Maternal Fat Intake during Pregnancy and Breastfeeding Initiation

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Graduate Program in Epidemiology and Biostatistics

A thesis submitted in partial fulfillment of the requirements for the degree in Master of Science

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By

Rachel Man

Graduate program in Epidemiology and Biostatistics

A thesis submitted in partial fulfillment
of the requirements for the degree of
Master of Science

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Abstract

**Introduction:** Breast milk provides health benefits for both mother and child. Prominent reasons for not initiating breastfeeding include lactation problems and perceived insufficient milk supply. Animal studies have shown that a high fat diet is associated with negative changes in the lactation process, while omega-3 supplementation appears to have positive effects. **Hypothesis:** 1. High maternal fat intake during pregnancy is associated with breastfeeding non-initiation. 2. Long-chain omega-3 fatty acid intake (EPA+DHA) is associated with breastfeeding initiation. 3. Maternal EPA+DHA intake modifies the relationship between total fat intake during pregnancy and breastfeeding initiation. **Materials and Methods:** The data for this study were taken from the Prenatal Health Project, a prospective cohort study in London, Ontario. Women 10-22 week’s gestation were recruited from ultrasound clinics and followed-up at the perinatal, infant (yr) and toddler (2-5 yrs) stage. Multivariable logistic regression analyses were conducted with blockwise data entry based on a directed acyclic graph (DAG) created to conceptualize the hypothesized relationships and potential confounders. **Results:** Contrary to our hypothesis, higher maternal fat (>35% fat), compared to ≤35% fat, was associated with a higher odds of breastfeeding initiation (OR=2.014 (95% CI: 1.002, 4.045)). Mothers who met the dietary EPA+DHA recommendations may have been more likely to breastfeed, but this did not achieve statistical significance. There was no significant interaction between percent fat intake and EPA+DHA intake. **Discussion and Summary:** Mothers whose diets were composed of a higher fat percentage were more likely to initiate breastfeeding compared to mothers with a lower percentage.
Acknowledgments

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List of Abbreviations

AI     Adequate Intake
ALA    Alpha-linoleic acid
AP     Attributable Proportion due to Interaction
BF     Breastfeeding
BMI    Body Mass Index
CD     Control Diet
CI     Confidence Interval
DAG    Directed Acyclic Graph
DHA    Docosahexaenoic Acid
EPA    Eicosapentaenoic Acid
FFQ    Food Frequency Questionnaire
HFD    High Fat Diet
LFD    Low Fat Diet
NICU   Neonatal Intensive Care Unit
OR     Odds Ratio
PHP    Prenatal Health Project
RDA    Recommended Dietary Allowance
RERI   Relative Excess Risk due to Interaction
SAS    Statistical Analysis Software
SES    Socio-economic Status
SI     Synergy Index
SQL    Structured Query Language
WHO    World Health Organization
Chapter 1: Introduction and Objectives

1.1 Introduction

Breastfeeding is the preferred method of feeding newborns due to the numerous health benefits it provides for both mother and child. Health Canada recommends that mothers breastfeed their child exclusively for the first six months, and continue breastfeeding for up to two years with supplementary feeding [1]. Although the percentage of mothers who initiate breastfeeding has increased slightly over the past decade in Canada, these rates vary greatly from province to province, with the lowest rates being under 60%. Therefore, it is of interest to examine the factors involved in the likelihood that a mother breasfeeds her child.

There are many factors which play a role in whether a mother initiates breastfeeding or not, including social and biological factors. In studies which examined breastfeeding in the perinatal period and early weaning, the most common reasons for not breastfeeding related to lactation challenges and insufficient milk supply. Animal studies have examined the association between fat intake and lactation, and found that animals that had diets composed of a high percentage of fat (approximately 60%) had altered mammary gland morphologies, decreased milk proteins and decreased milk production. It is unknown whether this association exists in humans.

Although a high fat intake in general appears to have negative effects on lactation in animals, omega-3 fatty acid supplementation in animals has been suggested to have positive effects on lactation structures. This is particularly interesting because mothers are encouraged to
increase their omega-3 fatty acid intake, especially eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA), due to their well-known benefits for infant development and association with maternal mental health.

The purpose of this thesis is to elucidate the association between fat intake (total and EPA+DHA) during pregnancy and breastfeeding initiation. We will examine this relationship using data from the Prenatal Health Project (PHP), which is a prospective cohort study with 2537 mothers from London, Ontario, recruited between 2002-2005. A more detailed description of the PHP is provided in chapter 3.

1.2 Research Objectives and Hypothesis

Based on the literature review, the following study objectives were developed. The primary objective of this thesis was to elucidate whether total dietary fat and EPA+DHA intake during pregnancy influences the likelihood that a mother will breastfeed, taking into consideration the various confounding factors known to be associated with both fat intake and breastfeeding initiation.

Research Objectives

Examine the:

1. Association between maternal total fat intake during pregnancy and breastfeeding initiation.

3. Interaction between maternal total fat intake and long-chain omega-3 fatty acid intake (EPA+DHA) during pregnancy and the effect on breastfeeding initiation.

Research Hypotheses

1. High maternal fat intake during pregnancy will decrease the likelihood of a mother initiating breastfeeding.

2. High EPA+DHA intake during pregnancy will increase the likelihood of a mother initiating breastfeeding.

3. There will be interaction between total fat intake and EPA+DHA intake, such that high EPA+DHA intake suppresses the negative effect of a high total fat intake during pregnancy on breastfeeding initiation.
Chapter 2: Literature Review

2.1 Overview of Literature to be discussed

Breastfeeding is the preferred method of feeding newborns and infants and is recommended by Health Canada, along with many other health organizations. This chapter will review the various health benefits breast milk provides for mother and child and the current breastfeeding initiation rates in Canada. Then, the social and biological factors that are linked to breastfeeding initiation are discussed. As mentioned in the introduction section, the most commonly reported reasons for not breastfeeding relate to lactation problems and insufficient milk supply. We will discuss the evidence from human and animal studies regarding how fat intake affects milk supply and lactation structures. Finally, this chapter will review long-chain omega-3 fatty acids, specifically (EPA+DHA), their benefits to infant development and maternal health, and how they potentially are beneficial to lactation.

2.2 Health Benefits of Breastfeeding

The benefits of breastfeeding to both mother and child are well established. Infants who are breastfed have a decreased risk of infectious morbidity, due to the transference of the mother’s antibodies and other immune factors through human milk. There is substantial evidence in the literature that breastfeeding, compared to formula feeding, significantly decreases the risk of infant acute otitis media (ear infection), atopic dermatitis, gastrointestinal infections and lower respiratory tract diseases [2]. Among preterm babies, breast milk is a significant protective factor
against necrotizing enterocolitis, the most common serious intestinal disease among premature infants [3]. Epidemiologic studies have also reported that infants with a history of being breastfed have decreased risk of type 2 diabetes and being overweight or obese later in life [2, 3]. Breastfeeding for at least 6 months is also associated with a reduced risk of acute lymphocytic leukemia and acute myelogenous leukemia [4]. Finally, several case-control studies have found that formula feeding is associated with an increased odds of Sudden Infant Death Syndrome (SIDS) compared to breastfeeding, with a meta-analysis reporting that infants who were formula-fed had twice the risk of SIDS compared to infants who were breastfed [2]. However, the American Academy of Pediatrics Task Force has suggested that this association may be due to factors related to breastfeeding rather than breastfeeding itself [3].

Breastfeeding is also associated with numerous health benefits for the mother. A large population-based cohort study found that women without a history of gestational diabetes had a 15% decrease in the risk of developing type 2 diabetes with each additional year of breastfeeding [5]. Many studies have also examined the association between breastfeeding and risk of postpartum depression and found that breastfeeding initiation and longer breastfeeding duration was associated with a decreased risk of depression [6-9]. Finally, epidemiologic studies have shown that breastfeeding is significantly associated with a reduced risk of breast and ovarian cancer [2].

There is prevailing evidence that breastfeeding is important for the health and development of the child, as well as the mother’s health, which explains why breastfeeding is the recommended feeding method for newborns and infants in Canada and most other countries.
2.3 Breastfeeding Recommendations and Rates

Due to the numerous health benefits it provides, breast milk is the preferred method of feeding for newborns and infants. Health Canada, the Canadian Paediatric Society and the World Health Organization (WHO) recommend that mothers breastfeed their child exclusively for the first six months, and continue to breastfeed with supplementary feeding for up to two years [10, 11]. Breastfeeding data from Health Canada come from the Canadian Community Health Survey (CCHS), which collects data on the health status, health care utilization and health determinants of Canadians. The CCHS considers that a mother initiated breastfeeding if she breastfed or tried to breastfeed, even only for a short time. In Canada, breastfeeding initiation rates have increased slightly, from 85% in 2003 to 89% in 2011-2012 [12]. However, these numbers vary widely from province to province, ranging from 57% in Newfoundland to 96% in British Columbia and the Yukon. Although breastfeeding initiation rates are relatively high, only 26% of mothers exclusively breastfed for six months in 2011-2012, although this had increased from 17% in 2003 [12]. It is therefore of interest to explore possible tangible factors that could increase breastfeeding rates.

2.4 Physiology of Breastfeeding

The mammary gland is the organ responsible for milk production and secretion. The basic cells of the mammary gland are milk-synthesizing alveoli, which form into lobules, and subsequently into larger lobes [13]. Small ducts from the alveoli join together to form larger ducts, which ultimately merge into one milk duct for milk secretion. There are two primary
processes in which the mammary glands develop the capacity for lactation: mammogenesis and lactogenesis. Mammogenesis begins in early pregnancy, where there is an increase in water, electrolyte and fat content in the breast, along with increased vascular supply [14]. In mid-pregnancy, the mammary gland acquires the capability for milk secretion, a process known as “lactogenesis I”. However, high levels of blood progesterone and estrogen prevent milk secretion during pregnancy, until after delivery [14]. Suckling triggers an increase in prolactin levels, which initiates “lactogenesis II” whereby alveoli are stimulated and cues high levels of milk production as well as milk secretion. Another important hormone during this process is oxytocin, which is responsible for contraction of cells around the alveoli for milk synthesis [15]. Milk is collected in the alveoli, and flows through small ducts which join to form larger ducts, and finally secretes out of the mammary duct.

2.5 Factors Associated with Breastfeeding Initiation

There is a multitude of factors which influence whether a mother breastfeeds or not. These include maternal social and biological factors, as well as factors relating to the child. All these factors are visually presented in a directed acyclic graph (DAG), shown in figure 2.1. Along with these variables, other factors associated with maternal fat intake and intermediate variables are included in the DAG, showing the relationships among the factors.
2.5.1 Maternal Demographic Factors

Socio-economic status, race, and age are all predictors of breastfeeding initiation. Several studies in the literature have found that mothers with lower socioeconomic status (SES) are less likely to initiate breastfeeding, using maternal education and household income as measures [16-19]. Educated mothers may be more likely to research information on infant health and engage in healthy behaviours, such as breastfeeding. Maternal employment has tended to reduce the likelihood of breastfeeding [17], although one study found that only full-time, not part-time, employment was associated with decreased breastfeeding initiation [20]. Race or ethnicity has also been correlated with rates of breastfeeding initiation, with the highest rates among Black and Asian mothers compared to white mothers [17]. However, mothers who are more acculturated are also less likely to breastfeed [21]. Therefore, cultural influence, rather than biological race, may be the key factor for breastfeeding behaviour. Maternal age has also been reported to be a predictor of breastfeeding initiation, with older women being more likely to initiate breastfeeding [21, 22].

2.5.2 Maternal Depression

The association between maternal depression and breastfeeding initiation appears to be bidirectional. Depression is associated with shorter breastfeeding duration and decreased odds of breastfeeding initiation [8, 23], and mothers who breastfeed are less likely to experience depressive symptoms [8]. Mothers with depressive symptoms are also more likely to report
having difficulties with breastfeeding and have decreased breastfeeding self-efficacy, which is the confidence a mother has in breastfeeding her child [23].

Studies have suggested that changes in hormone levels may be part of the mechanism of this association between depression and breastfeeding. One study followed women who intended to initiate breastfeeding, and found that women with increased depressive and anxiety symptoms had decreased levels of oxytocin, a hormone essential to milk ejection during lactation [24]. Another study reported that post-partum women with depression had significantly lower levels of plasma prolactin, another major hormone involved in milk production and lactation, although the researchers did not report the actual breastfeeding rates [25].

Breastfeeding also has an effect on maternal psychological health. Mothers who initiate breastfeeding [8] and who continue to breastfeed [9] are less likely to have post-partum depressive symptoms. Both lactogenic hormones oxytocin and prolactin are involved in anxiolytic and antidepressant effects [26]. Breastfeeding is also associated with the attenuation of neuroendocrine responses to stress. [27, 28]. A diminished stress response has, in turn, been reported to be associated with a decrease in depressive symptoms in mothers [29].

2.5.3 Maternal Smoking Status

Epidemiological studies have reported that mothers who smoke are less likely to breastfeed compared to mothers who do not smoke [21]. In fact, maternal smoking status has been shown to be the strongest predictor of breastfeeding initiation [30]. Furthermore, mothers who smoked at higher rates and those smoking for longer than five years had an increased risk of
failing to initiate breastfeeding. In other words, the frequency and duration of smoking, in addition to smoking status, also affected breastfeeding behaviour, perhaps implying a dose-response relationship. The association between smoking and breastfeeding initiation has also been shown in a cohort study of mothers with gestational diabetes [16]. The negative effect of smoking on breastfeeding initiation may be attributed to psychological factors. Mothers who choose not to smoke would be more likely to engage in healthy behaviours, such as breastfeeding. It has also been hypothesized that smoking could affect breastfeeding and lactation through the effects of nicotine, which suppresses prolactin, an essential hormone in milk production and secretion [31]. Therefore, smoking appears to decrease the mother’s likelihood of initiating breastfeeding.

2.5.4 Maternal Body Mass Index (BMI)

Studies have reported that underweight [32] and obese women [16, 32-34] are less likely to initiate breastfeeding compared to women with normal BMI. It is interesting to note that one study found this association between BMI and initiation, even though the intention to breastfeed was not different between obese and normal weight women [33]. Obese mothers are more likely to report having difficulties in producing milk, and are less likely to succeed in expression during lactation, which may be a reason for the reduction in initiation seen in this group [35]. In an animal study using rats, overweight/obese dams had a significantly lower prolactin response to suckling compared to rats with normal weight [36], which may in part explain the lactation difficulties experienced by obese mothers.
2.5.5 Maternal Diabetes

In general, mothers with any type of diabetes are less likely to initiate breastfeeding compared to women without diabetes [37-40]. Mothers with pre-gestational diabetes (diabetes prior to pregnancy) have the worst breastfeeding outcomes, especially when insulin-treated, compared to mothers with gestational diabetes [38]. One study reported that mothers with pre-gestational and gestational diabetes have delayed onset of lactogenesis II and were more likely to report having insufficient milk supply [37]. Another study also reported a similar association in a sample of mothers with type 1 diabetes [41]. This relationship between diabetes and delayed lactogenesis may in part explain the reduced breastfeeding initiation rates seen in diabetic mothers. Sparud-Lundin et al. [39] have also suggested that diabetic mothers experience more birth-related complications, such as cesarean section and neonatal hypoglycemia, which may explain the reduced rates of breastfeeding initiation in this population. Overall, mothers with any type of diabetes are less likely to initiate breastfeeding.

