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Serum PCB concentrations in residents of Calcasieu and Lafayette Parishes, Louisiana with comparison to the U.S. population

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HIGHLIGHTS

- The percentiles of serum total PCB concentrations were similar in both Parishes.
- The adjusted GM of total serum PCBs was higher in residents in Lafayette than in Calcasieu Parish.
- Serum total PCB levels in residents of both parishes increased linearly with age.
- The PCB congener profiles were similar in residents of both parishes.

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ABSTRACT

In 2002, a cross-sectional study designed to compare the serum dioxin toxic equivalent concentrations (TEQ) of a population-based sample of Calcasieu Parish, Louisiana residents, to Lafayette Parish was conducted. The mono-ortho polychlorinated biphenyls (PCBs) were measured in order to calculate the TEQ. We compared the sum of lipid adjusted serum concentrations of 27 PCB congeners (total PCBs) in residents of these two parishes and also by their demographic characteristics.

The geometric means (GM) [standard errors (SE)] of the concentrations (ng g^{-1} lipids) of total PCBs in participants from Calcasieu Parish and Lafayette Parish were 154 (11.8) and 168.6 (20.8) (T-test $p = 0.54$), respectively. Various percentiles of the distribution of serum total PCB concentrations were similar in the two parishes. After adjusting by age and race in the ANCOVA regression model, the adjusted GM for the lipid adjusted total PCBs was statistically higher in the residents in Lafayette than in Calcasieu Parish regardless of age or race ($P = 0.007$). The adjusted GM of lipid adjusted total PCBs for African Americans was significantly higher than for Whites ($p < 0.001$). Serum total PCB levels in residents of both parishes increased linearly with age ($P < 0.001$). The congener profiles were similar in residents of both parishes. We also compared the GMs of a sum of 8 PCBs in Calcasieu and Lafayette Parish residents to those from a representative sample of the U.S. general population in 2001–2002 and they were not significantly different between parishes or between the parish data and the U.S. general population.

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1. Introduction

The general population is exposed to polychlorinated biphenyls (PCBs) as mixtures of congeners primarily through ingestion and much less so through inhalation of the more volatile PCB congeners. PCBs are intrinsically lipophilic and bioaccumulate in animals throughout the food chain (e.g., fish) and eventually in humans (Gunderson, 1988). Although PCB production has ceased in most industrialized countries, PCBs still persist in the environment and thus in the food chain. Body burdens of PCBs have been reported to be influenced by a person's age, sex, race, and diet (Needham et al., 2005; Schaeffer et al., 2006; Patterson et al., 2008).

Calcasieu Parish, LA, includes a highly industrialized area near Lake Charles that contains many petrochemical and agro-chemical manufacturing and processing plants. These facilities are located in the parish because of petroleum and gas reserves discovered there during the early 1900s. In the late 1990s (65–70 years later), Calcasieu residents became concerned about possible exposure to dioxins and dioxin-like compounds from emissions by these industrial sources (Agency for Toxic Substances and Disease

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Registry, 1998; Agency for Toxic Substances and Disease Registry, 1999; Agency for Toxic Substances and Disease Registry, 2005). In 1998, at the request of the U.S. Environmental Protection Agency, the Agency for Toxic Substances and Disease Registry (ATSDR) assessed exposure to dioxins among a small sample of residents by measuring their serum dioxin concentrations. The dioxin toxic equivalent concentrations (TEQs) exceeded the 95th percentile of a reference sample, which was calculated from a few studies in the U.S. compiled by ASTDR and the National Center for Environmental Health (NCEH) Orloff et al., 2001. These findings provided the impetus for a broader investigation of environmental exposure to dioxins and volatile organic compounds in this area. In 2002, ATSDR used a cross-sectional study to compare the serum dioxin TEQ of a population-based representative sample of Calcasieu Parish residents, aged 15 years and older, to a similar group of residents of Lafayette Parish, which is demographically similar to Calcasieu Parish but has far fewer industrial facilities. Overall, the mean and distribution of serum dioxin TEQ concentrations in residents of both parishes were similar in all age groups and the serum dioxin TEQ for both parishes combined was not different from the NHANES population (Wong et al., 2008). While measuring one class of dioxin-like chemicals in order to calculate the TEQ, the remainder of the PCB congeners generally found in human serum were measured. This manuscript evaluates the PCB data for the same participants in the 2002 study.

