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# Fish consumption prior to pregnancy and pregnancy outcomes in the National Birth Defects Prevention Study, 1997-2011

**Renata H. Benjamin**[1], **Laura E. Mitchell**[1], **Mark A. Canfield**[2], **Adrienne T. Hoyt**[2], **Dejian Lai**[3], **Tunu A. Ramadhani**[2], **Suzan L. Carmichael**[4], **Amy P. Case**[2], **D. Kim Waller**[1], and **National Birth Defects Prevention Study**

[1]Department of Epidemiology, Human Genetics and Environmental Sciences, UTHealth School of Public Health, Houston, Texas

[2]Birth Defects Epidemiology and Surveillance Branch, Texas Department of State Health Services, Austin, Texas

[3]Department of Biostatistics, UTHealth School of Public Health, Houston, Texas

[4]Department of Pediatrics, Stanford University, Stanford, California

## Abstract

**Objective:** To evaluate the relationships between maternal fish consumption and pregnancy outcomes in a large, population-based sample of women in the United States.

**Design:** We collected average fish consumption prior to pregnancy using a modified version of the semi-quantitative Willett food frequency questionnaire. We estimated adjusted odds ratios (aORs) and 95% confidence intervals (CIs) for associations between different levels of fish consumption and preterm birth (<37 weeks), early preterm birth (<32 and <35 weeks), and small for gestational age infants (SGA; <10$^{th}$ percentile).

**Setting:** The National Birth Defects Prevention Study (NBDPS).

**Subjects:** Control mother-infant pairs with estimated delivery dates between 1997 and 2011 (n=10,919).

**Results:** No significant associations were observed between fish consumption and preterm birth or early preterm birth (aORs 0.7–1.0 and 0.7–0.9, respectively). The odds of having an SGA infant were elevated (aOR 2.1, 95% CI: 1.2, 3.4) among women with daily fish consumption compared

**Address for correspondence:** Renata Benjamin, University of Texas Health Science Center at Houston (UTHealth), School of Public Health, 1200 Pressler Street, E511, Houston, TX 77030, Renata.H.Benjamin@uth.tmc.edu, Phone: 713-500-9955, Fax: 713-500-0900.

Authorship:

R.H.B. was involved in study design, literature review, data analysis, and manuscript writing L.E.M., M.A.C., T.A.R, S.A.C., and A.P.C. were involved in study design and manuscript revisions A.T.H. replicated analyses and was involved in manuscript revisions D.L. supervised statistical methods and reviewed the manuscript D.K.W. was the senior investigator involved in study design, analysis, and manuscript revisions</author_notes>

**Conflict of Interest:** None

**Ethical Standards Disclosure:** This study was conducted according to the guidelines laid down in the Declaration of Helsinki and all procedures involving human subjects were approved by the Institutional Review Board for each center. Approval for this secondary analysis was granted by The University of Texas Health Science Center at Houston Committee for the Protection of Human Subjects.

to women consuming fish less than once per month. No associations were observed between other levels of fish consumption and SGA (aORs 0.8–1.0).

**Conclusions:** High intake of fish was associated with 2-fold higher odds of having an SGA infant, while moderate fish consumption prior to pregnancy was not associated with preterm or SGA. Our study, like many other studies in this area, lacked information regarding preparation methods and the specific types of fish consumed. Future studies should incorporate information on nutrient and contaminant content, preparation methods, and biomarkers to assess these relationships.

### Keywords

fish intake; preterm birth; small for gestational age; pregnancy complications

## Introduction

Fish, including both freshwater and saltwater fish and shellfish species, provide high quality protein and nutrients, including long chain omega-3 polyunsaturated fatty acids (docosahexaenoic acid (DHA) and eicosapentaenoic acid (EPA))[1–3]. DHA and EPA are important for fetal neural and retinal development and they may reduce inflammatory processes, increase vasodilation, reduce platelet aggregation, and influence the onset of labor through prostaglandin synthesis[1,2,4]. However, fish may also contain contaminants, such as methylmercury and persistent organic pollutants, which may adversely affect fetal development and impact pregnancy outcomes[5].