2.5.6 Breastfeeding Intention

The mother’s beliefs and plans to breastfeed during pregnancy have significant effects on breastfeeding outcome. Several studies have reported a positive association between maternal prenatal intention to breastfeed and breastfeeding initiation [16, 22, 42-44]. One population-based study examined a cohort of mothers in the UK and reported that maternal intention to breastfeed was actually a stronger predictor than all other demographic predictors combined [45].
2.5.7 Social Support

Informal support from the mother’s partner, family and friends can have a significant impact on breastfeeding outcome. A review by Mitchell-Box and Braun [46] identified true experimental or quasi-experimental studies that examined interventions for the male partner to improve the mother’s breastfeeding outcome. Overall, an increase in male-partner support (educational sessions about health benefits of breastfeeding, support strategies, etc.) significantly increased the likelihood of breastfeeding initiation. One study by Fein et al. [47] used data from The Infant Feeding Practices II study (IFPS), a longitudinal cohort study of pregnant women, to examine the association between social support and breastfeeding outcomes. The researchers reported that mothers whose families supported breastfeeding were approximately 8 times more likely to initiate breastfeeding compared to those with non-supportive families. Additionally, mothers with clinicians who supported breastfeeding also had increased odds of breastfeeding initiation.

2.5.8 Parity and Breastfeeding Experience

Overall, studies report that multiparity is positively associated with breastfeeding [22, 38, 48, 49]. This may be because mothers who have had other children have previous knowledge and experience on breastfeeding. Studies show that previous breastfeeding experience is positively associated with breastfeeding intention [50, 51] and breastfeeding initiation [52]. This association is also not a surprise. Mothers who have already breastfed probably knew about the
health benefits of breast milk, and have an advantage to overcoming the challenges associated with breastfeeding, unlike a first-time mother.

### 2.5.9 Galactagogues

In cases where milk production is poor, medications are sometimes prescribed by physicians to enhance lactation. Substances that are used to promote milk production are called galactagogues, and are generally categorized as pharmaceutical and herbal. One review by Zuppa et al. [53] summarized the effects, biological mechanisms and safe doses of various galactagogues, such as Domperidone and Metoclopramide. In another study, it was reported that mothers using Domperidone had a significant relative increase of greater than 70% in daily milk production compared to mothers in the placebo group [54]. Fenugreek, an herbal supplement, was also reported to significantly increase breast milk production [55].

### 2.5.10 Gestational Age

A few studies have reported that mothers who gave birth to preterm or late preterm infants were less likely to initiate breastfeeding, compared to mothers with full term babies [56, 57]. However, among infants admitted to the NICU, the effect of gestational age was reversed – term infants were significantly less likely to be breastfed compared to pre-term infants [58]. Gestational age alone has a clear association with breastfeeding, however it alters the relationship between NICU admission and breastfeeding.
2.5.11 Delivery Method

 Mothers who have cesarean births, planned or unplanned, are less likely to initiate breastfeeding compared to mothers who give vaginal birth. [59]. Mothers with cesarean births are at a higher risk of various complications, including blood loss, infection, and injury to internal organs, such as the intestines and bladder. If a mother experiences these negative outcomes, it may inhibit or decrease her ability to initiate breastfeeding in hospital. Women who planned to have cesarean sections also have a less favourable attitude towards breastfeeding and are less likely to intend to breastfeed [59].

2.5.12 Neonatal Intensive Care Unit (NICU) Admission

 Studies have found that newborns admitted to the Neonatal Intensive Care Unit (NICU) were less likely to be breastfed in the first hour [60] and in the first few days post-partum [16, 61] compared to healthy newborns. However, this relationship appears to depend on gestational age. According to databases from 27 states in the U.S., Colaizy and Morriss [62] reported that NICU admission was associated with a decreased likelihood of initiating breastfeeding among term infants, but was a protective factor for breastfeeding initiation among preterm infants. Recently, the trends of breastfeeding among infants admitted to the NICU from 2006-2012 in Ohio were examined [58]. Almost 40% of term infants admitted to the NICU were not being breastfed, and preterm infants in the NICU were significantly more likely to be breastfed compared to term infants in the NICU. Therefore, for full-term babies, being admitted to the
NICU appeared to decrease the chances of the mother initiating breastfeeding, while NICU admission for preterm infants increased the chances of breastfeeding.

### 2.6 Milk Supply and Breastfeeding Non-initiation

There are a variety of reasons a mother may not initiate breastfeeding or has a shorter than desired duration of breastfeeding, with the most commonly reported reason being self-perceived insufficient milk supply [43, 63-66]. The prevalence of mothers who truly experience physical barriers to breastfeeding is unknown, though it was been suggested that the number may be close to 5% [43, 63]. Recently, Lou et al. [63] conducted a cross-sectional study with 341 women and reported that greater than 50% of the participants reported insufficient milk supply within the first two days post-partum, which may influence the mother to not initiate breastfeeding. In turn, it has also been reported that delayed initiation is associated with shorter breastfeeding duration [63]. In a cohort study,[67] it was found that the main reasons mothers had a shorter duration of breastfeeding than desired included problems associated with lactation and milk pumping, as well as concerns regarding whether the infant was getting enough nutrition and gaining enough weight. Similarly, another study interviewed more than 700 mothers throughout the first year post-partum, and reported that concern regarding milk supply was the most common reason for breastfeeding cessation, persistent throughout early and later months post-pregnancy [68]. Therefore, perceived insufficient milk supply affects many mothers and is an important factor in whether a mother breastfeeds or not.
2.7 Maternal Fat Intake, Milk Supply and Breastfeeding Performance

2.7.1 Dietary (Fat) Intake and Milk Production in Humans

There is little information in the literature on how fat intake affects milk supply in humans. In one study, one woman was under observation for a duration of two months, during which her diet was modified from 0 to 70% of total energy from fat, with different feeding periods of varying caloric intake, fat calories and type of fat [69]. Although the fatty acid composition of her breast milk changed with her diet, the total fat content in milk and milk volume remained relatively constant. Other studies have examined the effect of diet on lactation, but not focused on the effects of fat. A study by Strode et al. [70] reported that a major reduction in energy intake (at least 1500 kcal/day) did not reduce milk production or milk intake by the infants. Similarly, another study reported that short-term fasting during Ramadan had no effect on milk output [71]. It has been hypothesized that mothers with a low caloric intake will be able to maintain milk output with energy reserves, as long as their caloric intake is not below a critical value [72]. Therefore, caloric intake appears to not have a substantial effect on milk volume, but the effect of fat intake on milk volume has not been studied in human populations.

2.7.2 Fat Intake and Milk Production in Animals

Several animal studies have examined the relationship between fat intake during pregnancy and breastfeeding outcome, and found that fat intake has effects on the structures and process of lactation. Using pregnant mice, Hernandez et al. [73] examined the effect of
consuming a high fat diet (HFD, 60% kcal from fat) compared to a low fat diet (LFD, 10% kcal from fat) on lactation. They found that mothers fed a HFD had delayed lactation, disrupted mammary gland morphologies and decreased mRNA expression of milk protein genes, indicating that a high fat diet may decrease the mother’s ability to synthesize and secrete milk. Similar results were reported in a randomized controlled trial [74]. Mice that were fed a HFD (52.6% fat) also had impaired lactogenesis, decreased expression of milk proteins (α-lactalbumin (lactose), β-casein, WAP (protein), ACC (lipid synthesis)), and abnormal side-branching and alveolar mammary gland development, in comparison to mice fed a standard diet (5.2% fat). In non-pregnant mice, those fed a HFD had abnormal development of mammary gland structures, including partial deficit in the myoepithelium in the mammary duct, which plays an important role in maintaining structures for milk ejection [75]. These abnormalities may lead to a delay in formation of lobuloalveoli (for milk secretion) and ultimately lactation failure. Mice fed a HFD (60% fat) also have abnormal changes in the mammary ducts, terminal end buds (TEB) and epithelial cells, as well as delayed mammary gland development compared to mice fed a control diet (12% fat) [76]. However, diet loss (switching back to a control diet) appeared to restore the changes in the TEB’s and mammary duct. Additionally, these changes were observed only in pubertal mice and not in adult mice, and therefore the effects of diet may be time-dependent.

A review by Rasmussen [77] also reports that the effects of a HFD were different depending on when the diet was fed. Obese rats, as a result of being fed a chronic HFD, had increased fat content in their milk, but had decreased milk volume. The pups from obese rats were also much more likely to die in the first few days after birth. They speculated that one reason for the increased risk of death was inadequate initiation of lactation, since a large proportion of pups had no visible milk in their stomachs. Rats that were fed a HFD during the
lactation period also had a similar effect of decreased milk production. However, those that were fed a HFD at conception did not become obese, and actually had an increase of milk yield. It was suggested that this model did not represent obesity per se, but rather the effects of the high fat diet itself. Purcell et al. [78] also conducted a randomized controlled trial and found that rats on a HFD (60% fat), compared to a control diet (17% fat), spent a greater amount of time nursing and caring for their pups. This suggests that there may be a positive effect on lactation, however actual milk yield was not measured. The effect of a chronic low-fat control diet (7% fat) or high-fat diet (35% fat) on lactation has also been examined [79]. In comparison to mice on a control diet, those on a HFD have altered mammary gland and mammary structure morphology, as well as significantly less mammary development. Additionally, their butyrophilin expression in the mammary gland, an important protein involved in milk fat globule secretion, was significantly less compared to mice on a CD. In accordance with the report by Rasmussen [77], HFD dams had a decreased number of viable pups, and those that survived had little to no milk in their stomach.

Taken together, these findings from animal studies suggest that a high fat diet may have negative effects on the mammary gland, associated structures and the process of lactation, but could depend on the timing of high fat consumption.

2.7.3 Fat Intake during Pregnancy and Lactation

Dietary fat intake during pregnancy affects health and developmental outcomes of the child. Fat is an important source of energy for the growing fetus, and the fatty acids are
important for structural lipids in the brain and blood vessels [80]. Fat is also needed as the vehicle for transfer of fat-soluble vitamins (A, D, E and K) and other biological substances. Long-chain omega-3 fatty acids in particular play an essential role in fetal central nervous system development, with irreversible damage to brain development if there is an inadequate amount available for the fetus [81]. Fat, along with other macro and micronutrients, are transferred to the fetus via the placenta. An increase of dietary long-chain omega-3 fatty acid leads to higher concentrations of the fatty acids in cord blood, increasing the supply for the fetus [82]. After birth, nutrients are provided externally, either through breast milk or other sources, such as formula. Although the percent fat content in breastmilk is not altered by the mother’s diet, the fatty acid composition of breast milk is dose-dependent on the fatty acids from the mother’s diet [83, 84]. It is therefore essential that mothers consume the necessary fats during pregnancy and lactation for normal child development. The recommended fat intake for pregnant and breastfeeding women is not different from the recommended intake for non-pregnant non-breastfeeding women. In terms of the percentage of total caloric intake, it is suggested that women consume 20 – 35% of their total calories from fat, with no more than 10% from trans fats and saturated fatty acids [10, 82].

2.7.4 General Intake of EPA+DHA and Dietary Sources

Omega-3 fatty acids are a type of polyunsaturated fatty acid, named for having a double bond at the 3rd carbon position relative to the methyl group. They play an important role in numerous physiological functions, such as blood clotting and functions in the brain [85]. Alpha-linoleic acid (ALA) is an omega-3 fatty acid which can’t be made inside the body. ALA can be
converted into eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA), shown in figure 2.2. Our bodies convert only a small percentage of ALA into EPA and DHA, and thus it is important to get preformed EPA and DHA from the diet. Dietary sources of ALA are found primarily in plants, such as flaxseed, canola oil and walnuts, while the vast majority of dietary EPA and DHA are found in fish and fish oils.[86]. There currently are no Recommended Dietary Intakes (RDAs) value for omega-3 fatty acids. However, there are different sources of recommendations from various organizations which strive to approximate the RDA values. In 1999, the Workshop on the Essentiality of and Recommended Dietary Intakes (RDIs) for Omega-6 and Omega-3 Fatty Acids was held at the National Institutes of Health in Maryland, United States. This workshop consisted of leading scientists and investigators on fatty acid research regarding infant nutrition and health, who collaborated to produce dietary recommendations based on their expertise and evidence in the literature. The workshop recommended that 0.35% by weight of total fatty acids should be present as DHA, in order to support healthy mental development in infants. This translates to a recommendation of approximately 300 mg DHA/day. However, the daily intake of DHA amongst pregnant women in North America is closer to 80 mg/day [87]. Another source of recommendations is the Australian government and New Zealand health authorities, who have published extensive information on recommended intakes for many nutrients, including omega-3 fatty acid intake for both pregnant women and the general population [10]. For adults aged 19 years and older, the recommended intake of EPA+DHA for men is 160 mg/day and 90mg/day for women. [87]. The recommendations on EPA+DHA for pregnant and lactating women (aged 19-50 years) are 115mg/day and 145 mg/day respectively. Canada’s Food Guide recommends an intake of at least 150 grams of cooked fish per week, as well as following Health Canada’s advice on consuming
certain types of fish to limit exposure to environmental contaminants, such as mercury [88]. The main dietary sources of EPA and DHA are fish, fish oils and marine sources, however women can also obtain EPA and DHA from supplements, and DHA from specifically enriched egg and dairy products. The summary of recommendations of dietary omega-3 fatty acids can be found in Appendix A.

2.7.5 Maternal and Child Health Benefits of Long-Chain Omega-3 Acids

As suggested by animal studies, a high fat intake during pregnancy appears to have a negative effect on breastfeeding. However, mothers are encouraged to increase their intake of omega-3 fatty acids, especially EPA and DHA, which are known to provide many benefits to both mother and child. Evidence in the literature reports that omega-3 fatty acid supplementation is associated with slightly prolonged gestation, slightly increased birth weight, and reduced risk of preterm birth [82]. Omega-3 fatty acids have been linked with maternal mental health. Higher EPA and DHA intakes have been shown to have independent associations with decreased depressive symptoms during pregnancy [89-91] Omega-3 fatty acids inhibit the increase of plasma proinflammatory cytokines, which are associated with stress and depression [90]. A review by Bloch and Hannestad [92] reports that there is strong evidence that the omega-6:omega-3 ratio plays a vital role in the pathogenesis of depression, but omega-3 supplements have only a small and non-significant effect as treatment for depression. Omega-3 fatty acids have also been shown to be beneficial to the infant’s health. EPA+DHA intake is known to improve both neuro-developmental outcomes and psychomotor development of the infant [93]. Infants who consume formula fortified with DHA, compared to those without DHA, have
increased visual and neural system maturation [94]. Additionally, visual acuity is lower for infants whose mothers have decreased DHA status [95]. Animal studies have also reported that deprivation of omega-3 fatty acids is associated with nonreversible visual and behavioural deficits. [93]. It can be concluded that intake of omega-3 fatty acids, in particular EPA and DHA, plays an important role in both the mother’s and child’s health during pregnancy.