The purpose of this analysis is to characterize the nature and extent of human body burdens of select PCB congeners in a population-based sample of Calcasieu Parish residents and to compare their total lipid adjusted serum concentrations to residents in nearby, less industrialized Lafayette Parish. We also compare total PCB concentrations in residents in 3 Calcasieu Parish areas: the industrial corridor, industrial buffer, and outer ring (Wong et al., 2008). Additionally, we compare the serum concentrations of a sum of 8 PCBs (PCB 74, 99, 118, 138, 153, 170, 180, 187) in each parish and in both parishes combined with the United States' general population concentrations by using data from the 2001–2002 National Health and Nutrition Examination Survey (2001–2002 NHANES) to determine if there may be a regional difference.

2. Methods

The details of the study design, target and comparison area, sampling design and data collection have been reported (Wong et al., 2008). In brief, the target group consisted of individuals who had resided in Calcasieu Parish for the last five years and were at least 15 years old. Similarly, the comparison group consisted of individuals who had resided in Lafayette Parish for the last five years, had never resided in Calcasieu Parish, and were at least 15 years old. In addition, participants could not weigh less than 95 lb; could not have lost more than 15 lb within the last year; could not have been suffering from hemophilia or any bleeding disorders; and could not have been diagnosed for cancer or undergone chemotherapy in the four weeks prior to collection of their blood samples. Women who were pregnant or breastfeeding within the last six months were also excluded. The lengths of time for these exclusionary criteria were chosen based on medical reasons to ensure normal metabolic state of the participants. Sampling was accomplished by a multi-stage cluster sampling design. Census blocks within the 10 sectors were identified using a geographic information system and 2000 Census data. One cluster from each of the 9 Calcasieu sectors and 3 clusters in the 10th Lafayette sector were randomly selected as the sites at which a household enumeration would be conducted and participants selected.

Each participant read and signed a consent form approved by the Centers for Disease Control and Prevention (CDC) Humans Subjects Institutional Review Board, after which the interviewer administered a questionnaire to consenting participants. They were also asked to provide 60 mL of blood, which was collected by a trained phlebotomist according to a standardized protocol. The serum was harvested and analyzed for PCBs by the Division of Laboratory Sciences at NCEH, CDC.

2.1. Blood sample analysis for PCBs

High resolution gas chromatography-high resolution mass spectrometry with isotope dilution quantification was used to measure the concentrations of 34 PCB congeners in each participant; two different PCB congener pairs could not be separated, leaving 32 PCB measurements. Whole weight concentrations of these 32 measurements were adjusted to lipid weight concentrations (Phillips et al., 1989) and summed to calculate total PCB serum concentrations. These 32 PCB congeners were as follows: the mono-ortho substituted PCB congeners 66, 74, 105, 118, 156, 157, 167, and 189; the di or higher substituted ortho PCBs 44, 49, 52, 87, 99, 101, 110, 128, 138–158, 146, 149, 151, 153, 170, 172, 177, 178, 180, 183, 187, 194, 196–203, 199, and 206. Serum samples were handled using universal precautions. Weighed serum aliquots (mean = 15 g, range 3–27 g) were spiked with carbon-13 labeled ($^{13}C_{12}$) internal standards, and the analytes of interest were isolated in hexane using a C_{18} solid phase extraction procedure followed by a Power-Prep/6 (Fluid Management Systems) automated cleanup and enrichment procedure using multilayered silica gel (acidic, basic, and neutral silica) and alumina columns coupled to an AX-21 carbon-containing column. Each analytical run consisted of eight unknown samples, two method blanks, and two quality control samples. Following the sample cleanup, the eluate was concentrated to 350 μL using a TurvoVapII (Caliper Life Science) and then transferred to silanized auto sampler vials containing a solution of 2 μL of dodecane and 8 μL decane as a "keeper solvent". This solution was allowed to concentrate at room temperature to about 2 μL. Before quantification, each vial was reconstituted with 10μL of $^{13}C_{12}$ – labeled external standard in nonane. One microliter of extract was injected using a GC PAL (Leap Technology) auto sampler into a Hewlett–Packard 6890 gas chromatograph operated in the splitless injection mode with a flow of 1 mL min^{-1} helium and chromatographed through a DB-5 ms capillary column (30 m × 0.25 mm × 0.25 um film thickness). The PCB congeners were quantified using selected ion monitoring at 10,000 resolving power using a Thermo Electron MAT95 XP (5 kV) magnetic sector mass. The total sum was calculated for 27 PCB congeners because five of the PCB congeners were detected in less than 50% of the samples.

