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Maternal Fish Consumption and Infant Birth Size and Gestation: New York State Angler Cohort Study

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Published: 2 June 2003

Received: 5 March 2003

Environmental Health: A Global Access Science Source 2003, **2**:7

Accepted: 2 June 2003

This article is available from: <http://www.ehjournal.net/content/2/1/7>

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Abstract

Background: The scientific literature poses a perplexing dilemma for pregnant women with respect to the consumption of fish from natural bodies of water. On one hand, fish is a good source of protein, low in fat and a rich source of other nutrients all of which have presumably beneficial effects on developing embryos and fetuses. On the other hand, consumption of fish contaminated with environmental toxicants such as polychlorinated biphenyls (PCBs) has been associated with decrements in gestation and birth size.

Methods: 2,716 infants born between 1986–1991 to participants of the New York State Angler Cohort Study were studied with respect to duration of maternal consumption of contaminated fish from Lake Ontario and its tributaries and gestation and birth size. Hospital delivery records (maternal and newborn) were obtained for 92% of infants for the ascertainment of gestation (weeks), birth size (weight, length, chest, and head circumference) and other known determinants of fetal growth (i.e., maternal parity, history of placental infarction, uterine bleeding, pregnancy loss or cigarette smoking and infant's race, sex and presence of birth defect). Duration of maternal fish consumption prior to the index infant's birth was categorized as: none; 1–2, 3–7, 8+ years, while birth weight (in grams), birth length (in centimeters), and head and chest circumference (in centimeters) were left as continuous variables in multiple linear regression models. Birth size percentiles, ponderal indices and head to chest circumference ratios were computed to further assess proportionality and birth size in relation to gestational age.

Results: Analysis of variance failed to identify significant mean differences in gestation or any measure of birth size in relation to duration of maternal lifetime fish consumption. Multiple linear regressions identified gestational age, male sex, number of daily cigarettes, parity and placental infarction, as significant determinants of birth size.

Conclusions: The results support the absence of an adverse relation between Lake Ontario fish consumption and reduced birth size as measured by weight, length and head circumference.

Biological determinants and maternal cigarette smoking during pregnancy remain important determinants of birth size.

Background

Consumption of fish from fresh and marine bodies of waters poses an interesting paradox. On one hand, there is increasing and rather convincing observational and experimental data underscoring the beneficial effects of marine fish consumption on fetal growth and gestation [1–3]. On the other hand, consumption of environmentally contaminated fish has been associated with decrements in gestation and birth weight in some studies [4–6]. Animal evidence suggests that Rhesus monkeys, rats and mice exposed to polychlorinated biphenyls (PCBs) in utero have reductions in length of gestation and growth [7–9]. The results from accidental environmental exposures also report adverse effects on birth size and ectodermal manifestations among fetuses to various polyhalogenated hydrocarbons [10,11]. One occupational study has reported a negative relation between PCB exposure and infant birth weight, which no longer remained significant after adjusting for gestation and other variables related to birth weight [12]. Results from a birth cohort study in the Faroe Islands, a community with a high intake of marine fish, whale meat and blubber, supported a relation between marine fatty acids and diminished birth weight for gestation, but the effects were not attributed to the mercury or PCB exposure [13].

Fish consumption is a major dietary route of exposure for humans to PCBs [14–16]. Among anglers in the Great Lakes basin, sport fish consumption is the largest dietary contributor to persistent compounds [17]. Concern about consumption of fish from contaminated bodies of water has fostered research focusing on such consumption and pregnancy outcomes including the gestational age and birth weight of exposed infants. For example, consumption of fish from the Baltic Sea has been linked to preterm delivery and reduced birth weight and, possibly, fetal growth restriction [18]. Similar associations have been reported for women consuming fish from the Great Lakes with an effect comparable in magnitude to that reported for cigarette smoking, i.e., 160–190 grams [4]. A few investigators have evaluated risks associated with fish consumption in the context of cigarette smoking, a known determinant of fetal growth. For example, Olsen et al. [19] has reported a positive relation between marine fishmeals and placental weight but only among non-smoking women. Other findings remain equivocal with several authors reporting decrements in gestation and birth weight associated with fish consumption [4–6,20,21] while others do not [22–24].

