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INSUFFICIENT DHA INTAKE IN PREGNANT AND LACTATING WOMEN OF BATON ROUGE, LOUISIANA: FURTHER NUTRITION EDUCATION NEEDED

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INSUFFICIENT DHA INTAKE IN PREGNANT AND LACTATING WOMEN OF BATON ROUGE, LOUISIANA: FURTHER NUTRITION EDUCATION NEEDED

by

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Introduction.

Long chain polyunsaturated fatty acids (LCPUFAs) are nutrients required for optimal health, maturation, and growth.[1,2] Docosahexaenoic acid (DHA) is an omega-3 LCPUFA that is essential for the mother's health as well as the retinal and neural development of the infant.[1,3-6] The developing infant relies on human milk and/or formula as its sole source of nutrients. Breast milk is the preferred provision of nutrients in the first six months of life and has all necessary fatty acids.[3] However, due to a lack of evidence supporting an optimal DHA concentration, human milk substitutes or infant formulas contain differing amounts of LCPUFAs.[6] While concentrations of other LCPUFAs are fairly consistent among human breast milk, concentrations of DHA vary significantly based on maternal intake.[7]

Common sources of dietary DHA include fish and supplements (i.e. fish oils, prenatal supplements).[8] Evidence suggests that infants fed breast milk with higher DHA content have more favorable developmental outcomes in several areas including vision and central nervous system function in addition to health benefits for the mother.[4,9,10] Since the early 2000s, there has been a documented decline in the DHA concentration of human milk in the United States. The average DHA content according to several studies before 2007 was 0.19% of total milk fatty acids.[1] After 2007, the mean DHA content was 0.17%. Both of these values are far below the worldwide average of 0.30%.[1,5]

Juber et al comments that the low levels of DHA in the milk of U.S. mothers may be due to conflicting recommendations for DHA intake and the risks of consuming seafood for pregnant or lactating women.[1,6] In 2004, the Food and Drug Administration along with the Environmental Protection Agency issued guidelines warning women of the risks of consuming fish with high levels of methyl mercury during pregnancy and lactation.[11] After the release of these recommendations, a decrease in fish (which is rich in DHA and other essential LCPUFAs) was seen among pregnant and breastfeeding women in the US.[1] In 2008, the World Organization of Perinatal Medicine along with several other international entities published the recommendation that pregnant and lactating women consume 200 mg of DHA daily.[12] This requirement can be met using supplements or seafood sources that are low in methyl mercury such as salmon or rainbow trout.[13] This advice could have appeared contradictory and unintentionally contributed to a decrease in DHA consumption, and therefore a decrease in breast milk concentrations of DHA by giving the impression that the food sources rich in DHA (the seafood group) were unsafe to consume during these life stages.[1,14]

The estimated worldwide average DHA concentration of breast milk (by weight; percentage of total fatty acid content) reported by a meta-analysis in 2007 was 0.32±0.22%.[5] This value has since been regarded as a reference point for DHA concentration in infant formulas, which largely attempt to mimic human milk.[5] It is largely unknown if this is the optimal value for DHA concentration of infant formula, although, one study by Birch and colleagues reported that infants fed formula with a 0.34% DHA concentration was optimal for promoting sharpness of vision.[4]

Further and more current research is needed to find the optimal level of DHA concentration, and ways to increase DHA intake safely, especially in pregnant and lactating women. To begin to address this need, the objective of this research was to determine the current intake of DHA among pregnant and lactating women in Baton Rouge, Louisiana and compare it to the World Association of Perinatal Medicine guidelines.[12] Another goal of this study was to determine the most common sources of DHA intake in this population.

Literature Review.

Chemical composition of DHA

Chemically, a fatty acid consists of a non-aromatic carbon chain with an attached carboxylic acid.[15] Categories of these fatty acids are named according to the number of double bonds in this chain.[15] For example, saturated fatty acids contain exclusively double bonds, monounsaturated fatty acids have one double bond, and polyunsaturated fatty acids (PUFAs) have between two and six double bonds in their aliphatic chain.[16] Some PUFAs, specifically the omega-3 and omega-6 types, cannot be synthesized by the body and therefore must be present in the diet.[12] These types of essential PUFAs have double bonds at the omega-6 or omega-3 positions and are named based on the position of the first double bond in the carbon chain.

