–	5.2	3.1	6.9	–
Tin (Sn)	7.3	12.3	0.199	9.8	10.2	10.1	–	7.9	12.9	10.2	–
Tantalum (Ta)	18.7	22.2	–	13.3	19.6	**35.6**	0.005	17.4	21.9	21.0	–
Terbium (Tb)	9.4	8.7	–	6.4	7.4	16.4	0.132	7.0	8.4	9.5	–
Thulium (Tm)	57.0	54.8	–	55.4	58.2	53.4	–	52.9	55.6	61.5	–
Yttrium (Y)	8.0	10.2	–	7.6	12.0	8.1	–	6.9	10.4	13.8	–
Ytterbium (Yb)	9.4	12.0	–	9.3	9.5	15.4	–	10.6	9.4	8.3	–
Minority elements											
Gold (Au)	42.2	39.7	–	37.5	42.0	45.7	–	32.5	**49.3**	46.5	0.037
Bismuth (Bi)	12.7	12.9	–	15.8	8.1	13.9	0.215	14.8	11.1	13.0	–
Osmium (Os)	3.0	2.8	–	3.8	2.8	1.4	–	2.8	3.9	1.4	–
Platinum (Pt)	11.1	12.3	–	9.6	8.5	20.3	0.111	4.1	15.8	**16.7**	0.008
Ruthenium (Ru)	26.3	22.9	–	24.9	20.0	29.9	–	18.2	29.7	24.7	0.155
Titanium (Ti)	6.8	10.7	–	10.2	10.9	3.3	–	13.4	4.0	9.0	0.090

Table 1, continued.

Chemical	Birth place				Smoking				Educational level			
	Catalonia	Rest of Spain	Abr.	p-value	Non	Former	Current	p-value	Primary or less	Secondary	University	p-value
Essential trace elements												
Cobalt (Co)	40.3	44.5	30.8	–	**50.3**	25.9	34.9	0.003	43.0	39.5	36.3	–
Chromium (Cr)	7.0	18.7	9.9	0.064	**15.5**	3.7	6.8	0.019	**20.7**	5.8	6.5	0.010
Manganese (Mn)	69.8	71.2	84.1	0.124	79.6	70.2	64.5	0.102	75.8	67.4	76.0	–
Molybdenum (Mo)	92.6	93.3	79.9	0.053	88.3	91.4	90.2	–	95.0	91.5	85.9	0.165
Nickel (Ni)	7.0	3.5	3.4	–	7.1	4.3	4.0	–	0.0	8.4	6.6	0.072
ATSDR's priority list												
Silver (Ag)	89.0	83.1	79.6	0.221	88.2	87.1	77.8	–	83.1	86.3	86.9	–
Aluminium (Al)	2.0	8.8	3.1	0.084	5.8	2.1	0.0	0.223	6.5	2.0	2.7	–
Barium (Ba)	5.6	7.1	16.3	0.072	4.0	11.5	12.9	0.042	10.0	10.6	6.0	–
Beryllium (Be)	7.8	9.2	17.5	0.122	9.2	14.7	5.0	0.186	17.6	7.6	8.2	0.133
Cadmium (Cd)	97.5	100	98.3	–	96.0	100	100	0.140	93.9	100	99.2	0.015
Mercury (Hg)	95.8	100	95.4	–	97.3	96.3	94.5	–	**100**	88.0	**100**	<0.001
Palladium (Pd)	4.4	13.5	3.4	0.057	6.8	1.8	10.4	0.038	7.4	2.6	6.9	–
Strontium (Sr)	100	98.7	100	0.174	100	99.4	100	–	100	100	99.5	–
Thorium (Th)	1.4	1.6	0.0	–	0.7	2.2	0.0	–	0.0	0.0	2.4	–
Thallium (Tl)	76.6	59.0	68.4	0.069	71.3	73.6	68.7	–	68.3	78.1	69.1	–
Uranium (U)	6.1	13.2	1.7	0.122	9.6	4.8	1.1	0.162	7.4	6.5	5.6	–
Vanadium (V)	1.1	1.3	0.0	–	1.4	0.6	0.0	–	0.9	2.1	0.0	0.157
Rare earth elements												
Cerium (Ce)	5.2	6.1	3.6	–	4.7	6.3	3.3	–	3.2	5.0	5.8	–
Dysprosium (Dy)	4.6	13.2	5.5	–	7.1	8.8	0.0	0.103	6.0	2.0	9.2	0.094
Erbium (Er)	9.3	14.2	9.1	–	11.5	12.8	2.0	0.091	9.0	5.9	13.3	0.224
Europium (Eu)	61.2	65.4	62.1	–	64.4	63.5	54.3	–	**78.7**	48.9	62.0	0.001
Gallium (Ga)	10.9	13.2	10.4	–	10.7	12.6	9.9	–	9.7	5.2	15.8	0.115
Gadolinium (Gd)	5.8	2.9	3.6	–	4.4	8.0	0.0	0.113	2.1	4.3	6.5	–
Holmium (Ho)	7.6	13.2	3.6	0.239	10.0	8.8	0.0	0.055	8.8	4.9	8.8	–
Indium (In)	31.9	26.2	29.8	–	**35.9**	33.2	12.6	0.010	38.6	26.7	28.6	–
Lanthanum (La)	4.5	7.3	5.5	–	3.3	8.8	3.3	–	3.2	3.6	7.3	–
Lutetium (Lu)	6.3	**20.3**	1.7	0.005	**12.1**	6.1	0.0	0.024	**13.0**	1.3	9.0	0.019
Niobium (Nb)	8.2	5.8	1.9		3.3	11.0	5.0	0.151	4.8	9.7	5.0	–
Neodymium (Nd)	9.2	6.1	1.9	0.208	4.2	11.8	4.7	0.146	2.3	7.9	8.8	0.170
Praseodymium (Pr)	2.7	4.8	3.8	–	2.4	6.4	0.0	0.161	2.3	1.5	5.1	–
Samarium (Sm)	4.8	4.8	3.8	–	4.2	7.5	0.0	0.193	2.3	1.5	7.7	0.076
Tin (Sn)	8.4	15.1	10.4	–	13.7	9.7	2.0	0.073	10.1	8.4	11.0	–
Tantalum (Ta)	**25.5**	21.5	7.0	0.010	21.3	23.5	13.4	–	16.6	27.0	18.4	–
Terbium (Tb)	9.2	13.2	5.5	–	11.2	10.0	2.1	0.175	7.9	9.4	9.4	–
Thulium (Tm)	53.0	63.8	57.2	–	57.7	55.7	51.7	–	64.3	50.1	55.1	–
Yttrium (Y)	9.4	11.2	7.2	–	6.1	15.8	4.7	0.053	5.5	8.4	11.6	–
Ytterbium (Yb)	11.3	13.8	7.2	–	13.4	12.1	2.1	0.080	8.3	12.1	11.3	–
Minority elements												
Gold (Au)	42.2	32.0	44.0	–	36.9	43.9	44.8	–	**54.5**	28.3	41.9	0.008
Bismuth (Bi)	14.5	10.5	10.1	–	14.7	9.7	13.9	–	5.9	16.4	14.0	0.122
Osmium (Os)	3.0	6.4	0.0	0.122	1.7	4.2	3.6	–	2.5	2.7	3.3	–
Platinum (Pt)	10.6	18.6	9.4	–	15.1	11.2	4.7	0.147	17.3	11.8	8.8	–
Ruthenium (Ru)	20.8	35.1	26.0	0.144	27.2	21.2	23.9	–	**36.1**	12.8	25.9	0.006
Titanium (Ti)	**12.6**	5.4	1.9	0.033	6.8	13.4	5.4	–	4.8	11.5	9.2	–

Table 1, continued.

Chemical	Occupational social class				Was breastfed			Breastfed her children (women)			
	I-II	III	IV–V	p-value	Yes	No	p-value	Never	≤6 months	> 6 months	p-value
Essential trace elements											
Cobalt (Co)	38.4	38.5	41.2	–	36.7	**58.9**	0.019	45.7	25.5	**58.5**	0.016
Chromium (Cr)	3.2	**15.8**	15.3	0.002	11.3	4.9	–	11.7	7.7	26.6	0.056
Manganese (Mn)	70.0	67.5	83.5	0.060	72.6	75.3	–	83.5	81.3	73.2	–
Molybdenum (Mo)	90.3	90.7	90.0	–	89.2	90.6	–	88.1	89.9	90.7	–
Nickel (Ni)	7.8	3.5	4.0	–	2.6	**19.9**	<0.001	3.2	2.8	2.0	–
ATSDR's priority list											
Silver (Ag)	88.1	83.5	83.5	–	87.2	86.1	–	88.6	79.4	92.1	0.194
Aluminium (Al)	1.7	3.4	6.1	–	4.4	0.0	–	1.4	2.4	11.9	0.137
Barium (Ba)	6.5	7.4	12.1	–	8.6	3.2	–	14.2	10.7	6.1	–
Beryllium (Be)	8.9	6.4	15.8	–	9.9	7.6	–	12.6	**13.5**	2.8	0.046
Cadmium (Cd)	97.7	96.6	100		98.1	97.1	–	100	100	100	–
Mercury (Hg)	97.3	89.8	**100**	0.006	97.0	90.5	0.138	100	100	100	–
Palladium (Pd)	5.8	3.8	7.4	–	5.9	9.0	–	0.0	5.7	7.1	0.121
Strontium (Sr)	100	99.0	100	0.236	99.7	100	–	100	100	100	–
Thorium (Th)	2.4	0.0	0.0	–	1.4	0.0	–	1.4	2.8	1.3	–
Thallium (Tl)	72.1	72.5	69.1	–	71.4	77.2	–	62.2	68.6	77.7	0.225
Uranium (U)	6.1	1.4	10.5	0.109	6.3	10.7	–	0.0	8.1	**11.1**	0.044
Vanadium (V)	1.4	0.0	0.7	–	1.1	0.0	–	3.2	0.0	0.0	0.182
Rare earth elements											
Cerium (Ce)	6.4	1.9	5.2	–	5.6	4.5	–	4.6	5.7	4.8	–
Dysprosium (Dy)	7.8	1.9	7.6	–	5.7	10.7	–	3.7	5.7	10.9	–
Erbium (Er)	11.6	2.9	13.7	0.126	9.5	16.8	–	5.1	17.2	13.4	0.129
Europium (Eu)	60.9	44.2	**76.3**	0.001	58.4	69.9	–	64.7	57.4	62.3	–
Gallium (Ga)	13.9	9.5	8.8	–	13.4	6.3	–	20.4	8.5	13.7	–
Gadolinium (Gd)	7.6	3.1	2.0	0.172	2.8	**15.6**	0.009	1.4	5.3	5.3	–
Holmium (Ho)	9.9	1.7	9.1	0.135	7.2	12.3	–	6.9	8.5	8.9	–
Indium (In)	27.0	20.5	**42.2**	0.016	27.9	44.7	0.064	28.1	33.2	31.7	–
Lanthanum (La)	5.5	2.9	6.7	–	5.7	6.1	–	3.7	5.7	4.8	–
Lutetium (Lu)	8.2	0.0	**13.1**	0.013	5.9	**19.7**	0.024	3.2	8.1	14.5	0.186
Niobium (Nb)	8.8	1.0	6.9	0.209	6.4	4.9	–	12.0	0.0	6.6	0.123
Neodymium (Nd)	8.6	6.0	4.1	–	7.9	6.5	–	7.1	5.3	12.1	–
Praseodymium (Pr)	4.1	1.9	3.3	–	4.0	1.6	–	3.7	5.7	4.8	–
Samarium (Sm)	5.0	5.5	3.3	–	5.6	1.6	–	5.9	5.7	4.8	–
Tin (Sn)	10.7	7.2	9.4	–	11.5	8.2	–	11.4	12.4	13.2	–
Tantalum (Ta)	21.9	26.2	14.9	0.233	19.6	26.8	–	14.8	18.2	30.9	0.174
Terbium (Tb)	11.3	0.0	**12.8**	0.010	7.9	18.5	0.102	5.1	12.0	10.2	–
Thulium (Tm)	54.1	40.5	**68.5**	0.005	50.7	**73.8**	0.023	55.8	58.7	51.9	–
Yttrium (Y)	9.7	4.6	10.7	–	10.0	11.0	–	3.7	21.5	10.1	0.063
Ytterbium (Yb)	14.1	3.1	10.6	0.102	9.4	**23.0**	0.032	5.1	17.2	15.5	0.090
Minority elements											
Gold (Au)	38.9	30.5	51.1	0.054	39.8	30.7	–	49.8	40.6	30.2	0.127
Bismuth (Bi)	15.1	8.2	11.7	–	11.9	**26.5**	0.029	15.5	13.4	10.3	–
Osmium (Os)	22.9	4.3	2.3	–	3.4	0.0	–	3.1	3.8	2.0	–
Platinum (Pt)	9.7	3.4	**21.6**	0.005	10.7	22.2	0.088	10.8	10.5	14.5	–
Ruthenium (Ru)	22.9	15.0	**32.9**	0.049	20.0	**35.7**	0.044	19.2	29.9	22.6	–
Titanium (Ti)	11.2	4.8	7.3	–	9.8	6.5	–	11.1	7.7	11.9	–

*Iron, copper, selenium, zinc, lead, arsenic, and antimony were detected in all participants, and are hence not included in the table.