Preterm and small for gestational age (SGA) infants are at increased risk of morbidity, mortality, and long term developmental deficits[6,7]. Growth restriction and preterm delivery can sometimes be attributed to known causes, such as medical conditions and gestation of multiples; however, the etiology remains unclear in many cases and novel approaches to prevention are needed. Recent studies[8–15] suggest that consuming fish during pregnancy may increase birthweight and help to protect against preterm birth; however, concerns remain about the effects of contaminants found in fish on fetal health. These concerns are heightened by several recent studies that have reported associations between high consumption of specific types of fish and increased risk of preterm birth or SGA[16–18].

Most of the studies that have assessed the associations between fish intake and pregnancy outcomes have been conducted in coastal European countries (Norway, Spain, France, and Denmark), where fish consumption habits are different than those in the United States (US) [9,10,13–17]. Per capita fish consumption in Norway is twice as high as that of the US and inland farmed fish, including tilapia and catfish, make up a larger proportion of the domestic fish supply in the US than in Europe[19]. Prior US studies examining the relationships between fish consumption and birth outcomes have focused on specific populations: one was a clinical trial of women at high risk for preterm birth[11] and two were cohorts of predominantly non-Hispanic white women (66–88%) living in specific geographic regions (Boston and Washington State)[18,20,21]. Results from European studies and prior US studies may not generalize to the US population as a whole.

The objective of this study was to evaluate associations between fish consumption and preterm birth or SGA in a diverse sample of US women. To do so, we used data from the National Birth Defects Prevention Study (NBDPS), which surveyed a population-based sample of women as part of a case-control study of birth defects. Only control participants, who delivered an infant without a major structural birth defect, were included in the current analyses. To our knowledge, this is the largest US study to examine the relationship between maternal fish intake and preterm birth and SGA.

## Methods

### Population and Design

The NBDPS was a multi-site, population-based, case-control study of birth defects with ten participating sites across the United States (Arkansas, California, Georgia/Centers for Disease Control and Prevention (CDC), Iowa, Massachusetts, New Jersey, New York, North Carolina, Texas, and Utah)[22]. Controls were unmatched, live-born infants without a major birth defect randomly selected from hospital records or birth certificates who were born during the same time period and from the same geographic area as cases. Mothers were interviewed via a computer assisted telephone interview (CATI) between six weeks and 2 years after delivery[22]. Interviews were conducted between 1997 and 2013 for infants with estimated due dates between 1997 and 2011. Participation rates were 67% among case mothers and 64% among control mothers.

The NBDPS used a shortened version of the semi-quantitative Willett food frequency questionnaire (FFQ) developed for the Nurse's Health Study to collect information on average maternal diet in the year prior to pregnancy, including information on how often women ate a 3 to 5 ounce serving of fish[23]. The questionnaire had 16 possible responses for the frequency of fish consumption, ranging from never/<1 month to 6 times or more per day.

The NBDPS maternal interview collected information about the infant including sex, date of birth, and due date. For our primary analysis, preterm delivery was defined as a birth occurring at less than 37 week of gestation. For additional sensitivity analyses, early preterm birth was defined as a delivery occurring before 35 weeks of gestation and before 32 weeks of gestation. Since this was a secondary analysis of an existing study, we had limited power to evaluate early preterm delivery. However, since research suggests that associations between fish or fish oil consumption and preterm birth may differ between early and late preterm birth[14], we sought to evaluate whether the associations between fish consumption levels and preterm birth differed when restricting preterm to earlier gestational ages. Infant birthweight was collected from medical records or birth certificates. SGA was defined as an infant with a birthweight below the $10^{th}$ percentile for the infant's sex and gestational age compared to a reference population (2011 US birth certificate data)[24]. Cut-offs for the $10^{th}$ percentiles of birthweight were determined separately for each infant sex and within each sex they were determined separately for each week in gestation. While use of birthweight curves specific to maternal race/ethnicity and parity have been used in some studies, prior studies of fish consumption and SGA have used birthweight curves specific to infant sex and

gestational age only. In order to compare our results to prior findings, we chose to use comparable birthweight measures.