Another class of unsaturated fatty acids with non-aromatic chains longer than 18 carbons that are further unsaturated beyond six double bonds are called long chain polyunsaturated fatty acids (LCPUFAs), and they require other fatty acids as precursors for their synthesis.[16] LCPUFAs begins with parent fatty acids, alpha-Linolenic acid (ALA) and Linoleic acid (LA), which are both present in plasma lipids, storage lipids, plasma membrane phospholipids, and intracellular cholesterol esters.[16] One of the LCPUFAs synthesized in this manner, DHA, is found mostly in plasma membrane phospholipids.[17] Dietary ALA and LA chains are desaturated and elongated enzymatically.[17] ALA is converted to Eicosapentanoic acid(EPA) and DHA via several enzymatic elongations and desaturations.[9] DHA can also be synthesized from EPA via a series of desaturation and chain elongations.[9] Omega-3 and omega-6 fatty acids compete for elongation and desaturation enzymes, which makes the human body inefficient at converting ALA and EPA to DHA.[9,17] For these reasons, DHA may be considered an essential nutrient and must be consumed in the human diet.[9,17]

Recommendations for DHA Consumption in Pregnancy and Lactation

The 2015-2020 Dietary Guidelines for Americans recommend that pregnant and lactating women consume between 8 and 12 ounces of seafood choices that are high in DHA but low in methylmercury to promote infant health.[14] This is based on the 2009 Dietary Reference Intakes which recommend that pregnant and breastfeeding women consume 10% of the Adequate Intake (AI) for omega-3 fatty acids in the form of DHA or EPA which equates to roughly 100 mg per day, a recommendation much lower than those set by other organizations.[18] For Example, the World Organization of Perinatal Medicine, Early Nutrition Academy, and the Child Health Foundation recommend that pregnant and lactating women consume at least 200 mg of DHA per day.[12,18] Seafood is a good source of long chain omega-3 fatty acids and consuming one to two portions of it each week, such as salmon or other low-mercury fatty fish, can meet the recommended intake.[12] Despite these recommendations, studies have shown that some populations of women are not consuming enough DHA to meet these requirements.[19-23]

DHA In Infant Formula

Many studies have been conducted that showcase the benefits of DHA for infant health.[3] Because of these benefits, including optimal long-term cognitive development, the current recommendation of the American Dietetic Association is that infants under six months of age who are not fed breast milk should consume at least 0.2% of their total fat intake as DHA.[3] Although breast milk is still the preferred source of nutrients for infants of this age, a human milk substitute can also meet this standard.[3] As stated in the Position of the American Dietetic Association and Dietitians of Canada paper, lower levels of DHA in brain tissues and blood lipids in infants fed formulas devoid of DHA suggest that neural development could suffer from this omission.[3] As infants who do not consume LCPUFAs such as DHA in the diet must synthesize them from precursors, and may have suboptimal neurodevelopment due to the lower levels of DHA in blood .[24] According to Kent et al, most studies done with DHA supplementation suggest that infants fed formula containing 0.12-0.36% DHA by weight reap the most neurological benefit, which could have significant effects for brain development and function.[24] In addition to the neurodevelopmental benefits, Birch and Colleagues found that visual acuity was improved in infants fed formula in which DHA accounted for 0.34% of the total fatty acid content.[4]

Attempting to mimic human milk as much as possible, infant formulas have contained DHA beginning in 2002.[4] By 2006, over 80% of infant formula in the United States contained DHA.[25] Today, there is still no requirement for the amount of DHA that infant formulas must contain. However, various clinical studies have evaluated common infant formulas having DHA content that ranges from none to 0.96% of the total fatty acid content of the formula, most being in the 0.32-0.96% range.[4,25,26] The current recommended DHA content of human milk is 0.3% of total fatty acid content, which is based off of the worldwide average.[12] Further research is necessary to determine if this is the optimal value, as one has not been defined.[12] According to Lien et al, infant formulas could use this 0.3% as a reference point if the goal is to mimic human milk.[27] In addition, further research exploring safe and regulated methods for adding DHA and other beneficial LCPUFAs to infant formula is needed.[24]

Benefits of DHA Intake for Mother and Infant

Various studies have been conducted examining the associations between maternal DHA intake and neurodevelopment of the visual system.[28-30] One randomized control trial using a 400 mg daily DHA supplement found that maternal DHA intake was related to infant visual acuity, and more infant girls had a visual acuity lower than the average in the placebo group compared to the DHA intervention group.[28] This relationship between visual acuity and maternal DHA intake was also reported by Makrides and colleagues from their study focusing on preterm infants, which have an elevated risk for visual impairments compared to term infants.[29] Judge and colleagues also reported that supplemental DHA throughout pregnancy plays a role in visual development and results in increased visual acuity at four months of age in a randomized controlled trial using a DHA functional food as a supplement vehicle.[30] It is well documented that the development of the visual system is linked to DHA intake, but more needs to be examined on this topic.

