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SCIENCE DIRECT
Environmental Research 97 (2005) 170–177
Environmental Research
www.elsevier.com/locate/envres

Predictors of organochlorines in New York City pregnant women, 1998–2001 ☆

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Received 6 May 2004; received in revised form 20 July 2004; accepted 30 July 2004
Available online 9 September 2004

Abstract

Organochlorine compounds (OCs) have been found widely in human tissues. However, levels have been rapidly declining since their virtual ban in the 1970s. We measured 1,1′-dichloro-2,2′-bis(4-chlorophenyl)ethylene (DDE), polychlorinated biphenyls (PCBs), and *trans*-nonachlor (TN) in 194 pregnant women in New York City and examined demographic and dietary predictors of their levels in serum. Serum OC levels were low (median μg/L: 0.64 DDE, 0.79 PCB); TN was largely below the level of detection (74%). In multivariate models, levels of OCs increased with age; DDE was higher in women not born in the US or Puerto Rico; PCB were higher in women who bought fresh fish and lower in those with higher body mass indices.

Keywords: DDE; PCB; Organochlorines; Fish; Pregnant women; Diet

1. Introduction

Organochlorine compounds (OCs) such as 1,1′-dichloro-2,2′-bis(4-chlorophenyl)ethylene (DDE), polychlorinated biphenyls (PCBs), and *trans*-nonachlor, are persistent, lipophilic compounds that are practically ubiquitous in the environment. Because of concern about damage to the environment and harm to human health, their commercial use in the US has gradually ceased since 1970, and levels of many residues in humans have declined (Craan and Haines, 1998; Wolff, 1999).

DDE is a biodegradation product of 1,1-bis (*p*-chlorophenyl)-2,2,2-trichloroethane (DDT), the insecticide that was used for agricultural purposes and in public health programs to eradicate malaria. DDT was manufactured and used in the US from 1945 until 1972 (EPA, 1979). Despite the ban, small amounts of DDT and its major metabolite DDE are still detectable in the environment in the US, and DDT is still used internationally to control malaria.

Commercially used PCBs were mixtures of 209 individual compounds or congeners that differed according to degree of chlorination and were marketed under the trade name Aroclor (ATSDR, 1997). They have been used widely in the US from the 1940s until 1977. Their chemical stability led to their use as plasticizers, coolants and lubricants in transformers and capacitors, surface coatings, adhesives, organic diluents, carbonless duplicating paper, and pesticide extenders. Although commercial production of PCBs ceased in the US in the late 1970s, PCB residues are still found widely in the environment. Estimated half-lives of individual PCB congeners in human populations range from <1 month to >40 years, depending on structural position and degree of chlorination.

trans-Nonachlor is a persistent residue of chlordane, a mixture of chlorinated bicyclic compounds that was used as a pesticide in the US from 1948 to 1988. Chlordane use was first restricted as a termiticide in 1983, and it was completely banned in 1988 (ATSDR, 1994).

☆No reprints will be available.
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0013-9351/$ - see front matter
doi:10.1016/j.envres.2004.07.014

Bioaccumulation of OCs through the food chain led to nonoccupational exposure of humans through the diet, largely meat, milk, and fish (Kutz et al., 1991). Since major industrial discharges into the environment have diminished, additional exposure sources have been identified including fruits, vegetables, and ambient air (Lovett et al., 1997). In addition, lifestyle and demographic factors are known to influence levels of OCs in the body. Although levels measured recently in younger populations are low, they are still commonly detectable, and effects on fetal growth and development are reported (Longnecker and Rogan, 2001; Schantz et al., 2003; Wolff and Landrigan, 2002). In this study we examined a number of these factors to determine the predictors of *trans*-nonachlor, DDE, and PCB levels in a population of pregnant women in New York City (NYC) in 1998–2001.