To date, there has been limited attention paid to fish consumption amongst other known determinants of gestation and fetal growth in an attempt to weigh risk in relation to these factors. This gap may reflect the utilization of maternal self-report or birth certificate data for the collection of information on birth size and potential confounders. Both sources vary in terms of the validity and reliability of information on maternal pre- and gravid disease and pregnancy complications and require cautious interpretation of findings [25–27]. We believe that this has hampered a more complete interpretation of findings regarding the hazards of fish consumption on fetal development. The message to the public remains unclear despite the potential health hazard associated with fish consumption. This hazard reflects the persistent and lipophilic nature of PCBs and related compounds and their ability to bioaccumulate within the aquatic food chain. Consistent with this exposure scenario, we undertook a study to assess consumption of contaminated fish and birth size in the context of other determinants of gestation and fetal growth. In addition, we attempted to assess risks posed by such chronic low levels of exposure by estimating the effect of fish consumption on the proportionality of birth size [28].

Methods

Study sample

The referent study population comprised 4,226 infants born between 1986–1991 to 7,564 female and 10,518 male participants in the New York State Angler Cohort Study (NYSACS). This time period coincided with the five years prior to the initiation of the NYSACS. Using a cross-sectional design, the NYSACS selected a stratified random sample of licensed anglers aged 18–40 years who resided in 16 counties in close proximity to Lakes Erie and Ontario. Surveys were systematically mailed in four waves to 30,000 anglers to assess three research objectives in the overall NYSACS: 1) characterize recent (in 1991) species specific fish consumption behaviors and knowledge of fish consumption health advisories among anglers; 2) to characterize exposure in targeted individuals to persistent environmental pollutants such as PCBs among men and women consuming large amounts of fish; and 3) to assess fish consumption in relation to reproductive and developmental endpoints. After two follow-up attempts, 39% of male and 49% of female anglers returned completed questionnaires and comprise the study cohort. A more complete description of the NYSACS is provided elsewhere [29].

In addition to completing questions regarding offspring, cohort members were individually linked to the New York State Live Birth Registry to verify offspring using an *a priori* matching algorithm following Institutional Review Board approval. The research staff at the New York State Health Department, who was masked to fish consumption status, confirmed all linkages. Study participants voluntarily completed an 8-page self-administered questionnaire on fish consumption habits and select sociodemographic characteristics. (Questionnaire available upon request.)

Given the small number of multiple births, the dependent nature of pregnancy outcomes and to minimize recall bias, we restricted the study sample to the most recent singleton births ($n = 2,716$; 70%). This approach recognizes the dependent nature of pregnancy outcomes (i.e., repetition of adverse outcomes such as low birth weight in successive pregnancies) [30]. Based upon *post hoc* power estimates, our study was able to detect a 61-gram reduction in birth weight based upon an 80% power and 5% alpha.

Data collection

Data were collected from two sources – mailed self-administered questionnaires and hospital delivery records. The 8-page questionnaire ascertained information on lifetime fish consumption and select sociodemographic characteristics such as household income in four mutually exclusive categories. Hospital delivery records were abstracted to elicit information on known determinants of birth size and birth weight, length, head and chest circumference.

Duration of fish consumption referred to the number of years consuming any fish from Lake Ontario, the most polluted Great Lake [31], and its tributaries. Sport fish from the Great Lakes fish are among the most highly exposed fish species with respect to PCBs, dioxin and mirex [31]. However, sport fish from Lakes Erie and Ontario are within the tolerance limits for mercury. For analysis, duration of fish consumption was categorized into four categories: none, 1–2, 3–7, and 8+ years.