Another benefit of DHA intake during pregnancy and lactation that has been explored by many researchers is the relationship between DHA intake and infant neurodevelopment of the infant.[31-34] A clinical trial by Gould et al found in a population of non-smoking women that babies born to mothers in the DHA group had higher cognitive scores at 18 months of age than the control group.[31] It was also found by Jensen et al that children whose mothers supplemented with DHA during lactation had higher scores on a test of sustained attention at 5 years of age, suggesting long-term neurocognitive benefits from DHA supplementation.[32] Concurrently, Kuratko suggests that DHA is important for school performance later in life, and has been found in most studies to have favorable roles in at least one area of cognition or behavioral area.[33] Judge et al found also that maternal supplementation of DHA had significant effects on performance of problem-solving tasks at nine months of age.[34] Each of the studies gave rationale for their findings, but additional research is needed in this area to further understand this relationship.

Several studies have also been conducted which explore the neurocognitive benefits of DHA intake in specific populations. [35-37] Rogers et al found that these neurocognitive benefits of DHA supplementation, both in pregnancy and in lactation, may be of special benefit to vulnerable infants to help optimize brain maturation.[35] This agrees with the findings of Ramakrishnan and colleagues who reported potential developmental benefits of prenatal DHA supplementation for infants who experience reduced caregiver interactions and fewer opportunities for stimulation associated with poor quality home environments.[36] Insufficient DHA intake has also been shown to increase depressive-like behavior in post-pubescent animals, suggesting that DHA sufficiency may play a role in regulating mood in response to emotional stressors in adolescence.[37]

A host of other benefits seen from sufficient DHA intake have been shown in various studies.[38-42] One such study reports that very premature infants had reduced severity of several diseases common in this population such as retinopathy and cholestasis when given an IV emulsion of fish oil. The same infants had increased erythrocyte plasma and erythrocyte DHA14 days after the infusion, which suggests a potential for long-term neurodevelopmental benefits in this population.[38] Complementarily, another study found longer gestation duration, higher birth weight, and shorter hospital stays in another population of preterm infants.[39] It has been hypothesized by Carlson et al that adequate DHA intake could decrease the frequency of early preterm birth, the preterm delivery with the highest morbidity risk, but this study has yet to be completed.[40] Courville et al suggest that maternal DHA consumption is related to improved infant body composition and insulin sensitivity in their research with term infants.[41] Judge and colleagues studied maternal DHA intake in relation to sleep-wake cycles, an ability highly associated with developmental outcomes later in life, and found that infants in the DHA intervention group had better sleep organization patterns following parturition.[42]

DHA Sources

Seafood is the major source of dietary LCPUFAs, such as DHA. One study by Wu et al reported that women who consumed less than 75g of fish per week had lower dietary DHA intake as well as lower DHA concentrations in body tissue, specifically erythrocytes.[43] Blood concentrations of fatty acids, including DHA, are indicative of status.[44] Dietary supplements containing preformed DHA have been shown to improve blood DHA status.[44] One concern with fish intake in these populations is the risks associated with methylmercury consumption. However, the benefits of fish intake far exceed the potential risks as long as fish high in methylmercury such as shark, swordfish, tilefish, and king mackerel are avoided.[14,45] Aside from improving DHA status, marine foods have also been shown to have the added benefit of a cardio protective effect.[46] One study explored an alternate method of DHA supplementation for children, as many do not consume enough fish to meet DHA requirements.[47] This study by Hawthorne and colleagues reported increased phospholipid DHA content in children fed juice supplemented with either 50 or 100 mg of microencapsulated algal DHA in juice.[47]

Methods and Materials.

Participants

Dietary data were collected in two studies. One study focused on overweight pregnant women, another on breastfeeding women of varying body mass indexes (BMIs, kg/m^2). In order to qualify for the first study, the Louisiana moms and babies (LAMBS) study, participants were more than 17 weeks pregnant, between the ages of 18 and 35 years; tested negative for diabetes; have a BMI between 25.0-29.9 kg/m^2; and planned to deliver and receive care at Woman's Hospital, Baton Rouge, Louisiana. Participants with kidney disease, liver disease, polycystic ovarian syndrome, multiple fetuses; history of hypertension, hyperlipidemia, hyperglycemia, uncontrolled thyroid disorder; who were pregnant or breastfeeding in the past 6 months or planning a cesarean delivery; or that tested positive for Human Immunodeficiency Virus (HIV), sepsis, Hepatitis B, group B streptococcus, or syphilis were excluded from the study. Participants in the LAMBS study were recruited from outpatient clinics at Woman's Hospital using a pre-screening. The pre-screen included questions about height, weight, current gestational age, plans to deliver at Woman's Hospital in Baton Rouge, Louisiana, and plans to be cared for by a physician at Woman's Hospital.