2. Materials and methods

2.1. Study population

The study population consisted of 194 nulliparous women who were randomly selected to represent equal numbers of Black, Latina, and Caucasians from a cohort established to examine the effects of exposure to indoor pesticides on fetal growth and neurodevelopment. The cohort population has been described in detail elsewhere (Berkowitz et al., 2004). Briefly, the Children's Environmental Health Study is a prospective study, which is following an ethnically diverse cohort of mother–infant pairs at the Mount Sinai Hospital in New York City. The mothers were recruited consecutively during early pregnancy from the Prenatal Clinic and two private practices at Mount Sinai Hospital. Mothers who agreed to participate signed a written consent form according to the guidelines of the Institutional Review Board of the Mount Sinai School of Medicine. The study is limited to 404 primiparas without such pregnancy complications as hypertension and diabetes who had singleton births. These were among 479 mothers who agreed to take part in a longitudinal study of their infants, starting during their third trimester of pregnancy; a total of 1885 mothers were invited to participate, a response rate (25%) comparable to that seen in other prospective cohorts. A subset of the 404 mothers was randomly selected for this study, with approximately equal distributions by race, the number being dictated by budget.

A questionnaire was administered to the mothers during their third trimester to obtain information on characteristics such as environmental exposures, sociodemographic characteristics, maternal health, maternal smoking, alcohol consumption, and caffeine intake. Detailed questions were included with regard to buying and eating fish, including any obtained from local waters. The questionnaires were administered in either English or Spanish by bilingual interviewers. In addition, a standardized food frequency questionnaire (FFQ) was self-administered to obtain information on usual maternal dietary intake during pregnancy (Block et al., 1990). Maternal plasma for OC determination was obtained from blood samples collected during the third trimester at the time of routine blood sampling.

2.2. Laboratory methods

Details concerning the analytical method, based on gas chromatography and electron capture detection, have been reported (Gammon et al., 2002). The limit of detection (0.07 ng/mL; LD) was defined as three times the standard deviation of a low-level serum pool run with each batch over the course of a year's analyses. Four peaks were summed to assess PCB levels (PCB-4 = IUPAC Nos. 118, 153, 138, and 180) as these are the most common and highest-level congeners in most people, they represent a large proportion of the total, they are strongly correlated with total PCBs, and this sum has been used by many researchers. Further, the four-peak sum was appropriate for our data, as the levels of all other congeners were near the LD (i.e., PCB Nos. 28, 56, 66, 74, 99, 101, 178, and 187). To create the PCB-sum of four congeners, we used the actual value reported. This is preferred to a censored value such as LD, LD/2, etc., because it more closely resembles the actual distribution of the data (Berkowitz et al., 2003; Fitzgerald et al., 2004). Among the four congeners there were three zero values and no nonpositive values. PCB 118 had 31% below 0.07, PCB 153 had two values below the LD, PCB 138 had 16% below the LD, and PCB 180 had 28% below 0.07 μg/L. Because PCBs were the sum of four congeners, the LD for PCBs was set at 0.3 μg/L.

2.3. Statistical methods

Variables that were potentially related to OC levels were selected on the basis of recently published analyses in other populations (Laden et al., 1999; Moysich et al., 2002). To adjust for potential laboratory drift, we included a categorical variable for the three sets in which the OCs were processed. Demographic variables were age, race, country of birth, BMI (weight/height^2 as kg/m^2), years of education, smoking (never/ever >90 cigarettes lifetime), and prepregnancy alcohol intake. Few women smoked or consumed alcohol during pregnancy; we did not include these variables further. The environmental interview included specific fish intake questions: whether they purchased fresh and if so at a local fish store or supermarket, whether they or friends or relatives fished in local waterways, whether they ate such fish, and how much canned fish they ate (never, <1/month, ⩽2/month, 1/week, 2/week and 3+/week). The trends in both cases were the same and the data from the collapsed intervals are presented. The canned fish consumption variable was collapsed to never, any–2/month, ⩾1/week due to small numbers. The trends in both cases were the same and the data from the collapsed intervals are presented. Only 13 women responded to the question about consumption of local fish, and this variable was not included in further analyses. Dietary variables selected from the FFQ included fruit, vegetable, dairy, fish, and meat intake. FFQ data were available for 114 women; none of the food intakes were significantly correlated with OCs and these variables were not considered further. Compared with responders, the women who did not return their FFQs (80/194) were less educated, more non-White, and younger, but there were no differences in other demographic data (birthplace, smoking) or in OC levels.