2.2. Statistical data analysis

Statistical analysis was performed using SUDAAN software (Research Triangle Institute, Release 9.0, Research Triangle Park, NC) and SAS software (Version 9.1; SAS Institute, Cary, NC, USA). SAS and SUDAAN procedures were used to produce weighted estimates for proportions, geometric means, medians and percentiles. We set statistical significance at a p-value of less than or equal to 0.05. Demographic and lifestyle characteristics by parish were compared by age, sex, race, and length of residency in the respective parish, smoking status, and consumption of locally caught fish by using the weighted chi-square test. Student's t-test was used to compare the weighted mean difference in total serum PCB (ng g^{-1} lipid) concentrations between Calcasieu and Lafayette Parish residents.

Table 1
Characteristics of the participants by Parish.

Characteristic	Calcasieu (n = 274)	Lafayette (n = 113)	χ^2 (p-value)
Sex			
Male	127 (51.25%)	47 (41.69%)	
Female	147 (48.75%)	66 (58.31%)	2.60 (0.11)
Age			
15–29 years	72 (22.87%)	23 (18.90%)	
30–44 years	65 (23.30%)	30 (31.75%)	
45–59 years	73 (32.02%)	30 (29.49%)	
⩾60 years	64 (21.80%)	30 (19.86%)	0.82 (0.48)
Race			
White	243 (84.72%)	101 (90.93%)	
African-American	27 (15.28%)	10 (9.07%)	0.85 (0.36)
Ate locally caught fish (ever)			
Yes	239 (89.31%)	54 (54.24%)	
No	30 (10.69%)	48 (45.76%)	12.56 (0.007)
Ate locally caught fish (past year)			
Yes	165 (75.28%)	37 (73.67%)	
No	67 (24.72%)	14 (26.33%)	0.02 (0.89)
Year moved into Parish			
1981+	105 (38.38%)	62 (55.76%)	
1961–1980	90 (34.26%)	27 (23.89%)	
1941–1960	63 (23.13%)	18 (16.44%)	
1900–1940	16 (4.24%)	6 (3.91%)	2.18 (0.10)
Occupational exposure to dioxin			
Yes	62 (23.33%)	12 (10.74%)	
No	212 (76.67%)	101 (89.26%)	4.42 (0.04)
Use pesticides			
Yes	234 (81.42%)	102 (91.02%)	
No	39 (18.58%)	10 (8.98%)	2.54 (0.12)
Ever smoked			
Yes	167 (66.80%)	66 (60.31%)	
No	107 (33.20%)	47 (39.69%)	1.95 (0.17)
Currently smoke			
Yes	76 (84.13%)	24 (72.83%)	
No	23 (15.87%)	10 (27.17%)	0.40 (0.53)
Smoked in past 5 years			
Yes	99 (62.2%)	34 (51.99%)	
No	68 (37.8%)	33 (48.01%)	2.31 (0.15)

Weighted simple linear regression analysis was used to examine the association between the log-transformed serum total PCB level as the dependent variable and parish, age in years (continuous), sex, race, and length of residency as independent variables. Analysis of Covariance (ANCOVA) using Satterthwaite adjusted Wald F-tests was used to compare mean logarithmic total PCB level by parish. The least square geometric mean (LSGM) concentrations of total PCBs were calculated and compared for each categorical variable in the final model. Race was categorized into two groups (Whites and African Americans). To arrive at the final model, backward elimination with SUDAAN was used to eliminate the nonsignificant interactions one at a time, and the model was rerun to determine whether the beta coefficients for significant main effects or interactions changed by more than 10%. If any changes were observed, the nonsignificant main effect in the model was retained. Once the backward procedure was completed, main effects and interactions were added back into the model one at a time to determine whether any were significant ($P < 0.05$). All significant variables were retained in the final model. In order to examine whether there was a regional difference compared to the U.S. general population, the concentrations of 8 PCBs (PCB 47, 99, 118, 138 + 158, 153, 170, 180, and 187) were summed to compute the sum total PCB concentration. When computing the sum, we did not use data from samples with any missing data for 6 PCBs (118, 138 + 158, 153, 170, 180 and 187) when comparing between each parish and between combined Calcasieu and Lafayette Parish concentrations with 2001–2002 NHANES data. These 8 PCBs were used because they are the most frequently detected congeners with the largest contribution to the sum (Turner et al., 2005; Axelrad et al., 2009). Because the parish data were collected only for person's age 15 years and older, the GM, the median, the 75th percentile and the 95th percentile were generated from the NHANES parish data with the same age group. For the calculation of the distribution concentrations, those concentrations less than the limit of detection (LOD) were assigned a concentration equal to the LOD divided by the square root of 2 Hornung and Reed (1990). For comparisons to NHANES data, the national and parish-specific results that were less than the limit of detection were also evaluated by substitution with both the LOD and the LOD divided by 2 to determine if these assumptions alter the findings.