*P-values >0.250 are not shown. All p-values were computed using Fisher's exact test (two-tail test).

*When the difference among the percentages of detection was greater than 10% and the corresponding p-value was <0.05, the highest percentage is highlighted and in bold type.

[a] Excluding underweight participants.

Table 2a. Differences by sex in concentrations of essential trace elements detected in >70% of the population.

	Cu (copper) (µg/mL)		**Mn (manganese) (ng/mL)**		**Mo (molybdenum) (ng/mL)**	
	Median (P25-P75)	aGM (CI 95%)	Median (P25-P75)	aGM (CI 95%)	Median (P25-P75)	aGM (CI 95%)
All	0.709 (0.619-0.805)	0.712 (0.694-0.730)	8.23 (0.31-10.92)	3.87 (3.17-4.73)	2.73 (2.05-3.55)	2.09 (1.78-2.44)
Sex						
Male	0.649 (0.589-0.720)	0.651 (0.629-0.673)	6.91 (0.31-9.47)	2.90 (2.17-3.88)	2.74 (2.09-3.79)	2.13 (1.69-2.69)
Female	0.786 (0.697-0.841)	0.770 (0.746-0.794)	9.30 (5.72-11.81)	4.98 (3.80-6.53)	2.73 (2.00-3.51)	2.05 (1.65-2.54)
p-value	<0.001	<0.001	0.002	0.008	0.540	0.803

	Fe (iron) (mg/dL)		**Se (selenium) (ng/mL)**		**Zn (zinc)** (µg/dL)	
	Median (P25-P75)	aGM (CI 95%)	Median (P25-P75)	aGM (CI 95%)	Median (P25-P75)	aGM (CI 95%)
All	34.9 (31.9-37.7)	34.6 (34.1-35.2)	182.3 (162.3-206.5)	181.5 (176.6-186.6)	598.7 (536.6-660.5)	590.4 (577.9-603.0)
Sex						
Male	37.2 (34.0-39.7)	36.8 (36.0-37.6)	189.1 (163.8-206.9)	181.1 (173.9-188.5)	625.1 (576.2-689.5)	624.9 (606.5-643.8)
Female	33.4 (30.6-35.5)	32.8 (32.2-33.5)	178.8 (160.6-206.5)	181.9 (175.2-188.9)	573.4 (517.6-622.3)	562.1 (546.7-577.8)
p-value	<0.001	<0.001	0.438	0.868	<0.001	<0.001

aGM: Geometric mean adjusted for age. N = 240 (113 male, 127 female).
p-value: median, Mann–Whitney's U test; aGM, Wald test.

	Pb (lead) (µg/dL)		**Ag (silver)** (ng/mL)		**As (arsenic)** (ng/mL)		**Cd (cadmium)** (ng/mL)	
	Median (P25-P75)	aGM (CI 95%)	Median (P25-P75)	aGM (CI 95%)	Median (P25-P75)	aGM (CI 95%)	Median (P25-P75)	aGM (CI 95%)
All	1.62 (1.06-2.57)	1.71 (1.59 -1.84)	0.091 (0.023-0.183)	0.065 (0.052-0.081)	3.10 (1.52-5.98)	3.15 (2.77-3.60)	0.309 (0.193-0.462)	0.315 (0.278-0.358)
Sex								
Male	1.92 (1.18-3.08)	2.04 (1.84-2.26)	0.078 (0.020-0.172)	0.058 (0.042-0.080)	2.84 (1.55-4.90)	2.84 (2.35-3.43)	0.303 (0.177-0.453)	0.279 (0.232-0.335)
Female	1.40 (0.96-2.28)	1.47 (1.34-1.62)	0.113 (0.035-0.215)	0.071 (0.052-0.097)	3.64 (1.51-7.25)	3.46 (2.90-4.13)	0.332 (0.240-0.496)	0.351 (0.296-0.417)
p-value	0.009	<0.001	0.148	0.358	0.179	0.133	0.123	0.073

	Hg (mercury) (ng/mL)		**Sb (antimony)** (ng/mL)		**Sr (strontium)** (ng/mL)		**Tl (thallium)** (ng/mL)	
	Median (P25-P75)	aGM (CI 95%)	Median (P25-P75)	aGM (CI 95%)	Median (P25-P75)	aGM (CI 95%)	Median (P25-P75)	aGM (CI 95%)
All	3.33 (1.84-5.24)	2.72 (2.29-3.23)	3.81 (3.49-4.16)	3.83 (3.75-3.90)	21.5 (16.9-26.9)	21.7 (20.7-22.8)	0.019 (0.001-0.037)	0.009 (0.007-0.011)
Sex								
Male	3.68 (1.79-5.27)	2.35 (1.82-3.02)	3.79 (3.46-4.14)	3.83 (3.72-3.94)	20.7 (16.5-25.3)	21.2 (19.8-22.8)	0.020 (0.001-0.039)	0.010 (0.007-0.014)
Female	2.85 (1.84-5.04)	3.08 (2.44-3.90)	3.82 (3.51-4.21)	3.83 (3.72-3.93)	22.6 (17.3-27.3)	22.1 (20.7-23.6)	0.016 (0.001-0.036)	0.008 (0.005-0.011)
p-value	0.440	0.119	0.576	0.991	0.220	0.399	0.471	0.314

aGM: Geometric mean adjusted for age. N = 240 (113 male, 127 female).
p-value: median, Mann–Whitney's U test; aGM, Wald's test.

Essential trace elements. Women.

	Cu (copper) (µg/mL)		Mn (manganese) (ng/mL)		Mo (molybdenum) (ng/mL)	
	Median (P25-P75)	aGM (CI 95%)	Median (P25-P75)	aGM (CI 95%)	Median (P25-P75)	aGM (CI 95%)
All	0.786 (0.697-0.841)	0.769 (0.744-0.796)	9.30 (5.72-11.81)	4.98 (3.80-6.53)	2.73 (2.00-3.51)	2.04 (1.64-2.55)
Age (years)						
18-44	0.705 (0.642-0.848)	0.735 (0.696-0.775)	10.19 (6.26-12.09)	5.72 (3.78-8.65)	2.47 (1.80-3.79)	1.72 (1.22-2.43)
45-64	0.783 (0.722-0.860)	0.788 (0.743-0.836)	8.32 (0.31-10.22)	3.72 (2.35-5.88)	2.73 (2.14-3.24)	2.07 (1.41-3.03)
≥65	0.805 (0.773-0.828)	0.808 (0.755-0.864)**	10.92 (5.91-11.81)	5.81 (3.44-9.83)	2.90 (2.18-3.34)	2.71 (1.74-4.20)
Body Mass Index						
Normal	0.728 (0.652-0.827)*	0.748 (0.709-0.788)	9.28 (0.31-11.55)*	4.01 (2.61-6.16)	2.76 (1.76-3.61)	1.58 (1.11-22.25)
Overweight	0.802 (0.767-0.832)	0.779 (0.734-0.828)	10.92 (8.33-11.86)	6.64 (4.09-10.77)	2.90 (2.28-3.43)	2.64 (1.77-3.94)
Obese	0.812 (0.775-0.860)	0.792 (0.726-0.864)	6.26 (0.31-10.72)	3.91 (1.94-7.91)	2.31 (1.74-3.56)	2.30 (1.29-4.11)
Weight change in last 6 months						
Lost 4-5 Kg	0.851 (0.767-0.934)	0.850 (0.738-0.979)	11.37 (9.29-12.22)*	11.02 (3.58-33.91)	2.81 (2.05-3.73)	2.02 (0.79-5.18)
Little or no change (± 3 Kg)[a]	0.781 (0.694-0.829)	0.758 (0.731-0.786)	9.15 (4.86-11.61)	4.60 (3.45-6.12)	2.80 (1.99-3.51)	2.09 (1.65-2.66)
Gained 4-5 Kg	0.793 (0.769-0.853)	0.848 (0.750-0.957)	10.19 (7.41-11.86)	6.87 (2.61-18.08)	2.25 (1.91-2.67)	1.56 (0.69-3.52)
Was breastfed						
No	0.710 (0.695-0.809)	0.746 (0.674-0.826)	9.29 (5.74-11.86)	5.14 (3.82-6.93)	2.67 (2.15-2.99)	1.89 (0.96-3.70)
Yes	0.800 (0.698-0.853)	0.774 (0.744-0.804)	7.68 (0.31-11.81)	3.60 (1.64-7.90)	2.73 (2.00-3.51)	2.01 (1.56-2.59)
Birth place						
Catalonia	0.781 (0.704-0.829)	0.771 (0.736-0.808)	8.41 (0.31-11.16)*	4.06 (2.82-5.84)	2.90 (2.03-3.53)	2.24 (1.65-3.04)
Rest of Spain	0.802 (0.722-0.860)	0.776 (0.718-0.839)	10.22 (5.93-11.81)	5.13 (2.79-9.43)	2.66 (2.29-2.99)	2.31 (1.39-3.84)
Abroad	0.767 (0.651-0.853)	0.760 (0.708-0.816)	10.62 (8.77-12.25)	7.38 (4.24-12.86)	2.36 (1.78-3.61)	1.54 (0.97-2.44)
Educational level						
Primary schooling or less	0.805 (0.728-0.832)	0.753 (0.700-0.809)	10.92 (5.91-11.87)	6.01 (3.41-10.62)	2.95 (2.23-3.21)	2.71 (1.69-4.33)
Secondary schooling	0.804 (0.765-0.851)	0.800 (0.748-0.857)	10.22 (0.31-12.29)	4.68 (2.73-8.03)	2.55 (1.80-3.51)	1.98 (1.27-3.10)
University	0.750 (0.656-0.841)	0.763 (0.726-0.801)	9.15 (5.34-10.72)	4.69 (3.18-6.93)	2.67 (1.90-3.40)	1.82 (1.32-2.51)
Occupational social class						
I-II (more affluent)	0.766 (0.651-0.829)	0.760 (0.723-0.800)	8.77 (4.73-10.72)	4.39 (2.89-6.66)	2.72 (1.76-3.56)	1.79 (1.27-2.51)
III	0.781 (0.698-0.829)	0.740 (0.693-0.789)	9.29 (5.74-11.86)	4.58 (2.68-7.84)	2.40 (2.21-3.25)	2.37 (1.53-3.66)
IV-V (less affluent)	0.805 (0.767-0.851)	0.799 (0.754-0.847)	11.05 (6.96-12.47)	6.61 (4.08-10.73)	2.95 (1.94-3.34)	2.45 (1.65-3.62)
Smoking						
Non-smoker	0.802 (0.705-0.829)	0.785 (0.748-0.823)	10.62 (6.26-12.25)*	5.89 (4.06-8.55)	2.47 (1.94-3.21)	1.91 (1.40-2.61)
Former smoker	0.769 (0.697-0.810)	0.757 (0.714-0.803)	8.41 (4.86-11.43)	4.44 (2.80-7.06)	2.80 (1.99-3.61)	2.14 (1.46-3.16)
Current smoker	0.710 (0.658-0.878)	0.746 (0.684-0.815)	8.06 (0.31-10.04)	3.63 (1.83-7.21)	2.95 (2.14-3.40)	2.31 (1.30-4.11)
Breastfed her children						
Never	0.775 (0.636-0.871)	0.775 (0.730-0.823)	9.27 (6.33-12.09)	5.99 (3.74-9.61)	2.40 (1.80-3.73)	2.27 (1.53-3.36)
≤6 months	0.783 (0.745-0.836)	0.754 (0.700-0.812)	9.74 (5.93-11.44)	5.21 (2.92-9.30)	2.55 (1.78-3.25)	1.96 (1.21-3.18)
>6 months	0.802 (0.705-0.832)	0.772 (0.731-0.816)	9.31 (0.31-11.81)	4.11 (2.66-6.34)	2.86 (2.23-3.51)	1.90 (1.32-2.73)

aGM: Geometric mean adjusted for age. N = 127.

*p-value<0.05 (Kruskal-Wallis test). **p-value<0.05 (Wald test; aGM of the corresponding category against the first category of the variable, except where otherwise noted).