## Eligibility Criteria

NBDPS control participants who delivered a live born singleton infant were eligible for inclusion in this study. Mother-infant pairs were excluded if fish consumption data were missing or if the mother had Type I or Type II diabetes prior to pregnancy. Women with diabetes diagnosed prior to pregnancy were excluded from analyses because it is strongly associated with both preterm birth and large for gestational age[25,26] and, with <1% of births among women with Type I diabetes[27], there would not be an adequate number of exposed women to assess confounding. For the SGA analyses, mother-infant pairs were also excluded if the infant's birthweight or sex was not provided or if the infant's gestational age fell outside the range of gestational ages for which a 10$^{th}$ percentile standard was available, i.e., <24 or >42 weeks at delivery.

## Statistical Analyses

To facilitate comparisons with existing literature, we categorized the 16 fish consumption categories from the FFQ as follows: less than once per month, 1 to 3 times per month, 1 time per week, 2 to 6 times per week, and 1 time per day or more. The following potential confounders were selected *a priori*[6,7,28,29] from variables collected in the NBDPS interview and categorized as follows: maternal race/ethnicity (non-Hispanic white, non-Hispanic black, US born Hispanic, foreign born Hispanic, US born other, and foreign born other), maternal age (16–19, 20–29, 30–39, and 40–49), maternal education (≤12 years/HS or GED, 13–15 years/some college or AA, and ≥16/college degree or higher), maternal pre-pregnancy BMI (<18.5, 18.5-<25, 25-<30, and ≥30 kg/m$^2$), household income (<$20,000, $20,000-$50,000, and >$50,000), household size (1–2 people, 3–4 people, 5–6 people, and 7+ people), smoking (no smoking in pregnancy versus any smoking in pregnancy), alcohol use (no alcohol use in periconceptional period versus alcohol use in the periconceptional period), gestational diabetes (no gestational diabetes versus diabetes during pregnancy), hypertension (no hypertension, hypertension with medication, and hypertension without medication), parity (0, 1, 2, and 3 or more prior live births), maternal height (quartiles), as well as average daily intake of calories, carbohydrates, total fat, protein, iron, and zinc in the year prior to pregnancy, calculated from the FFQ[23] and divided into quartiles of intake to allow for non-linear relationships. Hispanic and other (predominantly Asian) race/ethnicity were divided into US born and foreign born because the rates of preterm birth and SGA differ between the groups[30,31]. Furthermore, the associations are in opposite directions, with foreign born Asian mothers at increased risk and foreign born Hispanic mothers at decreased risk of adverse outcomes compared to US born mothers[31]. Non-Hispanic white and black mothers were not further divided by nativity due to the low proportion of foreign born mothers in these groups. The distribution of potential confounders was assessed for differences across fish consumption levels by chi-square tests.

Crude odds ratio (cOR) estimates for the association between each outcome and fish consumption categories were calculated by simple logistic regression. We used 95% confidence intervals (CIs) to assess whether the odds of having a preterm delivery or an

SGA infant differed by level of fish intake using women who reported eating fish less than once a month or never as the reference group. We used logistic regression and the change in estimate method to identify confounders for inclusion in the adjusted model. The initial full multivariable logistic regression model contained indicator variables for four levels of fish intake and all covariates that were described above and that were associated with the outcome ($p<0.25$) in simple logistic regression. The final model estimating adjusted odds ratios (aOR) and 95% confidence intervals for each outcome contained the levels of fish intake and those covariates that resulted in a 10% or greater change in one of the adjusted odds ratios for fish consumption when they were dropped from the full model. Additional sensitivity analyses were conducted looking at the association between fish consumption and early preterm births (<32 weeks and <35 weeks gestation) and SGA restricted to full term infants only.