2.7.6 Omega-3 Fatty Acid Intake and Breastfeeding Performance in Animals

A study by Meher et al. [96] examined the effect of omega-3 fatty acid supplementation (EPA+DHA) in rats that had vitamin B12 deficiency, folic acid deficiency, and rats with normal levels of vitamin B12 and folic acid. For both deficiency groups, acini (which form lactating ducts and can expand when filled with milk) were absent. However, when these groups were supplemented with omega-3 fatty acids, the number of acini increased in the mammary glands. This suggests that dietary EPA and DHA intake has a positive effect on the structures required for successful lactation. To our knowledge, there are no human studies in the literature that examine the effect of EPA and DHA intake on breastfeeding performance.

2.8 Conclusion

Breastmilk is the unequaled method of feeding for newborns and infants, providing numerous health benefits to both mother and child. It is therefore of interest to examine tangible factors that can increase a mother’s chance of initiating breastfeeding. The most commonly reported reason for not breastfeeding relates to challenges with lactation and self-reported
insufficient milk supply. In humans, maternal caloric intake appears to have little effect on milk supply, while there is little information on fat intake and milk volume. Animal studies have examined the relationship between a high fat intake and lactation, and found that mice and rats fed a high fat diet have altered mammary gland morphologies, decreased milk proteins, delayed lactogenesis and decreased milk volume. Therefore, it appears that a higher fat intake has a negative effect on the structures and process of lactation. However, long-chain omega-3 fatty acid supplementation (EPA and DHA) appears to have a positive effect on lactation structures. Therefore, the effect of fat intake on breastfeeding may depend on the type of fat consumed. Factors related to breastfeeding initiation (discussed in section 2.5) and maternal fat intake (total and EPA+DHA) are summarized by a DAG in figure 2.1, representing the relationships among the different factors. To our knowledge, this is the first study to directly examine the relationship between dietary fat intake during pregnancy and breastfeeding initiation.
Figure 2.1 Directed Acyclic Graph of Maternal Fat Intake, Breastfeeding Initiation and Covariates
Figure 2.2 Omega-3 Fatty Acid Metabolic Pathway

Alpha-linoleic acid (ALA)

Δ-6 Desaturase

Eicosapentaenoic acid (EPA)

Docosahexaenoic acid (DHA)

Long-chain omega-3 fatty acids
Chapter 3: Methods

3.1 Study Sample

3.1.1 Recruitment

The data for this thesis are from the Prenatal Health Project (PHP), a prospective cohort study. This thesis was completed based on secondary analyses of these data. Women 10-22 weeks gestation were recruited from 10 ultrasound clinics in London, Ontario between 2002 to 2005 and followed subsequently as indicated in section 3.1.2 below. The PHP was approved by the research ethics board at the University of Western Ontario at each stage, as shown in Appendix B.1, B.2 and B.3. Inclusion criteria were being English-speaking, a resident in the Middlesex County, and having a normal, singleton pregnancy. Women who were younger than 16 or had a pregnancy with a fetal anomaly were not eligible for the study. Candidates were asked if they would be willing to speak to a research assistant after their ultrasound appointment. Those who were interested were given a letter of information about the study and informed consent was obtained. Mothers were also asked to provide their email addresses, phone numbers and an additional contact name and phone number in order to reduce the rate of attrition. Figure 3.1 shows the recruitment process, with the final PHP cohort consisting of 2357 mothers.
3.1.2 Data Collection and Management

After initial recruitment and the prenatal interview during the participants’ first trimester, there were three additional time-points of data collection – perinatal, infant (2-12 months) and toddler (2 to 5 years). The PHP study flowchart is presented in Figure 3.2.

Prenatal

Data on maternal demographics, diet, BMI, social support, food security, smoking status, and diabetes were collected during the prenatal period. During the recruitment process at the ultrasound clinics in London, eligible and interested women were given a Food Frequency Questionnaire (FFQ) to complete at home, before their scheduled phone interview. Participants were contacted by the interviewers within a week of recruitment to schedule a date and time for the phone interview. In the interview, trained research assistants utilized an approved script in order to guide participants through the prenatal survey. The PHP cohort consisted of 2357 mothers.

Perinatal

Data on pregnancy weight gain, birth weight, gestational age and delivery method were collected in the perinatal period. Birth data were abstracted from the mother and child’s hospital charts by a trained medical records technician. Information included details on pregnancy complications, birth outcomes, delivery information and other pregnancy factors, which made up the perinatal database (n=2357).
Infant

Data on breastfeeding initiation and admission to the NICU were collected at the infant stage (2-12 months). Every attempt was made to reconnect with the study participants. Research assistants followed a standard procedure of contacting the participants, and a call log was kept for each participant to keep track of the date and time of each attempt to reach them. At the time that the infant survey was conducted, the majority of children in the study were already greater than 1 year old. Therefore, the infant sample was only a subset of the PHP, with a total sample of 655.

Toddler

Breastfeeding initiation data were also collected at the toddler stage (2 to 5 years). For this follow-up, participants were recontacted for a postnatal telephone interview. Similar to the data collection during infancy, every attempt was made to re-contact the participants, regardless of whether they were part of the infant subsample or not, and a detailed call log was kept for each participant. The toddler sample consisted of 1607 mother-toddler pairs.

Data from the various surveys and hospital charts were collected, using only a 5 digit study identification number to represent each participant to ensure confidentiality. All information linking the participant’s personal name, address and telephone number to the study ID number was separately stored in a locked cabinet in a secure room. The data were collected on various platforms, then consolidated to a common platform using SAS (Statistical Analysis Software), and were stored as SAS data files.
3.1.3 Selection of Sample for Current Study

For the current study, mothers were included if breastfeeding initiation information (either from the infant or toddler survey) and prenatal omega-3 intake data were available. In order to remove unlikely total caloric intake values, we excluded participants with values greater than the 99th percentile and less than the 1st percentile of log of the total caloric intake. This led to the exclusion of 35 participants with unlikely caloric intake values and resulted in a total sample size of 1705 for the breastfeeding initiation analysis. The participant flow diagram for the breastfeeding initiation analysis is shown in Figure 3.3.

3.2 Measures

The source of the data, original coding of the variables and the final coding of the variables are summarized in Table 3.1.

3.2.1 Prenatal Maternal Fat Intake

Data on maternal food intake were obtained via the 106-item FFQ, which is a tool designed to measure the participants’ average food intake in the past month. Details and methodology for the FFQ development and validation have been published elsewhere [97, 98]. Dietary information was analyzed using the CANDAT Nutrient Calculation System, a software program that converted items on the questionnaire into their nutritional components to estimate maternal macronutrient and micronutrient intake.
Maternal fat intake was captured through the food frequency questionnaire in the prenatal interview as a continuous variable in grams of fat consumed per day. The main exposure variable, maternal percentage fat intake, was derived from the grams of fat intake per day and the daily total caloric intake. We decided to categorize percentage fat intake (rather than leaving it continuous) because we wanted to see the results in reference to following the recommendations of percentage fat intake for women, as discussed in the literature review in Chapter 2. Originally, our exposure variable consisted of three categories: inadequate fat intake (<20%), adequate fat intake (20 – 35%), and excessive fat intake (>35%). However, due to the small number of mothers who had inadequate fat intake who also did not initiate breastfeeding, the final exposure variable was dichotomized to less than or adequate fat intake (≤35%) and excessive fat intake (>35%).

3.2.2 Prenatal Maternal EPA+DHA Intake

The recommendations for EPA+DHA intake for pregnant and lactating women were discussed in the literature review in chapter 2 and are summarized in Appendix A. Taking into account the age of the participants in our study, the conservative amount of 115 mg per day was chosen as the cut point for recommendation of EPA and DHA intake for our analysis. To estimate omega-3 (EPA+DHA) intake, fish consumption was used as a proxy. A study by Olsen et al. [99] demonstrated that three frequency questions about fish intake were almost as accurate in explaining the variation of plasma EPA+DHA in pregnant women as detailed assessment by interview and a self-administered questionnaire. Self-reported fish consumption is moderately correlated with plasma EPA+DHA, with Pearson correlation coefficients ranging from 0.44-0.58.
for EPA and 0.37-0.63 for DHA [94, 99]. For this study, four questions in the prenatal FFQ were used to estimate prenatal EPA+DHA intake, using various types of marine food: 1) canned tuna fish (3-4 oz); 2) dark meat fish e.g., mackerel, salmon, sardines, or bluefish (3-5 oz); 3) other fish (3-5 oz); 4) shrimp (3 med.), lobster (1/4 cup cooked) or scallops (3 med.). Using these portion sizes, participants reported their frequency of consumption, ranging from zero to four-or-more times a day, and weekly and monthly options. The daily intake frequency of each marine food group was then multiplied by the average EPA+DHA content of the specified portion size to obtain the intake of EPA+DHA in mg per day.

3.2.3 Breastfeeding Initiation

Breastfeeding initiation was captured from surveys at both the infant and child follow-ups. If available, the breastfeeding initiation data from the infant survey were used in preference over the child survey because it was anticipated that the mothers’ recall of breastfeeding practices would be more accurate in the infant period. The infant survey was only completed by a subsample of mothers in our cohort, therefore breastfeeding initiation data were obtained from the child survey for the participants who were not part of that subsample. In the infant survey, mothers were asked “Are you currently breastfeeding your baby”, and if they answered no, they were asked “Did you ever breastfeed your baby”. Participants were considered to have initiated breastfeeding if they answered “yes” to either of the above questions. For the child survey, mothers were asked “How did you feed your child at birth”, choosing from either formula or breast-feeding. Mothers were categorized as having initiated breastfeeding if they answered
breast-feeding. The breastfeeding questions for the infant and child survey can be found in Appendix B.4 and B.5, respectively.

We assessed the agreement between the two sources of breastfeeding initiation data for the 557 mothers who had breastfeeding initiation data in both the infant and child surveys. The answers were concordant in 515 mothers (92.5%). Discordant answers were found in only 32 participants (7.5%).

3.2.4 Baseline Covariates

Maternal pre-pregnancy BMI was calculated using the mother’s height and weight prior to pregnancy, self-reported in the prenatal survey. The equation BMI=weight (kg)/height² (m²) was used. In accordance with Health Canada [100], BMI was categorized as underweight (< 18.5 kg/m²), normal weight (18.5 - 24.9 kg/m²), overweight (25.0 - 29.9 kg/m²) and obese (>30.0 kg/m²). Due to a small cell size for mothers who were underweight and did not initiate breastfeeding, BMI was re-categorized as under/normal weight (<24.9 kg/m²), overweight (25.0 – 29.9 kg/m²) and obese (>30.0 kg/m²). Although not ideal, grouping underweight and normal weight mothers together did not greatly limit our ability to control for the effects of maternal BMI, since the evidence in the literature focused on the effects of maternal overweight and obesity on breastfeeding initiation, rather than the effects of underweight.

Maternal socioeconomic status was represented by education and household income. In the prenatal interview, mothers were asked to self-report their highest education level (elementary school, some high school, completed high school, some college/university,
university, college diploma degree, trade school or other). For this analysis, this variable was condensed into two groups: completed university/college and other. Household income was captured in the prenatal survey, which reflected the total gross annual income from paid employment, government assistance, student loans and inheritance. Participants went through a process of indicating their household income from broader categories down to the final precise categories. This question was designed to maximize response rates by allowing respondents to report themselves into a broader income group, should they feel reluctant to report a more precise income. In order to reduce the number of incomplete responses and due to small cell sizes, the final income variable consisted of four groups: < $30,000, $30,000 - $59,999, $60,000 - $79,999, and >$80,000.

Maternal marital status was captured in the prenatal survey, using five available options. There were a small number of mothers who were separated/divorced and no widows, therefore the final marital status variable was condensed into three categories: married, common-law and single/never married/separated/divorced.

Maternal social support was documented in the prenatal interview using scales developed by Turner and Marino [101]. The three social support scales account for support from a husband or partner, family and friends. Participants indicate whether they strongly agree, agree, neither agree or disagree, disagree or strongly disagree to a combined total of 32 questions. The final social support score is a combination from the three scales, with a higher score representing greater social support.

Residency status was used as a proxy for ethnicity. For mothers who were not born in Canada, two dates were used to calculate residence duration: date the mother came to Canada
from the prenatal survey and the survey date from the child survey. Originally, mothers were categorized as born in Canada, long-term resident (> 8 yrs) and short-term resident (< 8 yrs). However, due to a small cell size of short-term residents who did not initiate breastfeeding, this variable had to be dichotomized into born in Canada and not born in Canada.

Mothers were also asked during the prenatal survey whether their current pregnancy was planned or unplanned.

Food security was captured during the prenatal interview. Originally, participants had four available options (not at all difficult, not very difficult, somewhat difficult, very difficult) to describe the difficulty in meeting food commitments. Because of a small number of mothers who found it very difficult to meet food commitments, we combined participants who indicated their difficulty level as somewhat and very difficult.

3.2.5 Prenatal Covariates

Total maternal caloric intake was obtained using the food frequency questionnaire in the prenatal survey. To remove implausible or unlikely caloric intake values, participants with values greater than the 99 percentile or less than the 1 percentile were excluded from analysis, using the log of the total caloric intake. (The original caloric intake variable was heavily right skewed, and logging the variable resulted in a much more normal distribution). As a result, participants who had lower than 807.09 calories or higher than 4184.95 calories were not included in any analyses. After exclusion of these participants, we debated whether to include the original variable or the log version in further analyses. According to Vittinghoff [102], “a natural
criterion for assessing the necessity for transformation is whether important substantive results
differ qualitatively before and after transformation. If not, it may be reasonable not to use the
transformations”. For the total caloric intake variable, the odds ratio did change substantially
from the original variable to the log version. Therefore, we decided to use the log version for
further analyses.

The absolute amount of weight gain during pregnancy was not available in our dataset.
Instead, in a pregnancy risk scoring system in hospital, women were reported as gaining weight
above or below a certain critical value. Weight gain ≤ 20 lbs was considered to be insufficient
and weight gain ≥ 20 lbs was considered to be excess. Due to a small cell size of mothers who
gained insufficient weight and did not breastfeed, this variable was collapsed into a binary
variable: appropriate or less than appropriate weight gain and excess weight gain.

Maternal smoking status before and during pregnancy was self-reported during the
prenatal interview. Participants were categorized into non-smokers, smoked before but not
during pregnancy and smoked before and during pregnancy. There was only one mother who did
not fit into one of those categories because she was a non-smoker before pregnancy, but smoked
during. We decided to group her into the third category, since her health behaviour is likely more
similar to the mothers who also smoked during their pregnancy.