Participants for the second study were recruited using flyers that were posted around the community at places such as retail shops, prenatal clinics, and physicians' offices including Woman's Hospital. In order to qualify for the breast milk study, participants were required to have a full-term delivery (defined as ≥37 gestational weeks); plan to breastfeed for at least four weeks; be 18 to 40 years of age, willing and able to provide breast milk samples during between 6am and 10am; and have not been pregnant or breastfeeding in the past year. After expressing interest in the study, subjects were contacted prior to delivery to schedule a pre-screening based on the inclusion criteria and given more information about the study. Participants that used tobacco during lactation, had more than one alcoholic beverage per week; or had presumed or confirmed congenital birth defects were excluded from the study. Participants from both studies completed informed written consents in order to participate.

Dietary Intake Estimation

Trained interviewers from Louisiana State University, School of Nutrition and Food Sciences, performed dietary recall interviews in person or via telephone. A 24-hour dietary recall is a method of estimating dietary intake in which the participant recalls everything they consumed in the past 24 hours, as well as gives information about meal times and location of meals. Information about dietary supplement intake was collected as part of the interview. Recalls were collected from participants using the Nutrient Data System for Research(NDSR) software at 17-20, 22, 24, 26, 30, 32, and 36 weeks for the LAMBS study, and at two, three, and four weeks postpartum for the breastmilk study.[48] The NDSR software versions 2014,2015, 2016, and 2017 developed by the NCC, University of Minnesota, Minneapolis, MN, USA was used to collect and analyze all dietary data.[48]

Interviewers performed the recalls guided by the automated NDSR software using a four-stage, Multiple-Pass technique. As guided by the NDSR software, the multiple pass technique is used to gather dietary data as accurately as possible. The interview begins by asking participants to list all foods and beverages consumed the day before starting at midnight along with the time of consumption. Next, the list is read back to the participant for confirmation and a series of prompts lead the interviewer through asking the participant about the portion sizes, cooking methods, meal label and meal location to form a detailed list. This more detailed list is read to the participant again for confirmation and they are given the option to edit the list at any time during the interview. The same process is followed for collecting nutrient and dietary supplement data. Prompts containing questions about supplement brand, number of times consumed, and number of units per time are answered and the supplement list is repeated to the participant again at the conclusion of the supplement recall. Both participants and interviewers were provided a Food Amounts Booklet which contained two-dimensional illustrations of food measuring tools, bowls, cups, and common food shapes such as meats and amounts to report portion sizes as accurately as possible. Figure 1 shows an example illustration from the booklet.[49] Each recall takes approximately one to one and a half hours to conduct. The NDSR provides a full analysis of macro- and micronutrient intake including carbohydrates, fat, protein, minerals, and vitamins as well as other specific nutrients such as DHA. Dietary intake was calculated using an average of the repeated dietary recalls from breastfeeding (n=3) and pregnant (n=7) participants in these studies. To assess DHA intake for both populations, the nutritional analysis data were compared to the 2015-2020 DGAs.[50]

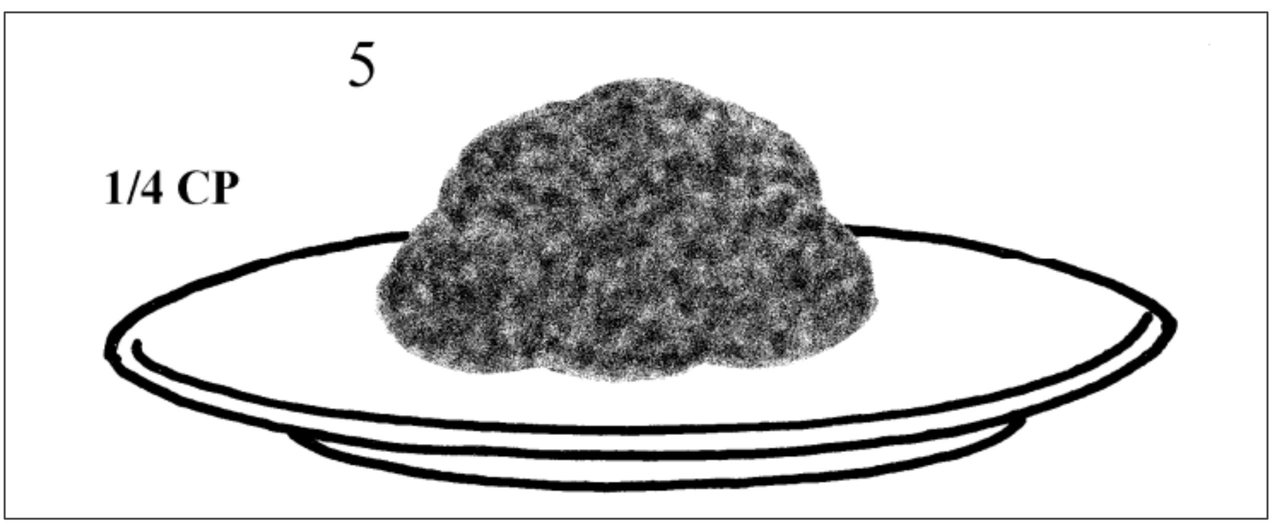


Figure 1. Mound 5 from interviewer Food Amounts Booklet.[49]