We assessed interactions between the level of fish intake and the following covariates: maternal race/ethnicity and maternal education. Interaction terms were retained in the multivariable model if the group of interaction terms was significantly associated with the outcome (likelihood ratio test $p<0.05$). We checked model fit for the final models using the Hosmer and Lemeshow Goodness-of-Fit test ($p<0.05$ indicating poor fit). All analyses were conducted using SAS software, Version 9.4 (SAS Institute Inc., Cary, NC, USA). Finally, we assessed how robust the association estimates were to unmeasured confounding by conducting a sensitivity analysis looking at the strength of association that an unmeasured confounder would need to have with both the exposure and the outcome to explain the observed association (E-value)[32]. The E-value aids in assessment of causality in observational studies that may be affected by confounding by quantifying the strength of association an unmeasured confounder would need to have to explain the results: a large value implies a strongly associated unmeasured confounder would need to be present, while a small value implies a weakly associated unmeasured confounder could explain the observed association[32].

## Results

There were 11,829 control mothers included in the NBDPS with estimated due dates between 1997 and 2011 (version 10), and 11,451 (97%) women delivered singletons with a gestational age of at least 20 weeks and were eligible for inclusion in this study. Mothers missing fish consumption data (n=461) or with preexisting Type I or Type II diabetes (n=71) were excluded, leaving 10,919 mother-infant pairs for the preterm analysis. Infants were additionally excluded from the SGA analysis if they were missing birthweight (n=145), infant sex (n=10), or had a gestational age outside the gestational age range of 24 to 42 weeks (n=48). These exclusions left 10,716 mother-infant pairs for the SGA analysis. Overall, 853 (7.8%) infants were preterm and 828 (7.7%) were SGA, while 46 (0.4%) infants were both preterm and SGA.

Women reported 3.3 servings of fish per month on average and 31.6% (n=3,446) of women reported eating no fish or eating it less than once per month (Table 1). Maternal sociodemographic characteristics differed across fish consumption categories (chi-square $p<0.05$, Table 1). Women in the highest consumption group were more likely to be black,

foreign born Hispanic, or foreign born other (self-reported race as Asian, Native American, or other), as compared to women in the lowest consumption group, who were more likely to be white or US-born Hispanic. Women in the highest and lowest consumption groups were more likely to have a high school education or less compared to women with moderate consumption (1–3 times per month, 1 time per week, or 2–6 times per week). Women who consumed fish 1–3 times per month, 1 time per week, or 2–6 times per week were more likely to have a college degree than women who consumed fish daily or less than once a month.

### Preterm Birth

The percent of infants born preterm ranged from 6.7% to 7.6% among women eating fish 1 time per week, 2–6 times per week, or 1 time per day or more compared to 8.2% of infants born preterm among women reporting fish consumption less than once per month (Table 2). After assessing potential confounding (variables assessed shown in the online supporting information, Table S1), maternal race/ethnicity was the only variable retained in the adjusted model and no significant interactions were found (*p*-values 0.31 and 0.38). After adjustment, we observed no association between fish consumption levels and preterm birth (aORs 0.7–1.0). Restricting to early preterm births (<32 weeks and <35 weeks) versus full term births (≥37 weeks), results were similar in both analyses. Results for early preterm birth are presented for <35 weeks only due to sample size limitations (Table 2). We observed no association between fish consumption and early preterm delivery <35 weeks (aORs 0.7–0.9). Odds ratios were not reported for the highest consumption category because this group only contained one early preterm infant.

### SGA

The percent of SGA infants among fish consumers ranged from 7.1% to 20.4% compared to 8.0% among women reporting fish consumption less than once per month (Table 3). After assessing potential confounding (variables assessed shown in the online supporting information, Table S2), the final adjusted model included maternal race/ethnicity and maternal education and no significant interactions were found between fish consumption and either covariate (*p*-values 0.69 and 0.99). Adjusted odds of having an SGA infant for women who ate fish 1–3 times per month (aOR 0.9, 95% CI: 0.8, 1.1), once per week (aOR 1.0, 95% CI: 0.8, 1.2), or 2–6 times per week (aOR 0.8, 95% CI: 0.7, 1.1) were not significantly different compared to women who ate fish less than once per month (Table 3). Consuming fish once per day or more was associated with increased odds of having an SGA infant (aOR: 2.1, 95% CI: 1.2, 3.4) as compared to fish consumption less than once per month. Adjustment for confounders had the greatest impact in the highest consumption category, lowering the odds ratio from 2.9 to 2.1 (Table 3).