Maternal diabetes was captured at two time points – in the prenatal interview and
perinatal period using hospital chart abstraction. Mothers who reported having type1 or type 2
diabetes in the prenatal interview were coded as “diabetic”. Participants who had carbohydrate
intolerance of pregnancy (one abnormal value on 75 gram oral glucose tolerance test), diet-
controlled gestational diabetes, insulin-controlled gestational diabetes or overt diabetes were coded as “diabetic” for this analysis.

3.2.6 Perinatal Covariates

Size for gestational age, controlling for sex, was calculated using infant birth weight and infant gestational age using data abstracted from infant charts. Gestational age was confirmed using three separate sources: mid-trimester ultrasound assessment records, self-reported last menstrual period and records from the delivery chart. For gestational age estimates that agreed within one week, the age from the infant’s delivery chart was used. For those estimates that did not agree within one week, we further referred to hospital charts. The final estimate was determined by an expert, using all available clinical documentation. The categorization of birth weight for gestational age was defined using the population standards for Canadians published by Kramer et al. [103]. Infants < 10th percentile of Canadian births, controlling for sex and gestational age, were considered to be small-for-gestational-age (SGA). Similarly, infants > 90th percentile, for their sex and gestational age, were considered to be large-for-gestational-age (LGA). Infants who fell between these two percentages were categorized as appropriate-for-gestational-age.

The type of delivery method was obtained through data abstraction from the mother’s hospital chart. Mothers were originally categorized as having a vertex, breech, cesarean section due to failed vertex, or cesarean section delivery. For analysis, the final variable was condensed to vertex/breech delivery and cesarean section, since evidence in the literature focuses on
cesarean birth in comparison to vaginal, and did not distinguish between vertex and breech presentation.

Neonatal admission to specialized care was obtained from the mother’s hospital chart. Infants were considered to be admitted to specialized care if their records showed they had been transferred to any one of the following: Triage/7 east nursery, Paediatric Critical Care Unit (PCCU), NICU triage or NICU admission.

### 3.3 Data Analysis

Analyses were completed using SAS Statistical Analysis Software (SAS) 9.3. First, frequency tables were for mothers who initiated breastfeeding and those who did not initiate breastfeeding. Variables with too few observations in some cell (n<10) were pooled (see Table 3.1). Univariable analyses were conducted between breastfeeding initiation and the newly categorized covariates. Since breastfeeding non-initiation was considered a rare event (approximately 13%), it was appropriate to use logistic regression for the multivariable analysis, using odds ratios to estimate relative risk, at the \( \alpha=0.05 \) level. To make it easier for the reader, analyses were done in terms of the odds of initiating breastfeeding, rather than non-initiation.

For the first and second research objective, the association between maternal fat intake, maternal EPA+DHA intake and breastfeeding initiation was examined, accounting for hypothesized confounders. This multivariable analysis was completed based on the hypothesized causal model shown in figure 3.4. The causal model was derived from the DAG, shown in figure 2.1. Some variables could not be included because unfortunately, our dataset did not contain
these measures (e.g. breastfeeding intention). Other variables were removed because they were ancestor variables (occurred before maternal fat intake) and/or did not connect to both exposure and outcome, either directly or indirectly. The remaining variables in the analytic model were confounders and were entered into the model with backwards elimination. This was conducted in a block-wise manner, with a p-value of 0.2 (two-tailed) as a cut-off for elimination of the variables. The blocks of variables consisted of baseline variables (maternal BMI, household income, education, marital status, social support, residency status, planned pregnancy, food security), prenatal variables (pregnancy weight gain, total caloric intake, smoking status, maternal diabetes, omega-3 intake) and perinatal variables (birth weight for gestational age, NICU admission, delivery method).

For the third study objective, the interaction between maternal percentage fat intake and maternal EPA+DHA intake was examined. Researchers have argued that assessing additive interaction is more indicative of the causal mechanism [104]. Multiplicative interaction was assessed using the variable percent_fat*EPA_DHA and multivariable logistic regression, after the final model was built using backward elimination. According to the framework shown in Figure 2.1, there is a causal pathway from maternal fat intake and EPA+DHA intake to breastfeeding initiation. For this analysis, additive interaction was assessed using relative excess risks due to interaction (RERI), attributable proportion due to interaction (AP), and the synergy index (SI), using methods proposed by Zou [105].
Table 3.1 Summary of Original and Final Variables

<table>
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<th>Variable</th>
<th>Description</th>
<th>Original Coding</th>
<th>Re-coding for Analysis</th>
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<tr>
<td><strong>MAIN VARIABLES OF INTEREST</strong></td>
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| Percent fat intake    | Prenatal percentage of fat from total daily caloric intake (kcal), from FFQ in prenatal survey. Obtained by multiplying grams of fat intake by 9 to get kcals, then dividing by total caloric intake. Final variable dichotomized due to small cell size. | 0 = <20%  
1 = 20 – 35%  
2 = >35% | 0 = ≤ 35%  
1 = > 35% |
| EPA+DHA intake        | Prenatal EPA+DHA intake during pregnancy in mg, from FFQ in prenatal survey. Final variable dichotomized based on dietary guidelines for pregnant women.                                                             | continuous                           | 0 = ≥115 mg  
1 = <115 mg |
| Breastfeeding initiation | Breastfeeding initiation derived from infant survey (“Are you currently breastfeeding your baby” and “Did you ever breastfeed your baby”) and toddler survey (“How did you feed your child at birth”). | 0 = did not initiate breastfeeding  
1 = initiated breastfeeding | unchanged |
<p>| <strong>COVARIATES</strong>        |                                                                                                                                                                                                        |                                      |                           |
| Total caloric intake  | Total calories (kcal) consumed per day by participant, obtained from FFQ in the prenatal interview. Calculated using the Candat program. Final variable was logged due to skewness of the original variable and substantial change in odds ratio from original to logged variable. | continuous                           | continuous (logged)       |
| Smoking status | Smoking status before and during pregnancy, from prenatal interview. Combined pre-pregnancy and during pregnancy smoking status into final variable. | Pre-pregnancy smoking: 0=no, 1=yes  Smoking during pregnancy: 0=no, 1=yes | 0 = non-smoker 1 = smoked before, but not during pregnancy 2=smoking before and during pregnancy |
|----------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------|
| Maternal Body Mass Index (BMI) | Prenatal body mass index (kg/m²) from prenatal survey, calculated from height and weight and grouped according to Health Canada guidelines. Final variable re-categorized due to small cell size. | 1= BMI &lt;18.5 (underweight) 2= 18.5 ≤ BMI &lt;25 (normal) 3= 25 ≤ BMI &lt;30 (overweight) 4= 30 ≤ BMI (obese) | 0= BMI &lt; 25 (underweight and normal weight) 1= 25 ≤ BMI &lt;30 (overweight) 1= 30 ≤ BMI (obese) |
| Planned pregnancy | From prenatal survey: “Was your current pregnancy planned” | 0=no 1=yes | 0=yes 1=no |
| Social support | Maternal social support from husband/partner, family and friends, using scales developed by Turner and Marino, from prenatal interview. Higher score represents greater social support. | continuous | unchanged |
| Pregnancy weight gain | Categorized from qualitative part of “risk factors during pregnancy” from hospital charts. Excess and insufficient weight gain was noted, but not general weight gain. Final variable re-categorized due to small cell size. | 0= 20 lbs or less 1= appropriate 2= 40 lbs or more | 0= insufficient/appropriate weight gain (&lt;40 lbs) 1 = excess weight gain (≥ 40 lbs) |
| Birth weight for gestational age | Birth weight for gestational age, controlled for sex, using the population standards for Canadians published by Kramer et al in 2001. | 0= &lt;3rd percentile (severe sga) 1= 3rd – 10th percentile | 0= 10th - 90th percentile (aga) 1= &lt;10th percentile (sga) |</p>
<table>
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<th>Variable</th>
<th>Description</th>
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</thead>
<tbody>
<tr>
<td>Final variable re-categorized</td>
<td>Final variable re-categorized due to small cell size.</td>
<td>(moderate sga) 1 = &lt; $15,000 2 = $15,000 - $29,999 3 = $30,000 - $59,999 4 = $60,000 - $79,999 0 = ≥ $80,000</td>
<td>2 = &gt;90th percentile (lga) 3 = &gt;90th percentile (lga) 4 = cesarean section 0 = vaginal birth (vertex/breech) 1 = cesarean section (failed vertex and planned cesarean)</td>
</tr>
<tr>
<td>Method of delivery</td>
<td>Method of delivery abstracted from hospital charts. Dichotomized into vaginal birth (vertex/breech) and cesarean section for final variable.</td>
<td>1 = vertex 2 = breech 3 = cesarean section (failed vertex) 4 = cesarean section</td>
<td></td>
</tr>
<tr>
<td>NICU admission</td>
<td>NICU admission, abstracted from hospital charts. Includes being transferred to Triage/7 east nsy, PCCU admission, NICU triage and NICU admission.</td>
<td>0 = no 1 = yes</td>
<td>unchanged</td>
</tr>
<tr>
<td>Place of birth</td>
<td>Originally residency status. Residence duration was calculated using date mother came to Canada (prenatal survey) and toddler survey date. Final variable re-categorized due to small sample size, represents place of birth.</td>
<td>0 = born in Canada 1 = long-term resident (&gt; 8 years) 2 = new resident (≤ 8 years)</td>
<td>0 = born in Canada 1 = not born in Canada</td>
</tr>
<tr>
<td>Household income</td>
<td>Household income, categorized from 17 response option question in the prenatal interview. Final variable re-categorized due to small cell size.</td>
<td>4 = &lt; $15,000 3 = $15,000 - $29,999 2 = $30,000 - $59,999 1 = $60,000 - $79,999 0 = ≥ $80,000</td>
<td>3 = &lt; $30,000 2 = $30,000 - $59,999 1 = $60,000 - $79,999 0 = ≥ $80,000</td>
</tr>
</tbody>
</table>
Figure 3.1. Flow diagram of Participant Recruitment

Approached during ultrasound appt
n=3656

- Refused
  N= 909

- Recruited
  N= 2747

  Completed prenatal survey
  N= 2421

    Did not complete perinatal survey
    N= 12

    Completed perinatal survey
    N= 2409

    Gestational age and birth data provided
    N= 2383

      Elimination of duplicates (for participants recruited twice for 2 different pregnancies, random elimination of one child from study) n=26

      Final Prenatal Health Project Cohort
      N= 2357

  Did not complete prenatal survey
  N= 326

    Completed perinatal survey
    N= 173

    Gestational age and birth data not available (no follow-up)
    N= 38
    Miscarriage n=7
    Abortion n=3
    Neonatal death n=1
    No birth data n=12
    Loss to follow-up n=15
Figure 3.2. Prenatal Health Project Study Flowchart

Prenatal
Gest. Age 10-22 wks
N = 2357

Perinatal
N = 2357

Sub-sample: infant
Child < 1 year old
N = 655

Toddler/preschooler
Child 2-5 years old
N = 1607
Figure 3.3. Participant Flowchart for Breastfeeding Initiation Analysis

Total PHP Cohort
n=2357

BF initiation data not available
N= 600

Know whether initiated BF
N= 1757

Prenatal omega-3 intake data not available
N= 17

Know prenatal omega-3 intake
N= 1740

Exclusion of participants with unlikely total caloric intake values
N = 35

Cohort for BF initiation analysis
N= 1705

Did not initiate BF
N= 216

Initiated BF
N= 1489
Figure 3.4. Analytic Diagram

Baseline (Pre-pregnancy)
- Maternal BMI
- SES
  - Marital status
  - Social support
- Ethnicity
- Planned pregnancy
- Food security

Prenatal
- Pregnancy weight gain
- Total caloric intake
- Smoking
- Maternal Fat intake (Total, EPA+DHA)
- Maternal diabetes

Perinatal
- Birth weight for gestational age
- Delivery Method
- BF initiation
- NICU admission
Chapter 4: Results

4.1 Description of Study Population for Current Analysis

There were 1705 eligible participants for this study. The distribution of characteristics of interest for this study population is shown in Table 4.1 and Table 4.2. The mean age of the participants was 30 years, with the majority of them being well educated (77% had a university or college degree), and married (81%). Approximately 7% of mothers had a prenatal fat intake that comprised >35% of the total caloric intake, and 44% reached the recommended intake of 115 mg of omega-3 fatty acids (EPA+DHA) per day. Of the participants, 35% were either overweight or obese (BMI >25.0) and 6% had carbohydrate intolerance, gestational or overt diabetes. About 19% of the cohort smoked before pregnancy, but only 8% continued to smoke throughout their pregnancy. Most mothers were born in Canada, while 8% were long-term residents (> 8 years) and 3% were short-term residents (≤ 8 years).

4.2 Breastfeeding Initiation Frequencies

The distributions of variables of interest in mothers who initiated and did not initiate breastfeeding are shown in tables 4.3 and 4.4. In our sample, 87% of mothers initiated breastfeeding, while 13% did not. Just by estimation, the following variables seemed comparable between participants who initiated and did not initiate breastfeeding: prenatal percentage fat intake, maternal diabetes, pregnancy weight gain, birth weight for gestational age, NICU
admission and place of birth. Meeting the omega-3 recommendations, being a non-smoker, having a lower BMI, vertex or breach delivery, higher household income, university/college degree, being food secure and being married stood out as factors that were more frequently seen in women who initiated breastfeeding. Again, this was an estimation and no statistical tests were performed.

4.3 Breastfeeding Initiation Univariable Analysis

Table 4.5 represents the univariable logistic regression results, which shows the association between each of the covariates and breastfeeding initiation. The odds ratios shown refer to the odds of initiating breastfeeding. The following factors each have a significant, univariable association with breastfeeding initiation: smoking status, pre-pregnancy BMI, planned pregnancy, maternal diabetes, delivery method, household income, education, food insecurity, being in a common-law relationship, and total caloric intake.

4.4 Breastfeeding Initiation Multivariable Analysis

The multivariable logistic regression results are shown in Table 4.6. To obtain the final model, the backwards elimination method was used. Variables were entered in temporal blocks, first with baseline variables, then prenatal variables, and finally perinatal variables. Only the variables that had a significance level of p-value ≤0.20 were kept in the model at each step. The full process of backwards elimination is shown in Appendix C.
From the first block (baseline variables), pre-pregnancy BMI, household income, education, place of birth and food security were maintained into the second model.

For the second block (baseline and prenatal variables), the prenatal variables that remained included prenatal percentage fat intake, prenatal omega-3 intake, total caloric intake, smoking status and maternal diabetes. The effects of place of birth and food security were attenuated and the p-values both increased beyond statistical significance with the addition of the prenatal variables, and therefore were eliminated at this stage.