[a] To compute Wald's test for 'weight change in last 6 months', categories 'lost 4-5 kg' and 'gained 4-5 kg' were compared against the category 'little or no change (± 3 Kg)'.

Table 3a, continued.

	Fe (iron) (mg/dL)		**Se (selenium) (ng/mL)**		**Zn (zinc)** (µg/dL)	
	Median (P25-P75)	aGM (CI 95%)	Median (P25-P75)	aGM (CI 95%)	Median (P25-P75)	aGM (CI 95%)
All	33.4 (30.6-35.5)	32.8 (32.1-33.5)	178.8 (160.6-206.5)	181.9 (175.7-188.2)	573.4 (517.6-622.3)	561.9 (546.3-578.0)
Age (years)						
18-44	32.5 (29.9-34.5)	32.2 (31.2-33.3)	173.6 (153.4-192.1)*	175.5 (166.6-184.8)	566.6 (514.8-608.1)	548.0 (524.3-572.8)
45-64	33.7 (31.9-35.7)	33.1 (31.9-34.3)	191.0 (173.2-236.3)	196.4 (185.4-208.0)**	583.7 (537.0-632.8)	580.3 (552.6-609.3)
≥65	35.4 (30.0-36.9)	33.4 (32.1-34.8)	178.5 (145.0-186.9)	174.2 (163.1-186.0)	580.7 (481.7-640.7)	562.1 (531.5-594.5)
Body Mass Index						
Normal	33.4 (30.6-34.9)	33.5 (32.4-34.6)	176.3 (160.6-212.6)	187.8 (177.7-198.4)	571.3 (534.1-612.6)	576.5 (552.1-602.0)
Overweight	33.0 (29.5-35.5)	31.9 (30.7-33.1)	178.5 (151.5-192.1)	174.3 (163.7-185.5)	565.6 (481.7-612.4)	527.9 (502.7-554.5)**
Obese	34.1 (31.5-36.4)	32.7 (31.0-34.5)	183.9 (166.5-210.3)	178.2 (162.6-195.1)	589.1 (558.8-622.3)	572.3 (532.9-614.6)
Weight change in last 6 months						
Lost 4-5 Kg	31.9 (31.8-32.9)	32.8 (30.0-35.8)	183.2 (144.4-197.5)	177.4 (153.2-205.4)	622.3 (565.6-648.8)	615.4 (546.7-692.7)
Little or no change (± 3 Kg)[a]	33.6 (30.1-35.7)	32.8 (32.1-33.5)	178.5 (160.4-204.3)	181.8 (175.1-188.7)	573.4 (515.5-613.7)	555.7 (539.3-572.7)
Gained 4-5 Kg	34.3 (30.9-34.7)	33.0 (30.6-35.6)	178.0 (166.8-210.7)	185.9 (163.9-210.9)	566.1 (528.8-668.2)	595.0 (537.3-658.8)
Was breastfed						
No	32.7 (29.8-34.9)	32.9 (31.0-35.0)	168.5 (156.2-178.5)	174.4 (157.3-193.4)	556.5 (499.4-606.5)	566.3 (522.9-613.3)
Yes	33.6 (30.1-35.5)	32.8 (32.0-33.6)	180.7 (160.5-207.0)	182.4 (175.4-189.7)	580.0 (524.5-623.2)	563.2 (546.5-580.5)
Birth place						
Catalonia	34.1 (31.8-35.7)*	33.6 (32.7-34.6)	182.3 (162.8-210.3)	186.3 (177.7-195.3)	578.1 (536.5-613.7)	575.9 (554.6-598.1)
Rest of Spain	33.4 (30.6-36.3)	33.0 (31.6-34.6)	178.5 (160.4-194.1)	179.6 (166.0-194.4)	580.7 (517.6-632.1)	580.5 (545.1-618.2)
Abroad	32.2 (28.8-34.1)	31.0 (29.7-32.3)**	175.2 (153.4-191.0)	174.9 (162.8-188.0)	552.9 (427.1-613.8)	520.2 (491.1-550.9)**
Educational level						
Primary schooling or less	34.6 (29.5-35.5)	31.9 (30.5-33.3)	178.5 (159.6-210.3)	179.9 (167.2-193.6)	580.7 (503.7-630.1)	552.1 (519.9-586.3)
Secondary schooling	33.1 (31.9-36.4)	33.3 (31.9-34.7)	171.5 (162.8-188.8)	177.9 (165.9-190.7)	582.9 (514.8-612.6)	553.4 (522.8-585.8)
University	33.2 (30.6-35.0)	33.0 (32.1-34.0)	181.9 (160.6-208.8)	184.8 (175.7-194.3)	571.7 (528.8-623.2)	570.8 (547.8-594.8)
Occupational social class						
I-II (more affluent)	33.6 (30.6-34.9)	32.9 (31.9-34.0)	179.8 (166.3-218.2)	188.6 (178.9-198.9)	579.9 (529.8-637.4)	581.8 (556.8-608.0)
III	33.1 (29.8-36.4)	32.4 (31.1-33.8)	171.5 (147.0-189.5)	168.2 (157.1-180.1)**	568.7 (437.0-612.4)	529.8 (500.7-560.7)**
IV-V (less affluent)	33.6 (31.5-35.5)	32.9 (31.7-34.2)	186.5 (162.8-210.3)	182.1 (171.3-193.6)	580.7 (519.1-622.3)	560.8 (532.9-590.2)
Smoking						
Non-smoker	33.6 (29.9-36.4)	32.7 (31.8-33.6)	178.5 (153.4-198.9)	178.9 (170.5-187.8)	569.3 (508.9-612.4)	560.6 (538.8-583.2)
Former smoker	32.4 (30.9-34.6)	32.5 (31.4-33.7)	178.8 (169.9-213.0)	187.7 (176.8-199.3)	578.1 (526.3-617.1)	557.9 (531.1-586.0)
Current smoker	33.6 (31.7-35.2)	33.8 (32.0-35.6)	175.2 (162.3-212.6)	179.2 (164.0-195.9)	603.8 (514.8-647.5)	575.3 (534.7-618.9)
Breastfed her children						
Never	32.5 (29.9-34.7)	32.8 (31.6-34.0)	176.3 (156.2-188.9)	176.1 (165.8-187.1)	566.1 (515.5-612.4)	558.6 (531.3-587.3)
≤6 months	33.7 (32.2-36.6)	33.5 (32.1-35.1)	183.2 (175.1-213.0)	191.9 (178.1-206.7)	565.6 (514.8-605.0)	555.6 (522.4-590.9)
>6 months	33.9 (30.1-35.8)	32.4 (31.4-33.5)	178.5 (151.4-210.3)	182.1 (172.2-192.5)	580.7 (532.0-637.4)	568.3 (542.6-595.2)

aGM: Geometric mean adjusted for age. N = 127.

*p-value<0.05 (Kruskal-Wallis test). **p-value<0.05 (Wald test; aGM of the corresponding category against the first category of the variable, except where otherwise noted).

[a] To compute Wald's test for 'weight change in last 6 months', categories 'lost 4-5 kg' and 'gained 4-5 kg' were compared against the category 'little or no change (± 3 Kg)'.

Table 3b. Differences by sociodemographic characteristics in concentrations of chemicals from the ATSDR's Substance Priority List detected in >70% of the population. Women.

	Pb (lead) (µg/dL)		Ag (silver) (ng/mL)		As (arsenic) (ng/mL)	
	Median (P25-P75)	aGM (CI 95%)	Median (P25-P75)	aGM (CI 95%)	Median (P25-P75)	aGM (CI 95%)
All	1.40 (0.96-2.28)	1.47 (1.34-1.61)	0.113 (0.035-0.215)	0.071 (0.053-0.096)	3.64 (1.51-7.25)	3.46 (2.89-4.15)
Age (years)						
18-44	1.06 (0.81-1.40)*	1.04 (0.90-1.20)	0.113 (0.038-0.190)	0.067 (0.042-0.106)	2.30 (1.18-5.00)*	2.57 (1.96-3.37)
45-64	1.85 (1.35-2.88)	1.90 (1.61-2.24)**	0.091 (0.043-0.210)	0.067 (0.040-0.113)	5.14 (2.74-10.69)	5.25 (3.89-7.08)**
≥65	2.02 (1.11-2.78)	1.88 (1.56-2.27)**	0.136 (0.021-0.215)	0.087 (0.048-0.158)	2.73 (1.53-8.13)	3.29 (2.33-4.64)
Body Mass Index						
Normal	1.27 (0.87-1.90)	1.50 (1.30-1.74)	0.122 (0.041-0.195)	0.778 (0.048-0.126)	3.64 (1.26-7.13)	3.86 (2.96-5.03)
Overweight	1.48 (1.04-2.21)	1.34 (1.14-1.58)	0.089 (0.018-0.156)	0.057 (0.033-0.098)	2.65 (1.52-6.43)	2.96 (2.19-4.00)
Obese	1.78 (1.11-2.82)	1.41 (1.11-1.79)	0.111 (0.021-0.232)	0.069 (0.031-0.152)	5.97 (2.87-8.79)	4.70 (3.03-7.29)
Weight change in last 6 months						
Lost 4-5 Kg	1.63 (1.11-1.78)	1.81 (1.21-2.70)	0.190 (0.160-0.265)*	0.277 (0.080-0.962)	1.49 (1.30-7.25)	3.35 (1.56-7.20)
Little or no change (± 3 Kg)[a]	1.40 (0.96-2.28)	1.47 (1.33-1.63)	0.103 (0.035-0.195)	0.064 (0.047-0.088)	3.89 (1.51-7.31)	3.55 (2.92-4.31)
Gained 4-5 Kg	1.05 (0.77-1.85)	1.23 (0.87-1.74)	0.089 (0.018-0.710)	0.090 (0.031-0.264)	2.30 (1.67-3.90)	2.70 (1.39-5.22)
Was breastfed						
No	1.40 (1.32-1.81)	1.47 (1.11-1.95)	0.091 (0.026-0.195)	0.052 (0.021-0.128)	4.73 (3.31-5.55)	4.41 (2.60-7.49)
Yes	1.35 (0.95-2.33)	1.48 (1.33-1.65)	0.103 (0.035-0.193)	0.068 (0.049-0.096)	3.40 (1.49-7.25)	3.41 (2.79-4.17)
Birth place						
Catalonia	1.77 (0.96-2.51)*	1.58 (1.39-1.80)	0.136 (0.063-0.233)	0.099 (0.066-0.148)	5.45 (2.65-9.22)*	4.78 (3.78-6.05)
Rest of Spain	1.44 (1.26-2.13)	1.39 (1.12-1.72)	0.080 (0.023-0.293)	0.056 (0.028-0.110)	4.14 (1.51-5.56)	2.77 (1.87-4.10)**
Abroad	1.06 (0.77-1.63)	1.32 (1.09-1.61)	0.096 (0.008-0.160)	0.045 (0.024-0.083)**	1.67 (1.28-3.07)	2.16 (1.51-3.08)**
Educational level						
Primary schooling or less	1.32 (1.04-2.78)	1.28 (1.05-1.56)	0.064 (0.021-0.185)	0.050 (0.027-0.094)	3.90 (1.01-6.52)	2.70 (1.84-3.94)
Secondary schooling	1.75 (1.05-2.28)	1.48 (1.23-1.79)	0.156 (0.063-0.215)	0.090 (0.049-0.164)	3.64 (1.97-7.25)	4.16 (2.90-5.97)
University	1.33 (0.89-2.12)	1.56 (1.36-1.79)	0.098 (0.041-0.219)	0.076 (0.049-0.117)	3.40 (1.35-7.25)	3.57 (2.75-4.64)
Occupational social class						
I-II (more affluent)	1.48 (0.93-2.14)	1.59 (1.37-1.84)	0.114 (0.041-0.236)	0.089 (0.055-0.143)	4.31 (1.35-8.79)	4.02 (3.03-5.34)
III	1.27 (0.96-2.28)	1.41 (1.17-1.71)	0.098 (0.064-0.156)	0.073 (0.040-0.135)	3.31 (1.84-6.43)	3.27 (2.27-4.70)
IV-V (less affluent)	1.40 (1.04-2.78)	1.36 (1.15-1.62)	0.111 (0.008-0.215)	0.050 (0.029-0.086)	3.61 (1.51-5.55)	3.06 (2.20-4.25)
Smoking						
Non-smoker	1.32 (0.4-2.28)	1.37 (1.20-1.56)	0.124 (0.023-0.190)	0.074 (0.049-0.112)	4.73 (1.47-7.13)	3.34 (2.59-4.30)
Former smoker	1.74 (1.00-2.31)	1.54 (1.31-1.82)	0.103 (0.045-0.215)	0.071 (0.042-0.119)	2.95 (1.52-7.25)	3.74 (2.73-5.12)
Current smoker	1.53 (1.06-1.95)	1.67 (1.31-2.13)	0.114 (0.018-0.193)	0.065 (0.030-0.141)	2.87 (1.67-5.56)	3.34 (2.09-5.33)
Breastfed her children						
Never	1.19 (0.85-1.77)*	1.41 (1.19-1.67)	0.110 (0.038-0.232)	0.075 (0.044-0.127)	3.95 (1.49-6.32)	3.62 (2.64-4.96)
≤6 months	1.78 (1.14-2.14)	1.47 (1.20-1.81)	0.141 (0.018-0.215)	0.065 (0.034-0.125)	4.81 (2.59-10.11)	4.53 (3.07-6.68)
>6 months	1.56 (1.04-2.78)	1.52 (1.30-1.77)	0.111 (0.026-0.190)	0.072 (0.044-0.118)	3.89 (1.47-6.86)	2.89 (2.16-3.87)

aGM: Geometric mean adjusted for age. N = 127.