Statistical Analyses

Descriptive data about age, height, weight, race/ethnicity, marital status, parent education level, and food intake was collected. BMI (kg/m^2) and average DHA intake per day (mg) were calculated. Descriptive info about the content of the foods that were consumed was collected during the 24-hour recalls. The relationships between variables for normally distributed data were examined using Pearson's r correlations. Data that were not normally distributed were analyzed using Spearman's rho. ANOVA and Mann-Whitney were used to examine predictors of DHA intake. Data were examined and analyzed using Statistical Package for the Social Sciences (SPSS) (IBM Corp. Released 2016, Version 24.0, Armonk, NY). A p value of < 0.05 was considered statistically significant.

Results.

Subject Description: Breast Milk Study

Thirty-one participants were enrolled in the breast milk study but data from seven could not be included due to underreporting or subject drop out so data from 24 participants were included in the data set. Seventeen participants (70.83%) participants were Caucasian, four (16.67%) were African American, two (8.33%) were Hispanic or Latino, and 1 participant (4.17%) was Asian. In terms of highest maternal education level, one participant (4.17%) answered ‘high school’, four (16.67%) participants answered ‘some college’, five (20.83%) participants answered ‘4-year post high-school degree’, 13 (54.17%) participants answered ‘post-graduate degree’, and one (4.17%) participants answered ‘other’ or chose not to answer. In terms of highest paternal education level, one participant (4.17%) answered ‘high school’, four (16.67%) participants answered ‘some college’, ten (41.67%) participants answered ‘4-year post high-school degree’, three (12.50%) participants answered ‘post-graduate degree’, three (12.50%) participants answered ‘2-Year Post High-School Degree’, and three (12.50%) participants answered ‘other’ or chose not to answer. Nineteen (79.17%) of the participants were married and 5 were single. The mean pre-pregnancy BMI of the participants was 27.6 ± 6.1 kg/m^2. The mean age of the participants was 31.04 ± 4.29 years. The mean number of previous pregnancies was 1.3 ± 1.8.

Table 2. Descriptive characteristics of the study population of breastfeeding women (breast milk study) in the Greater Baton Rouge area

	Mean ± SD	Min-Max
Age (years)	31.0 ± 4.3	18.0-39.0
Body Mass Index (BMI) (kg/m^2)	27.6 ± 6.1	19.6-36.5
Number of Previous Pregnancies	1.3 ± 1.8	0.0-8.0

Subject Description: LAMBS study

Three hundred and forty-one women were screened for study eligibility. Twenty-four participants were enrolled in the LAMBS study following the screening but data from one participant could not be included because of noncompliance. A total of 23 pregnant women classified as overweight with BMIs between 25.2 and 29.8 kg/m2 were included in the study. Thirteen participants (62%) were Black, six (29%) were White, and two (9%) were Hispanic. The mean pre-pregnancy BMI of the participants was 27.6 ± 1.5 kg/m^2. The mean age of the participants was 26.5 ± 4.1 years. The mean gestational age at entry was 19.0 ± 1.2 weeks.

Table 3. Descriptive characteristics of the study population of overweight pregnant women (LAMBS Study) in the Greater Baton Rouge area

	Mean ± SD	Min-Max
Age (years)	26.5 ± 4.1	20.0-34.0
Body Mass Index (BMI) (kg/m^2)	27.6 ± 1.5	25.2-29.8
Gestational Age at entry (weeks)	19.0 ± 1.2	16.5-20.0

Dietary Intake: Breast Milk Study

Three repeated twenty four-hour dietary recalls were collected for dietary intake of this population of breastfeeding women (**Table 3**). The average saturated fat and total fat intakes were greater than the 2015-2020 DGAs recommendations.[14] According to these guidelines, 20-35% of total kilocalories should consist of dietary fat, with no more than 10% of total kilocalories from saturated fat.[14]

Omega-3 DHA Intake: Breast Milk Study

On average, the study population did not meet the recommendations set forth for DHA intake during lactation (200mg/day).[10] 83% (n=20) women consumed a prenatal supplement, and 46% (n=11) women out of 24 consumed a prenatal supplement that contained DHA. Two participants met the recommendation of 200 mg DHA/day before supplementation and all but 5 women consumed less than 50% of the recommendation.[10] After supplementation, seven women met the recommendation for DHA consumption. However, 12 women had an intake less than 50% of the recommendation after supplementation. The population's consumption of DHA without the outlying recall is reported in **Table 3.**