3. Results

Blood samples with quantities sufficient for laboratory analysis were available for 415 participants but 28 participants were excluded because of quality control issues with their PCB measurements. Altogether, 387 participants, aged 15–91 years with a mean of 45.5 years, had quantifiable serum PCB concentrations.

Participants in Calcasieu Parish and Lafayette Parish were very similar in age, sex, race, and smoking status (Table 1). There were more Calcasieu Parish participants who reported eating one or more types of locally caught fish ($p = 0.007$). Calcasieu residents had significant greater potential occupational exposures to dioxin ($p = 0.04$).

Most of the 32 measured PCB congeners had detection rates of 65% or more (Fig. 1). Detection rates for PCBs 110, 128, 149, 151, and 189 were below 50% and were excluded from the summation for total PCBs, which were calculated based on the remaining 27 PCB congeners. The detection rate between the two parishes was very similar. PCBs 74, 138, 153, and 180 were detected in all of the samples from both parishes. In addition, PCBs 52 and 118 were measured in all samples from Lafayette Parish and PCB 99 in all samples from Calcasieu Parish.

Total serum lipid PCB concentrations (ng g^{-1} lipids) ranged from 21.3 to 986 in residents of Calcasieu Parish and from 17.5 to 968 in Lafayette Parish residents. When Calcasieu Parish participants were divided into three distinct geographic areas based on their proximity to known sources (industrial corridor, industrial buffer, and the outer ring), the weighted geometric mean of total PCB concentrations among persons in these three areas were similar to each other and to Lafayette Parish. The GMs (SEs) of the serum lipid total PCBs concentrations (ng g^{-1} lipids) for Calcasieu and Lafayette Parishes were 154.1 (11.8) and 168 (20.8), respectively (T-test $p = 0.54$); combining residents of both parishes, the overall GM (SE) was 161 (13.1). The GM of serum total PCB concentrations in Calcasieu and Lafayette Parishes residents did not differ by sex, race, the year moved to parish, smoking status, or consumption of locally caught fish (Table 2). Additionally, the GM of the serum total PCBs for African Americans was higher than that of Whites in Lafayette Parish residents ($p = 0.002$), but there was no statistical difference by race for Calcasieu Parish residents ($p = 0.33$).

The various percentiles of the distribution of the total PCBs concentrations were similar in both parishes (Fig. 2). Total PCBs concentrations increased with age in both parishes (Table 2). When age was stratified into four age groups (15–29 years, 30–44 years, 45–59 years, and 60 years or older), the GM of total PCBs in Lafayette Parish residents among the 60 years and older was higher than the GM in Calcasieu Parish residents from the same age grouping ($p = 0.004$) (Table 2 and Fig. 3). The GM of total PCBs in Lafayette

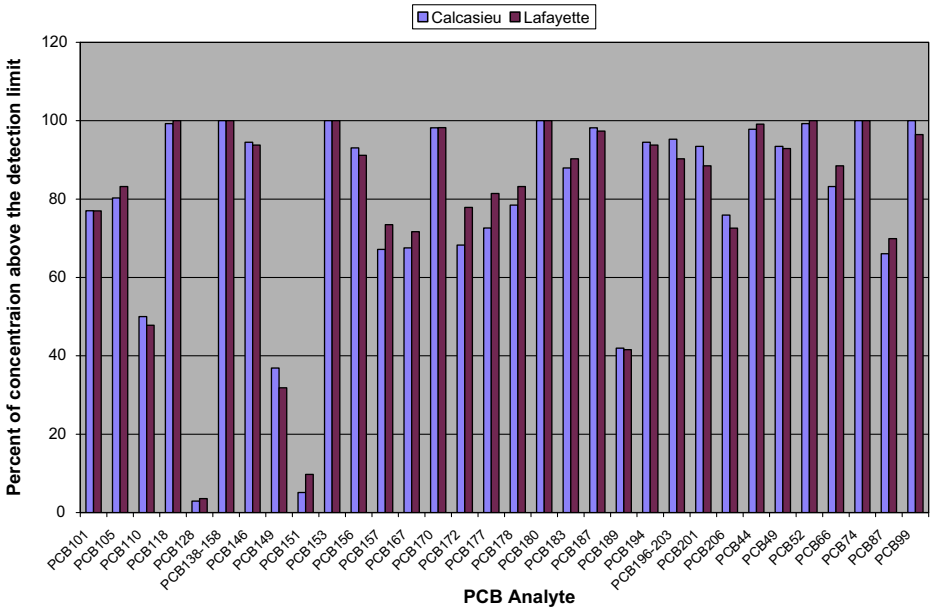

Fig. 1. Percent of concentration above the limit of detection for PCB congeners.