Restricting the SGA analysis to term deliveries (≥37 weeks) resulted in nearly identical estimates as the analysis of all SGA births. The highest fish consumption level was associated with elevated odds of having an SGA infant (aOR 2.2, 95% CI: 1.3, 3.6; Table 3). Adjusted odds ratios for the other consumption categories were nearly identical to estimates for the full sample and ranged from 0.8 to 1.0.

Based on the sensitivity analysis calculating the E-value of the robustness to unmeasured confounding, an unmeasured confounder would have to be associated with both the outcome and the exposure by a ratio of 3.6 above and beyond adjustment for the measured confounders to fully explain the observed 2.1-fold higher odds of SGA among daily fish consumers. An unmeasured confounder associated with both the exposure and outcome by a ratio of 1.7 or higher above and beyond the measured confounders could move the confidence interval to include the null.

## Discussion

Our finding of an average of 3.3 servings (3–5 ounces) of fish per month is similar to other studies of US women that reported fish consumption of 3 to 3.5 ounces per week[33,34]. In this study, a higher proportion of women reported consuming fish less than once a month (31.6%) than European studies, where 8–18% of women reported no fish consumption[8,9,16].

A recent meta-analysis that pooled data from 19 European birth cohorts found an 11–13% reduction in preterm birth among women eating fish twice a week or more compared to women eating fish once a week or less[12]. Studies that have categorized fish consumption in a similar manner to our study reported odds ratios for preterm birth of 0.84 for 2 times per week versus once a week or less[13] and 0.65 for 2 times per week or more versus less than once a month[9]. While our association estimates of a 10–30% decrease in the odds of preterm birth among women eating fish twice a week or more were similar in magnitude to these European studies, our study lacked the precision needed to find an association of this magnitude. In contrast to most of the previous studies, one recent US study reported an increased risk of preterm birth among women consuming lean fish more than once per week[18]. We did not observe an increased risk of preterm birth among high consumers in our study, however, we were unable to evaluate lean fish consumption specifically.

Women reporting daily fish consumption had twice the odds of having an SGA infant compared to women who reported eating fish less than once a month; however, this estimate was based on 21 SGA infants and only a small proportion of women reported consumption levels this high. These findings should be replicated in future studies by included a high consumption category. Several prior studies have found an elevated risk of SGA among women consuming high levels of fatty fish[16], shellfish (oysters, mussels, shrimp, prawns, lobster, and crab)[9], crustaceans (a component of shellfish: shrimp, prawns, lobster, and crab)[17], and canned tuna[17]. The adjusted odds ratio estimates for SGA among women consuming shellfish, crustaceans, and canned tuna twice a week or more were of similar magnitude to our findings (ORs 2.14, 2.45, and 2.49, respectively)[9,17]. As shellfish and canned tuna are among the most commonly eaten fish types in the US[3], they may also have been the most commonly eaten types of fish among the women in our study who reported daily consumption of fish.

Evidence of a relationship between high maternal fish consumption and decreased birth weight has also been previously reported in the US. Mohanty et al. used a different outcome measure, low birth weight (<2500 g), and reported a 2.2-fold higher risk among women

consuming lean fish more than once per week compared to non-consumers[21]. While we were unable to evaluate lean fish consumption specifically and replicate this finding in our study, lean fish, including canned light tuna, breaded fish products, and catfish, are also commonly eaten species in the US[3].