Nonparametric methods (Spearman correlation and Kruskal–Wallis test) were used to examine associations between OC levels and sociodemographic or dietary variables. Multiple linear regression and logistic regression analyses were used to examine predictors of OC levels. For TN, we compared women with levels above the LD with those below the LD. Results were identical using tertiles; the upper tertile cutpoint for TN was 0.060 μg/L (upper tertiles vs. low-medium tertiles). We examined DDE and PCB as continuous log-transformed values and as tertiles. Because of the low concentrations, and to be consistent with TN, we present models that predicted the highest compared with the lower two tertiles of DDE and PCBs (based on values in μg/L) using logistic models. Results for DDE and PCBs were similar using continuous variables. We also modeled lipid-corrected DDE and PCBs (ng/g; using the Akins algorithm; Akins et al., 1989), but there were residual effects for triglycerides and cholesterol in these models (cholesterol was retained in the DDE model-building and triglycerides in the PCB model). Therefore we present the models for DDE and PCB tertiles (from values as μg/L) in which triglycerides and cholesterol were included as covariates. Logistic regression models were built starting with variables that were associated with OCs in nonparametric analyses ($P<0.1$) plus triglycerides, cholesterol, quadratic age variable for DDE, and a variable for the three laboratory sets. The age-squared term is commonly used with biomarkers of organochlorines, which often show a quadratic relationship with age. Although "fishing from local waters" was associated with OC levels, the numbers were small (see Table 3), and it was not included in multivariate analyses. We selected variables using backward elimination from a model for each OC that contained the variables that were significant in the summary analyses, with variables retained if the P value was <0.10. Identical final logistic regression models were obtained using a stepwise selection method with $P=0.10$ to enter or to stay in the model. Analyses were performed using SAS PC v 9.1 (Cary, NC).

3. Results

This sample of 194 mothers was composed of 66 Blacks, 64 Latinas, and 64 Caucasians. Their overall mean age was 25 years. Caucasian mothers were older (mean 32 years) than Blacks (21 years) and Latinas (22 years). The racial/ethnic differences were responsible for many of the relationships with demographic factors. Approximately one third had at least a bachelor's degree and one third reported ever smoking or consuming any type of alcohol before their pregnancy. The median DDE, PCB, and *trans*-nonachlor levels were <1 μg/L in maternal serum (Table 1). Maternal serum *trans*-nonachlor levels were largely (74%) below the limit of detection. The levels of maternal OC levels in relation to selected characteristics are shown in Table 2. DDE, PCB, and TN levels increased with age and differed by ethnicity. Significantly higher levels of all three OCs were observed in Caucasian mothers (who were also older) compared to Black or Latina mothers.

Foreign-born mothers had higher levels of DDE and PCBs compared to US- or Puerto Rican (PR)-born mothers. They included 13 Whites, mainly European, among whom the median DDE (2.4 μg/L) and PCB (1.3 μg/L) levels were higher than those of US-born Caucasians (1.0 and 1.0, respectively; $n=51$; $P\leqslant 0.05$, Kruskal–Wallis test). These differences were not attributable to age, which did not differ if stratified by birthplace and race (not shown). TN levels in Caucasians were similar regardless of origin. Aside from one Mali-born Black woman, all non-US-born Black and

Table 1
Distribution of maternal organochlorine levels, Children's Environmental Health Study, Mount Sinai Hospital 1998–2001

	LD	% >LD	Median (μg/L)	IQR	Median (ng/g lipid)[a]	IQR
DDE	0.07	97.4	0.64	0.377–1.22	111	77–228
PCB	0.30	94.3	0.79	0.548—1.28	151	92–254
trans-Nonachlor	0.07	26.3	0.041	0.003–0.072	6.4	0.9–14

$N=194$, $N=174$ lipid-based, IQR = interquartile range.

[a]Serum lipids calculated using Akins algorithm from triglycerides and cholesterol (Akins et al., 1989).