Table 2
Geometric mean serum sum of 27 PCBs concentrations (ng g^{-1} lipids) and standard error of geometric mean by demographic and other characteristics.

		Calcasieu sub-areas			Calcasieu (n = 274)	Lafayette (n = 113)	P-value of T-test between Calcasieu and Lafayette
		Industrial Corridor (n = 131)	Industrial Buffer (n = 113)	Outer Ring (n = 30)			
Overall		163.1 (15.4)	156.9 (16.8)	124.5 (14.5)	154.1 (11.8)	168 (20.8)	0.54
Sex	Male	161.4 (19.7)	126.3 (21.1)	130.8 (20.6)	132.1 (16.9)	190.9 (36.9)	0.12
	Female	165.3 (18.7)	204.6 (25)	119.9 (14.0)	181.1 (16.1)	154.2 (13.4)	0.20
Age	15–29 years	77.3 (16.1)	59.6 (3.6)	54.4 (9.8)	62.1 (4.2)	54.4 (3.3)	0.15
	30–44 years	110.8 (13.0)	152.1 (28.0)	102.3 (13.1)	135.4 (18.3)	149.9 (23)	0.62
	45–59 years	220.3 (7.5)	206.1 (21.6)	209.8 (60.5)	209.1 (16.7)	219.4 (14.0)	0.64
	⩾60 years	286.9 (18.1)	305.0 (53.3)	259.7 (14.5)	293.1 (31.3)	403.6 (7.5)	0.004
Race	White	165.2 (16.7)	148.5 (15.5)	120.7 (15.0)	148.0 (11.1)	157.0 (18.7)	0.68
	African-American	159.7 (22.2)	198.9 (53.3)	99.6 (30.7)	187.4 (42.5)	316.9 (76.9)	0.12
Ever ate locally caught fish	Yes	164.0 (15.7)	149.0 (19.0)	127.8 (16.3)	148.8 (13.5)	169.5 (23.6)	0.44
	No	160.8 (37.3)	253.3 (32.3)	N/A	208.4 (27.3)	160.3 (18.4)	0.14
Past Year	Yes	152.5 (17.4)	151.8 (22.3)	133.0 (15.7)	149.5 (16.1)	155.3 (6.9)	0.75
Ate local fish	No	172.0 (29.0)	135.2 (18.3)	117.3 (24.9)	140.1 (14.2)	231.6 (98.4)	0.25
Year moved to Parish	1981+	113.9 (216)	149.1 (22.7)	109.9 (31.3)	137.7 (17)	140.6 (24.7)	0.92
	1961–1980	155.5 (18.3)	119.5 (14.3)	109.2 (14.8)	124.4 (10.9)	154.5 (36.1)	0.39
	1941–1960	224.4 (12.1)	210.6 (28.0)	263.6 (68.5)	215.8 (21)	284.4 (49.1)	0.17
	1900–1940	385.7 (41.9)	452.5 (74.6)	236.2 (3.9)	382.1 (48.4)	423.3 (95.5)	0.69
Occupational dioxin exposure	Yes	167.0 (25.8)	162.1 (24.6)	126.6 (12.6)	157.4 (17.1)	185.0 (23.3)	0.34
	No	162.8 (17.3)	155.4 (18.2)	123.7 (19.0)	153.1 (12.9)	166.7 (22.2)	0.59
Use pesticides	Yes	170.0 (16.9)	154.0 (14.8)	119.5 (24.1)	153.3 (11)	175.0 (22.1)	0.37
	No	124.8 (21.3)	169.7 (42.6)	158.0 (48.1)	161.1 (30.3)	117.9 (18.0)	0.20
Ever smoked	Yes	175.8 (18.4)	154.9 (16.0)	119.7 (20.1)	153.9 (12.4)	177.0 (29.0)	0.45
	No	150.3 (20.2)	162.3 (26.6)	132.3 (26.2)	154.5 (16.6)	156.5 (12.1)	0.92
Currently smoke	Yes	181.2 (36.5)	153.7 (18.8)	71.9 (11.0)	145.2 (16.2)	126.7 (5.6)	0.26
	No	154.6 (35.3)	70.5 (25.7)	N/A	88.6 (27.7)	138.5 (39.1)	0.29