Our study was limited by collecting fish consumption using a single question in the FFQ. A previous study demonstrated that a one-item FFQ about fish consumption correlated more closely with plasma DHA concentrations and comparably correlated with methylmercury intake compared to a four- or thirty-six-item FFQ[35]. Longer FFQs were found to provide no advantage over one-item FFQs in ranking intakes of fish, DHA, and methylmercury[35]. As in many previous studies, we were unable to assess which types of fish were consumed by women in the highest consumption group and how preparation methods may have impacted nutrient and contaminant contents. Since both fish and shellfish are sources of nutrients and possibly contaminants, more detailed consumption and preparation data should be collected in future studies. Additionally, since this was a secondary analysis of data from a study of birth defects in which the critical window for development of the outcome occurs early in pregnancy, this study queried average fish consumption during the year prior to conception. Prior studies of fish consumption and pregnancy outcomes vary widely in the timing of collection of fish consumption data, with studies collecting FFQ data in the first trimester[9,18,21], second trimester[11,13,14,16], third trimester[8], or at multiple points in pregnancy[10,15,17]. It is possible that some women in the present study may have changed their consumption habits during pregnancy. Recently Razzaghi & Tinker reported no differences in seafood consumption between pregnant and non-pregnant US women using both detailed 30-day fish intake data and 24-hour dietary recalls collected in the National Health and Nutrition Examination Survey from 1999 to 2006[36]. Additionally, women were asked to recall their average consumption during the year prior to pregnancy, which may have introduced recall bias. Finally, there may be residual confounding or bias affecting our observed associations. Our calculated E-value of 3.6 indicates only a strong unmeasured confounder could fully explain the association observed between daily fish consumption and SGA. None of the potential confounders we did evaluate were associated this strongly with the outcome. While our results are fairly robust to unmeasured confounding and we assessed a number of potential confounders in our analyses, we cannot rule out the possibility that women who reported daily fish consumption may have had other co-occurring health behaviors or dietary patterns that were not assessed and may be driving the results.

The strengths of our study include the large sample size and the diverse study population from multiple regions across the US. We assessed the association between high fish consumption and SGA infants. Previous studies that have grouped fish consumption by quartiles may have masked elevated risk in high consumers by grouping them with moderate consumers. We would not have observed an association between high fish consumption and SGA if we had grouped women consuming fish 2 to 6 times per week with the highest consumers (1 or more times per day). Additionally, as our sample was based on NBDPS controls, none of the infants in our analyses had chromosomal abnormalities or other major structural birth defects, which can impact gestational age at birth and birth weight, and we were able to assess potential confounding by other dietary components calculated from the FFQ.

To the best of our knowledge, this is the first US study to observe an elevated risk of SGA among women reporting daily fish consumption. The elevated risk of SGA we observed among high fish consumers should be confirmed and future studies should collect more detailed data on fish consumption to investigate whether a specific component or contaminant is associated with SGA. Currently the US Food and Drug Administration (FDA) recommends that when eating fish from commercial sources, women of childbearing age and pregnant women should eat 2 to 3 servings of fish lower in methylmercury ("best choices") or 1 serving of fish with moderate methylmercury content ("good choices"), while avoiding high mercury fish[37]. Our results are consistent with the FDA recommendation in suggesting that, with respect to the risk of preterm birth and SGA, moderate intake of fish may be beneficial and high intake may be harmful. These results add to the body of evidence that women of childbearing age should be counseled on appropriate fish consumption for a healthy pregnancy.

## Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

## Acknowledgments

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**Table 1.**

Maternal sociodemographic characteristics associated with fish consumption frequency in the National Birth Defects Prevention Study, 1997–2011

