ASSESSMENT OF HUMAN EXPOSURE TO PCBS IN THE ANNISTON COMMUNITY HEALTH SURVEY

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Abstract

We measured levels of 35 ortho-substituted polychlorinated biphenyl congeners (PCBs) in a sample of 765 adults from Anniston, Alabama, who participated in the Anniston Community Health Survey (ACHS). Demographic, questionnaire data and blood samples were collected in 2005-2007. Forty six percent of the study participants were African American and 70% were female. The median of the sum of 35 PCB congeners (total PCBs) was 3.28 ng/g whole weight with a range of 0.11-170 ng/g whole weight. Total PCBs were 4 to 5 times higher in Anniston than corresponding percentiles for the US general population from the 2003-2004 National Health and Nutrition Examination Survey (NHANES). In Anniston, the geometric means for total PCBs for the three age groups (20-39, 40-59, 60+ year old) were about three times higher for African American participants than for White participants. Geometric means for the 60+ year old age group by race were 1874 ng/g lipid (10.9 ng/g whole weight) for African Americans and 683.8 ng/g lipid (4.21 ng/g whole weight) for Whites. Geometric means for the White participants, while lower than those of African American participants, were still about two times higher than NHANES Whites for the two older age groups (40-59, 60+).

Introduction

An estimated 1.3 billion pounds of polychlorinated biphenyls (PCBs) were produced in Anniston, Alabama, by Monsanto/Solutia Corporations between 1929 and 1971. In the early 1990s, high levels of PCBs found in various environmental matrices caused community concerns over potential health effects due to PCBs exposure and led to several limited investigations. In 2003, the Agency for Toxic Substances and Disease Registry funded the Anniston Environmental Health Research Consortium to conduct further research in this population. The consortium included participants from 13 academic institutions and community representatives. The goal of the present study was to characterize the environmental PCBs exposure in adult Anniston residents in this community.

Materials and Methods

Study Design and Population

The Anniston Community Health Survey (ACHS) is a cross-sectional study that randomly selected 3,320 households from a commercial list of all residential properties in Anniston, Alabama (population 24,000). It oversampled locations in West Anniston (2,224 households) - the location of the former PCB manufacturing facility. From those, 1823 households were successfully contacted and 1,110 individuals randomly selected from consenting households agreed to complete the Community Health Survey. Of the 1,110 participants, 774 visited the study office and provided a fasting blood sample. Of these, 765 participants with valid PCB and lipid measurements were included in the present study. The study was reviewed and approved by the appropriate Institutional Review Boards. Written informed consent was obtained from all participants at the time of the household survey and the survey was administered by a trained interviewer.

Chemical Analyses

Blood samples were collected in 2005-2007 from 774 adult residents of Anniston, Alabama. Two milliliters of sera were sent to the laboratory within 2 weeks of the blood collection where it was stored at

-70°C until chemical analysis. Eight samples failed to meet quality control requirements and were discarded. One person had missing lipid measurements. Thirty-five ortho-substituted PCBs were measured in serum by the Centers for Disease Control and Prevention's National Center for Environmental Health laboratory using high-resolution gas chromatography/isotope-dilution high-resolution mass spectrometry (HRGC/ID-HRMS). The analytical methodology employed for the measurement of PCBs in serum has been reported previously.[1] Briefly, serum specimens (2mL) were fortified with $^{13}C_{12}$-labeled internal standards and diluted with concentrated formic acid and water using a 215 liquid handler (Gilson Inc.; Middleton, WI) for automation. Automated solid phase extraction (SPE) and silica:silica/sulfuric acid lipid degradation were performed on the Rapid Trace SPE work station (Caliper Life Sciences Inc.; Hopkinton, MA). Samples were injected into a Hewlett-Packard 6890 gas chromatograph equipped with a DB-5ms capillary column (30m x 0.25 mm x 0.25 μm film thickness) coupled to a Thermo Finnigan MAT95 XP mass spectrometer operated in EI mode using selected ion monitoring at 10,000 resolving power. The concentration of each analyte was calculated from its calibration curve. Study specimens were analyzed in batches of 24 specimens intermixed with quality control (n=3) and method blank (n=3) samples.[1] All data were reviewed using comprehensive quality assurance and quality control (QA/QC) procedures and the analytical results were reported on both a whole-weight and lipid-adjusted basis. Serum total lipids were calculated using an enzymatic "summation" method using triglyceride and total cholesterol measurements.[2] All geometric means were calculated using the limit of detection divided by the square root of 2 substituted for measurements below the detection limit.[3] We compared the Anniston data to the results from the 2003-2004 NHANES.[4]