For the third block (baseline, prenatal and perinatal variables), the only perinatal variable that reached the required significance to be included was delivery method. The inclusion of the perinatal variables attenuated the effect of maternal diabetes and increased the p-value above the required value of 0.20, and therefore was eliminated in the third model. The final model consisted of prenatal percentage fat intake, prenatal omega-3 intake, pre-pregnancy BMI, household income, education, total caloric intake, smoking status, and delivery method.

The final multivariable model found that prenatal percentage fat intake was a significant predictor of breastfeeding initiation, with an odds ratio of 2.014 (95% C.I: 1.002, 4.045). Mothers who had a diet composed of > 35% fat were approximately twice as likely to initiate breastfeeding compared to mothers who had a diet composed of \( \leq 35\% \) fat. Other significant factors that were associated with increased odds of breastfeeding initiation included education (OR=0.503; 95% C.I: 0.349, 0.725), total caloric intake (OR=1.940; 95% C.I: 1.123, 3.352), smoking status (smokers who stopped during pregnancy vs. non-smokers: OR=0.605; 95% C.I: 0.384, 0.953; smokers throughout pregnancy vs. non-smokers: OR=0.441; 95% C.I: 0.265, 0.734), household income ($60,000-$79,999 vs. >$80,000: OR=0.574; 95% C.I: 0.386, 0.856).
and delivery method (OR=0.617; 95% C.I: 0.433, 0.880). Mothers with less than a university or college education were half as likely to initiate breastfeeding compared to those with a degree. Smoking had a negative effect on initiating breastfeeding. Mothers who smoked before, but not during pregnancy, were less likely to breastfeed, and those who smoked before and during pregnancy were even less likely to initiate breastfeeding. Mothers with a lower household income were less likely to breastfeed. Finally, mothers who gave birth via cesarean section were almost half as likely to breastfeed compared to mothers who gave birth vaginally (vertex/breech).

Of the variables in the final model, prenatal omega-3 intake and pre-pregnancy BMI did not reach significance at p-value≤0.05.

4.5 Multiplicative and Additive Interaction

Interaction between maternal percentage fat intake and EPA+DHA intake was assessed in both the multiplicative and additive scale. An interaction term for percentage fat intake and EPA+DHA intake was added in the final multivariable logistic regression model, and resulted in a p-value of 0.2725. At the α=0.05 level, there was no interaction between fat intake and EPA+DHA intake in the multiplicative scale. To assess additive interaction, we calculated the relative excess risk due to interaction or RERI to be -1.37 (95% CI: -3.07, 2.23), proportion due to interaction or AP was -0.87 (95% CI: -4.53, -0.36) and synergy index (SI) was 0.29 (95% CI: 0.017, 5.13). All three terms suggested that there was a negative interaction, but not significant. Therefore, we found no interaction between percentage fat intake and EPA+DHA intake in both the multiplicative and additive scale. These results are shown in Table 4.7.
4.6 Collinearity

We were aware of the possible problem of collinearity between maternal fat intake and total caloric intake, as these two variables are invariably correlated. We assessed collinearity using the variance inflation factor (VIF), which estimates the amount of increased instability or variance of the coefficient estimates, compared to what it would have been if the explanatory variables had no correlation (i.e. no collinearity). There is no formal threshold which tells us whether the amount of collinearity is too high; general rules of thumb are that a VIF >4 or >10 may suggest problems with collinearity. The VIF for total caloric intake and the original continuous fat intake variable was 4.23. However, when we examined at the VIF for total caloric intake and percent fat intake, the VIF was decreased to 1.00, indicating that there was no concern for collinearity between the percent fat intake and total caloric intake variables used in our analyses.
Table 4.1. Characteristics of Sample Population (Categorical Variables)

<table>
<thead>
<tr>
<th>Maternal Characteristics (Categorical)</th>
<th>Frequency (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Prenatal percentage fat intake</strong> (n=1705)</td>
<td></td>
</tr>
<tr>
<td>&lt; 20%</td>
<td>30 (2%)</td>
</tr>
<tr>
<td>20 – 35%</td>
<td>1556 (91%)</td>
</tr>
<tr>
<td>&gt; 35%</td>
<td>119 (7%)</td>
</tr>
<tr>
<td><strong>Prenatal EPA+DHA intake</strong> (n=1705)</td>
<td></td>
</tr>
<tr>
<td>≥115 mg</td>
<td>753 (44%)</td>
</tr>
<tr>
<td>&lt;115 mg</td>
<td>952 (56%)</td>
</tr>
<tr>
<td><strong>Smoking status</strong> (n=1685)</td>
<td></td>
</tr>
<tr>
<td>non-smoker smoked before, but not during pregnancy</td>
<td>1363 (81%)</td>
</tr>
<tr>
<td>smoked before and during pregnancy</td>
<td>190 (11%)</td>
</tr>
<tr>
<td><strong>Pre-pregnancy BMI</strong> (n=1647)</td>
<td></td>
</tr>
<tr>
<td>&lt; 18.5 kg/m²</td>
<td>58 (4%)</td>
</tr>
<tr>
<td>18.5 – 24.99 kg/m²</td>
<td>1004 (61%)</td>
</tr>
<tr>
<td>25 – 30 kg/m²</td>
<td>367 (22%)</td>
</tr>
<tr>
<td>&gt; 30 kg/m²</td>
<td>218 (13%)</td>
</tr>
<tr>
<td><strong>Planned pregnancy</strong> (n=1705)</td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>1299 (76%)</td>
</tr>
<tr>
<td>No</td>
<td>406 (24%)</td>
</tr>
<tr>
<td><strong>Maternal diabetes</strong> (n=1705)</td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>104 (6%)</td>
</tr>
<tr>
<td>No</td>
<td>1601 (94%)</td>
</tr>
<tr>
<td><strong>Pregnancy weight gain</strong> (n=1705)</td>
<td></td>
</tr>
<tr>
<td>Insufficient (≤ 20 lbs)</td>
<td>57 (3%)</td>
</tr>
<tr>
<td>Appropriate (20 &lt; wg &lt; 40)</td>
<td>1441 (85%)</td>
</tr>
<tr>
<td>Excess (≥ 40 lbs)</td>
<td>207 (12%)</td>
</tr>
<tr>
<td><strong>Birth weight for gestational age</strong> (n=1695)</td>
<td></td>
</tr>
<tr>
<td>3rd percentile (severe sga)</td>
<td>30 (2%)</td>
</tr>
<tr>
<td>3rd – 10th percentile (moderate sga)</td>
<td>81 (5%)</td>
</tr>
<tr>
<td>10th – 50th percentile (aga)</td>
<td>614 (36%)</td>
</tr>
<tr>
<td>50th – 90th percentile (aga)</td>
<td>754 (45%)</td>
</tr>
<tr>
<td>&gt;90th percentile (lga)</td>
<td>216 (13%)</td>
</tr>
<tr>
<td><strong>Delivery method</strong> (n=1627)</td>
<td></td>
</tr>
<tr>
<td>vertex/breech</td>
<td>1280 (79%)</td>
</tr>
<tr>
<td>cesarean section</td>
<td>347 (21%)</td>
</tr>
<tr>
<td><strong>NICU admission</strong> (n=1705)</td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>124 (7%)</td>
</tr>
<tr>
<td>No</td>
<td>1581 (93%)</td>
</tr>
<tr>
<td><strong>Residency Status</strong> (n=1676)</td>
<td></td>
</tr>
<tr>
<td>Born in Canada</td>
<td>1482 (88%)</td>
</tr>
<tr>
<td>Long-term resident (&gt; 8 years)</td>
<td>138 (8%)</td>
</tr>
<tr>
<td>New resident (≤ 8 years)</td>
<td>56 (3%)</td>
</tr>
<tr>
<td><strong>Household income</strong> (n=1625)</td>
<td></td>
</tr>
<tr>
<td>&lt; $15,000</td>
<td>22 (1%)</td>
</tr>
<tr>
<td>$15,000 - $29,999</td>
<td>106 (7%)</td>
</tr>
<tr>
<td>$30,000 - $59,999</td>
<td>379 (23%)</td>
</tr>
<tr>
<td>$60,000 - $79,999</td>
<td>438 (27%)</td>
</tr>
<tr>
<td>&gt; $80,000</td>
<td>680 (42%)</td>
</tr>
<tr>
<td><strong>Education</strong> (n=1703)</td>
<td></td>
</tr>
<tr>
<td>University or college</td>
<td>1303 (77%)</td>
</tr>
<tr>
<td>Less than university or college</td>
<td>400 (23%)</td>
</tr>
</tbody>
</table>
### Table 4.2. Characteristics of Sample Population (Continuous Variables)

<table>
<thead>
<tr>
<th>Maternal Characteristics (Continuous)</th>
<th>Mean (±SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maternal Age in Years (n=1705)</td>
<td>30 (±5)</td>
</tr>
<tr>
<td>Social Support (n=1666)</td>
<td>77 (±9)</td>
</tr>
<tr>
<td>Total Caloric Intake (kcal) (n=1705)</td>
<td>2000 (±587)</td>
</tr>
</tbody>
</table>

*Frequencies exclude participants who were < 1% or >99% of the logged total caloric intake; Sample size variation by maternal characteristic was based on missing data pattern.*
Table 4.3. Cross-tabulations of Breastfeeding Initiation and Categorical Covariates

<table>
<thead>
<tr>
<th>Covariate</th>
<th>Initiated breastfeeding n (row%)</th>
<th>Did not initiate breastfeeding n (row%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>1489 (87%)</td>
<td>216 (13%)</td>
</tr>
<tr>
<td>Prenatal percentage fat intake (n=1705)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>≤ 35%</td>
<td>1383 (87%)</td>
<td>203 (13%)</td>
</tr>
<tr>
<td>&gt; 35%</td>
<td>106 (89%)</td>
<td>13 (11%)</td>
</tr>
<tr>
<td>Prenatal DPA+DHA intake (n=1705)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>≥ 115 mg</td>
<td>678 (90%)</td>
<td>75 (10%)</td>
</tr>
<tr>
<td>&lt; 115 mg</td>
<td>811 (85%)</td>
<td>141 (15%)</td>
</tr>
<tr>
<td>Smoking status (n=1685)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>non-smoker</td>
<td>1216 (89%)</td>
<td>147 (11%)</td>
</tr>
<tr>
<td>smoked before, but not during pregnancy</td>
<td>157 (83%)</td>
<td>33 (17%)</td>
</tr>
<tr>
<td>smoked before and during pregnancy</td>
<td>97 (73%)</td>
<td>35 (27%)</td>
</tr>
<tr>
<td>Pre-pregnancy BMI (n=1647)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt; 25 kg/m²</td>
<td>952 (90%)</td>
<td>110 (10%)</td>
</tr>
<tr>
<td>25 – 30 kg/m²</td>
<td>309 (84%)</td>
<td>58 (16%)</td>
</tr>
<tr>
<td>&gt; 30 kg/m²</td>
<td>178 (82%)</td>
<td>40 (18%)</td>
</tr>
<tr>
<td>Planned pregnancy (n=1705)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>1148 (88%)</td>
<td>151 (12%)</td>
</tr>
<tr>
<td>No</td>
<td>341 (84%)</td>
<td>65 (16%)</td>
</tr>
<tr>
<td>Maternal diabetes (n=1705)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>82 (79%)</td>
<td>22 (21%)</td>
</tr>
<tr>
<td>No</td>
<td>1407 (88%)</td>
<td>194 (12%)</td>
</tr>
<tr>
<td>Pregnancy weight gain (n=1705)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Appropriate or ≤ appropriate (≤ 40 lbs)</td>
<td>1309 (87%)</td>
<td>189 (13%)</td>
</tr>
<tr>
<td>Excess (&gt; 40 lbs)</td>
<td>180 (87%)</td>
<td>27 (13%)</td>
</tr>
<tr>
<td>Birth weight for gestational age (n=1695)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10th – 90th percentile (aga)</td>
<td>1197 (88%)</td>
<td>171 (12%)</td>
</tr>
<tr>
<td>&lt; 10th percentile (sga)</td>
<td>93 (84%)</td>
<td>18 (16%)</td>
</tr>
<tr>
<td>&gt; 90th percentile (lga)</td>
<td>191 (88%)</td>
<td>25 (12%)</td>
</tr>
<tr>
<td>Delivery method (n=1627)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>vertex/breech</td>
<td>1133 (89%)</td>
<td>147 (11%)</td>
</tr>
<tr>
<td>cesarean section</td>
<td>285 (82%)</td>
<td>62 (18%)</td>
</tr>
</tbody>
</table>
### Table 4.4. Cross-tabulations of Breastfeeding Initiation and Continuous Covariates