*p-value<0.05 (Kruskal-Wallis test). **p-value<0.05 (Wald test; aGM of the corresponding category against the first category of the variable, except where otherwise noted).

[a] To compute Wald's test for 'weight change in last 6 months', categories 'lost 4-5 kg' and 'gained 4-5 kg' were compared against the category 'little or no change (± 3 Kg)'.

Table 3b, continued.

	Cd (cadmium) (ng/mL)		**Hg (mercury) (ng/mL)**		**Sb (antimony)** (ng/mL)	
	Median (P25-P75)	aGM (CI 95%)	Median (P25-P75)	aGM (CI 95%)	Median (P25-P75)	aGM (CI 95%)
All	0.330 (0.241-0.494)	0.351 (0.316-0.391)	2.85 (1.84-5.04)	3.09 (2.69-3.56)	3.82 (3.51-4.21)	3.82 (3.74-3.92)
Age (years)						
18-44	0.301 (0.197-0.452)	0.310 (0.262-0.367)	2.57 (1.79-4.24)*	2.82 (2.28-3.47)	3.76 (3.37-4.07)	3.69 (3.56-3.83)
45-64	0.375 (0.283-0.504)	0.419 (0.348-0.504)**	3.87 (2.39-8.41)	4.28 (3.39-5.39)**	3.75 (3.49-4.28)	3.83 (3.68-3.99)
≥65	0.379 (0.239-0.462)	0.345 (0.279-0.427)	2.24 (1.59-4.02)	2.33 (1.79-3.04)	4.00 (3.54-4.65)	4.06 (3.88-4.25)**
Body Mass Index						
Normal	0.304 (0.197-0.404)*	0.335 (0.283-0.398)	2.97 (2.01-5.04)	3.31 (2.69-4.09)	3.76 (3.52-4.09)	3.88 (3.74-4.03)
Overweight	0.399 (0.278-0.566)	0.395 (0.325-0.479)	2.28 (1.84-5.46)	3.00 (2.36-3.79)	3.89 (3.51-4.65)	3.83 (3.67-4.00)
Obese	0.301 (0.187-0.391)	0.291 (0.220-0.385)	3.43 (2.47-4.91)	3.35 (2.38-4.72)	3.98 (3.61-4.14)	3.77 (3.55-4.01)
Weight change in last 6 months						
Lost 4-5 Kg	0.354 (0.181-0.695)	0.376 (0.238-0.593)	1.79 (1.66-5.37)	3.00 (1.66-5.43)	3.74 (3.48-4.10)	3.83 (3.47-4.22)
Little or no change (± 3 Kg)[a]	0.329 (0.245-0.462)	0.353 (0.314-0.397)	2.97 (1.98-5.32)	3.18 (2.74-3.70)	3.76 (3.51-4.21)	3.80 (3.70-3.90)
Gained 4-5 Kg	0.241 (0.207-0.593)	0.318 (0.214-0.471)	2.33 (1.76-3.15)	2.30 (1.38-3.83)	4.08 (3.79-4.54)	4.12 (3.78-4.48)
Was breastfed						
No	0.320 (0.267-0.504)	0.372 (0.273-0.509)	4.02 (2.08-4.24)	2.89 (1.91-4.38)	4.07 (3.79-4.55)	4.05 (3.78-4.34)
Yes	0.337 (0.203-0.462)	0.338 (0.301-0.381)	2.85 (1.86-5.37)	3.15 (2.69-3.69)	3.76 (3.50-4.14)	3.79 (3.69-3.89)
Birth place						
Catalonia	0.320 (0.242-0.460)	0.346 (0.299-0.402)	3.43 (2.24-6.23)*	3.73 (3.10-4.49)	3.76 (3.53-4.07)	3.79 (3.67-3.92)
Rest of Spain	0.354 (0.267-0.462)	0.314 (0.245-0.402)	2.87 (1.84-5.32)	3.12 (2.29-4.25)	4.04 (3.54-4.68)	3.88 (3.68-4.10)
Abroad	0.356 (0.203-0.610)	0.397 (0.317-0.497)	2.08 (1.52-3.20)	2.09 (1.58-2.77)**	3.76 (3.49-4.25)	3.84 (3.66-4.04)
Educational level						
Primary schooling or less	0.308 (0.193-0.462)	0.313 (0.250-0.393)	3.50 (1.84-4.47)	2.67 (1.99-3.59)	3.92 (3.54-4.51)	3.75 (3.57-3.95)
Secondary schooling	0.393 (0.282-0.610)	0.409 (0.330-0.507)	2.35 (1.74-4.93)	2.84 (2.15-3.77)	3.89 (3.53-4.08)	3.84 (3.66-4.03)
University	0.320 (0.227-0.452)	0.345 (0.295-0.403)	2.82 (2.12-6.58)	3.45 (2.82-4.23)	3.76 (3.49-4.23)	3.85 (3.72-3.98)
Occupational social class						
I-II (more affluent)	0.329 (0.227-0.494)	0.347 (0.292-0.411)	3.32 (2.22-6.70)	3.81 (3.07-4.74)	3.75 (3.47-4.14)	3.81 (3.67-3.95)
III	0.330 (0.271-0.459)	0.341 (0.273-0.424)	2.49 (2.12-4.55)	2.97 (2.25-3.92)	3.76 (3.49-4.00)	3.67 (3.51-3.85)
IV-V (less affluent)	0.358 (0.253-0.566)	0.378 (0.310-0.460)	2.97 (1.74-4.38)	2.52 (1.96-3.23)**	4.00 (3.58-4.64)	3.94 (3.78-4.11)
Smoking						
Non-smoker	0.301 (0.201-0.403)*	0.294 (0.258-0.335)	2.72 (1.84-4.47)	2.79 (2.30-3.39)	3.89 (3.53-4.31)	3.86 (3.74-3.99)
Former smoker	0.337 (0.203-0.504)	0.332 (0.282-0.390)	3.13 (1.97-6.41)	3.58 (2.81-4.55)	3.74 (3.50-4.11)	3.79 (3.64-3.95)
Current smoker	0.695 (0.426-1.130)	0.724 (0.570-0.921)**	2.87 (1.78-5.46)	3.19 (2.23-4.58)	3.75 (3.47-4.08)	3.77 (3.54-4.00)
Breastfed her children						
Never	0.277 (0.173-0.426)*	0.302 (0.251-0.364)	2.82 (2.07-4.47)	2.90 (2.28-3.70)	3.63 (3.45-4.08)	3.75 (3.60-3.91)
≤6 months	0.386 (0.326-0.610)	0.446 (0.355-0.561)**	3.87 (2.35-6.47)	4.37 (3.25-5.89)**	4.00 (3.55-4.34)	3.89 (3.70-4.10)
>6 months	0.354 (0.267-0.462)	0.356 (0.300-0.422)	2.39 (1.67-4.91)	2.73 (2.18-3.41)	3.92 (3.54-4.21)	3.85 (3.71-4.01)

aGM: Geometric mean adjusted for age. N = 127.
*p-value<0.05 (Kruskal-Wallis test). **p-value<0.05 (Wald test; aGM of the corresponding category against the first category of the variable, except where otherwise noted).
[a] To compute Wald's test for 'weight change in last 6 months', categories 'lost 4-5 kg' and 'gained 4-5 kg' were compared against the category 'little or no change (± 3 Kg)'.

Table 3b, continued.

	Sr (strontium) (ng/mL)		**Tl (thallium) (ng/mL)**	
	Median (P25-P75)	aGM (CI 95%)	Median (P25-P75)	aGM (CI 95%)
All	22.6 (17.3-27.3)	22.1 (20.9-23.4)	0.016 (0.001-0.036)	0.008 (0.005-0.011)
Age (years)				
18-44	20.0 (15.3-24.1)*	19.7 (18.0-21.5)	0.006 (0.001-0.033)	0.005 (0.003-0.009)
45-64	25.8 (20.7-29.1)	24.6 (22.3-27.1)**	0.020 (0.003-0.036)	0.009 (0.005-0.016)
≥65	22.6 (20.2-27.3)	23.3 (20.9-26.1)**	0.019 (0.007-0.037)	0.011 (0.006-0.021)
Body Mass Index				
Normal	21.6 (16.4-25.1)	21.1 (19.2-30.8)	0.016 (0.001-0.034)	0.008 (0.005-0.014)
Overweight	24.7 (18.7-28.2)	23.2 (20.9-25.8)	0.019 (0.006-0.037)	0.009 (0.005-0.017)
Obese	21.4 (20.2-26.6)	22.7 (19.5-26.4)	0.007 (0.001-0.036)	0.004 (0.002-0.009)
Weight change in last 6 months				
Lost 4-5 Kg	33.7 (23.7-38.9)*	34.1 (27.1-42.8)**	0.028 (0.013-0.076)	0.021 (0.005-0.087)
Little or no change (± 3 Kg)[a]	22.6 (17.6-27.1)	21.7 (20.4-23.0)	0.015 (0.001-0.036)	0.007 (0.005-0.010)
Gained 4-5 Kg	16.9 (16.8-26.2)	20.1 (16.5-24.4)	0.030 (0.001-0.057)	0.007 (0.002-0.026)
Was breastfed				
No	22.4 (17.3-27.3)	21.0 (17.8-24.7)	0.022 (0.001-0.037)	0.008 (0.003-0.022)
Yes	22.6 (17.6-27.6)	22.4 (21.0-23.8)	0.014 (0.001-0.033)	0.007 (0.005-0.010)
Birth place				
Catalonia	22.6 (18.7-28.2)	23.0 (21.3-24.9)	0.021 (0.007-0.037)	0.012 (0.008-0.018)
Rest of Spain	25.3 (20.7-28.5)	22.0 (19.3-25.1)	0.005 (0.001-0.032)	0.003 (0.001-0.006)**
Abroad	19.2 (15.3-24.7)	20.4 (18.1-23.0)	0.011 (0.001-0.061)	0.007 (0.004-0.015)
Educational level				
Primary schooling or less	21.6 (17.1-28.5)	21.2 (18.8-23.9)	0.032 (0.001-0.037)	0.007 (0.004-0.015)
Secondary schooling	22.6 (18.7-25.8)	23.1 (20.6-25.9)	0.015 (0.006-0.045)	0.010 (0.005-0.019)
University	21.9 (16.9-26.9)	22.1 (20.3-24.0)	0.015 (0.001-0.031)	0.007 (0.004-0.011)
Occupational social class				
I-II (more affluent)	22.8 (16.8-26.9)	22.1 (20.1-24.2)	0.014 (0.001-0.031)	0.006 (0.004-0.011)
III	22.6 (18.7-26.4)	22.0 (19.5-24.7)	0.013 (0.006-0.029)	0.009 (0.005-0.019)
IV-V (less affluent)	24.7 (19.1-28.5)	22.5 (20.2-25.0)	0.028 (0.001-0.037)	0.007 (0.004-0.013)
Smoking				
Non-smoker	22.6 (17.6-28.2)	22.0 (20.3-23.8)	0.015 (0.001-0.032)	0.007 (0.004-0.012)
Former smoker	23.7 (18.3-27.6)	23.2 (21.0-25.6)	0.020 (0.0010.051)	0.008 (0.004-0.014)
Current smoker	21.3 (16.9-25.1)	20.3 (17.5-23.4)	0.011 (0.003-0.036)	0.009 (0.004-0.021)
Breastfed her children				
Never	21.6 (16.4-26.4)	21.6 (19.5-23.9)	0.015 (0.001-0.045)	0.007 (0.004-0.013)
≤6 months	24.2 (19.1-26.9)	22.7 (20.1-25.7)	0.011 (0.001-0.036)	0.006 (0.003-0.013)
>6 months	22.6 (19.2-27.3)	22.2 (20.2-24.4)	0.019 (0.007-0.035)	0.009 (0.005-0.016)

aGM: Geometric mean adjusted for age. N = 127.
*p-value<0.05 (Kruskal-Wallis test). **p-value<0.05 (Wald test; aGM of the corresponding category against the first category of the variable, except where otherwise noted).
[a] To compute Wald's test for 'weight change in last 6 months', categories 'lost 4-5 kg' and 'gained 4-5 kg' were compared against the category 'little or no change (± 3 Kg)'.