Results and Discussion

Demographic characteristics of the study participants stratified by race are summarized in Table 1. The study sample was 46% African American and 70% female. Median age was 54 years for the African American participants and 58 years for the White participants. Body mass index (BMI) distributions were similar for both races. About half of the participants resided in their current residence for at least 13 years and about one quarter of the participants lived at their current residence for over 30 years. More African Americans (89%) lived in West Anniston - the neighborhood adjacent to the former plant - than Whites (79%). The median distance of the current residence from the plant was 2.19 kilometers (km) for African Americans and 3.83 km for Whites (data not shown). African American participants also reported a history of eating more local livestock, fish, and clay than the White study participants (75% vs 51%, 68% vs 46%, and 66% vs 21%, respectively; data not shown).

Geometric means, medians, 75th, 90th and 95th percentiles and their corresponding 95% confidence intervals for all participants combined, as well as by race, are presented in Table 2. Comparisons with the 2003-2004 NHANES results are also provided. The geometric mean for the sum of 35 PCB congeners (total PCBs) was 3.04 ng/g whole weight and the median was 3.27 ng/g whole weight (range = 0.11-170.4 ng/g whole weight). The median for the Anniston participants was about four times higher than the median from the 2003-2004 NHANES (3.28 ng/g vs 0.83 ng/g whole weight). The median for Anniston also approximates the 95th percentile from the NHANES (3.53 ng/g whole weight). In the Anniston survey, African Americans had more than two times higher total PCBs than Whites for the geometric mean and median, and about three times higher total PCBs at the 75th, 90th and 95th percentiles. Increases in PCB levels in African Americans relative to Whites are also observed in the NHANES but are limited to 90th and 95th percentiles and are less pronounced. The geometric mean for Whites from the Anniston survey is comparable to the 90th percentile for Whites in NHANES (2.76 ng/g vs 2.64 ng/g whole weight) and the 90th and 95th percentiles are three times higher in the Anniston Whites than in the NHANES Whites. Total PCBs for all selected percentiles are about five times higher in the Anniston African Americans compared with their NHANES counterparts (95th percentile = 31.3 ng/g vs 6.52 ng/g whole weight).

Lipid adjusted geometric means and the 95% confidence intervals for total PCBs are presented in Table 3 for the three age groups (20-39, 40-59, and 60+ year old) by survey and race (whole weight data for NHANES for these particular age groups were not readily available). In the low age group (20-39 year old), the Anniston African Americans have a total PCBs geometric mean that is two times higher than the

Anniston Whites. However, the geometric means for the Anniston Whites, NHANES Whites and NHANES African Americans within this age group are similar and have overlapping confidence intervals. In the 40-64 year old group, the Anniston African Americans' total PCBs (870.9 ng/g lipid) are more than three times higher than the NHANES African Americans (246.6 ng/g lipid) and almost three times higher than the Anniston Whites (306.1 ng/g lipid). As expected, the highest total PCB levels were observed in the oldest age group (60+ year old) for both surveys and racial groups. Total PCB levels were again almost 3 times higher in the Anniston African Americans (1874 ng/g lipid) than in the Anniston Whites (683.8 ng/g lipid) and PCB levels in the NHANES African Americans (630.1 ng/g lipid) were almost two times higher than the NHANES Whites (332.8 ng/g lipid). No substantial gender differences were observed between males and females of both races in the Anniston survey (903 vs 849 ng/g lipid for African Americans, p=0.67, and 349 vs 324 ng/g lipid for Whites, p=0.54, respectively; data not shown).