Table 2
Distribution of maternal organochlorine levels (medians, μg/L) in relation to selected maternal characteristics, Children's Environmental Health Study, Mount Sinai Hospital 1998–2001

Characteristics	Median *trans*-nonachlor (ng/mL)	% > LD	*P* value	Median DDE (ng/mL)	*P* value	Median PCB[a] (ng/mL)	*P* value
Maternal age (years)							
<20 ($n=57$)	0.004[b]	7.0		0.408		0.629	
20–24 ($n=59$)	0.018	11.9		0.537		0.636	
25–29 ($n=27$)	0.055	40.7		1.111		0.928	
30–34 ($n=38$)	0.074	50.0		1.160		0.994	
⩾35 ($n=13$)	0.143	76.9		1.253		1.842	
K–W[c]			<0.0001		<0.0001		<0.0001
Spearman[d]			(0.55, <0.0001)		(0.51, <0.001)		(0.32, <0.0001)
Race							
Black ($n=66$)	0.017	15.2		0.470		0.734	
Hispanic ($n=64$)	0.018	10.9		0.478		0.659	
White ($n=64$)	0.076	53.1		1.158		1.128	
K–W[c]			<0.0001		<0.0001		<0.0001
Country of birth							
US ($n=157$)	0.041	27.4		0.549		0.754	
Puerto Rico ($n=6$)	0.046	33.3		0.635		0.714	
Other ($n=31$)	0.046	19.4		2.469		0.960	
K–W[c]			0.043		<0.0001		0.155
Education							
<High School ($n=44$)	0.034	11.4		0.454		0.629	
H.S. grad ($n=38$)	0.009	5.3		0.466		0.779	
Some college—assoc. degree ($n=46$)	0.022	21.7		0.556		0.655	
Bachelors or higher ($n=65$)	0.070	50.8		1.146		1.156	
K–W[c]			<0.0001		<0.0001		<.0001
BMI pre-pregnancy[e] (kg/m^2)							
<18.5 ($n=9$)	0.013	22.2		0.565		1.201	
18.5–24.5 ($n=134$)	0.047	30.6		0.781		0.868	
25.0–29.9 ($n=30$)	0.016	13.3		0.423		0.637	
⩾30 ($n=21$)	0.042	19.0		0.484		0.617	
K–W[c]			0.048		<0.001		0.007
Spearman[d]			(−0.17, 0.016)		(−0.24, <0.001)		(−0.22, 0.0016)
Cigarette smoking[f]							
Ever smoked ($n=70$)	0.031	22.9		0.543		0.770	
Never smoked ($n=124$)	0.047	28.2		0.716		0.807	
K–W[a]			0.17		0.14		0.94
Alcohol consumption[g]							
Reported yes ($n=74$)	0.057	16.7		0.912		0.953	
Reported no ($n=120$)	0.024	41.9		0.515		0.717	
K–W[a]			0.0001		<0.001		0.0089

[a]Sum of PCBs 118, 138, 153, and 180.
[b]0.00335 is the smallest positive value in the data set.
[c]Kruskal–Wallis test.
[d]Spearman correlation coefficient (r_s, p).
[e]TN and DDE were also correlated with weight gain during pregnancy (r_s and −0.22 and −0.24, age-partialed).
[f]Smoked at least one cigarette a day for as long as 3 months.
[g]Pre pregnancy alcohol consumption.

Latina women were from the Caribbean or South/Central America ($n = 18$). Non-US-born Black women had significantly higher DDE (0.9; $n = 7$) than US-born Blacks (0.5 μg/L; $n = 59$; $P < 0.05$). Non-US-born Latinas had significantly higher DDE (6.1 μg/L; $n = 11$) than US-born Latinas (0.4 μg/L; $n = 47$) or PR-born Latinas (0.6 μg/L; $n = 6$; $P < 0.01$). PCBs and TN did not differ among the Black and Latina subgroups with regard to origin, but the numbers in some subgroups were small.