Women were asked to check whether they had consumed fish from Lake Ontario and its tributaries for each year starting with 1955 up to and including the year of birth of the index child. Cohort members were queried about frequency of fish consumption meals only for 1991 or the year they were enrolled into the NYSACS. Since cohort members were selected to be between the ages of 18–40 years, the period of fish consumption duration typically referred to lifetime consumption for most cohort members consistent with the persistent bioaccumulation of PCBs in aquatic ecosystems. Years consuming fish were summed into a duration variable, which has previously

been found to be an important determinant of subtle alterations in human reproduction (e.g., decreased fecundability and shortened menstrual cycle length) in the NYSACS [32,33].

Hospital delivery records for mothers and infants were obtained for 92% of infants from 101 hospitals throughout New York State to ascertain information on known determinants [34] of fetal growth as measured by birth size. Hospital closure or the inabilities of hospital staff to locate records were the main reasons for not obtaining missing records. Gestational age and birth size measurements were abstracted from hospital delivery records by trained nurses/researchers who were blinded to maternal fish consumption status. Health insurance and marital status were abstracted from medical records in their original formats and dichotomized for analysis – insured yes/no and married/unmarried. Gestational age was the clinical (obstetric) estimate listed in the medical record. Birth size measurements included birth weight (grams), birth length (centimeters) and head and chest circumference (centimeters). To permit comparison of birth size outcomes for infants in this study with live born infants in the United States, percentiles for birth weight, length and head circumference were established for each infant in the sample using recognized published standards [35]. These growth standards are infant sex specific. For each infant, a ponderal index (PI) was calculated as a measure of proportionality of birth size using the established formula: 100 times birth weight in grams divided by the cube of birth length in centimeters [36]. A second measure of proportionality and fetal growth restriction, the head to chest ratio, was calculated for all infants. This ratio is derived from the following formula: head circumference in centimeters divided by chest circumference in centimeters [37]. The PI and head to chest ratio are indices intended to give patterns of proportionality based on traditional measures of birth size, i.e., weight, length, chest circumference, and head circumference.

The following study covariates or known determinants of fetal growth (34) were abstracted from hospital delivery records and operationalized in a manner most consistent with most hospital records: maternal and infant race (white/nonwhite), parity (left continuous), uterine bleeding during pregnancy (yes/no), history of previous spontaneous abortion (yes/no), cigarette smoking during pregnancy (yes/no; if yes, average number daily cigarettes smoked during pregnancy), evidence placental infarction (yes/no), infant sex (male/female), gestational age (left continuous), placental infarction (yes/no), and birth defect (yes/no). Birth defects, a heterogeneous grouping of defects recorded in hospital delivery records, were included given that affected infants are reported to have lighter or heavier birth weights depending upon the

nature of the defect. In the abstraction process, nurses were instructed to note any discrepancies or uncertain information for review by the study's developmental pediatrician who made all final coding decisions while remaining blinded to fish consumption status.

Analysis

Descriptive statistics were performed to assess consumption patterns by select covariates and birth size measures. Statistical significance ($p < 0.05$) was determined with the chi-square statistic or Student-T test depending upon level of measurement for each variable. The analytic phase of analysis included use of analysis of variance to assess potential effect modification between fish consumption, gestational age and mean birth size measurements. Gestational age was categorized as: preterm <37 weeks, term 37–41 weeks, and post-term 42+ weeks. Separate multiple linear regression models were tested to identify determinants of birth weight, length, head and chest circumference. Specification of the model for each measure of birth size included duration of maternal fish consumption in four categories, infant characteristics (i.e., gestation, sex and birth defects) and maternal characteristics (i.e., parity, placental infarction, uterine bleeding, and average number daily cigarettes smoked during pregnancy). Subsequently, the analyses were rerun after excluding 469 infants for whom birth defects were noted in hospital delivery records. Variables for each multivariate model were selected using a $p = 0.25$ cut point and were retained in the final model if the covariate achieved statistical significance $p < 0.05$ (38). Duration (in four categories) of maternal sport fish consumption was forced into the model while all other covariates were entered using a forward stepwise approach. Models were run using SAS v8.01 (39). Missing data were uniformly omitted from all analyses and account for varying totals.