appeared higher, though not statistically significant, than in Calcasieu, among 30–44 years (p = 0.62) and 45–59 years (p = 0.64) old but not among the 15–29 years old. Among the reported fish eaters, the GM (SE) (ng g^{-1} lipids) in persons age 60 years or older in Lafayette Parish was 431 (38.4), which was significantly higher (p = 0.004) than Calcasieu Parish residents [280(32)]. Interestingly, among the 60 years or older, the proportion of those who reported eating any locally caught fish in the past 5 years in Calcasieu and Lafayette Parishes were 91.1% and 41.2%, respectively (χ^2 $p < 0.01$). However, there was no difference in the GMs between parishes for those who reported that they had not eaten any locally caught fish for the last 5 years (p = 0.77) (see Table 3).

As mentioned above, the only age group in which Calcasieu Parish residents had higher serum PCB concentrations, although not statistically significant, was for the 15–29 years: 62.1 ng g^{-1} vs. 54.4 ng g^{-1}. These data included one 17 year old Calcasieu Parish male smoker, who reportedly did not eat fish, but had a total PCBs concentration of 918 ng g^{-1} lipids, which was greater than the 75th percentile plus 1.5 times of the inner-quartile of the 15–29 year old age group. Excluding this outlier, the GM (SE) for

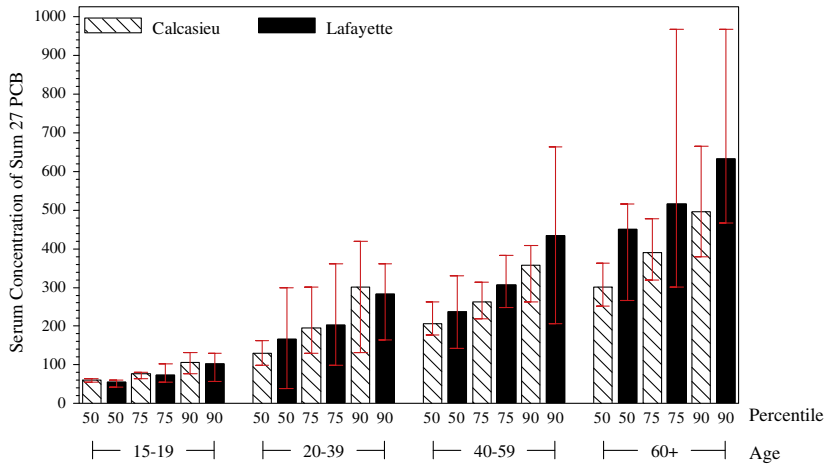

Fig. 2. Serum concentrations (ng g^{-1}) of total PCBs by percentiles in each parish by age groups.

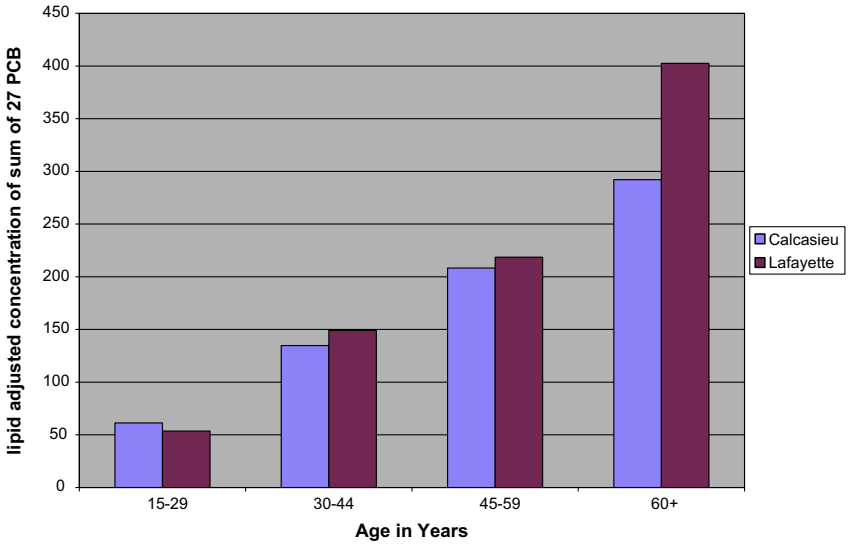

Fig. 3. Geometric Means by Parishes and age groups.