Higher OC levels were observed in mothers with higher levels of education, consistent with their older age (mean 26 years for at least high-school education compared with mean 20 years for less than high-school education). BMI was inversely correlated with maternal OC levels (Table 2). OC levels were higher in mothers who never smoked compared to those who ever smoked, but this difference was not statistically significant (Table 2). Smoking did not differ by age, but ever-smokers were more likely to be Black and Latina if they were US/PR-born (47/61; 77%) or White if non-US-born (7/9; 70%). Higher OC levels were observed in mothers who reported prepregnancy alcohol consumption than in mothers who reported no alcohol consumption (Table 2).

From the environmental questionnaire, mothers who reported that they purchased fresh fish ($n = 129$) had nonsignificantly higher OC levels than mothers who did not ($n = 65$; Table 3). DDE and PCB levels were higher among mothers who bought fish from major supermarkets ($n = 18$) compared with mothers who bought fish from a local fish store ($n = 111$) but not significantly ($0.05 < P \leqslant 0.10$); TN levels were higher among those who patronized local fish stores ($P = 0.057$). The 8 mothers who reported fishing in local waters had significantly lower OC levels than those who reported no local fish consumption. More frequent consumption of canned fish was associated with higher concentrations of OCs, although the median TN by fish consumption was below the limit of detection in both fish-consumption strata. However, the proportion of TN values above the LD also increased significantly with increasing consumption of canned fish (Table 3). Fish consumption as reported by the 114 women who returned an FFQ was not associated with OCs.

We conducted multivariate logistic regression to examine relationships between OCs and selected predictor variables. For DDE, BMI, pregnancy weight gain, smoking, prepregnancy alcohol use, canned fish consumption, and triglycerides were eliminated from the

Table 3
Organochlorine levels in relation to maternal fish consumption during pregnancy reported by questionnaire, Children's Environmental Health Study, Mount Sinai Hospital, 1998–2001

Fish intake from Environmental Questionnaire ($n = 194$)	Median maternal organochlorine levels (μg/L)					
	trans-Nonachlor	P value	DDE	P value	PCB[a]	P value
Buy fresh fish?						
Yes ($n = 129$)	0.047		0.712		0.833	
No ($n = 65$)	0.029		0.540		0.730	
K–W[b]		0.53		0.20		0.23
Source of fresh fish[c]						
Local fish store ($n = 111$)	0.048		0.643		0.792	
Major supermarket ($n = 18$)	0.013		0.975		0.968	
K–W[b]		0.057		0.080		0.10
Fished in local waters[d]						
Yes ($n = 8$)	0.003		0.324		0.580	
No ($n = 173$)	0.042		0.681		0.833	
K–W[b]		0.026		0.030		0.022
Eat canned fish?						
Never ($n = 41$)	0.013		0.425		0.611	
Any–2/month ($n = 115$)	0.036		0.676		0.843	
$\geqslant$1/week ($n = 38$)	0.063		0.813		0.805	
K–W[b]		<0.001		0.027		0.022
Spearman[e]		(0.27, <0.001)		(0.19, 0.007)		(0.17, 0.018)

[a]Sum of PCBs 118, 138, 153 and 180.
[b]Kruskal–Wallis test.
[c]Three women who said that they obtained fish from a friend were omitted from this analysis variable.
[d]Thirteen women had missing data.
[e]Spearman correlation coefficient (r_s, p).

Table 4
Multivariate models for maternal characteristics and environmental questionnaire variables as predictors of organochlorine levels, $n = 194$, Children's Environmental Health Study, Mount Sinai Hospital 1998–2001