In conclusion, total PCBs for 50th, 75th, 90th and 95th percentiles were 4 times to 5 times higher in Anniston than the corresponding percentiles observed in the 2003-2004 NHANES. While the Anniston survey included a higher proportion of African American participants than NHANES, age specific analyses stratified by race found that the geometric means for total PCBs were about three times higher for both racial groups from Anniston than the corresponding geometric means from the NHANES groups. These results suggest that Anniston adult study participants over 40 years old living in the community surrounding the former PCB production facilities have elevated total PCB levels in comparison to the levels found in the US general population. For the African American Anniston participants, this increase was also evident in the 20-39 year old age group.

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Table 1. Selected demographic characteristics of the participants of the Anniston Community Health Survey.

Variable		African American (n=353)	White (n=412)
Age, Median (Range) yrs		54 (18-93)	58 (19-92)
Age groups (yrs)	18-39	63 (19%)	80 (19%)
	40-59	161 (36%)	143 (35%)
	60+	129 (45%)	189 (46%)

Gender	Female	138 (70%)	289 (70%)
	Male	105 (30%)	123 (30%)
Current Residence (yrs)	≤ 4	90 (26%)	107 (26%)
	5-13	102 (29%)	89 (22%)
	14-30	85 (24%)	101 (25%)
	>30	76 (22%)	115 (28%)
BMI (kg/m^2)	≤ 24	61 (17%)	91 (22%)
	25-29	79 (22%)	122 (30%)
	30-39	164 (47%)	147 (36%)
	≥ 40	49 (14%)	52 (13%)

Table 2. Geometric means, selected percentiles and 95% confidence intervals for the sum of 35 PCBs in the Anniston Community Health Survey and NHANES 2003-2004 (ng/g whole weight).

		Selected Percentiles (95% Confidence Intervals)				
	GM (95% CI)[a]	50th	75th	90th	95th	Sample size
Anniston 2005-6						
Total	3.04 *(2.83-3.34)*	3.28 (2.96-3.66)	7.40 (6.53-8.56)	15.4 (13.6-17.2)	22.2 (19.4-27.5)	765
African American	5.03 (4.44-5.69)	5.76 (4.73-6.63)	12.2 (10.6-14.2)	21.1 (18.9-24.8)	31.3 (24.1-24.8)	353
White	2.05 (1.82-2.30)	2.24 (2.04-2.50)	4.26 (3.74-4.86)	7.75 (6.66-9.89)	10.8 (9.84-9.89)	412
NHANES 2003-4						
Total	0.82 (0.78−0.86)	0.83 (0.76−0.91)	1.63 (1.50−1.75)	2.64 (2.48−2.81)	3.53 (3.23−3.92)	1866
African American	0.88 (0.73-0.98)	0.77 (0.57-0.91)	1.79 (1.26-2.29)	3.85 (2.69-5.15)	6.52 (4.25-8.39)	453
White	0.88 (0.82−0.94)	0.92 (0.81−1.03)	1.68 (1.57−1.81)	2.64 (2.44−2.88)	3.44 (3.08−3.79)	873

a. GM – geometric mean, CI – confidence interval.

Table 3. Geometric means for the sum of 35 PCBs and their corresponding 95% confidence limits in the Anniston Community Health Survey and NHANES 2003-2004 by race and age group (ng/g lipid).

	Anniston, 2005-6		NHANES, 2003-4	
Age group	African American [b]	White [c]	African American	White
20-39 years[a]	175.1 (139.9-219.2)	68.8 (58.7-80.4)	83.9 (72.7-96.9)	82.8 (76.5-89.7)
40-60 years	870.9 (756.6-1002)	306.1 (272.2-344.1)	246.6 (209.2-290.6)	181.5 (161.9-203.3)
60+ years	1874 (1602-2193)	683.8 (617.5-757.2)	630.1 (491.0-808.7)	332.8 (312.8-354.1)

a. 18-39 for Anniston Survey (4 persons younger than 20).
b. The corresponding whole weight geometric means were 0.93 ng/g, 5.22 ng/g, and 10.93 ng/g.
c. The corresponding whole weight geometric means were 0.39 ng/g, 1.99 ng/g, and 4.21 ng/g.