<table>
<thead>
<tr>
<th>NICU admission (n=1705)</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>104 (84%)</td>
<td>20 (16%)</td>
</tr>
<tr>
<td>No</td>
<td>1385 (88%)</td>
<td>196 (12%)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Born in Canada (n=1704)</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>1285 (87%)</td>
<td>197 (13%)</td>
</tr>
<tr>
<td>No</td>
<td>203 (91%)</td>
<td>19 (9%)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Household income (n=1625)</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; $30,000</td>
<td>105 (82%)</td>
<td>23 (18%)</td>
</tr>
<tr>
<td>$30,000 - $59,999</td>
<td>324 (85%)</td>
<td>55 (15%)</td>
</tr>
<tr>
<td>$60,000 - $79,999</td>
<td>370 (84%)</td>
<td>68 (16%)</td>
</tr>
<tr>
<td>&gt; $80,000</td>
<td>624 (92%)</td>
<td>56 (8%)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Education (n=1703)</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>University or college</td>
<td>1173 (90%)</td>
<td>130 (10%)</td>
</tr>
<tr>
<td>Less than university or college</td>
<td>314 (79%)</td>
<td>86 (21%)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Food security (n=1703)</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>not at all difficult</td>
<td>1078 (89%)</td>
<td>140 (11%)</td>
</tr>
<tr>
<td>not very difficult</td>
<td>353 (85%)</td>
<td>61 (15%)</td>
</tr>
<tr>
<td>very/somewhat difficult</td>
<td>56 (79%)</td>
<td>15 (21%)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Marital Status (n=1705)</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Married</td>
<td>1224 (89%)</td>
<td>158 (11%)</td>
</tr>
<tr>
<td>Common-law</td>
<td>187 (82%)</td>
<td>42 (18%)</td>
</tr>
<tr>
<td>Single/never married/separated/divorced</td>
<td>78 (83%)</td>
<td>16 (17%)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Mean (± SD)</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Initiated breastfeeding (n=1489)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Did not initiate breastfeeding (n=216)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Caloric Intake (kcal) (n=1705)</td>
<td>2016 (±594)</td>
<td>1890 (±532)</td>
</tr>
<tr>
<td>Social Support (n=1666)</td>
<td>76.84 (±9.23)</td>
<td>76.05 (±8.46)</td>
</tr>
<tr>
<td>Variable</td>
<td>Odds Ratio (95% Confidence Interval)</td>
<td></td>
</tr>
<tr>
<td>-----------------------------------------------</td>
<td>--------------------------------------</td>
<td></td>
</tr>
<tr>
<td><strong>Prenatal percentage fat intake (n=1705)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>≤ 35% (ref)</td>
<td>--</td>
<td></td>
</tr>
<tr>
<td>&gt; 35%</td>
<td>1.197 (0.660, 2.169)</td>
<td></td>
</tr>
<tr>
<td><strong>Prenatal EPA+DHA intake (n=1705)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>≥115 mg (ref)</td>
<td>--</td>
<td></td>
</tr>
<tr>
<td>&lt;115 mg</td>
<td>0.636 (0.472, 2.117)</td>
<td></td>
</tr>
<tr>
<td><strong>Smoking status (n=1685)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>non-smoker (ref)</td>
<td>--</td>
<td></td>
</tr>
<tr>
<td>smoked before, but not during pregnancy</td>
<td>0.575* (0.381, 0.869)</td>
<td></td>
</tr>
<tr>
<td>smoked before and during pregnancy</td>
<td>0.335* (0.220, 0.511)</td>
<td></td>
</tr>
<tr>
<td><strong>Pre-pregnancy BMI (n=1647)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt; 25 kg/m² (ref)</td>
<td>--</td>
<td></td>
</tr>
<tr>
<td>25 – 30 kg/m²</td>
<td>0.616* (0.437, 0.867)</td>
<td></td>
</tr>
<tr>
<td>&gt; 30 kg/m²</td>
<td>0.514* (0.346, 0.764)</td>
<td></td>
</tr>
<tr>
<td><strong>Planned pregnancy (n=1705)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes (ref)</td>
<td>--</td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>0.690* (0.504, 0.945)</td>
<td></td>
</tr>
<tr>
<td><strong>Maternal diabetes (n=1705)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>0.514* (0.314, 0.842)</td>
<td></td>
</tr>
<tr>
<td>No (ref)</td>
<td>--</td>
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<tr>
<td><strong>Pregnancy weight gain (n=1705)</strong></td>
<td></td>
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</tr>
<tr>
<td>Appropriate/less than appropriate (≤ 40 lbs) ref</td>
<td>0.962 (0.625, 1.482)</td>
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</tr>
<tr>
<td>Excess (&gt; 40 lbs)</td>
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<td></td>
</tr>
<tr>
<td><strong>Birth weight for gestational age (n=1695)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10th – 90th percentile (aga) (ref)</td>
<td>--</td>
<td></td>
</tr>
<tr>
<td>&lt;10th percentile (sga)</td>
<td>0.738 (0.435, 1.253)</td>
<td></td>
</tr>
<tr>
<td>&gt;90th percentile (lga)</td>
<td>1.091 (0.698, 1.706)</td>
<td></td>
</tr>
<tr>
<td><strong>Delivery method (n=1627)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>vertex/breech (ref)</td>
<td>--</td>
<td></td>
</tr>
<tr>
<td>cesarean section</td>
<td>0.596* (0.431, 0.825)</td>
<td></td>
</tr>
<tr>
<td><strong>NICU admission (n=1705)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>0.736 (0.446, 1.214)</td>
<td></td>
</tr>
<tr>
<td>No (ref)</td>
<td>--</td>
<td></td>
</tr>
<tr>
<td><strong>Born in Canada (n=1704)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes (ref)</td>
<td>--</td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>1.638 (1.000, 2.683)</td>
<td></td>
</tr>
<tr>
<td><strong>Household income (n=1625)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt; $30,000</td>
<td>0.410* (0.242, 0.694)</td>
<td></td>
</tr>
<tr>
<td>$30,000 - $59,999</td>
<td>0.529* (0.356, 0.785)</td>
<td></td>
</tr>
<tr>
<td>$60,000 - $79,999</td>
<td>0.488* (0.335, 0.711)</td>
<td></td>
</tr>
<tr>
<td>&gt; $80,000 (ref)</td>
<td>--</td>
<td></td>
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<td></td>
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<tr>
<td>----------------------</td>
<td>------------------</td>
<td>-------------------------------</td>
</tr>
<tr>
<td><strong>Education</strong> (n=1703)</td>
<td>University or college (ref)</td>
<td>--</td>
</tr>
<tr>
<td></td>
<td>Less than university or college</td>
<td></td>
</tr>
<tr>
<td><strong>Food security</strong> (n=1703)</td>
<td>not at all difficult (ref)</td>
<td>--</td>
</tr>
<tr>
<td></td>
<td>not very difficult</td>
<td></td>
</tr>
<tr>
<td></td>
<td>very/somewhat difficult</td>
<td></td>
</tr>
<tr>
<td><strong>Marital Status</strong> (n=1705)</td>
<td>Married (ref)</td>
<td>--</td>
</tr>
<tr>
<td></td>
<td>Common-law</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Single/never married/separated/divorced</td>
<td></td>
</tr>
<tr>
<td><strong>Total caloric intake (log-kcal)</strong> (n=1705)</td>
<td></td>
<td>1.997* (1.232, 3.235)</td>
</tr>
<tr>
<td><strong>Social Support</strong> (n=1666)</td>
<td></td>
<td>1.009 (0.994, 1.025)</td>
</tr>
</tbody>
</table>

*significant at p-value ≤0.05.
Table 4.6. Univariable and Final Model for Multivariable Logistic Regression on Breastfeeding Initiation (Odds of Initiating Breastfeeding)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Univariable</th>
<th>Final Model¹ (Multivariable)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Odds Ratio (95% Confidence Interval)</td>
<td></td>
</tr>
<tr>
<td>Prenatal percentage fat intake</td>
<td></td>
<td></td>
</tr>
<tr>
<td>≤ 35% (ref)</td>
<td>1.197 (0.660, 2.169)</td>
<td>2.014* (1.002, 4.045)</td>
</tr>
<tr>
<td>&gt; 35%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Prenatal EPA+DHA intake</td>
<td></td>
<td></td>
</tr>
<tr>
<td>≥115 mg (ref)</td>
<td>0.636 (0.472, 2.117)</td>
<td>0.781 (0.561, 1.087)</td>
</tr>
<tr>
<td>&lt;115 mg</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maternal BMI</td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt; 25 kg/m² (ref)</td>
<td></td>
<td>0.774 (0.532, 1.127)</td>
</tr>
<tr>
<td>25 – 30 kg/m²</td>
<td>0.616* (0.437, 0.867)</td>
<td>0.652 (0.422, 1.005)</td>
</tr>
<tr>
<td>&gt; 30 kg/m²</td>
<td>0.514* (0.346, 0.764)</td>
<td></td>
</tr>
<tr>
<td>Household Income</td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt; $30,000</td>
<td>0.410* (0.242, 0.694)</td>
<td>0.683 (0.370, 1.260)</td>
</tr>
<tr>
<td>$30,000 - $59,999</td>
<td>0.529* (0.356, 0.785)</td>
<td>0.805 (0.516, 1.255)</td>
</tr>
<tr>
<td>$60,000 - $79,999</td>
<td>0.488* (0.335, 0.711)</td>
<td>0.574* (0.386, 0.856)</td>
</tr>
<tr>
<td>&gt; $80,000 (ref)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Education</td>
<td></td>
<td></td>
</tr>
<tr>
<td>University/college (ref)</td>
<td></td>
<td>0.503* (0.349, 0.725)</td>
</tr>
<tr>
<td>Less than university/college</td>
<td>0.405* (0.300, 0.546)</td>
<td></td>
</tr>
<tr>
<td>Total Caloric Intake (log-kcal)</td>
<td></td>
<td>1.997* (1.232, 3.353)</td>
</tr>
<tr>
<td></td>
<td>1.940* (1.123, 3.352)</td>
<td></td>
</tr>
<tr>
<td>Smoking Status</td>
<td></td>
<td></td>
</tr>
<tr>
<td>non-smoker (ref)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>smoked before, but not during pregnancy</td>
<td>0.575* (0.381, 0.869)</td>
<td>0.605* (0.384, 0.953)</td>
</tr>
<tr>
<td>smoked before and during pregnancy</td>
<td>0.335* (0.220, 0.511)</td>
<td>0.441* (0.265, 0.734)</td>
</tr>
<tr>
<td>Delivery Method</td>
<td></td>
<td></td>
</tr>
<tr>
<td>vertex/breech (ref)</td>
<td></td>
<td>0.596* (0.431, 0.825)</td>
</tr>
<tr>
<td>cesarean section</td>
<td></td>
<td>0.617* (0.433, 0.880)</td>
</tr>
</tbody>
</table>

¹Final model including only variables with p-value ≤0.20; *significant at p-value ≤0.05.
Table 4.7 Multiplicative and Additive Interaction between Percentage Fat and EPA+DHA Intake

<table>
<thead>
<tr>
<th>Multiplicative Interaction</th>
<th>Additive Interaction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Percent_fat*EPA_DHA</td>
<td>p-value = 0.2725</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>RERI</td>
<td>-1.37 (95% CI: -3.07, 2.23)</td>
</tr>
<tr>
<td>AP</td>
<td>-0.87 (95% CI: -4.53, -0.36)</td>
</tr>
<tr>
<td>SI</td>
<td>0.29 (95% CI: 0.017, 5.13)</td>
</tr>
</tbody>
</table>
Chapter 5: Discussion

5.1 Overview

This current study aimed to examine the effect of maternal fat intake during pregnancy on breastfeeding initiation. Previous animal studies have shown that mice and rats fed a diet composed of 50-60% fat had negatively altered lactation structures and lactation processes compared to those fed a diet composed of 10-15% fat. However, omega-3 fatty acid supplementation appeared to have positive effects. To our knowledge, this is the first human epidemiological study to look at the relationship between total fat and EPA+DHA intake during pregnancy and breastfeeding initiation. This study used data from the PHP, a longitudinal cohort study of mothers from the first trimester of pregnancy with follow-up at the infant and toddler stages.

Contrary to our hypothesis, higher maternal fat intake during pregnancy was associated with a significant increased likelihood of breastfeeding. Mothers who had a diet composed of >35% fat of their total caloric intake were twice as likely to initiate breastfeeding compared to mothers who had a diet composed of ≤35% fat. Mothers who met the recommendations of EPA+DHA intake had an increased chance of breastfeeding initiation, however the result was not significant. There was no multiplicative or additive interaction between percentage fat intake and EPA+DHA intake.
5.2 Interpretation of Main Study Results

5.2.1 Percentage Fat Intake and Breastfeeding Initiation

Based on animal studies that examined the relationship between high fat diet and the lactation structures and process, we expected a higher maternal fat intake to decrease the odds of breastfeeding initiation. However, from this study, we found the inverse. We will propose several reasons why a higher fat intake would increase the chances of a breastfeeding initiation.

The evidence that a high fat diet alters lactation structures and milk supply comes from animal studies, using mice and rats. Although animal models are useful and are utilized to a great extent in the world of research, animals do not necessarily have the same biochemical mechanisms or physiological responses as humans. Additionally, breastfeeding is a behaviour that is influenced by both biological and social factors for humans, unlike animals. Finally, the animal studies considered a high fat diet to be composed of 50-60% fat, while our study considered >35% to be a high fat diet based on dietary guidelines. This difference in categorization may be another reason why our results differed compared to the animal studies. For example, the negative effects of fat may only occur at the extreme higher levels of percentage fat intake, and since most of the mothers in our study did not reach those levels, we may have not been able to observe the effects shown in animal studies.

It may be that the benefits of fat override the negative effects it has on lactation structures. Fat is an essential component to the process of lactation. During lactogenesis I in mid-pregnancy, there is a rise in mRNA for milk proteins and enzymes involved in milk production.
and secretion. During this period, the fat droplets in cells responsible for milk secretion increase in size, and later on become the major cell component in these cells [3].

Another possible explanation for the observed association could be due to certain social factors. Previous studies have reported that mother’s body image concerns are associated with gestational weight gain [106] and breastfeeding duration [107]. For mothers whose priority is body image, rather than the baby’s health, they may restrict food consumption (and have less fat intake) to avoid unwanted weight gain during pregnancy. These women may have other priorities in addition to their child’s health, and are probably also less likely to engage in healthy behaviours for the child’s health, such as breastfeeding.

5.2.2 EPA+DHA intake and breastfeeding initiation

Mothers who met the adequate intake recommendations for EPA+DHA intake (≥115 mg/day) were more likely to initiate breastfeeding, but this result was not significant. As mentioned previously, a study showed that omega-3 fatty acid supplement in rats had a positive effect on the structures required for successful lactation [96]. It is unknown whether mothers in our study who met the EPA+DHA requirements had lactation structures different from mothers who did not meet the requirements. We believe that this observed trend was more likely due to a social reason rather than a biological one. Mothers who met the recommendations for EPA+DHA intake are probably more educated about the benefits of consuming omega-3 fatty acids for the child’s health and their own health, and are also probably more likely to engage in other healthy behaviours, such as breastfeeding.
5.2.3 Interaction between Percent fat intake and EPA+DHA intake

We examined whether the effect of fat intake on breastfeeding initiation depended on the type of fat consumed, specifically long-chain omega-3 fatty acids, since it is well known that mothers are recommended to increase their intake of omega-3 during pregnancy. Based on evidence in the literature, we hypothesized that a higher EPA and DHA intake would increase a mother’s likelihood of breastfeeding. We predicted that the effect of fat intake on breastfeeding would depend on the type of fat consumed, and having a higher intake of the long-chain omega-3 fatty acids would attenuate the negative effect of total fat intake on breastfeeding. However, from our study, we found that there was no significant interaction between percent fat intake and EPA+DHA intake on breastfeeding initiation in the additive or multiplicative scale. This suggests that the effects of percentage fat intake are not affected by the amount of EPA+DHA intake, and vice versa. Since the absolute amount of EPA+DHA is very small, it may not have a substantive effect on lactation relative to the overall intake of fat. Therefore, our results show that consuming at least the recommended amount of EPA and DHA did not significantly affect the relationship between total fat intake and breastfeeding initiation.

5.3 Study Strengths

This study has a number of strengths. The dataset is from a prospective cohort study, which allows us to obtain temporality that is not possible from a cross-sectional study. Moreover, there were multiple times points of follow-up in the post-natal period, allowing us to have access to valuable information at multiple stages of the child’s life. The PHP consists of a large sample
of mothers (n=2357), which gave us a relatively large sample size (n=1706) for our current study. Information on social factors, maternal health, maternal diet, infant health and other pregnancy information was collected, making the PHP a source of rich information on a large number of mothers in London, Ontario.

The breastfeeding variable had a number of strengths. First, information regarding breastfeeding initiation was available for the majority (75%) of the total number of mothers in the PHP cohort. Second, the information on breastfeeding was taken from both the infant and toddler survey. We suspect that the recall accuracy during the infant survey is quite high, since the child was <1 year old and not too much time will have passed since the mother initiated or did not initiate breastfeeding. For participants who were not part of the infant survey subset, breastfeeding initiation data were taken from the toddler survey (2-5 years old). The chances of recall bias is greater for these mothers, since more time has passed since they breastfed or did not breastfeed their child. We explored the agreement between the surveys at the two time points, and found that of mothers who completed both the infant and toddler survey (n=557), less than 8% of mothers had discordant answers about initiating breastfeeding. These numbers suggest that the breastfeeding initiation variable we constructed, using both time points, is quite accurate.