Results

A description of the sample by maternal fish consumption is presented in Table 1. Infants were predominantly born to married women (93%) covered by health insurance (98%). Approximately 45% of households had incomes above \$40,000. Mothers who consumed fish were significantly older than non-consumers but the difference was negligible. Mothers consuming fish for 8+ years were more likely to be parity 2+ than non-consumers, i.e., 32% and 23%, respectively. However, no other significant differences with respect to reproductive history were observed across categories of maternal fish consumption (data not shown). Mothers in the highest fish consumption category smoked significantly more cigarettes per day than mothers in other categories of consumption. No difference in frequency or mean alcohol consumption during pregnancy was observed by consumption status.

No significant mean differences in any measure of birth size (including percentiles, ratios or indices) were observed across categories of fish consumption and gestation. See additional file 1: fish consumption and birth size. One noted exception was that post-term infants whose mothers reported consuming fish for 8+ years had slightly smaller head circumferences than other infants, but these effects were negligible (<1 cm) and based on small sample sizes. Similar findings were observed for chest circumference though the findings only attained borderline ($p = 0.06$) significance.

The results of multiple linear regression analysis where the same model was tested for each measure of birth size (excluding percentiles) are presented in Table 2, and reflect the absence of a significant effect for fish consumption on birth weight, length or head circumference. Cigarette smoking during pregnancy was significantly associated with all birth size measures as were gestational age, male gender and parity. Specifically, cigarette smoking during pregnancy was associated with a predicted decrement in birth weight, length, head and chest circumference while gestation, parity and male gender conferred positive effects. Overall, the models with study covariates included accounted for between 10–21% of the variation in birth size measures.

Similar results were observed after restricting the analysis to infants without birth defects (Table 3). Fish consumption was not significantly associated with birth weight, length or head circumference. However, consumption of fish for 8+ years was significantly associated with a decrement in chest circumference (-0.49 ; 95%CI = $-0.87, -0.11$). However, this finding was based on half the sample size ($n = 1,050$) reflecting a sizable amount of missing data on chest circumferences in hospital records. A second observed difference when restricting to infants free of birth defects was that uterine bleeding no longer remained significantly associated with birth length. However, uterine bleeding was of borderline ($p = 0.0551$) significance in the analysis using all infants regardless of birth defects.

Discussion

We did not find any evidence of an adverse relation between duration of maternal consumption of fish from Lake Ontario and its tributaries and gestational age or birth size. Overall, our findings agree with the results of earlier investigators who reported no adverse effects associated with fish consumption [22–24] and support the voluminous body of literature denoting gestation, male sex, parity, cigarette smoking, placental infarction, and birth defects as determinants of fetal growth and birth size. We are using fish consumption as a proxy for PCB exposure while simultaneously assessing the effect of fish

Table 1: Infant and maternal characteristics of study sample by maternal fish consumption