| | | Fish Consumption Frequency (Row %) | | | | | Chi-square *P* value |
|---|---|---|---|---|---|---|---|
| | N | <1/month | 1–3/month | 1/week | 2–6/week | ≥1/day | |
| Total | 10 919 | 31.6 | 33.3 | 21.0 | 13.1 | 1.0 | |
| Age at conception (years) | | | | | | | <0.001 |
| 16–19 | 1286 | 49.5 | 27.6 | 13.5 | 8.0 | 1.3 | |
| 20–29 | 5707 | 33.5 | 33.6 | 20.1 | 12.0 | 0.8 | |
| 30–39 | 3625 | 22.0 | 35.2 | 25.1 | 16.6 | 1.1 | |
| 40–49 | 166 | 16.9 | 31.3 | 27.7 | 23.5 | 0.6 | |
| Race/Ethnicity | | | | | | | <0.001 |
| White | 6373 | 34.6 | 35.6 | 19.4 | 10.1 | 0.3 | |
| Black | 1173 | 16.3 | 31.9 | 25.8 | 23.4 | 2.7 | |
| Hispanic, US born | 1122 | 37.9 | 31.6 | 19.6 | 10.2 | 0.8 | |
| Hispanic, Foreign born | 1502 | 26.2 | 30.1 | 25.8 | 16.3 | 1.6 | |
| Other, US born | 378 | 34.9 | 29.9 | 17.5 | 16.1 | 1.6 | |
| Other, Foreign born | 323 | 25.4 | 21.7 | 21.7 | 26.9 | 4.3 | |
| Education | | | | | | | <0.001 |
| ≤High School | 4409 | 38.5 | 29.3 | 18.1 | 12.6 | 1.5 | |
| Some College | 2918 | 31.4 | 35.2 | 20.3 | 12.4 | 0.8 | |
| College or Higher | 3504 | 22.8 | 37.2 | 25.2 | 14.4 | 0.5 | |
| Height (cm) | | | | | | | 0.006 |
| ≤158 | 2770 | 32.0 | 31.3 | 21.2 | 14.2 | 1.4 | |
| 159-≤163 | 2750 | 31.0 | 35.4 | 19.9 | 12.9 | 0.9 | |
| 164-≤171 | 2466 | 32.7 | 33.8 | 20.7 | 12.0 | 0.8 | |
| ≥172 | 2528 | 30.9 | 34.3 | 21.2 | 13.1 | 0.6 | |
| Previous live births | | | | | | | <0.001 |
| 0 | 4332 | 35.0 | 31.5 | 20.0 | 12.6 | 0.9 | |
| 1 | 3574 | 29.6 | 35.4 | 21.3 | 12.8 | 1.0 | |
| 2 | 1867 | 29.8 | 33.9 | 22.3 | 13.4 | 0.6 | |
| 3+ | 1143 | 27.7 | 32.9 | 22.0 | 15.8 | 1.6 | |
| Smoking during pregnancy | | | | | | | <0.001 |
| No | 8905 | 29.6 | 33.7 | 22.2 | 13.6 | 1.0 | |
| Yes | 1964 | 40.6 | 31.8 | 15.6 | 11.0 | 1.0 | |
| Household income | | | | | | | <0.001 |
| <$20,000 | 3205 | 36.2 | 29.9 | 18.7 | 13.5 | 1.8 | |
| $20,000-$50,000 | 3226 | 34.0 | 35.0 | 19.1 | 11.4 | 0.6 | |
| >$50,000 | 3611 | 24.1 | 36.1 | 25.3 | 14.2 | 0.3 | |
| Number of people living in the household | | | | | | | 0.001 |
| 1–2 | 3618 | 33.0 | 31.6 | 20.8 | 13.9 | 0.7 | |
| 3–4 | 5025 | 30.3 | 35.2 | 21.4 | 12.4 | 0.8 | |

| | | Fish Consumption Frequency (Row %) | | | | | Chi-square *P* value |
|---|---|---|---|---|---|---|---|
| | N | <1/month | 1–3/month | 1/week | 2–6/week | ≥1/day | |
| 5–6 | 1137 | 31.2 | 34.0 | 20.3 | 13.3 | 1.1 | |
| 7+ | 251 | 31.5 | 29.1 | 22.7 | 13.9 | 2.8 | |

**Table 2.**

Crude and adjusted odds ratios for the associations between levels of fish consumption and preterm birth (<37 weeks gestational age) or early preterm birth (<35 weeks gestational age) in the National Birth Defects Prevention Study, 1997–2011