Table 4a. Blood concentrations of chemicals detected in over 70% of the population of Barcelona city in 2016 by sociodemographic characteristics. Essential trace elements. Men.

	Cu (copper) (µg/mL)		Mn (manganese) (ng/mL)		Mo (molybdenum) (ng/mL)	
	Median (P25-P75)	aGM (CI 95%)	Median (P25-P75)	aGM (CI 95%)	Median (P25-P75)	aGM (CI 95%)
All	0.649 (0.589-0.722)	0.649 (0.629-0.669)	6.91 (0.31-9.47)	2.90 (2.19-3.85)	2.74 (2.09-3.79)	2.12 (1.69-2.66)
Age (years)						
18-44	0.650 (0.580-0.727)	0.636 (0.609-0.664)	6.81 (0.31-10.47)	3.00 (1.94-4.65)	2.50 (2.15-3.52)	1.88 (1.35-2.60)
45-64	0.663 (0.613-0.717)	0.655 (0.621-0.690)	7.14 (0.31-9.63)	2.94 (1.74-4.99)	2.47 (1.99-3.48)	2.13 (1.43-3.16)
≥65	0.628 (0.610-0.736)	0.663 (0.620-0.708)	6.91 (0.31-8.92)	2.81 (1.45-5.46)	3.38 (2.38-4.82)	2.62 (1.60-4.31)
Body Mass Index						
Normal	0.621 (0.576-0.712)	0.635 (0.602-0.669)	6.00 (0.31-9.14)	1.61 (0.97-2.67)	2.94 (2.38-3.76)	2.76 (1.86-4.08)
Overweight	0.671 (0.615-0.733)	0.655 (0.626-0.686)	7.39 (4.61-9.18)	4.19 (2.68-6.53)	2.59 (2.03-3.63)	1.85 (1.31-2.61)
Obese	0.663 (0.607-0.723)	0.661 (0.613-0.713)	8.57 (0.31-10.20)	3.83 (1.85-7.91)	2.16 (1.88-3.82)	1.74 (0.99-3.03)
Weight change in last 6 months						
Lost 4-5 Kg	0.680 (0.634-0.723)	0.679 (0.611-0.755)	6.81 (0.31-8.34)	2.42 (0.85-6.93)	3.76 (0.07-3.83)	1.29 (0.59-2.85)
Little or no change (± 3 Kg)[a]	0.647 (0.586-0.717)	0.649 (0.628-0.671)	6.81 (0.31-9.14)	2.74 (1.98-3.80)	2.67 (2.10-3.60)	2.16 (1.69-2.76)
Gained 4-5 Kg	0.607 (0.579-0.747)	0.616 (0.554-0.685)	8.97 (6.57-10.61)	6.24 (2.18-17.87)	2.16 (1.88-3.05)	2.88 (1.30-6.35)
Was breastfed						
No	0.676 (0.580-0.733)	0.656 (0.606-0.710)	6.81 (0.31-8.92)*	2.51 (1.76-3.58)	2.78 (2.21-5.03)	2.77 (1.56-4.92)
Yes	0.656 (0.600-0.700)	0.650 (0.627-0.675)	9.08 (5.72-14.37)	5.06 (2.36-10.87)	2.67 (2.10-3.76)	2.06 (1.57-2.69)
Birth place						
Catalonia	0.636 (0.580-0.708)	0.641 (0.618-0.664)	6.81 (0.31-9.08)	2.83 (1.96-4.08)	2.94 (2.19-3.88)*	2.54 (1.94-3.32)
Rest of Spain	0.639 (0.601-0.733)	0.633 (0.582-0.689)	6.14 (0.31-10.47)	2.12 (0.90-4.99)	2.37 (1.99-2.79)	1.57 (0.84-2.96)
Abroad	0.676 (0.613-0.754)	0.689 (0.643-0.737)	8.23 (4.61-10.16)	3.84 (1.93-7.63)	2.59 (1.94-3.05)	1.36 (0.82-2.25)**
Educational level						
Primary schooling or less	0.625 (0.613-0.701)	0.650 (0.611-0.691)	6.48 (0.31-7.70)	2.73 (1.47-5.07)	2.75 (2.03-3.52)	1.98 (1.24-3.15)
Secondary schooling	0.668 (0.598-0.717)	0.669 (0.636-0.705)	8.23 (0.31-12.12)	2.84 (1.69-4.76)	2.78 (2.38-3.46)	2.46 (1.67-3.63)
University	0.628 (0.578-0.723)	0.632 (0.603-0.662)	6.70 (0.31-9.08)	3.04 (1.90-4.87)	2.59 (1.99-3.82)	1.95 (1.37-2.78)
Occupational social class						
I-II (more affluent)	0.634 (0.589-0.712)	0.639 (0.612-0.666)	6.57 (0.31-9.08)*	2.54 (1.67-3.84)	3.13 (2.43-4.12)*	2.91 (2.13-3.96)
III	0.637 (0.575-0.736)	0.634 (0.594-0.677)	6.14 (0.31-8.26)	1.87 (0.98-3.55)	2.28 (1.99-2.78)	1.65 (1.02-2.65)**
IV-V (less affluent)	0.671 (0.615-0.739)	0.677 (0.641-0.717)	8.34 (6.91-10.61)	5.00 (2.88-8.68)	2.42 (1.87-3.79)	1.46 (0.97-2.21)**
Smoking						
Non-smoker	0.641 (0.598-0.727)	0.650 (0.619-0.682)	8.23 (6.00-10.16)	4.13 (2.57-6.65)	2.43 (2.19-3.88)	2.04 (1.42-2.94)
Former smoker	0.663 (0.610-0.723)	0.656 (0.624-0.689)	6.53 (0.31-8.97)	2.47 (1.51-4.03)	2.59 (2.02-3.05)	2.13 (1.47-3.11)
Current smoker	0.625 (0.580-0.681)	0.635 (0.596-0.677)	6.48 (0.31-9.86)	2.04 (1.09-3.82)	2.99 (2.06-3.79)	2.24 (1.38-3.61)

aGM: Geometric mean adjusted for age. N = 113.
*p-value<0.05 (Kruskal-Wallis test). **p-value<0.05 (Wald test; aGM of the corresponding category against the first category of the variable, except where otherwise noted).
[a] To compute Wald's test for 'weight change in last 6 months', categories 'lost 4-5 kg' and 'gained 4-5 kg' were compared against the category 'little or no change (± 3 Kg)'.

Table 4a, continued.

	Fe (iron) (mg/dL)		**Se (selenium) (ng/mL)**		**Zn (zinc)** (µg/dL)	
	Median (P25-P75)	aGM (CI 95%)	Median (P25-P75)	aGM (CI 95%)	Median (P25-P75)	aGM (CI 95%)
All	37.2 (34.0-39.7)	36.7 (35.9-37.5)	188.9 (163.8-206.9)	180.4 (172.6-188.7)	625.1 (576.2-689.5)	624.4 (606.0-643.3)
Age (years)						
18-44	35.3 (35.3-39.1)	36.9 (35.8-38.1)	191.8 (166.2-201.6)	186.7 (175.1-199.1)	623.9 (576.8-674.9)	614.8 (589.1-641.7)
45-64	37.4 (32.9-40.5)	36.4 (35.0-37.8)	189.1 (155.0-209.6)	180.3 (166.8-194.8)	615.8 (558.6-695.0)	617.3 (586.3-650.0)
≥65	36.4 (34.0-42.9)	37.1 (35.3-38.9)	186.3 (135.8-212.8)	171.3 (155.4-188.8)	666.0 (576.9-767.5)	652.1 (611.2-695.8)
Body Mass Index						
Normal	37.2 (33.2-38.8)	35.7 (34.4-37.1)	178.7 (154.1-196.8)*	160.7 (149.4-172.8)	607.5 (535.8-674.1)*	587.8 (559.1-618.0)
Overweight	37.3 (34.0-40.2)	37.1 (35.9-38.4)	190.3 (163.8-214.1)	190.1 (178.4-202.5)**	666.0 (597.1-725.9)	646.6 (618.9-675.6)**
Obese	37.6 (35.8-41.3)	37.9 (35.9-40.0)	205.7 (179.9-217.1)	201.5 (181.6-223.4)**	651.6 (590.2-714.5)	647.2 (602.6-695.1)**
Weight change in last 6 months						
Lost 4-5 Kg	37.3 (34.2-38.2)	36.2 (33.6-39.0)	193.3 (179.2-217.1)	190.1 (162.6-222.2)	576.8 (532.2-645.9)	589.9 (532.7-653.2)
Little or no change (± 3 Kg)[a]	37.4 (34.3-39.8)	37.1 (36.2-37.9)	188.6 (163.8-206.9)	179.9 (171.4-188.9)	635.6 (586.5-699.7)	633.7 (613.9-654.2)
Gained 4-5 Kg	33.9 (30.0-37.6)	33.8 (31.4-36.5)	195.4 (158.2-206.2)	176.4 (150.9-206.2)	631.3 (429.1-666.8)	562.1 (507.6-622.5)**
Was breastfed						
No	38.9 (35.4-43.7)	38.6 (36.7-40.7)	165.4 (149.3-195.4)	172.8 (154.5-193.2)	674.9 (615.8-734.2)	655.6 (610.0-704.5)
Yes	37.3 (34.4-39.7)	36.9 (36.0-37.8)	191.8 (166.2-209.3)	183.1 (173.8-192.9)	631.3 (576.9-681.9)	627.8 (607.0-649.2)
Birth place						
Catalonia	37.4 (34.5-40.5)	37.0 (36.0-38.0)	188.2 (165.4-205.1)	178.3 (168.9-188.1)	625.1 (558.6-723.6)	619.3 (597.3-642.1)
Rest of Spain	35.6 (33.5-36.9)	35.6 (33.5-37.9)	191.8 (179.9-205.7)	192.6 (169.7-218.5)	635.6 (593.5-677.5)	627.6 (576.6-683.1)
Abroad	37.8 (34.0-39.7)	36.6 (34.9-38.5)	188.6 (162.7-217.7)	180.6 (163.2-199.8)	623.9 (615.8-674.9)	640.7 (598.6-685.7)
Educational level						
Primary schooling or less	36.8 (33.2-38.3)	35.9 (34.3-37.5)	184.1 (159.5-205.1)	177.4 (162.0-194.2)	631.3 (573.2-699.7)	620.2 (583.3-659.3)
Secondary schooling	38.8 (34.8-40.2)	37.5 (36.2-38.9)	189.1 (158.6-206.2)	173.6 (160.9-187.2)	625.1 (578.5-689.5)	629.7 (598.2-662.8)
University	36.9 (34.5-39.3)	36.6 (35.4-37.9)	191.8 (165.4-216.1)	188.1 (175.7-201.5)	623.9 (563.9-680.0)	622.4 (594.2-652.0)
Occupational social class						
I-II (more affluent)	37.2 (34.0-41.1)	37.0 (35.9-38.2)	187.2 (166.2-203.5)	178.6 (167.7-190.1)	635.6 (558.6-681.6)	617.1 (591.7-643.5)
III	37.9 (35.2-38.8)	36.4 (34.7-38.1)	178.7 (149.3-209.3)	175.2 (159.1-192.9)	622.0 (569.8-674.9)	622.6 (583.5-664.2)
IV-V (less affluent)	37.4 (33.2-39.7)	36.5 (35.1-38.0)	203.6 (163.8-215.6)	187.7 (172.8-204.0)	648.1 (596.7-699.7)	638.6 (604.0-675.2)
Smoking						
Non-smoker	37.8 (35.6-41.5)	37.8 (36.6-39.1)	191.8 (168.4-205.1)*	179.6 (167.9-192.2)	674.9 (619.3-734.2)*	653.1 (623.6-684.0)
Former smoker	36.8 (34.0-39.1)	36.3 (35.1-37.6)	203.4 (167.0-217.1)	195.4 (182.2-209.4)	617.6 (573.2-674.9)	616.4 (587.8-646.5)
Current smoker	37.2 (33.2-38.2)	35.6 (34.0-37.2)**	166.2 (140.6-188.2)	158.8 (145.3-173.6)**	608.2 (532.2-625.1)	590.2 (555.4-627.2)**

aGM: Geometric mean adjusted for age. N = 113.
*p-value<0.05 (Kruskal-Wallis test). **p-value<0.05 (Wald test; aGM of the corresponding category against the first category of the variable, except where otherwise noted).
[a] To compute Wald's test for 'weight change in last 6 months', categories 'lost 4-5 kg' and 'gained 4-5 kg' were compared against the category 'little or no change (± 3 Kg)'.