Omega-3 DHA Intake: LAMBS Study

On average, the study population did not meet the recommendations set forth for DHA intake during pregnancy (200 mg/day).[10] 33% (n=7) women consumed a prenatal supplement containing DHA. One participant met the recommendation of 200 mg DHA/day before supplementation. This participant consumed 6.94 servings of crawfish and this recall was considered an outlier due to the intake of 299 mg DHA/day compared to the average intake of other participants () and the other two recalls from this participant. The additional recalls from this participant were more representative of her usual diet and this recall was therefore excluded from analyses. The population's consumption of DHA without the outlying recall is reported in **Table 4.** After supplementation, seven women met the recommendation for DHA consumption.

Table 4. Docosahexaenoic acid (DHA) intake from dietary and supplemental sources by lactating (breast milk study) and overweight pregnant women (LAMBS study) in the Greater Baton Rouge area

	DHA in Breast Milk population (n=24)	DHA in LAMBS population (n=23)
Recommendation	≥200 mg/day	≥200 mg/day
From Diet (mg)	82.4 ± 170.2[a] 0.0-755.5[b]	72.0 ± 63.0[a] 9.0-237.0
Women Meeting Recommendation from Dietary intake	n=2	n=1
From Supplements (mg)	78.3 ± 121.0[a] 0.0-500.0[b]	99.7 ± 87.2[a] 0.0-250.0[b]
Dietary + Supplemental Intake (mg)	159.6 ± 195.0[a] 0.0-755.0[b]	151.6 ± 83.9[a] 0.0-467.0[b]
Women Meeting Recommendation After Supplementation	n=7	n=7

[a]Mean ± SD, [b]Min-max

Seafood Consumption: Breast Milk Study

Forty-six percent of this population (n=11) reported seafood consumption at least once in the three, 24-hour recalls. The majority of seafood was shellfish (40%), including shrimp, crabs, and clams, closely followed by salmon (36%). Other lean fish, such as tilapia, catfish or tuna, comprised 24% of seafood consumed. Six of the 24 participants consumed salmon, three consumed lean fish, and eight consumed shellfish on at least one occasion. The varieties of seafood were salmon, shrimp, crab, clams, tilapia, tuna, and catfish. The seafood intake of this population is reported in **Figure 3.**

The DHA content was relatively low in most varieties of seafood consumed by this population, with the exception of salmon. These fish included shrimp, crab, clams, tilapia, and catfish. The DHA content of common seafood varieties is shown in **Table 5.** The top sources of dietary omega-3 DHA in this population were salmon, shrimp, tilapia, eggs, chicken, and crab.

Table 5. Docosahexaenoic acid and Mercury content of common seafood varieties

Common Seafood Varieties	Omega-3 DHA per (mg/ 4 oz. serving)	Mercury (µg/ 4 oz. serving)
Salmon:	700-1,400	2
Crab	200-550	9
Tuna: white (albacore), canned	1,000	40
Pollock	600	6
Shrimp	100	100
Cod	200	8
Catfish	100-250	7
Clams	200-300	0
Tilapia	150	2
Shark**	1,250	151
Tilefish**	1,000	219
Swordfish**	1,000	147
Mackerel (King)**	450	110

**Denotes predator fish that contain high levels of methyl mercury and are not recommended for consumption by pregnant and lactating women.[46]

Figure 2. Percentage of total seafood consumed as each seafood variety by breastfeeding women in the Greater Baton Rouge Area (n=19)