DDE	Unadjusted models			Multivariate adjusted[a] *betas* for 3rd vs. lower two tertiles of DDE $n = 174$, $r^2 = 0.44$		
	Beta	SE	*P* value	Beta	SE	*P* value
Country of birth (Other vs. US/PR)	1.40	0.26	<0.001	1.83	0.36	<0.001
Age (years)	0.18	0.29	<0.001	1.01	0.36	0.004
Age*age	0.0031	0.0005	<0.001	−0.014	0.0062	0.026
Cholesterol ($n = 174$)	0.0086	0.0030	0.0105	0.0098	0.0042	0.020
PCB	Unadjusted models			Multivariate adjusted[a] *betas* for 3rd vs. lower two tertiles of PCB $n = 194$, $r^2 = 0.25$		
	Beta	SE	*P* value	beta	SE	*P* value
Age (years)	0.13	0.026	<0.001	0.14	0.030	<0.001
BMI (kg/m^2)	−0.11	0.035	0.001	−0.10	0.038	0.0097
Buy fresh fish (yes vs no)	0.26	0.17	0.126	0.38	0.19	0.050
***trans*-Nonachlor**	Unadjusted models			Multivariate adjusted[a] *betas* for *trans*-Nonachlor $\geqslant$LD vs. <LD $n = 174$, $r^2 = 0.24$		
	Beta	SE	*P* value	Beta	SE	*P* value
Age (years)	0.19	0.032	<0.001	0.20	0.036	<0.001
Smoking (ever vs. never smoked)	−0.14	0.17	0.415	−0.45	0.23	0.050
Cholesterol ($n = 174$)	0.0092	0.0033	0.005	0.0076	0.0036	0.036

Cutpoints for tertiles of DDE were 0.46–1.03, PCB 0.86–1.333 ng/mL. Cutpoints for TN were $\geqslant$LD ($n = 51$) vs. <LD ($n = 143$); LD = 0.07 ng/mL.
[a]The *betas* are adjusted mutually and for laboratory batch; $n = 194$ except as noted, because only 174 values were available for cholesterol and triglycerides. Models for DDE and TN without cholesterol, with $n = 194$, were almost identical to those presented. Multivariate models were based on backward elimination, as described in under Materials and methods, and were identical to models using forward stepwise inclusion.

full model. For PCB, race, country of birth, canned fish consumption, and cholesterol were eliminated. For TN, race, country of birth, BMI, pregnancy weight gain, triglycerides, and alcohol were not retained. Because of the differences in OCs by age, origin, and race, we checked for an interaction in the final models; none was significant. The resulting models explained 22–45% of the variance of the OC levels (Table 4). In the adjusted analyses, older age was associated with higher levels of DDE, PCB, and TN. Foreign birth was associated with higher DDE, BMI was inversely associated with PCBs, and ever-smoking was inversely associated with TN. Cholesterol positively predicted both DDE and TN. Women who purchased fresh fish had higher PCB levels (adjusted).

4. Discussion

In this population of young women, OC levels were quite low, with median values below 1 μg/L, consistent with reported levels in a few recent studies (Fitzgerald et al., 2004; Karmaus et al., 2002). A study of 20 mothers from the same hospital in 1990–1993 also showed low levels of DDE and PCBs, 1.3 and 1.7 μg/L (Berkowitz et al., 1996). In contrast, older women (e.g., 50–60 years average age) recruited from the same hospital in 1994–1996 had higher levels of DDE of 4.3 (GM; μg/L), PCBs 4.1, and TN 0.24 (Wolff et al., 2000). Age is a strong predictor of serum OC levels in our data, consistent with most other studies (Fitzgerald et al., 2004; Gladen et al., 1999; Laden et al., 1999; Moysich et al., 2002; Mussalo-Rauhamaa et al., 1988; Stehr-Green, 1989; Torres-Arreola et al., 1999). Country of birth was also a predictor of OCs, but in adjusted analyses only DDE was significantly higher in non-US-born women. Thus even at diminishingly low exposures, OC levels still show the ability of these persistent compounds to accumulate in the body. Alternatively, older women may have had higher exposures to these compounds in their youth when OCs were still in use in the US.

Other studies have also reported higher OC levels among non-US born women (James et al., 2002). In our study, DDE levels were higher among women who listed their place of birth as outside the US and PR. DDT is still in use in developing countries of the world, and indeed in Mexico mothers in their reproductive years have higher DDE levels than US women (GM 21.8 in 1999; Lopez-Carrillo et al., 2001). Underdeveloped European countries may also have higher DDT exposures, but the numbers of women in subgroups by geography was too small to examine this question further. We did not collect data about how long the women had been in the US. PCBs did not differ significantly by country of birth in the adjusted model, although non-US-born Caucasian women had higher levels than others. PCBs are generally higher in more developed countries; this effect may have also been due to older age among Caucasian women. Similarly non-US Caucasians had lower TN levels than US-born women. TN may be absorbed from exposure following use of chlordane as a termiticide in homes or from contamination of food. Fish in NYC waters are contaminated with chlordane residues, and levels were detectable in a number of homes in the surrounding area when they were tested in the 1980s (The Long Island Breast Cancer Study, 2003).