Table 4b. Differences by sociodemographic characteristics in concentrations of chemicals from the ATSDR's Substance Priority List detected in >70% of the population. Men.

	Pb (lead) (µg/dL)		**Ag (silver) (ng/mL)**		
	Median (P25-P75)	aGM (CI 95%)	Median (P25-P75)	aGM (CI 95%)	M
All	1.92 (1.18-3.08)	2.06 (1.86-2.28)	0.078 (0.020-0.172)	0.059 (0.041-0.083)	2.8
Age (years)					
18-44	1.32 (0.99-1.99)*	1.37 (1.18-1.58)	0.075 (0.020-0.135)	0.052 (0.031-0.086)	2.0
45-64	2.04 (1.46-2.95)	2.24 (1.88-2.68)**	0.088 (0.014-0.172)	0.049 (0.026-0.089)	2.9
≥65	3.28 (3.18-4.24)	3.46 (2.77-4.32)**	0.095 (0.023-0.173)	0.087 (0.041-0.188)	4.9
Body Mass Index					
Normal	1.32 (0.96-2.36)*	2.10 (1.76-2.51)	0.077 (0.002-0.132)	0.052 (0.029-0.095)	1.9
Overweight	2.13 (1.33-3.28)	2.04 (1.74-2.39)	0.078 (0.020-0.135)	0.050 (0.030-0.085)	4.3
Obese	1.95 (1.54-3.01)	2.03 (1.58-2.63)	0.101 (0.037-0.341)	0.111 (0.047-0.263)	4.3
Weight change in last 6 months					
Lost 4-5 Kg	2.13 (1.68-2.95)	2.65 (1.87-3.76)	0.182 (0.082-0.341)	0.205 (0.062-0.679)**	3.7
Little or no change (± 3 Kg)[a]	1.76 (1.14-3.18)	1.95 (1.75-2.18)	0.078 (0.014-0.132)*	0.051 (0.035-0.074)	2.8
Gained 4-5 Kg	1.95 (1.33-2.56)	2.90 (2.04-4.12)**	0.037 (0.030-0.271)	0.079 (0.024-0.263)	3.8
Was breastfed					
No	1.60 (1.11-2.55)	1.66 (1.33-2.07)	0.078 (0.067-0.174)	0.070 (0.030-0.165)	2.8
Yes	1.99 (1.30-3.13)	2.10 (1.89-2.33)	0.088 (0.022-0.175)	0.070 (0.047-0.105)	3.0
Birth place					
Catalonia	1.83 (1.30-2.99)	2.01 (1.78-2.28)	0.086 (0.037-0.174)	0.071 (0.046-0.108)	3.2
Rest of Spain	1.95 (0.92-3.08)	1.83 (1.37-2.44)	0.077 (0.002-0.136)	0.044 (0.016-0.117)	3.7
Abroad	1.99 (1.14-3.53)	2.43 (1.93-3.06)	0.047 (0.008-0.135)	0.036 (0.016-0.079)	2.0
Educational level					
Primary schooling or less	2.04 (1.32-3.12)	2.37 (1.92-2.91)	0.068 (0.020-0.107)	0.039 (0.019-0.080)	3.9
Secondary schooling	1.76 (1.20-4.98)	2.17 (1.83-2.58)	0.086 (0.020-0.188)	0.085 (0.047-0.153)	2.0
University[a]	1.81 (1.18-2.74)	1.82 (1.56-2.13)	0.078 (0.015-0.143)	0.055 (0.032-0.093)	3.9
Occupational social class					
I-II (more affluent)	1,99 (1.15-3.01)*	1.89 (1.65-2.18)	0.119 (0.050-0.198)	0.080 (0.049-0.130)	3.0
III	1.42 (1.09-2.04)	1.76 (1.42-2.18)	0.077 (0.008-0.101)	0.036 (0.017-0.077)	2.3
IV-V (less affluent)	2.24 (1.33-4.35)	2.68 (2.23-3.22)**	0.047 (0.020-0.135)	0.048 (0.025-0.091)	3.9
Smoking					
Non-smoker	1.33 (0.99-2.99)*	1.71 (1.46-2.00)	0.078 (0.020-0.173)	0.059 (0.034-0.104)	3.1
Former smoker	2.40 (1.54-3.0)	2.12 (1.81-2.49)	0.088 (0.030-0.198)	0.066 (0.037-0.117)	3.7
Current smoker	2.05 (1.32-2.36)	2.71 (2.21-3.32)**	0.067 (0.002-0.130)	0.047 (0.023-0.098)	2.7

aGM: Geometric mean adjusted for age. N = 113.
*p-value<0.05 (Kruskal-Wallis test). **p-value<0.05 (Wald test; aGM of the corresponding category against the first category of the variable, except where otherwise noted).
[a] To compute Wald's test for 'weight change in last 6 months', categories 'lost 4-5 kg' and 'gained 4-5 kg' were compared against the category 'little or no change (± 3 Kg)'.

Table 4b, continued.

	Cd (cadmium) (ng/mL)		**Hg (mercury) (ng/mL)**		**Sb (antimony)** (ng/mL)	
	Median (P25-	aGM (CI 95%)	Median (P25-	aGM (CI 95%)	Median (P25-	aGM (CI 95%)
All	0.303 (0.177-	0.285 (0.223-0.363)	3.68 (1.79-	2.40 (1.72-3.36)	3.79 (3.46-	3.82 (3.70-
Age (years)						
18-44	0.213 (0.129-	0.179 (0.127-0.251)	3.54 (1.53-	1.95 (1.20-3.16)	3.76 (3.36-	3.78 (3.60-
45-64	0.404 (0.223-	0.483 (0.320-	3.41 (2.25-	3.24 (1.81-5.81)	3.79 (3.37-	3.72 (3.52-
≥65	0.307 (0.225-	0.278 (0.166-0.466)	4.19 (1.22-	2.05 (0.98-4.26)	3.94 (3.55-	4.04 (3.76-
Body Mass Index						
Normal	0.213 (0.139-	0.219 (0.144-0.332)	3.15 (1.12-	1.06 (0.61-1.84)	3.62 (3.30-	3.73 (3.52-
Overweight	0.318 (0.223-	0.344 (0.239-0.496)	4.19 (1.96-	3.67 (2.26-	3.91 (3.50-	3.88 (3.69-
Obese	0.303 (0.185-	0.302 (0.166-0.548)	4.75 (2.94-	4.50 (2.05-	3.93 (3.37-	3.85 (3.55-
Weight change in last 6						
Lost 4-5 Kg	0.370 (0.129-	0.352 (0.151-0.821)	3.37 (2.33-	4.88 (1.51-15.72)	3.98 (3.43-	3.87 (3.44-
Little or no change (±	0.294 (0.184-	0.267 (0.205-0.348)	3.81 (1.91-	2.30 (1.60-3.31)	3.76 (3.47-	3.82 (3.69-
Gained 4-5 Kg	0.304 (0.151-	0.454 (0.195-1.057)	2.97 (1.09-	1.87 (0.58-6.05)	3.86 (3.24-	3.73 (3.32-
Was breastfed						
No	0.307 (0.135-	0.228 (0.122-0.426)	3.59 (1.91-	1.62 (0.67-3.91)	3.75 (3.25-	4.15 (3.82-
Yes	0.293 (0.177-	0.275 (0.205-0.368)	3.68 (1.55-	2.54 (1.69-3.83)	3.79 (3.50-	3.79 (3.65-
Birth place						
Catalonia	0.293 (0.181-	0.253 (0.189-0.338)	3.92 (2.59-	2.49 (1.67-3.72)	3.79 (3.41-	3.83 (3.68-
Rest of Spain	0.447 (0.177-	0.499 (0.253-0.986)	4.46 (2.96-	4.44 (1.73-11.39)	3.61 (3.35-	3.62 (3.30-
Abroad	0.298 (0.186-	0.301 (0.174-0.519)	1.29 (1.17-	1.41 (0.66-2.99)	4.05 (3.50-	3.90 (3.62-
Educational level						
Primary schooling or	0.409 (0.210-	0.260 (0.158-0.427)	4.60 (1.55-	3.27 (1.73-6.17)	3.93 (3.46-	3.89 (3.63-
Secondary schooling	0.283 (0.166-	0.327 (0.216-0.495)	2.75 (1.17-	0.95 (0.56-	3.81 (3.49-	3.84 (3.63-
University	0.284 (0.181-	0.268 (0.184-0.390)	4.29 (3.27-	4.31 (2.66-6.98)	3.62 (3.33-	3.76 (3.58-
Occupational social						
I-II (more affluent)	0.270 (0.177-	0.256 (0.183-0.359)	4.19 (2.92-	2.96 (1.87-4.70)	3.68 (3.47-	3.86 (3.69-
III	0.353 (0.184-	0.238 (0.141-0.401)	2.67 (1.12-	1.10 (0.54-	3.79 (3.37-	3.71 (3.45-
IV-V (less affluent)	0.318 (0.220-	0.390 (0.249-0.611)	3.10 (1.29-	2.92 (1.58-5.39)	3.94 (3.46-	3.82 (3.59-
Smoking						
Non-smoker	0.177 (0.128-	0.132 (0.096-0.181)	4.19 (2.63-	2.81 (1.65-4.79)	3.84 (3.55-	4.03 (3.83-
Former smoker	0.309 (0.191-	0.315 (0.227-	4.29 (1.91-	2.67 (1.54-4.62)	3.82 (3.50-	3.75 (3.56-
Current smoker	0.744 (0.393-	1.015 (0.603-	2.60 (1.16-	1.52 (0.75-3.07)	3.75 (3.25-	3.58 (3.35-

aGM: Geometric mean adjusted for age. N = 113.
*p-value<0.05 (Kruskal-Wallis test). **p-value<0.05 (Wald test; aGM of the corresponding category against the first category of the variable, except where otherwise noted).
[a] To compute Wald's test for 'weight change in last 6 months', categories 'lost 4-5 kg' and 'gained 4-5 kg' were compared against the category 'little or no change (± 3 Kg)'.

Table 4b, continued.

	Sr (strontium) (ng/mL)		**Tl (thallium) (ng/mL)**	
	Median (P25-P75)	aGM (CI 95%)	Median (P25-P75)	aGM (CI 95%)
All	20.7 (16.5-25.3)	21.3 (19.6-23.1)	0.020 (0.001-0.039)	0.010 (0.007-0.014)
Age (years)				
18-44	19.2 (16.0-23.4)*	19.2 (17.1-21.5)	0.020 (0.009-0.032)	0.011 (0.007-0.018)
45-64	21.1 (17.4-27.9)	20.5 (17.9-23.6)	0.007 (0.001-0.037)	0.005 (0.003-0.008)**
≥65	25.7 (18.8-30.2)	26.2 (22.0-31.2)**	0.035 (0.016-0.049)	0.021 (0.010-0.045)
Body Mass Index				
Normal	19.2 (16.0-22.1)*	19.7 (17.2-22.7)	0.016 (0.001-0.026)*	0.006 (0.003-0.012)
Overweight	23.4 (16.3-27.9)	22.7 (20.1-25.7)	0.031 (0.006-0.052)	0.013 (0.008-0.023)
Obese	21.1 (16.9-34.7)	21.0 (17.2-25.6)	0.022 (0.001-0.049)	0.009 (0.004-0.023)
Weight change in last 6 months				
Lost 4-5 Kg	22.3 (16.6-26.8)	23.4 (17.7-31.0)	0.029 (0.011-0.043)	0.018 (0.005-0.063)
Little or no change (± 3 Kg)[a]	20.7 (16.5- 25.3)	21.0 (19.3-23.0)	0.020 (0.001-0.039)	0.010 (0.007-0.014)
Gained 4-5 Kg	18.0 (15.7-25.3)	22.0 (16.6-29.2)	0.001 (0.001-0.031)	0.004 (0.001-0.013)
Was breastfed				
No	23.8 (19.2-30.1)	26.0 (21.2-31.9)	0.020 (0.012-0.035)	0.012 (0.005-0.029)
Yes	21.1 (16.3-24.9)	21.0 (19.1-23.1)	0.020 (0.001-0.039)	0.010 (0.007-0.015)
Birth place				
Catalonia	21.1 (17.6-24.9)	21.9 (19.9-24.2)	0.019 (0.001-0.036)	0.008 (0.005-0.013)
Rest of Spain	19.0 (15.5-28.3)	18.3 (14.6-23.0)	0.018 (0.001-0.056)	0.009 (0.003-0.025)
Abroad	20.7 (14.8-26.8)	21.1 (17.6-25.3)	0.026 (0.015-0.039)	0.017 (0.008-0.038)
Educational level				
Primary schooling or less	21.1 (16.0-25.7)	20.7 (17.5-24.4)	0.030 (0.001-0.058)	0.010 (0.005-0.021)
Secondary schooling	20.9 (16.9-21.9)	21.8 (19.0-25.1)	0.016 (0.003-0.028)	0.009 (0.005-0.017)
University	20.1 (16.6-27.7)	21.2 (18.7-24.0)	0.026 (0.001-0.037)	0.010 (0.006-0.017)
Occupational social class				
I-II (more affluent)	21.3 (17.1-27.3)	22.8 (20.4-25.4)	0.020 (0.009-0.035)	0.012 (0.007-0.020)
III	19.2 (16.1-23.1)	18.0 (15.1-21.3)	0.012 (0.001-0.020)	0.005 (0.002-0.011)
IV-V (less affluent)	19.5 (16.0-26.8)	21.4 (18.4-24.7)	0.028 (0.001-0.058)	0.010 (0.005-0.020)
Smoking				
Non-smoker	18.8 (15.7-24.9)	21.3 (18.7-24.2)	0.020 (0.001-0.046)	0.010 (0.006-0.017)
Former smoker	22.3 (18.9-27.7)	21.6 (18.9-24.7)	0.021 (0.011-0.039)	0.013 (0.007-0.023)
Current smoker	19.2 (17.1-21.8)	20.7 (17.5-24.5)	0.012 (0.001-0.032)	0.006 (0.003-0.012)