Characteristic	Maternal Fish Consumption (years)							
	0		1-2		3-7		8+	
	n	%	n	%	n	%	n	%
Infant Characteristics								
Gestational age (wks)								
<37	76	4	4	1	12	4	11	4
37-41	1582	88	288	89	259	87	254	89
42+	145	8	30	9	27	9	20	7
Infant race								
White	1697	99	355	98	324	100	310	99
Nonwhite	20	1	6	2	1	-	3	1
Maternal Characteristics								
Mean maternal age at birth* (years (SD))	1717	28.1(4.0)	361	28.1(4.1)	325	28.8(3.9)	313	28.7(3.9)
Marital status								
Married	1578	94	331	93	311	97	289	93
Unmarried	104	6	24	7	10	3	22	7
Health insurance								
Yes	1635	97	302	97	267	99	251	96
No	35	3	7	3	3	1	9	4
Household income								
<\$15,000	51	3	17	5	11	4	16	5
\$15,000-\$24,000	219	14	61	18	45	14	41	14
\$25,000-\$39,999	606	38	122	36	113	36	112	38
≥ \$40,000	739	46	141	41	145	46	125	43
Gravidity								
1	399	23	89	25	74	23	53	17
2	621	36	128	36	111	34	105	34
3+	697	41	144	40	140	43	155	50
Parity*								
0	575	34	126	35	103	32	75	24
1	755	44	142	39	147	45	137	44
2+	386	23	93	26	75	23	101	32
Mean number of daily cigarettes during pregnancy (SD)*	1605	2.6(6.5)	337	2.8(6.5)	306	2.3(5.5)	291	3.7(7.1)
Mean number of monthly alcoholic drinks during pregnancy (SD)	1633	0.2(2.4)	349	0.2(1.0)	310	0.3(2.1)	296	0.4(4.9)

NOTE: Duration of maternal fish consumption refers to the number of years eating fish from Lake Ontario and its tributaries between 1955 and infant's year of birth. * p < 0.05

consumption on pregnancy outcomes such as gestation and birth size. Specifically, our exposure measure relies on maternal report and focuses exclusively on fish consumed from Lake Ontario and its tributaries. These noteworthy limitations necessitate the need for cautious interpretation in the context of previous work. Other explanations for the absence of an observed effect may be the secular decline in the contaminant load of PCBs and other contaminants in fish [40], residual confounding stemming from our inability to control for duration of breastfeeding prior to the index pregnancy [41] or other unmeasured confounders. The absence of an effect for the highest cat-

egories of consumption fails to support the former explanation, which would be consistent with eating for longer periods of time including the 1970s when fish were most contaminated. Our study is unable to evaluate potential acute exposures associated with ingestion of a fish meal given that we only ascertained monthly meals for 1991 as a crude measure of recent consumption in the context of health advisories to the contrary. Upon further inspection of our data, however, we observed that the majority of women reporting having eaten fish from Lake Ontario and its tributaries reported eating fish in 1991 despite health advisories to the contrary.

Table 2: Predictors of birth size – multiple linear regression

Covariate	Weight		Length		Head Circumference		Chest Circumference	
	β Coefficient	95% CI	β Coefficient	95% CI	β Coefficient	95% CI	β Coefficient	95% CI
Duration of maternal fish consumption								
1–2 years	6.37	-46.75, 59.49	0.06	-0.23, 0.36	-0.04	-0.22, 0.14	-0.23	-0.54, 0.08
3–7 years	-20.46	-75.93, 35.02	0.03	-0.27, 0.33	-0.05	-0.24, 0.14	-0.24	-0.57, 0.09
8+ years	-37.62	-94.25, 19.01	0.06	-0.25, 0.36	-0.18	-0.38, 0.01	-0.29	-0.65, 0.06
Male infant	122.25	86.68, 157.85	0.82	0.62, 1.01	0.55	0.42, 0.67	0.37	0.17, 0.58
Number of daily cigarettes	-14.70	-17.45, -11.95	-0.07	-0.08, -0.05	-0.02	-0.03, -0.01	-0.04	-0.06, -0.03
Parity	99.64	75.78, 123.50	0.21	0.08, 0.34	0.20	0.12, 0.28	0.40	0.27, 0.54
Placental infarction	-232.84	-407.70, -57.97	-1.13	-2.07, -0.20			-1.25	-2.20, -0.30
Birth defect Gestation	83.94	31.92, 135.95	0.29	0.01, 0.58	0.25	0.07, 0.43		
	146.13	131.13, 161.13	0.59	0.50, 0.67	0.32	0.27, 0.37	0.51	0.42, 0.59
Uterine bleeding			-0.28	-0.56, 0.01				
R-squared	0.21		0.15		0.10		0.17	
n	2,404		2,289		2,461		1,231	