Table 3
Multiple regression results for sum of 27 PCB congeners on Log_{10} scale.

Independent variables and effect	Beta coefficient	Standard error	T-test *P*-value
Intercept	1.67	0.07	
Parish			
Calcasieu	−0.05	0.02	0.007
Lafayette	Ref	0	
Age in Years			
	0.02		<0.001
Race			
Whites	−0.20	0.04	<0.001
African Americans	ref	0	

the Calcasieu Parish group age 15–29 years old was 58.9 ng g^{-1} lipids. This GM did not differ significantly ($p = 0.25$) from that of Lafayette Parish participants from the same age group.

In the final ANCOVA model, the LSGM by parish was significantly different ($p < 0.01$) after adjusting for age and race in the final model (Table 4). The LSGM for the total PCBs in Lafayette was significantly higher than in Calcasieu ($p = 0.007$, Table 4). The total PCB concentrations linearly increased as age increased (linear trend $p < 0.001$). African Americans had higher LSGMs of total PCBs than Whites ($p < 0.01$, Table 4). The serum concentrations of a sum of 8 PCBs in Calcasieu Parish and Lafayette Parish residents were similar to each other. The GM, the median, estimated 75th percentiles, and 95th percentiles for the individual parish data and the combined parish data for the sum of the 8 PCBs were lower than the NHANES 2001–2002 (Table 5), but not statistically different. For the 15–29 year olds, the GM and various percentiles of the combined parish data were lower than the NHANES data when comparing their confidence intervals. For the older age groups, the GM and various percentiles of the combined parish data appeared to be lower than the NHANES data, but not statistically different (Table 5). Unlike the parish data, the detection rate

Table 4
Least square geometric means (LSGMs) and 95% confidence intervals (95% CI) for sum of 27 PCBs (ng g^{-1} lipids) by race, and parish of residence.

Categorical group	LSGM (95% CI)
Whites	153.24 (148.15–158.51)
African Americans	243.04 (202.48–291.73)
Lafayette	150.28 (139.78–161.57)
Calcasieu	169.71 (161.75–178.06)

Table 5
Lipid adjusted serum concentrations (ng g^{-1} lipid) of a sum1 of 8 PCBs for Calcasieu Parish, Lafayette Parish, and 2001–2002 NHANES participants 20 years and older.

PCB (8sum)		Unadjusted Geometric Mean (95% CI)	50th (95% CI)	75th (95%CI)	95th (95%CI)	Un-weighted sample size
Overall 15 years and older	NHANES 2001–2002	117.85 (107.84–128.79)	119.70 (105.80–133.20)	222.50 (205.60–235.60)	467.90 (420.60–510.60)	1998
	Combined parishes	108.48 (89.57–131.37)	125.50 (91.80–159.60)	203.50 (168.10–239.90)	372.40 (329.90–457.40)	387
	Calcasieu Parish	102.07 (85.01–122.56)	131.80 (93.50–148.50)	183.40 (159.70–224.90)	334.50 (267.30–423.00)	274
	Lafayette Parish	112.94 (84.19–151.5)	125.50 (29.10–328.30)	220.20 (111.20–457.40)	426.30 (328.30–593.00)	113
15–29 years old	Combined parishes	33.34 (30.34–36.64)	33.80 (29.70–37.70)	43.40 (37.70–54.10)	73.90 (59.10–87.20)	95
	NHANES 2001–2002	52.15 (47.94–56.73)	47.60 (42.70–51.60)	67.40 (60.30–75.60)	140.80 (110.70–190.60)	757
30–44 years old	Combined parishes	99.49 (76.72–129.01)	109.20 (82.20–125.50)	150.70 (125.00–178.80)	238.10 (163.40–334.50)	95
	NHANES 2001–2002	101.63 (93.28–110.73)	101.90 (89.70–114.10)	143.30 (133.20–155.70)	277.00 (229.00–348.40)	438
45–59 years old	Combined parishes	149.08 (131.04–169.59)	158.50 (138.10–182.20)	207.00 (188.40–230.70)	309.90 (230.70–511.80)	103
	NHANES 2001–2002	173.8 (159.19–189.75)	172.40 (157.50–199.70)	253.00 (231.90–283.10)	455.60 (354.90–622.60)	321
60 + years old	Combined parishes	246.38 (217.79–278.72)	249.10 (203.50–313.70)	349.20 (317.50–374.70)	593.00 (374.70–709.50)	94
	NHANES 2001–2002	287.92 (274.74–301.73)	279.80 (254.30–303.00)	404.60 (367.70–445.20)	701.10 (620.40–786.90)	482