aGM: Geometric mean adjusted for age. N = 113.
*p-value<0.05 (Kruskal-Wallis test). **p-value<0.05 (Wald test; aGM of the corresponding category against the first category of the variable, except where otherwise noted).
[a] To compute Wald's test for 'weight change in last 6 months', categories 'lost 4-5 kg' and 'gained 4-5 kg' were compared against the category 'little or no change (± 3 Kg)'.

Author Contributions Statement

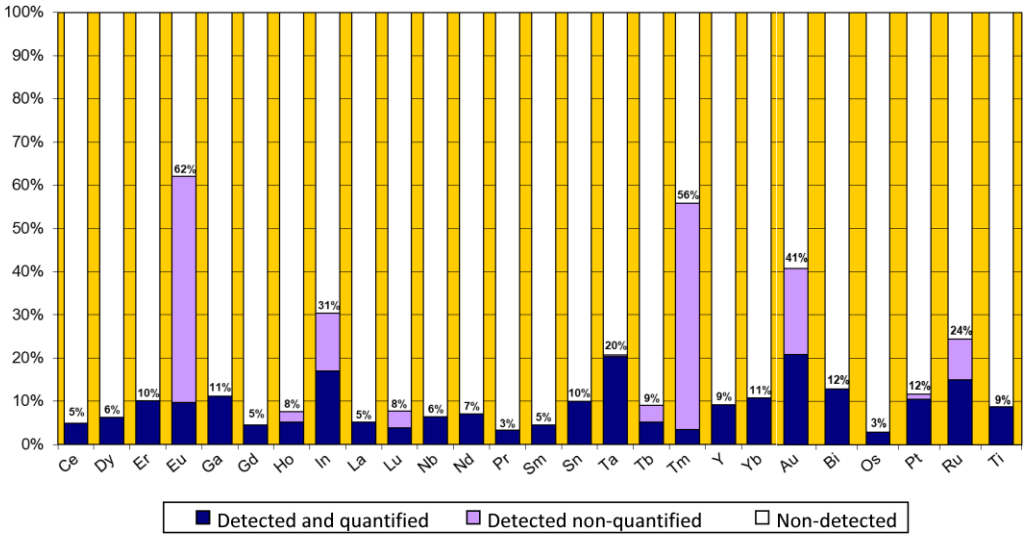
Miquel Porta, Magda Gasull, and José Pumarega: Conceptualization, Methodology, Project administration. Miquel Porta, Magda Gasull, José Pumarega, Luis Alberto Henríquez-Hernández, Manuel Zumbado, Octavio P. Luzardo: Funding acquisition. Magda Gasull, Judit Camargo, José Pumarega, Laura Campi: Formal analysis, Investigation, Visualization. Magda Gasull, Judit Camargo, José Pumarega, and Miquel Porta: Writing - Original Draft. Luis Alberto Henríquez-Hernández, Manuel Zumbado, Manuel Contreras-Llanes, Laura Oliveras, Patricia González-Marín, Octavio P. Luzardo, Anna Gómez-Gutiérrez, Juan Alguacil: Writing - Review & Editing. Miquel Porta: Supervision.

Declaration of interests

☒The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

☐The authors declare the following financial interests/personal relationships which may be considered as potential competing interests:

Percentages of detection of rare earth elements (REE) and minority elements
in a representative sample of the general adult population of Barcelona (Spain)



Graphical abstract

H I G H L I G H T S

- This is 1 of only 5 studies measuring ≥10 rare earth elements in a general population.
- Europium, thulium, gold, indium, ruthenium, and tantalum were detected in >20% of subjects.
- Increasing age and BMI were associated to higher concentrations of some elements.
- Weight change was a predictor of lead, strontium and silver concentrations.
- Only some elements were more frequently detected in the less affluent social classes.

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SUPPLEMENTAL MATERIAL

Supplemental Tables 1-4: Percentages of detection and quantification, and concentrations of 50 chemical elements (metals and other trace elements, rare earth elements, and minority elements). Results from the 2016 Barcelona Health Survey (N=240 participants). Weighted data.

Supplemental Figures 1-2: Spearman's correlation coefficients between chemical elements and persistent organic pollutants (POPs). Results from the 2016 Barcelona Health Survey (N=240 participants). Weighted data.

Supplemental Table 1. Detection and concentrations of 9 essential trace elements.

	Fe (iron) (mg/dL)	**Cu (copper)** (µg/mL)	**Se (selenium)** (ng/mL)	**Zn (zinc)** (µg/dL)	**Co (cobalt)** (ng/mL)	**Cr (chromium)** (ng/mL)	**Mn (manganese)** (ng/mL)	**Mo (molybdenum)** (ng/mL)	**Ni (nickel)** (ng/mL)
LOD	0.009	0.004	0.030	0.816	0.012	0.012	0.621	0.142	0.040
LOQ	0.136	0.066	0.450	12.24	0.050	0.050	1.30	0.500	0.230
N = 240									
Detection and quantification									
Detected (%)	100	100	100	100	38.9	9.7	73.4	89.7	5.5
Detected - quantified (%)	100	100	100	100	38.9	9.7	73.4	89.7	5.5
Detected - non quantified (%)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Non detected (%)	0.0	0.0	0.0	0.0	61.1	90.3	26.6	10.3	94.5
Median	34.9	0.710	182.5	598.7	<LOD	<LOD	8.33	2.73	<LOD
Mean	34.9	0.725	185.7	597.9	–	–	8.86	3.27	–
SD	4.37	0.148	38.7	95.9	–	–	19.16	3.83	–
Geometric mean	34.6	0.710	181.6	589.9	–	–	3.89	2.07	–
25th percentile	31.9	0.619	162.3	536.6	<LOD	<LOD	0.31	2.05	<LOD
75th percentile	37.7	0.808	206.9	660.5	0.196	<LOD	11.07	3.55	<LOD
90th percentile	40.6	0.878	234.0	729.9	0.309	<LOD	13.13	5.03	<LOD
95th percentile	42.9	1.018	250.2	765.9	0.439	2.40	15.38	6.48	111.0
Minimum	17.6	0.387	81.8	337.4	<LOD	<LOD	0.31	<LOD	<LOD
Maximum	48.3	1.426	311.3	913.5	6.091	4.36	238.51	41.35	11.04

LOD: limit of detection. LOQ: limit of quantification.

If the proportion of data below the LOQ was greater than 50%, the mean, standard deviation (SD), and geometric mean were not calculated.

Supplemental Table 2. Detection and concentrations of 15 elements from the ATSDR's Substance Priority List.

	Pb (lead) (µg/dL)	**Ag (silver)** (ng/mL)	**Al (aluminium)** (ng/mL)	**As (arsenic)** (ng/mL)	**Ba (barium)** (ng/mL)	**Be (beryllium)** (ng/mL)	**Cd (cadmium)** (ng/mL)	**Hg (mercury)** (ng/mL)	**Pd (palladium)** (ng/mL)
LOD	0.020	0.005	1.96	0.006	0.426	0.016	0.003	0.021	0.001
LOQ	0.136	0.012	27.82	0.093	1.80	0.120	0.045	0.110	0.005
Detection and quantification									
Detected (%)	100	85.8	3.4	100	8.3	10.3	98.1	96.4	5.7
Detected - quantified (%)	100	80.5	3.4	100	8.3	8.0	98.1	96.4	3.4
Detected - non quantified (%)	0.0	5.3	0.0	0.0	0.0	2.3	0.0	0.0	2.3
Non detected (%)	0.0	14.2	96.6	0.0	91.7	89.7	1.9	3.6	94.3
Median	1.63	0.092	<LOD	3.15	<LOD	<LOD	0.309	3.33	<LOD
Mean	2.17	0.434	–	5.29	–	–	0.460	4.47	–
SD	2.88	4.828	–	6.69	–	–	0.571	4.44	–
Geometric mean	1.68	0.064	–	3.12	–	–	0.328	2.70	–
25th percentile	1.06	0.025	<LOD	1.52	<LOD	<LOD	0.193	1.84	<LOD
75th percentile	2.57	0.188	<LOD	5.99	<LOD	<LOD	0.462	5.26	<LOD
90th percentile	3.81	0.373	<LOD	13.33	<LOD	0.068	0.898	9.92	<LOD
95th percentile	4.50	0.853	<LOD	17.41	5.00	0.160	1.235	13.83	<LOQ
Minimum	0.38	<LOD	<LOD	0.26	<LOD	<LOD	<LOD	<LOD	<LOD
Maximum	41.60	102.4	904.4	49.33	90.42	1.590	6.760	39.03	0.027

Supplemental Table 2. continued.

	Sb (antimony) (ng/mL)	**Sr (strontium)** (ng/mL)	**Th (thorium)** (ng/mL)	**Tl (thallium)** (ng/mL)	**U (uranium)** (ng/mL)	**V (vanadium)** (ng/mL)
LOD	0.150	0.798	0.004	0.001	0.002	0.093
LOQ	0.300	2.10	0.021	0.005	0.003	0.130
Detection and quantification						
Detected (%)	100	99.8	1.1	71.6	6.3	0.9
Detected - quantified (%)	100	99.8	1.1	69.4	6.3	0.9
Detected - non quantified (%)	0.0	0.0	0.0	2.2	0.0	0.0
Non detected (%)	0.0	0.2	98.9	28.4	93.7	99.1
Median	3.81	21.5	<LOD	0.019	<LOD	<LOD
Mean	3.87	23.0	–	0.024	–	–
SD	0.63	9.0	–	0.025	–	–
Geometric mean	3.82	21.6	–	0.008	–	–
25th percentile	3.49	16.9	<LOD	<LOD	<LOD	<LOD
75th percentile	4.16	26.9	<LOD	0.037	<LOD	<LOD
90th percentile	4.65	32.5	<LOD	0.065	<LOD	<LOD
95th percentile	4.83	38.9	<LOD	0.074	0.026	<LOD
Minimum	2.53	<LOD	<LOD	<LOD	<LOD	<LOD
Maximum	6.53	94.9	0.275	0.128	0.059	0.739

Supplemental Table 3. Detection and concentrations of 20 rare earth elements (REE).