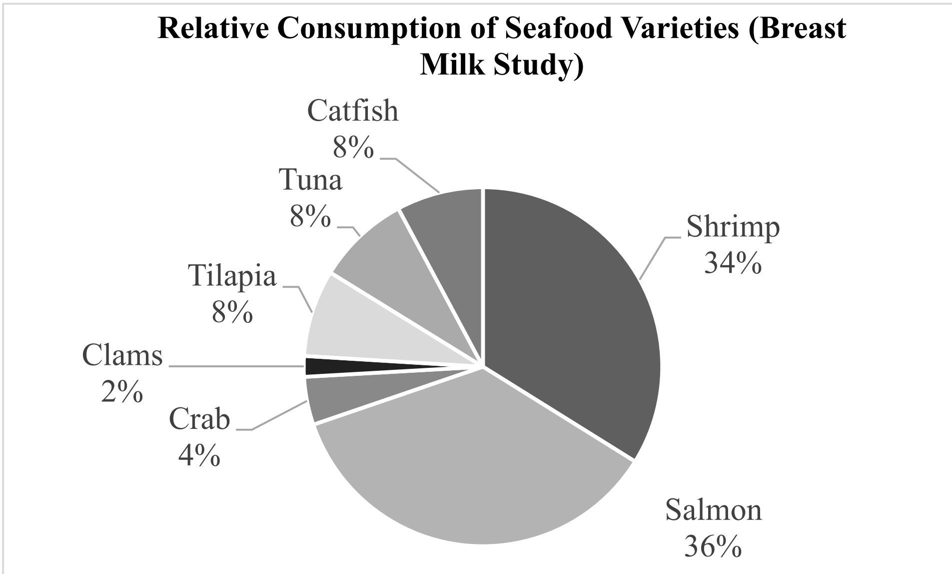
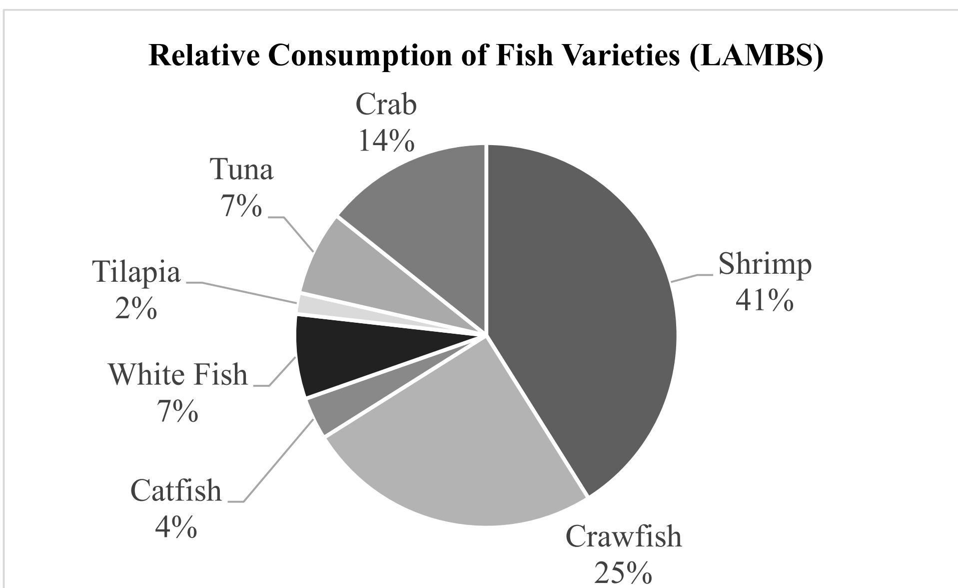


Figure 3. Percentage of total seafood consumed as each seafood variety by overweight pregnant women in the Greater Baton Rouge Area (n=11)



Further Examination into DHA intake: Breast Milk

There were no significant differences in dietary or total DHA intake for ethnicity, or paternal or maternal education level ($p \geq 0.05$). However, age was a significant factor for both dietary DHA intake and dietary plus supplemental DHA intake ($p \leq 0.05$). Age was the only factor that affected total DHA intake in this population. White women (*mdn*= 180.1 mg) consumed significantly more DHA than Non-White women (*mdn*= 33.7 mg), u = 26.5, z = -2.21, $p \leq 0.05$, r = -0.44.

Discussion and Conclusions.

The findings of these studies support the hypothesis that women in the Greater Baton Rouge area are not consuming adequate amounts of omega-3 LCPUFAs during pregnancy or breast feeding, related to the fact that these populations are not consuming seafood in adequate amounts to meet the recommended dietary intake of DHA.[14] These data are in accordance with research from other parts of North America and demonstrate a need for increased prenatal nutrition education for these populations.[20-23]

As presented in **Table 4**, both populations of women failed to consume adequate amounts of the omega-3 LCPUFA, DHA. The breast milk study population consumed an average 159.6 ± 195.0 mg/day omega-3 DHA, and the LAMBS study population consumed an average of 151.6 ± 83.9 mg/day of omega-3 DHA. The intake of total omega-3 DHA in both of these populations is notably more than that of the dietary or diet and supplement intake reported by Lewis and colleagues in their study of Midwestern pregnant women (48.0 ± 8.0 mg/day omega-3 DHA)[20] but is consistent with intake reported by De Vriese et al (140.0 ± 300.0 mg/day omega-3 DHA).[51] The breast milk study population had DHA intakes similar to the population studied by

Innis et al, in which pregnant women consumed 160.0 ± 20.0 mg/day omega-3 DHA.[28] The dietary omega-6:omega-3 ratio in these study populations was similar to that in Louisiana pregnant women as reported by Drewery and colleagues (9.0 ± 1.0),[52] but greater than that of the population of Canadian pregnant women studied by Denomme et al (6.3 ± 0.4).[23] A high dietary omega-6:omega-3 ratio has been shown to increase the risk of developing several chronic diseases including cardiovascular disease, cancer, and diabetes.[53]