Maternal fat intake was measured using a FFQ, which is a commonly used tool for dietary assessment in research studies. The advantages of a FFQ are that interviewers do not need to be highly trained, response rates are typically high, respondent burden is low and administration is easy [108]. It is also not required for the participant to change their customary diet, and the FFQ can be optically scanned, which reduces costs for data entry [109]. The FFQ was also completed via a telephone interview with guidance from a trained researcher, which allows for both consistent interpretation of questions and convenience for the participant.
Additionally, the FFQ used in the prenatal survey was validated in a small sample (n=22) of pregnant women in London, Ontario, against a 3-day food diary. Although the intake of EPA+DHA was not specifically validated, this measure was derived from specific marine foods and portions on the FFQ, similar to the study by Olsen et al. [99]. We therefore believe that the EPA+DHA measure used in our FFQ was an accurate measure of long-chain omega-3 fatty acid intake.

5.4 Study Limitations

There are a number of biological factors which were not captured in the PHP dataset, which may be associated with breastfeeding initiation. The rate that milk is produced in the mammary gland is influenced by the degree in which the breast is drained [110], and we did not have this information. We did not have information on the actual milk volume produced by the mother, thus we did not know which mothers actually had insufficient milk supply. Improper latching can also lead to a series of negative events, including nipple pain, interrupted milk transfer and decreased milk production. Challenges mothers may have faced with latching or breastfeeding was not captured in the PHP survey, since the study was not conducted with a focus on breastfeeding. Finally, there was no information on the mother’s intention to breastfeed, which is a major factor influencing the chances of breastfeeding initiation [16, 22, 43, 44].

Although the FFQ was validated and is a more low-cost and convenient method of collecting dietary information, there are certain disadvantages compared to a food diary or 24-hour dietary recall. For example, it does not provide the absolute nutrient values, but rather only
an estimation. There is a lack of detail for specific foods (when compared to food diaries), and variability depending on the length and structure of the specific questionnaire for that study [111].

There are a couple limitations specifically with the prenatal fat intake variable. Percent fat intake was categorized based on dietary recommendations discussed previously. However, by doing this, we are assuming that the participants in each category are equal in terms of their fat intake. Although this limited our ability to observe the effects of dietary fat on a continuous scale, dichotomization allowed for easier interpretation and application of our results to making medical recommendations. Additionally, fat intake was also categorized in animal studies (high fat diet vs. low fat), which allowed for easier comparison to our results. In the animal studies which examined fat intake and lactation, most of the high fat diets were very high in fat content (60% fat). For our analyses, we used the cut-off of >35% fat to be considered a “high fat” diet, and only a very small percentage of participants had a diet comparable to the high percent fat intake in the animal studies. Perhaps the effect of a high fat intake is only present at levels above 60%, which we could not elucidate due to the limitations of our study sample. Additionally, the fat intake variable had to be dichotomized due to small cell size, which meant that mothers with a low fat intake and a normal fat intake were grouped together. However, the evidence in the literature mainly concentrated on the effects of a high fat diet, therefore we do not think that combining mothers with less than adequate fat intake with adequate fat intake resulted in a big limitation to our ability to detect our hypothesized effect.

Finally, we could not account for EPA and DHA supplementation. In the prenatal survey, mothers were asked whether they took omega-3 supplements, answering either “yes” or “no”.
There were no data on the absolute amount of supplement, and the question did not distinguish the different types of omega-3 fatty acids (ALA, EPA, DHA). Therefore, we did not include these data in our analyses. However, there were only 23 participants who reported taking omega-3 supplements during pregnancy. Since this number is quite low, we believe that the inability to account for EPA+DHA supplements did not have a substantial effect on our results.

5.5 Future Studies and Conclusion

In this study, there was no information on actual milk production, and thus the number of mothers who experienced insufficient milk supply was unknown. It is important to examine whether fat intake has an effect on milk supply, and the number of women who actually experience biological barriers to breastfeeding. If there was an effect on milk supply, it would be of interest to see whether these effects are long-lasting. Therefore, it is important to examine the association between fat intake and breastfeeding duration in future studies.

In previous animal studies, researchers also did not distinguish between different types of fats in the diet, but rather only reported on the percent of fat in the diet. It would be interesting to examine whether saturated, unsaturated and trans fats have different effects on lactation and breastfeeding initiation. There are three major types of fats in our diet: saturated, unsaturated and trans. Typically, unsaturated (including long-chain omega-3 fatty acids, which are polyunsaturated) are considered “healthy” fats, while saturated and trans fats have been associated with negative health events. Saturated fat, found in many foods like meat, butter and whole milk, have been shown to raise LDL cholesterol levels, which in turn been shown to increase risk of heart disease [112]. Studies have shown that trans fats, found in commercially
fried foods and hydrogenated margarines, not only increase LDL cholesterol levels, but decrease HDL cholesterol, or “good” cholesterol as well. Health Canada recommends that Canadians limit their intake of saturated and trans fat intake [113]. However, a recent study has shown that dietary saturated fat may not actually influence plasma levels of fatty acids and cholesterol [114], therefore placing doubt in the influence of saturated fat consumption on various health outcomes. Nonetheless, it would interesting for future studies to examine whether different types of fats have varying effects on the lactation process, and in turn the likelihood of initiating breastfeeding.

From our results, we can conclude that dietary fat intake during pregnancy is a significant predictor of breastfeeding initiation. Consuming a diet >35% in fat was significantly associated with higher odds of breastfeeding initiation, and meeting the recommended intake of long-chain omega-3 fatty acids (EPA+DHA) appears to be associated with higher odds of breastfeeding initiation, though this did not reach significance. These results imply that fat intake is an important component of whether a mother breastfeeds or not. In the recent decades, people are more health conscious and much more aware of the food they consume [115]. With increased education, dietary guidelines, and interventions such as nutrition labelling, the general public is more educated about which foods are healthy and the consequences of an unhealthy diet. Perhaps this applies especially to mothers. We know that the mother’s diet is a significant part of a healthy pregnancy, and certain nutrients, such as folic acid and omega-3 fatty acids, are extremely important for child development. Fat has developed a bad reputation in terms of health consequences, and some mothers may want to decrease their fat intake due to this. However, fat is essential to the process of pregnancy, milk production and ejection and milk quality. Even though animal studies suggest that an extremely high fat intake (50-60%) is damaging to
lactation, our findings suggest that fat intakes >35% are associated with an increased likelihood of breastfeeding initiation. To conclude, mothers should ensure that they are consuming enough nutrients, including fat, to support their pregnancy and ability to breastfeed.

Overall, we can conclude that prenatal dietary fat is an important factor in breastfeeding initiation. Our results add to the literature regarding factors that affect whether a mother breastfeeds her child or not. Finally, our results can potentially aid in developing dietary fat guidelines specifically for women in the future.
Appendices
Appendix A: Recommendations of dietary LC-omega-3 fatty acids (EPA+DHA)

<table>
<thead>
<tr>
<th>Adults (19+ years)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Men</td>
<td>160 mg/day</td>
</tr>
<tr>
<td>Women</td>
<td>90 mg/day</td>
</tr>
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</table>

<table>
<thead>
<tr>
<th>Pregnancy</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>14-18 years old</td>
<td>110 mg/day</td>
</tr>
<tr>
<td>19-50 years old</td>
<td>115 mg/day</td>
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</tbody>
</table>

<table>
<thead>
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<th>Lactation</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>14-18 years old</td>
<td>140 mg/day</td>
</tr>
<tr>
<td>19-50 years old</td>
<td>145 mg/day</td>
</tr>
</tbody>
</table>
Appendix B.1: Ethics Approval for Prenatal Interview

The UNIVERSITY of WESTERN ONTARIO

Research Ethics Office - Dental Sciences Building, London, ON,
Telephone:

REVIEW BOARD FOR HEALTH SCIENCES RESEARCH INVOLVING HUMAN SUBJECTS (FULL BOARD)
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ONTARIO
OPERATES IN ACCORDANCE WITH AND CONFORMS TO THE TRI-COUNCIL POLICY STATEMENT
(ETHICAL CONDUCT FOR RESEARCH INVOLVING HUMANS)

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4) Dr. R. McManus, London Health Sciences Centre - Victoria Campus Representative (Endocrinology, Metabolism)
5) London Health Sciences Centre - University Campus Representative
6) Dr. L. Heller, Office of the President Representative (French)
7) Ms. S. Agranove, Office of the President Representative (Community)
8) Ms. S. Fincher-Stoll, Office of the President Representative (Legal)
9) Dr. D. Freeman, Faculty of Medicine Dentistry Representative (Clinical)
10) Dr. G. Woodbury, Faculty of Medicine Dentistry Representative (Basic, Epidemiology)
11) Dr. G. McCarthy, School of Dentistry Representative (Oral Biology)
12) Ms. D. Travis, Faculty of Health Sciences Representative (Nursing)
13) Dr. D. Junier, London Regional Cancer Centre Representative (Oncology)
14) Ms. N. Pux, London Clinical Research Association Representative (Nursing)
15) Dr. M. Gibson, Research Institutes Representative (Psychology)

Alternates are appointed for each member.

THE REVIEW BOARD HAS EXAMINED THE RESEARCH PROJECT ENTITLED:

Prediction of Preterm Birth

REVIEW NO: 08253E

AS SUBMITTED BY: Dr. M.K. Campbell - Epidemiology & Biostatistics, University of Western Ontario

AND CONSIDERS IT TO BE ACCEPTABLE ON ETHICAL GROUNDS FOR RESEARCH INVOLVING HUMAN SUBJECTS UNDER CONDITIONS OF THE UNIVERSITY'S POLICY ON RESEARCH INVOLVING HUMAN SUBJECTS.

APPROVAL DATE: April 26, 2001 (UWO Protocol, Letter of Information & Consent)

AGENCY: CIHR

AGENCY TITLE: c.c. Hospital Administration

P. Harding, Chair
Appendix B.2: Prenatal Ethics Approval (Revised Study End Date)

Office of Research Ethics
The University of Western Ontario

Telephone: Website www.uwo.ca/research/ethics

Use of Human Subjects - Ethics Approval Notice

Principal Investigator: Dr. M.K. Campbell
Revision Number: 08253E
Protocol Title: Prenatal Health Project
Department and Institution: Epidemiology & Biostatistics, University of Western Ontario
Sponsor: CIHR
Approval Date: 13-Jun-05
End Date: 30-Jun-05
Documents Reviewed and Approved: Revised Study End Date

Documents Received for Information:
This is to notify you that the University of Western Ontario Research Ethics Board for Health Sciences Research Involving Human Subjects (HSREB) which is organized and operates according to the Tri-Council Policy Statement and the Health Canada/ICH Good Clinical Practice Practice: Consolidated Guidelines; and the applicable laws and regulations of Ontario has received and granted expedited approval to the above named research study on the date noted above. The membership of this REB also complies with the membership requirements for REB's as defined in Division 5 of the Food and Drug

This approval shall remain valid until end date noted above assuming timely and acceptable responses to the HSREB's periodic requests for surveillance and monitoring information. If you require an updated approval notice prior to that time you must request it using the UWO Updated Approval Request Form.

During the course of the research, no deviations from, or changes to, the protocol or consent form may be initiated without prior written approval from the HSREB except when necessary to eliminate immediate hazards to the subject or when the change(s) involve only logistical or administrative aspects of the study (e.g. change of monitor, telephone number). Expedited review of minor change(s) in ongoing studies will be considered. Subjects must receive a copy of the signed information/consent documentation.

Investigators must promptly also report to the HSREB:
a) changes increasing the risk to the participant(s) and/or affecting significantly the conduct of the study;
b) all adverse and unexpected experiences or events that are both serious and unexpected

c) new information that may adversely affect the safety of the subjects or the conduct of the study

If these changes/ adverse events require a change to the information/consent documentation, and/or recruitment advertisement, the newly revised information/consent documentation, and/or advertisement, must be submitted to this office for approval.

Members of the HSREB who are named as investigators in research studies, or declare a conflict of interest, do not participate in discussion related to, nor vote on, such studies when they are presented to the HSREB.

Chair of HSREB: Dr. Paul Harding

Kalen Kueneman, BA (Hons), Ethics Officer HSREB (Expedited)

This is an official document. Please retain the original in your files.
Appendix B.3: Infant and Toddler Ethics Approval

Office of Research Ethics
The University of Western Ontario
Telephone: 
Website:  www.uwo.ca/research/ethics

Use of Human Subjects - Ethics Approval Notice

Principal Investigator: Dr. M.K. Campbell
Review Number: 10787E
Revision Number: 1
Protocol Title: Maternal and Infant Health, Health Services Needs and Utilization
Department and Institution: Epidemiology & Biostatistics, University of Western Ontario
Sponsor:
Ethics Approval Date: September 1, 2005  Expiry Date: March 31, 2010
Documents Reviewed and Approved: Revised Sample Size, Revised End Date, Revised Study Instrument
Documents Received for Information:

This is to notify you that The University of Western Ontario Research Ethics Board for Health Sciences Research Involving Human Subjects (HSREB) which is organized and operates according to the Tri-Council Policy Statement and the Health Canada/ICH Good Clinical Practice Practices: Consolidated Guidelines; and the applicable laws and regulations of Ontario has reviewed and granted expedited approval to the above named research study on the approval date noted above. The membership of this REB also complies with the membership requirements for REB's as defined in Division 5 of the Food and Drug Regulations.

This approval shall remain valid until the expiry date noted above assuming timely and acceptable responses to the HSREB's periodic requests for surveillance and monitoring information. If you require an updated approval notice prior to that time you must request it using the UWO Updated Approval Request Form.

During the course of the research, no deviations from, or changes to, the protocol or consent form may be initiated without prior written approval from the HSREB except when necessary to eliminate immediate hazards to the subject or when the change(s) involve only logistical or administrative aspects of the study (e.g. change of monitor, telephone number).

Expected review of minor change(s) in ongoing studies will be considered. Subjects must receive a copy of the signed information/consent documentation.

Investigators must promptly also report to the HSREB:
a) changes increasing the risk to the participant(s) and/or affecting significantly the conduct of the study;
b) all adverse and unexpected experiences or events that are both serious and unexpected;
c) new information that may adversely affect the safety of the subjects or the conduct of the study.

If these changes/adverse events require a change to the information/consent documentation, and/or recruitment advertisement, the newly revised information/consent documentation, and/or advertisement, must be submitted to this office for approval.

Members of the HSREB who are named as investigators in research studies, or declare a conflict of interest, do not participate in discussion related to, nor vote on, such studies when they are presented to the HSREB.