	Ce (cerium) (ng/mL)	**Dy (dysprosium)** (ng/mL)	**Er (erbium)** (ng/mL)	**Eu (europium)** (ng/mL)	**Ga (gallium)** (ng/mL)	**Gd (gadolinium)** (ng/mL)	**Ho (holmium)** (ng/mL)	**In (indium)** (ng/mL)	**La (lanthanum)** (ng/mL)	**Lu (lutetium)** (ng/mL)
LOD	0.015	0.001	0.001	<0.001	0.008	0.002	<0.001	<0.001	0.016	<0.002
LOQ	0.030	0.005	0.005	0.005	0.010	0.005	0.005	0.005	0.015	0.005
Detection and quantification										
Detected (%)	5.0	6.3	10.1	62.1	11.2	4.8	7.7	30.5	5.2	7.7
Detected - quantified (%)	5.0	6.3	10.1	9.7	11.2	4.8	5.2	17.1	5.2	3.9
Detected - non quantified (%)	0.0	0.0	0.0	52.4	0.0	0.0	2.5	13.4	0.0	3.8
Non detected (%)	95.0	93.7	89.9	37.9	88.8	95.2	92.3	69.5	94.8	92.3
Median	<LOD	<LOD	<LOD	<LOQ	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
Mean	–	–	–	–	–	–	–	–	–	–
SD	–	–	–	–	–	–	–	–	–	–
Geometric mean	–	–	–	–	–	–	–	–	–	–
25th percentile	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
75th percentile	<LOD	<LOD	<LOD	<LOQ	<LOD	<LOD	<LOD	<LOQ	<LOD	<LOD
90th percentile	<LOD	<LOD	0.009	<LOQ	0.126	<LOD	<LOD	0.011	<LOD	<LOD
95th percentile	<LOD	0.025	0.016	0.014	0.156	<LOD	0.006	0.018	0.226	<LOQ
Minimum	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
Maximum	3.32	0.218	0.132	0.051	0.481	0.326	0.047	0.176	1.047	0.035

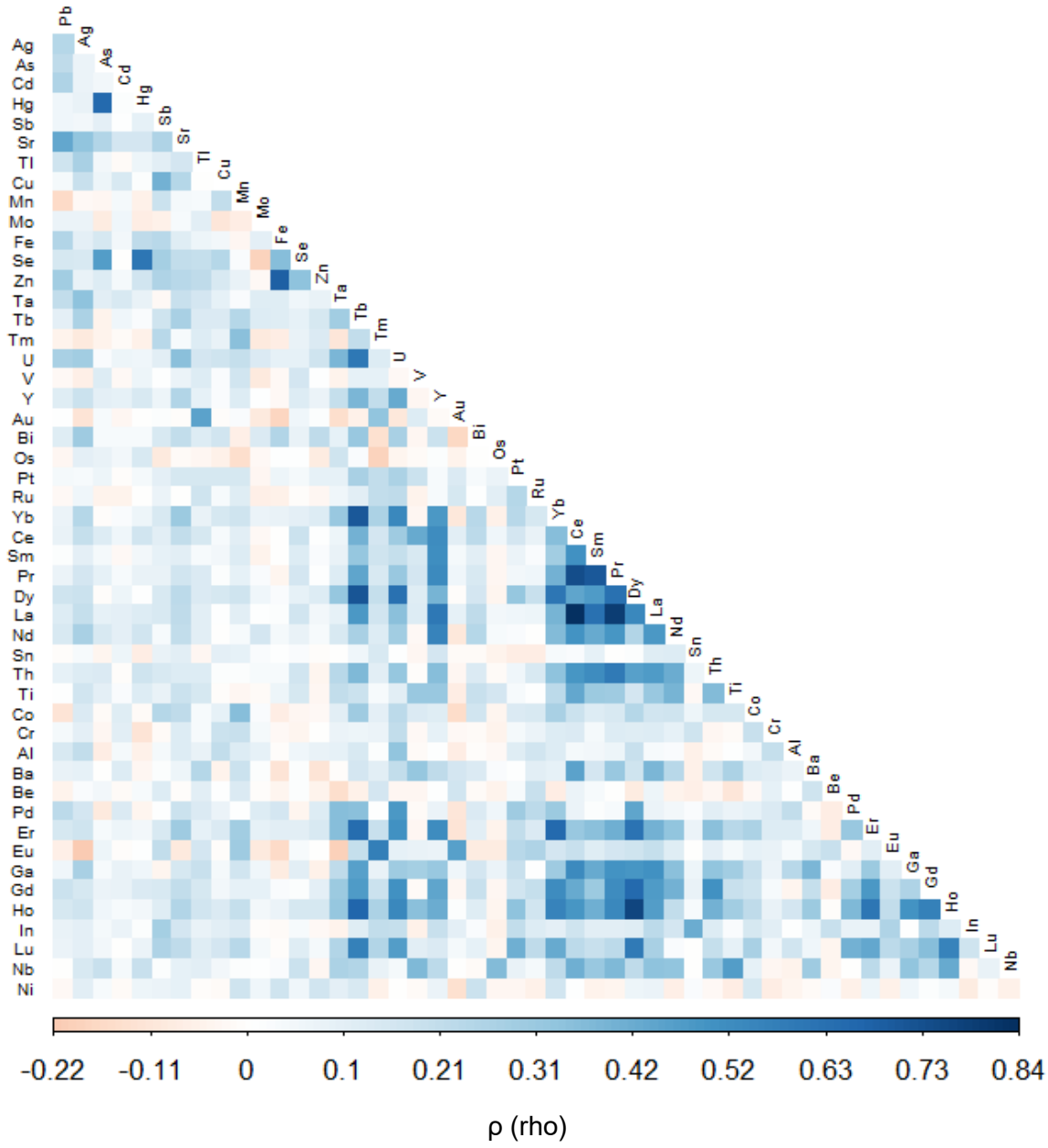
Supplemental Table 3. continued.

	Nb (niobium) (ng/mL)	**Nd (neodymium)** (ng/mL)	**Pr (praseodymium)** (ng/mL)	**Sm (samarium)** (ng/mL)	**Sn (tin)** (ng/mL)	**Ta (tantalum)** (ng/mL)	**Tb (terbium)** (ng/mL)	**Tm (thulium)** (ng/mL)	**Y (yttrium)** (ng/mL)	**Yb (ytterbium)** (ng/mL)
LOD	0.007	0.005	0.003	0.002	0.002	0.001	<0.001	<0.001	0.006	<0.001
LOQ	0.005	0.010	0.005	0.005	0.010	0.005	0.005	0.005	0.005	0.005
Detection and quantification										
Detected (%)	6.3	7.0	3.3	4.5	10.0	20.5	9.0	55.9	9.2	10.8
Detected - quantified (%)	6.3	7.0	3.3	4.5	10.0	20.3	5.1	3.5	9.2	10.8
Detected - non quantified (%)	0.0	0.0	0.0	0.0	0.0	0.2	3.9	52.4	0.0	0.0
Non detected (%)	93.7	93.0	96.7	95.5	90.0	79.5	91.0	44.1	90.8	89.2
Median	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOQ	<LOD	<LOD
Mean	–	–	–	–	–	–	–	–	–	–
SD	–	–	–	–	–	–	–	–	–	–
Geometric mean	–	–	–	–	–	–	–	–	–	–
25th percentile	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
75th percentile	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOQ	<LOD	<LOD
90th percentile	<LOD	<LOD	<LOD	<LOD	<LOD	0.020	<LOD	<LOQ	<LOD	0.006
95th percentile	0.125	0.091	<LOD	<LOD	4.03	0.044	0.006	<LOQ	0.113	0.010
Minimum	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
Maximum	2.614	0.910	0.251	0.201	39.36	0.421	0.189	0.037	1.052	0.081

Supplemental Table 4. Detection and concentrations of 6 other minority elements.

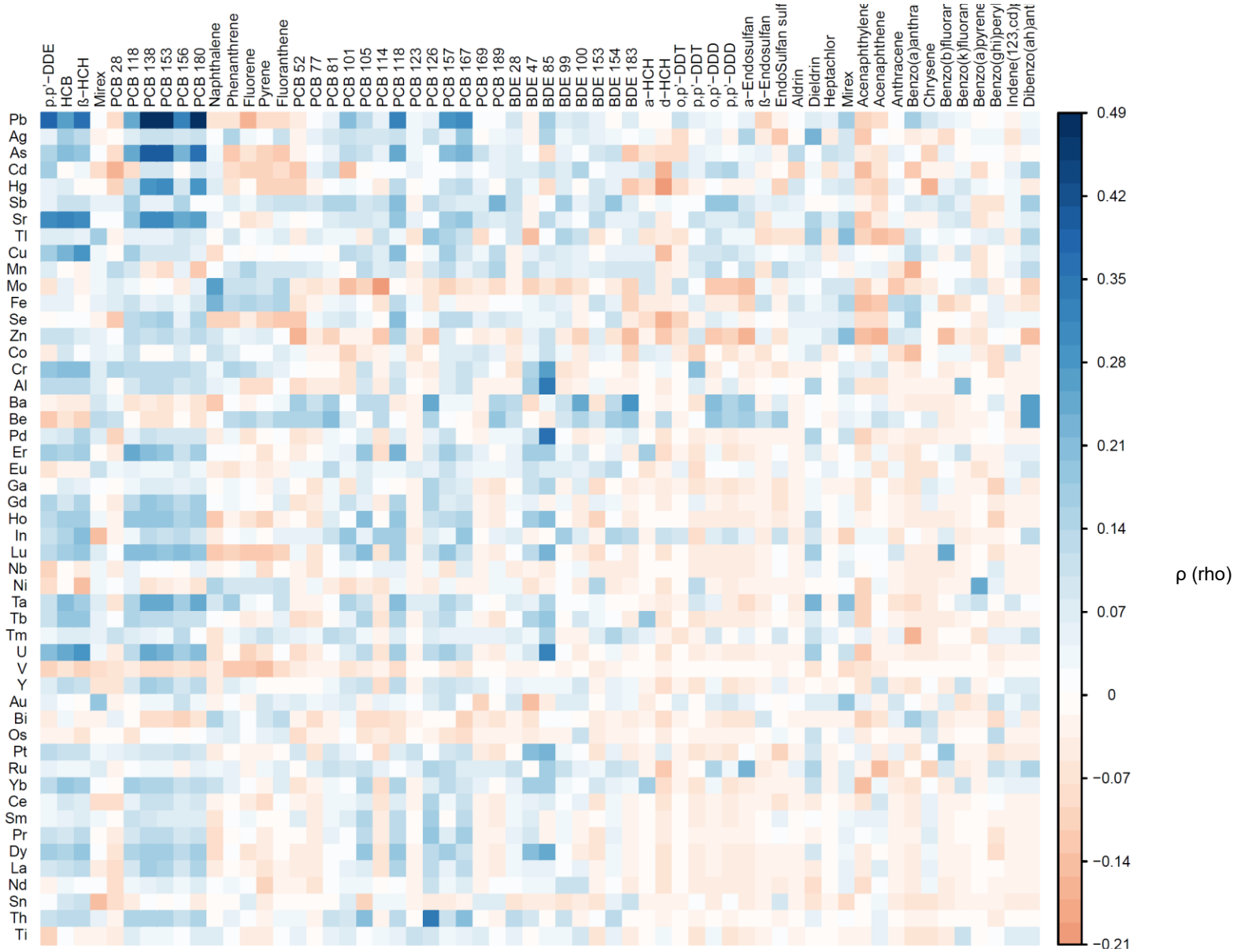
	Au (gold) (ng/mL)	**Bi (bismuth)** (ng/mL)	**Os (osmium)** (ng/mL)	**Pt (platinum)** (ng/mL)	**Ru (ruthenium)** (ng/mL)	**Ti (titanium)** (ng/mL)
LOD	0.003	0.007	0.002	0.001	0.001	0.083
LOQ	0.011	0.012	0.006	0.003	0.005	0.205
Detection and quantification						
Detected (%)	40.9	12.8	2.9	11.7	24.4	8.9
Detected - quantified (%)	20.8	12.8	2.9	10.5	14.9	8.9
Detected - non quantified (%)	20.1	0.0	0.0	1.2	9.5	0.0
Non detected (%)	59.1	87.2	97.1	88.3	75.6	91.1
Median	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
Mean	–	–	–	–	–	–
SD	–	–	–	–	–	–
Geometric mean	–	–	–	–	–	–
25th percentile	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
75th percentile	<LOQ	<LOD	<LOD	<LOD	<LOD	<LOD
90th percentile	0.105	0.113	<LOD	0.003	0.009	<LOD
95th percentile	0.140	0.159	<LOD	0.005	0.012	16.5
Minimum	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
Maximum	2.302	1.525	0.128	0.082	0.035	41.9

Supplemental Figure 1. Spearman's correlation coefficients between all 50 chemical elements analysed in the population of Barcelona city in 2016 (N=240). Weighted data.



Details of chemical symbols are provided in Supplemental Tables 1-4.

Supplemental Figure 2. Spearman's correlation coefficients between all 50 chemical elements and all 62 persistent organic pollutants (POPs) analysed in the population of Barcelona city in 2016 (N=240)[a]. Weighted data.



[a] Porta M, Pumarega J, Henríquez-Hernández LA, et al. Science of the Total Environment 2021.