NOTE: Duration of maternal fish consumption refers to the number of years eating fish from Lake Ontario and its tributaries between 1955 and infant's year of birth. CI = confidence interval; n = sample size for each model

Table 3: Predictors of birth size among infants without birth defects – multiple linear regression

Covariate	Weight		Length		Head Circumference		Chest Circumference	
	β Coefficient	95% CI	β Coefficient	95% CI	β Coefficient	95% CI	β Coefficient	95% CI
Duration of maternal fish consumption								
1–2 years	13.49	-41.42, 68.41	0.09	-0.21, 0.39	0.04	-0.15, 0.22	-0.16	-0.48, 0.16
3–7 years	-14.45	-72.70, 43.80	0.12	-0.20, 0.44	-0.03	-0.23, 0.16	-0.29	-0.64, 0.06
8+ years	-37.03	-96.66, 22.60	0.06	-0.27, 0.38	-0.15	-0.35, 0.05	-0.49	-0.87, -0.11
Male infant	117.04	79.91, 154.17	0.78	0.58, 0.98	0.56	0.43, 0.68	0.37	0.16, 0.59
Number of daily cigarettes	-14.79	-17.63, -11.95	-0.07	-0.08, -0.05	-0.02	-0.03, -0.01	-0.05	-0.06, -0.03
Parity	97.22	72.11, 122.34	0.23	0.09, 0.37	0.21	0.12, 0.29	0.37	0.23, 0.52
Placental infarction	-316.55	-511.55, -121.56	-1.57	-2.63, -0.51			-1.47	-2.56, -0.37
Gestation (weeks)	144.43	128.68, 160.17	0.56	0.47, 0.64	0.32	0.26, 0.37	0.49	0.40, 0.58
R-squared	0.21	0.14	0.11	0.17				
n	2,079	2,022	2,137	1,050				

NOTE: Restricted to infants without birth defects noted in hospital delivery records (n = 2,247). Duration of maternal fish consumption refers to the number of years eating fish from Lake Ontario and its tributaries between 1955 and infant's year of birth. CI = confidence interval; n = sample size for each model

We posit that one explanation for observed differences in results across studies is the lack of attention to known determinants of gestation and fetal growth when assessing fish consumption as well as the dependent nature of pregnancy outcomes. One frequently cited study reporting a negative association with Great Lakes fish consumption and birth size did not appear to include cigarette smoking in the model [4] as noted by at least one other author [42]. A few authors have noted that the fish consumption effect, despite being negatively associated with birth size, is small in comparison to other covariates important for fetal growth and development [12,24], which is more in keeping with our findings.

Several investigators have reported positive effects of maternal consumption of marine sport fish on gestation or the rate of fetal growth [1,3,19], or conversely an increased risk of preterm delivery or low birth weight associated with a maternal diet low in marine fish [43]. We did not observe (nor were we able to refute) these relations, though we did observe a negative albeit small association between maternal sport fish consumption and birth size among post-term infants, which disappeared after controlling for other determinants of fetal growth as measured by birth size. Still, we do not know what aspect of fish consumption, particularly, marine fish consumption, confers the positive effect on fetal growth as reported by other investigators.

The health benefits or hazards associated with fish consumption will require added attention to origin of fish – marine or fresh water – given the reported differences in stores of polyunsaturated fatty acids and N-3 fatty acid between the two types of fish [44–47]. Levels of N-3 fatty acids vary by fish species, oil content of fish, sex and age of fish, and factors exogenous to fish such as water temperature [47,48]. Oily fish from cold waters (whether marine or fresh bodies of water) are reported to have higher levels of N-3 fatty acids in comparison to fish from warmer bodies [45,47]. The ratio of N-3 to N-6 fatty acids has recently been suggested as being associated with gestation and birth weight [49] and this ratio is approximately four-times greater in marine fish in comparison to fresh water fish [45]. Type and species-specific fish consumption will remain important considerations in assessing exposure scenarios based on fish consumption.