1: The sum of 8 PCBs include PCB 74, 99, 118, 138, 153, 170, 180, or 187.

for the 8 PCBs in the NHANES 2001–2002 data ranged from 54% to 93%. Therefore, when values were less than the detection limit, we assigned values equal to the LOD divided by square root of 2. We also evaluated results less than the detection limit by assigning the value LOD or LOD/2 for the 8 PCBs, but the results did not change when comparing the GM and various percentiles of the 8 sum PCBs in the NHANES to the parish data (data not shown).

4. Discussion and conclusions

Descriptive analyses for this study indicated Calcasieu and Lafayette Parish residents had similar total PCB concentrations with each other and with the national background concentrations; thus, we did not observe a regional difference in total PCBs concentrations. When stratified by age groups, the GM among the 60 years and older age group in Lafayette Parish residents was higher than the corresponding GM in Calcasieu ($p = 0.004$), while levels between parishes in the other age groups were similar. However, after adjusting by race and age in the ANCOVA model, the LSGM of lipid-adjusted total PCBs of the Lafayette residents was statistically higher than for Calcasieu residents. Also, the LSGM of lipid-adjusted total PCBs in African Americans was significantly higher than Whites regardless of parish. Serum total PCB concentrations in residents of both parishes increased with age. These data are consistent with the 1999–2000 NHANES data in which the concentrations of PCBs increased with age and non-Hispanic blacks had the highest total PCBs concentrations (Needham et al., 2005). They are also consistent with the 2003–2004 NHANES data which showed that LSGMs increase with increasing age, and the LSGMs were higher for older African Americans than older Whites, but not for the younger age groups. In the 2003–2004 NHANES, the overall lipid-adjusted concentration for total PCBs was 134 ng g^{-1} (95% CI = 129–140 ng g^{-1}) (Patterson et al., 2009).

The purpose of this analysis was to characterize the nature and extent of human body burdens of select PCB congeners throughout Calcasieu Parish. The PCB concentrations and patterns in residents of Lafayette Parish were higher than those in Calcasieu Parish. When both parishes were combined, the PCB concentrations and patterns were similar to the U.S. general population. Therefore, we cannot deduce that there are differences in the degree of PCB exposure or exposure pathways.

There were several advantages and disadvantages to this study. One advantage was that there was sufficient serum available to measure a number of specific PCB congeners at low limits of detection (Fig. 1). This high detection rate helped to better characterize the nature and extent of PCB body burdens in both parishes. For instance, it was possible to determine that participants age 60 years and older in Lafayette Parish had higher sum serum PCB concentrations than did similarly aged participants in Calcasieu Parish, but that their concentrations were similar to those measured in the 2001–2002 NHANES.

One of the limitations of the study was that some of the un-weighted subgroup sample sizes were quite small; nevertheless the study design was based on the representative samples and analysis was carried out with the sampling weight and a complex study design. The other limitation is that out of 32 PCB congeners, only 27 PCB congeners had detection rates of 65% or more, and 5 PCB congeners were excluded from the analysis because their detection rates were below 50%. The sum of 8 PCB congeners observed in the Calcasieu samples appeared to be similar to that observed for background long-term levels reported in NHANES (Table 5) in the US. The lower chlorinated PCBs are more volatile, have shorter environmental and biological half-lives and were not detected in this study. However, if there had been sufficient recent exposure to the lower chlorinated PCB congeners in these participants, they would have been detected and measured by the analytical method used. The PCBs reported in this manuscript overall, can generally be considered indicators of longer-term exposure and are thus appropriate congeners to biomonitor in this community. Lastly, the collection of data needed to calculate body mass index (BMI) was not included in the study design; however, several confounding variables associated with PCB levels in the general U.S. population were examined and it was found that age was the most influential and that the contribution of BMI was negligible (McClure et al., 2010).

The PCB concentrations and patterns in residents of Lafayette Parish were higher than those in Calcasieu Parish. When both par-

ishes are combined, PCB body burdens in these two communities, based on sum serum PCB concentrations, were not statistically significantly different from the national background concentrations, and therefore based on this study, no concern regarding PCBs and health is indicated.

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