| | N[a] | Preterm N (%) | cOR (95% CI) | aOR[b] (95% CI) |
|---|---|---|---|---|
| **Preterm Birth (<37 weeks)** | | | | |
| Fish consumption[c] | | | | |
| <1/month | 3428 | 280 (8.2) | 1.0 (Reference) | 1.0 (Reference) |
| 1–3/month | 3629 | 293 (8.1) | 1.0 (0.8, 1.2) | 1.0 (0.8, 1.2) |
| 1/week | 2284 | 162 (7.1) | 0.9 (0.7, 1.1) | 0.8 (0.7, 1.0) |
| 2–6/week | 1426 | 109 (7.6) | 0.9 (0.7, 1.2) | 0.9 (0.7, 1.1) |
| ≥1/day | 104 | 7 (6.7) | 0.8 (0.4, 1.8) | 0.7 (0.3, 1.6) |
| Total | 10 871 | 851 (7.8) | | |
| Early Preterm Birth (<35 weeks)[d] | | | | |
| Fish consumption[c] | | | | |
| <1/month | 3255 | 107 (3.3) | 1.0 (Reference) | 1.0 (Reference) |
| 1–3/month | 3444 | 108 (3.1) | 1.0 (0.7, 1.3) | 0.9 (0.7, 1.2) |
| 1/week | 2179 | 57 (2.6) | 0.8 (0.6, 1.1) | 0.7 (0.5, 1.0) |
| 2–6/week | 1359 | 42 (3.1) | 0.9 (0.7, 1.3) | 0.8 (0.6, 1.2) |
| ≥1/day | 98 | NR | NR[e] | NR[e] |
| Total | 10 335 | 315 (3.0) | | |

cOR, crude odds ratio; CI, confidence interval; aOR, adjusted odds ratio; NR, not reported

[a] Observations missing maternal race/ethnicity (n=48) were excluded from analysis.

[b] Multivariable logistic regression models adjusted for maternal race/ethnicity.

[c] Average number of 3 to 5 ounce servings of fish eaten per month, week, or day during the year prior to pregnancy.

[d] Observations with gestational age 35–36 weeks at delivery (n=536) were excluded from analysis.

[e] Odds ratio not reported due to small cell size.

**Table 3.**

Crude and adjusted odds ratios for the associations between levels of fish consumption and small for gestational age infants (SGA; birthweight <10th percentile for gestational age and infant sex) among all infants and restricted to full term infants (37–42 weeks gestation) in the National Birth Defects Prevention Study, 1997–2011

| | N[a] | SGA N (%) | cOR (95% CI) | aOR[b] (95% CI) |
|---|---|---|---|---|
| **SGA, Any Gestational Age** | | | | |
| Fish consumption[c] | | | | |
| <1/month | 3338 | 267 (8.0) | 1.0 (Reference) | 1.0 (Reference) |
| 1–3/month | 3562 | 254 (7.1) | 0.9 (0.7, 1.1) | 0.9 (0.8, 1.1) |
| 1/week | 2230 | 177 (7.9) | 1.0 (0.8, 1.2) | 1.0 (0.8, 1.2) |
| 2–6/week | 1394 | 105 (7.5) | 0.9 (0.7, 1.2) | 0.8 (0.7, 1.1) |
| ≥1/day | 103 | 21 (20.4) | 2.9 (1.8, 4.8) | 2.1 (1.2, 3.4) |
| Total | 10 627 | 824 (7.8) | | |
| SGA, Full Term Infants (37–42 Weeks)[d] | | | | |
| Fish consumption[c] | | | | |
| <1/month | 3069 | 249 (8.1) | 1.0 (Reference) | 1.0 (Reference) |
| 1–3/month | 3274 | 240 (7.3) | 0.9 (0.7, 1.1) | 0.9 (0.8, 1.1) |
| 1/week | 2071 | 169 (8.2) | 1.0 (0.8, 1.2) | 1.0 (0.8, 1.2) |
| 2–6/week | 1291 | 99 (7.7) | 0.9 (0.7, 1.2) | 0.8 (0.7, 1.1) |
| ≥1/day | 96 | 21 (21.9) | 3.2 (1.9, 5.2) | 2.2 (1.3, 3.6) |
| Total | 9801 | 778 (7.9) | | |

cOR, crude odds ratio; CI, confidence interval; aOR, adjusted odds ratio

[a] Observations missing birth weight (n=145), infant sex (n=10), with gestational age outside the range (<24 or >42 weeks) with reference values (n=48), or missing maternal race/ethnicity or maternal education (n=89) were excluded from analysis.

[b] Multivariable logistic regression model adjusted for maternal race/ethnicity and maternal education.

[c] Average number of 3 to 5 ounce servings of fish eaten per month, week, or day during the year prior to pregnancy.

[d] Observations with gestational age <37 weeks at delivery (n=826) were excluded from analysis.