Our findings require careful interpretation for three key reasons: (1) the absence of maternal serum for quantifying PCB and other environmental exposures; (2) the retrospective reporting of fish consumption by mothers in this observational study; and (3) the potential selectiveness of our sample based on licensed fish holders who agreed to participation. Our exposure is maternally reported Lake Ontario fish consumption and is only a

crude proxy for PCB body burden. We recognize this limitation and have focused our attention on fish consumption rather than serum PCB concentration, *per se*. We were unable to directly assess the validity or reliability of fish consumption for this sample of mothers with respect to life time duration of fish consumption. Rather, we have circumstantial evidence from the overall New York State Angler Cohort Study, which attempted to evaluate the reliability (as measured by percent agreement) of self-reported fresh water fish consumption. Specifically, a subsample of 100 participants were randomly selected for telephone interviews approximately 3–6 months after receipt of the mailed self administered questionnaire. The percent agreement for the number of monthly species-specific fish meals consumed in 1991 ranged from 85–89% (Pearson $r = 0.4-0.7$) when comparing questionnaire and telephone interview data. With respect to response bias in the overall NYSACS, 100 non-participants were randomly selected and compared to respondents. Non-respondents more likely to be nonwhite, to have lower educational attainment and household incomes than respondents, but did not differ with respect to reported fish consumption (unpublished data available upon request). We recognize the potential for selection bias in that only 3% to 4% of infants were preterm or low birth weight in our sample. This may reflect our use of a state fish license registry as the sampling framework for ascertaining anglers in the NYSACS. As such, socially and economically disadvantaged families, traditionally at higher risk for these two adverse pregnancy outcomes, may be less able to purchase a fish license in comparison to more advantaged families. Such sampling may have resulted in under representation of women at highest risk of having an infant born preterm or of diminished size.

At this time, our findings add to rather than demystify the uncertainty regarding the relation between maternal fish consumption and infant gestation and birth size. Further clarification regarding the potential developmental sequelae associated with fish consumption remains an important public health priority, as fish remains an important dietary source of long chain n-3 fatty acids and proteins for vulnerable populations such as pregnant women, fetuses and infants. We support an earlier appeal for definitive work to demystify findings so the public can be advised accordingly (50). Such efforts should estimate risk based on valid and reliable PCB exposure data with concerted attention to other known determinants of outcomes such as gestation and fetal growth.

List of Abbreviations

NYSACS, New York State Angler Cohort Study

PCB, polychlorinated biphenyls

PI, ponderal index

Competing Interests

None of the authors have any competing interests, financial or otherwise.

Authors' Contributions

GMB, EFF, JEV, JMW, and MEM were instrumental in conceptualizing the research question and study design and in preparing the paper. PGT and MS were responsible for preparing the analytic files and implementing the analytic plan, under the direction of GMB and JMW, and in the preparation of this paper. MEM was solely responsible for reviewing medical records flagged by nurse abstractors. All authors have read and approved the final manuscript.

Additional material

Additional File 1

Birth Size Measures by Duration of Maternal Fish Consumption and Gestational Age. Table comparing means for measures of birth size by maternal fish consumption and gestational age of infants, New York State Angler Cohort Study, 1986 = 1991

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Acknowledgements

Supported in parts with grants from the Great Lakes Protection Fund (RM 791-3021) and the Agency for Toxic Substances & Disease Registry (H75/ATH29832800). The authors thank Bridget McGuinness for her technical assistance with file preparation, Terri Raimondo for programmatic technical assistance, Danielle Belser for verifying linkages, and Mary Ann Snyder and Sylvia Vena for medical record abstraction.

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Pre-publication history

The pre-publication history for this paper can be accessed here:

<http://www.biomedcentral.com/content/backmatter/1476-069X-2-7-b1.pdf>

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