Prior studies with pregnant women have reported low intakes of the omega-3 LCPUFA, DHA. Only two women in the breast milk study population and one woman in the LAMBS study population met the recommendation for DHA intake during pregnancy or lactation from solely dietary sources. Nineteen women consumed less than 50% of the DHA recommendation of 200 mg/day set forth by the World Organization of Perinatal Medicine.[12] The average DHA intake was 160.0 ± 195.0 mg/day among the breast milk study population, and 77.0 ± 59.0 mg/day among the LAMBS Study population. The differences in intake between these study populations and others may be due to varying methods for collecting nutrient intake data.[54] Some studies used 24-hour dietary recalls,[20,52] while others relied on food frequency surveys, or geographic cultural eating preferences and behaviors.[28]

Seven women in the LAMBS study (33%) and 11 women in the breast milk study (46%) consumed a prenatal supplement containing DHA. These data suggest that lower percentages of women in these studies are taking supplements in comparison to Drewery et al.'s Baton Rouge study population, in which 57% consumed supplements that contained DHA.[52] On average, supplements provided just under half of the recommended DHA intake for the breast milk study population, and just over half for the LAMBS study population (39% and 58%, respectively). After supplementation, seven women in the breast milk study population and seven women in the LAMBS study population met the recommendation for DHA intake. Additionally, 12 women in the breast milk study population had an intake less than 50% of the recommendation after supplementation. These data affirm the importance of prenatal supplementation during pregnancy and lactation to promote adequate omega-3 DHA intake as LCPUFA intake during these life stages has been shown to influence birth outcomes such as gestational weight and length, as well as neurodevelopmental and visual outcomes.[2,9] The 2015-2020 Dietary Guidelines for Americans recommend that PUFAs comprise the majority of fat intake, as they could potentially have antioxidant properties and help reduce HDL cholesterol, therefore lowering the risk of stroke and cardiovascular disease.[14]

Forty-six percent of the breast milk study population consumed seafood at least once, which is notably lower than data reported by Drewery et al in a population of pregnant women in Baton Rouge.[52] Of the surveyed pregnant women in the study by Drewery and colleagues, 87.1% consumed at least one type of fish.[52] In the breast milk study population, the average servings of seafood per day was 0.71 servings, most from seafood sources with a relatively low DHA content (17-223 mg DHA / 4 oz serving). These data are consistent with Drewery et al's findings in which fish with relatively low DHA content, tilapia and catfish, were the most commonly consumed types of fish.[52] Forty percent of the seafood in the breast milk study population was shellfish such as shrimp and crab, and 24% was lean fish such as tilapia, catfish, and tuna. None of the participants in either the breast milk study population or the LAMBS study population consumed fish high in methylmercury such as the predator fish, which suggests a decreased risk for methylmercury poisoning for these populations. This may also indicate that these populations are knowledgeable about methylmercury poisoning and actively avoid fish with high methylmercury concentrations to decrease the risk of methylmercury poisoning.[52]

The main contributors of DHA to the diet of the breast milk study population were salmon, chicken, shrimp, eggs, and crab. In the LAMBS study population, shrimp, crayfish, crab, tilapia, and oysters were the main contributors of dietary DHA. The differences between the two populations could potentially be rooted in seasonal variation and availability of crayfish and oysters in Louisiana. In the United States, eggs and chicken are consumed more often than seafood and may therefore be an alternative source of dietary DHA for those who seldom consume seafood.[20,52] These data correspond to a study by Lewis et al, which reported that only 2% of the omega-3 PUFA intake was comprised of fish and seafood, however, 65% of the DHA consumed was from fish and seafood sources.[20] Eggs and poultry such as chicken were also providers of DHA in Lewis' study.[20,41]

Some limitations of these studies were the small sample size and the use of the 24-hour recall as a dietary assessment method. The NDSR software was used to reduce the error of the 24-hour recall method, but further studies are needed to increase the accuracy of dietary assessment methods. Future studies may aim to increase the sample size of the population as well as include subjects from several geographic locations to assess omega-3 DHA intake by pregnant and breastfeeding women across North America.

In conclusion, DHA intakes by breastfeeding as well as overweight pregnant women in Baton Rouge, Louisiana are inadequate. These findings are congruent with those reported in other regions of North America. Inadequate intakes and levels of this fatty acid may play a role in adverse health outcomes for mothers, infants during development, and the fetus during gestation. Further study of the currently available prenatal and postnatal nutrition education for these populations and advances to improve this education is needed.

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