Pregnant women who bought fresh fish had significantly higher adjusted PCB levels. Exposure from eating fresh fish from contaminated waters has been well documented (Fitzgerald et al., 2004; Hanrahan et al., 1999). Our finding of an association of PCBs with having bought fresh fish is consistent with those reports. More specific questions, including kind of fish store or locally caught fish, were not associated with any OC, but the numbers were small. Limited data on fish intake from the FFQ did not support these associations, which is consistent with the fact that we administered the Block FFQ specifically asking about their average dietary habits during the pregnancy only, whereas the environmental questionnaire asked about general/lifetime consumption/purchase of fish. In addition, fewer Black and Latina women than Caucasians completed the FFQ, which may influence the associations.

Previous studies have reported an ethnic difference in OC levels where non-White women had higher residues compared to Caucasians. Ethnic differences have been reported for DDE in particular (James et al., 2002; Wolff et al., 2000). Here we observed higher DDE and PCB body burden levels in Caucasian women compared to non-Caucasians, which may be attributable to the older age of the Caucasian women in this study than non-Whites and the non-US birth of some Caucasian women with high levels.

History of smoking was found to be inversely associated with TN levels in this study. In contrast, a recent study on OC levels of neonates born to smoking mothers showed higher body burden levels in their offspring compared to the offspring of nonsmokers (Lackmann et al., 2000). The investigators suggest that smoking may facilitate OC uptake by a fetus. Smoking in our population differed by birthplace and race, which may have led to spurious associations.

For most past studies, DDE has been found to be two to four times higher than PCBs, a pattern that has become reversed in some recent reports. In our study median DDE levels were lower than PCB levels ($P<0.0001$, rank-sum test). There was a weak inverse association of BMI with all of the OCs, and it was significant for PCBs in the final models. Together, these two observations are consistent with ongoing exposure to PCBs in NYC women, as previously suggested (Wolff, 1999).

Published studies have reported both positive and negative associations of OC levels with BMI. These variations are likely due to timing of exposure and pharmokinetics of OCs and are affected by age and serum lipids. A recent study by Moysich et al. (2002) reported no evidence of an association between BMI and DDE levels but found a moderate inverse association between BMI and higher chlorinated PCBs and a weak positive correlation with lower chlorinated PCBs. BMI serves as a crude measure of the body's adipose reservoir. Unmetabolized OCs are stored in lipids and, for a population with similar overall intake, women with more adipose tissue have lower measured levels of OCs and a longer elimination half-life.

Even though serum OC levels in our population were very low, associations with environmental and socio-demographic variables were still detected. Whether such levels have implications for health is not known. One study found an inverse association of low levels of DDE with height in girls (Karmaus et al., 2002), while another found that fatty acids but not DDE levels were associated with birthweight in multivariate analyses (Grandjean et al., 2001). PCB levels in our population were higher than DDE levels, a pattern seen in some other recent studies (Cole et al., 2002; Nadon et al., 2002) but quite different from relative levels in earlier decades. In the 1960s, DDE levels were approximately 10 times PCB levels; in the 1970s they were approximately two to three times; in the 1980s they were about twice; and recently about equal (Wolff et al., 2000).

5. Conclusion

Our results and other recent reports, along with the suggestion that there exist continuing exposure to PCBs from the environment, indicate that levels of OCs are low but they continue.

Acknowledgments

We are grateful to Ahna Blutreich, Elissa Schnall, Marissa Savarese, Stefanie Meisel, and Martha Malagon for their extensive help in the conduct of this study, and we thank Zhisong Liu and Karen Ireland for the laboratory analyses. We thank Dr. Julie Britton for advice on the dietary analysis. This research was supported by grants from The New York Community Trust, ATSDR/CDC/ATPM, PO1ESO9584 from NIEHS, R827039 from EPA, and T35 ES07298 from NIEHS (short-term training grant to F.O.).

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