Chair of HSREB: Dr. Paul Harding
Deputy Chair: Susan Hoddinott

Ethics Officer to Contact for Further Information
Karen Kueneman  Janice Sutherland  Susan Underhill  Jennifer McEwan

This is an official document. Please retain the original in your files.
Appendix B.4: Breastfeeding Questions from Infant Survey

CURRENT FEEDING PRACTICES

"The next few questions are being used to gather information on current feeding practices among women in London/Middlesex."

23. Are you currently breastfeeding your baby?
   1. Yes
   2. No

   If No → 24. Did you ever breastfeed your baby?
   1. Yes
   2. No → skip to Q28

   25. How many days/weeks after delivery did you stop breastfeeding?
       _______ (# days)

   If Yes → 26. Has your baby ever received nutrients from a source other than breast milk, such as juice or formula?
   1. Yes
   2. No → skip to Q28

   27. At what age did your baby first receive nutrients from a source other than breast milk?
       _______ (# days) OR _______ (# weeks)

28. Who/what was the most influential in your decision to breastfeed or not to breastfeed?
   1. Knowledge/personal belief/preference
   2. Husband or baby’s father
   3. Mother or other female relative
      □ Please specify: ________________
   4. Friend
   5. Doctor
   6. Nurse
      □ Please specify: ________________
   7. Other health care provider
      □ Please specify: ________________
   8. Other resource
      □
Appendix B.5: Breastfeeding Questions from Child Survey

How I would like to ask you about your child’s eating behaviour, starting from when the child was an infant.

42. How did you feed your child at birth?
   ☐ Formula (SKIP TO Q45)
   ☐ breast-feeding

43. How old was your child when you stopped breast-feeding? _____ (Record in months of age)
   OR
   ☐ I have not stopped breast-feeding yet

44. Have you ever fed your child formula?
   ☐ No (SKIP TO Q46)
   ☐ Yes

45. How old was your child when he/she stopped drinking formula? _____ (Record in months of age)
   OR
   ☐ My child still drinks formula

46. How old was your child when you first started giving him/her milk (other than breast milk or formula) every day? _____ (Record in months of age)

47. What type of milk did you first give to your child?
   ☐ regular (homogenized) milk
   ☐ 2% milk
   ☐ 1% milk
   ☐ skim milk
   ☐ other, specify: ____________________________
   ☐ don’t know

48. At what age did you start giving your child solid foods (baby cereal, strained foods, crackers etc.)?
   _____ (Record in months of age)
Appendix C:

Univariable and Multivariable Logistic Regression on Breastfeeding Initiation (Odds of Initiating Breastfeeding)
<table>
<thead>
<tr>
<th>Variable</th>
<th>Univariable</th>
<th>Model 1&lt;sup&gt;1&lt;/sup&gt;</th>
<th>Model 2&lt;sup&gt;2&lt;/sup&gt;</th>
<th>Model 3&lt;sup&gt;3&lt;/sup&gt;</th>
<th>Final Model&lt;sup&gt;4&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Odds Ratio (95% Confidence Interval)</strong></td>
<td></td>
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<tr>
<td><strong>BLOCK 1: BASELINE</strong></td>
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<tr>
<td><strong>Pre-pregnancy BMI</strong></td>
<td></td>
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</tr>
<tr>
<td>&lt; 25 kg/m&lt;sup&gt;2&lt;/sup&gt; (&lt;ref&gt;)</td>
<td>--</td>
<td>0.616* (0.437, 0.867)</td>
<td>0.702 (0.486, 1.015)</td>
<td>0.727 (0.503, 1.050)</td>
<td>0.771 (0.528, 1.125)</td>
</tr>
<tr>
<td>25 – 30 kg/m&lt;sup&gt;2&lt;/sup&gt;</td>
<td>0.514* (0.346, 0.764)</td>
<td>0.601* (0.393, 0.919)</td>
<td>0.636* (0.414, 0.977)</td>
<td>0.639* (0.414, 0.987)</td>
<td>0.652 (0.422, 1.005)</td>
</tr>
<tr>
<td>&gt; 30 kg/m&lt;sup&gt;2&lt;/sup&gt;</td>
<td></td>
<td></td>
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<tr>
<td><strong>Household income</strong></td>
<td></td>
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<tr>
<td>&lt; $30,000</td>
<td>0.410* (0.242, 0.694)</td>
<td>0.702 (0.373, 1.321)</td>
<td>0.786 (0.431, 1.433)</td>
<td>0.677 (0.366, 1.249)</td>
<td>0.683 (0.370, 1.260)</td>
</tr>
<tr>
<td>$30,000 - $59,999</td>
<td>0.529* (0.356, 0.785)</td>
<td>0.786 (0.502, 1.229)</td>
<td>0.770 (0.499, 1.188)</td>
<td>0.810 (0.518, 1.267)</td>
<td>0.805 (0.516, 1.255)</td>
</tr>
<tr>
<td>$60,000 - $79,999</td>
<td>0.488* (0.335, 0.711)</td>
<td>0.587* (0.396, 0.870)</td>
<td>0.572* (0.386, 0.849)</td>
<td>0.565* (0.378, 0.843)</td>
<td>0.574* (0.386, 0.856)</td>
</tr>
<tr>
<td>&gt; $80,000 (&lt;ref&gt;)</td>
<td>--</td>
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</tr>
<tr>
<td><strong>Education</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>University/college (&lt;ref&gt;)</td>
<td>--</td>
<td>0.405* (0.300, 0.546)</td>
<td>0.449* (0.318, 0.636)</td>
<td>0.495* (0.348, 0.706)</td>
<td>0.494* (0.342, 0.712)</td>
</tr>
<tr>
<td>Less than university/college</td>
<td></td>
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<tr>
<td><strong>Place of Birth</strong></td>
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<tr>
<td>Yes (&lt;ref&gt;)</td>
<td>--</td>
<td>1.638* (1.000, 2.683)</td>
<td>1.438 (0.843, 2.452)</td>
<td>X</td>
<td>X</td>
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<tr>
<td>No</td>
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<td><strong>Food security</strong></td>
<td></td>
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<tr>
<td>not at all difficult (&lt;ref&gt;)</td>
<td>--</td>
<td>0.752 (0.544, 1.039)</td>
<td>0.803 (0.561, 1.150)</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>not very difficult</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>very/somewhat difficult</td>
<td>0.485* (0.267, 0.880)</td>
<td>0.550 (0.274, 1.103)</td>
<td>X</td>
<td>X</td>
<td>X</td>
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<tr>
<td><strong>Marital Status</strong></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Married (&lt;ref&gt;)</td>
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<td>0.575* (0.396, 0.835)</td>
<td>X</td>
<td>X</td>
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<tr>
<td>Common-law</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Single/never married/ separated/divorced</td>
<td>0.629 (0.358, 1.105)</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td><strong>Social Support</strong></td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>1.009 (0.994, 1.025)</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Planned pregnancy</td>
<td>Yes (ref)</td>
<td>No</td>
<td>X</td>
<td>X</td>
<td>X</td>
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<td></td>
<td></td>
<td>0.690* (0.504, 0.945)</td>
<td></td>
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<tr>
<td>Prenatal percentage fat intake</td>
<td>≤ 35% (ref)</td>
<td>1.197 (0.660, 2.169)</td>
<td>--</td>
<td>2.134* (1.066, 4.272)</td>
<td>--</td>
</tr>
<tr>
<td></td>
<td>&gt; 35%</td>
<td>0.636 (0.472, 2.117)</td>
<td></td>
<td>0.766 (0.553, 1.062)</td>
<td></td>
</tr>
<tr>
<td>Prenatal EPA+DHA intake</td>
<td>≥115 mg (ref)</td>
<td>0.575* (0.381, 0.869)</td>
<td>--</td>
<td>0.597* (0.382, 0.932)</td>
<td>--</td>
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<tr>
<td></td>
<td>&lt;115 mg</td>
<td>0.335* (0.220, 0.511)</td>
<td></td>
<td>0.430* (0.261, 0.710)</td>
<td></td>
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<tr>
<td>Total caloric intake (log)</td>
<td></td>
<td>1.997* (1.232, 3.235)</td>
<td></td>
<td>1.823* (1.071, 3.102)</td>
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<tr>
<td>Smoking status</td>
<td>non-smoker (ref)</td>
<td>0.514* (0.314, 0.842)</td>
<td></td>
<td>0.610 (0.344, 1.079)</td>
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<tr>
<td></td>
<td>smoked before, but not during pregnancy</td>
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<tr>
<td></td>
<td>smoked before and during pregnancy</td>
<td>--</td>
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<td></td>
</tr>
<tr>
<td>Maternal diabetes</td>
<td>Yes (ref)</td>
<td>0.514* (0.314, 0.842)</td>
<td></td>
<td>0.610 (0.344, 1.079)</td>
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<tr>
<td></td>
<td>No (ref)</td>
<td>--</td>
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<tr>
<td>Pregnancy weight gain</td>
<td>Appropriate or less than appropriate (ref)</td>
<td>--</td>
<td></td>
<td>X</td>
<td>X</td>
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<tr>
<td></td>
<td>&gt; 40 lbs</td>
<td>0.962 (0.625, 1.482)</td>
<td></td>
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<tr>
<td>Delivery method</td>
<td>vertex/breech (ref)</td>
<td>0.596* (0.431, 0.825)</td>
<td></td>
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<tr>
<td></td>
<td>cesarean section</td>
<td>--</td>
<td></td>
<td>0.639* (0.446, 0.914)</td>
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</tbody>
</table>
## Birth weight for gestational age

<table>
<thead>
<tr>
<th></th>
<th>10\textsuperscript{th} – 90\textsuperscript{th} percentile (ref)</th>
<th>&lt;10\textsuperscript{th} percentile (sga)</th>
<th>&gt;90\textsuperscript{th} percentile (lga)</th>
<th></th>
<th></th>
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</thead>
<tbody>
<tr>
<td></td>
<td>--</td>
<td>0.738 (0.435, 1.253)</td>
<td>1.091 (0.698, 1.706)</td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>

## NICU admission

<p>| | | | |</p>
<table>
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<tr>
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<tr>
<td>Baseline</td>
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<td>Baseline</td>
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<tr>
<td>Baseline</td>
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</tbody>
</table>

\*Baseline variables; \*Baseline and prenatal variables; \*Baseline, prenatal and perinatal variables; \*Final model including only variables with p-value ≤0.20; \*significant at p-value ≤0.05.
Bibliography


Rachel Man

EDUCATION:

**Western University**  2013 – Present

*Candidate for Master of Science in Epidemiology and Biostatistics*
Supervisor: Dr. M Karen Campbell
Thesis: Maternal fat intake during pregnancy and breastfeeding initiation
*(in preparation for submission)*

**University of Guelph**  2012

*Bachelor of Science in Biomedical Science, Honours*
Supervisor: Dr. Pavneesh Madan
Thesis: Assessment of mitochondrial function in fast and slow-cleaving bovine preimplantation embryos

WORK EXPERIENCE:

**Western University, Dept. of Epidemiology and Biostatistics**  2015

*Teaching Assistant*
- Prepared and ran tutorial sessions for 2\textsuperscript{nd} year undergraduate Introduction to Epidemiology course
- Designed review questions and consulted with students one-on-one

**Western University, Dept. of Epidemiology and Biostatistics**  2013 - Present

*Research Assistant*
- Cleaned and re-coded statistical data using SAS statistical program
- Conducted various analyses (descriptive, multivariable regression) on datasets
- Contacted study participants and conducted research interviews

**University of Guelph, Ontario Veterinary College**  2011 - 2012

*Research Assistant*
- Performed laboratory procedures, such as *in-vitro* fertilization, RNA extraction and PCR
- Completed the Summer Leadership Research Program and attended various research conferences

**TD Waterhouse**  2010

*Operations Officer*
- Distributed mail, organized documents and processed bill payments
- Completed customer requests, including opening accounts and withdrawals
PUBLICATIONS, PRESENTATIONS and CONFERENCES:

Publications:


**Presentations:**

**Poster:** R Man, C O’Connor, K Speechley, MK Campbell. “Maternal fat intake during pregnancy and breastfeeding initiation”, CSEB (Canadian Society for Epidemiology & Biostatistics Conference, Mississauga, ON. 2015


**Oral:** R Man. “Maternal fat intake during pregnancy and breastfeeding initiation and duration”, Student Thesis Presentation Day, Department of Epidemiology and Biostatistics, Western University. 2014

**Oral:** R Man, V Kalatharan. “Vegetable and Fruit Consumption in Middlesex – London” (for Population Health Surveillance Course), Middlesex-London Health Unit. 2014

**Oral:** R Man. “Assessment of mitochondrial function in fast and slow-cleaving bovine preimplantation embryos”, University of Guelph. 2012

**Poster:** R Man, K Perkel, C Elliott, P Madan. “Assessment of Mitochondrial Function during Bovine Preimplantation Embryogenesis”, Summer Leadership Research Program Poster Presentations, University of Guelph OVC. 2011

**Conferences:**


Canadian Society for Epidemiology and Biostatistics Conference, McMaster University (Attendee) May 2014


International Society for Stem Cell Research (ISSCR) 9th Annual Meeting, Metro Convention Centre, Toronto (Attendee) June 2011

Rachel Man rman@uwo.ca June 2015
SCHOLARSHIPS and AWARDS:

**Graduate Teaching Assistantship**
Western University 2015

**Carol Buck Graduate Scholarship**
Western University, $5,000 2014
Awarded annually to top student in the Epidemiology and Biostatistics cohort

**Ontario Graduate Scholarship**
University of Western Ontario, $15,000 2014 - 2015

**Student Thesis Presentation Winner**
Dept. of Epidemiology and Biostatistics, Western University 2014

**Children’s Health Research Institute Graduate Award**
Western University, $10,000 2013 - 2014

**Western Graduate Research Scholarship**
Dept. of Epidemiology and Biostatistics, Western University, $4,500 2013 - 2014

**Biomedical Sciences Research Award of Merit**
Dept. of Biomedical Sciences, University of Guelph, Among 12 finalists for best research performance in the Biomedical Research Program 2012

**Undergraduate Research Assistantship**
Dept. of Biomedical Sciences, University of Guelph, $6,000 2011

**Queen Elizabeth II Aiming for the Top Scholarship**
University of Guelph, $14,000 2008 - 2012

**Dean’s Honour List**
Dept. of Biomedical Sciences, University of Guelph 2008 - 2012

**University of Guelph Entrance Scholarship**
University of Guelph, $3,000 2008

**College of Biological Science College Roll of Distinction**
University of Guelph 2010 - 2012

Rachel Man  rman@uwo.ca  June 2015
OTHER ACADEMIC EXPERIENCE:

Elected Position:

SOGS (Society of Graduate Students) Representative for the Dept. of Epidemiology and Biostatistics, Western University 2013 - present

Professional development workshops:

Attended Geographic Information System (GIS) in Health Care Workshop, Western University Dec 2014

Attended Excel 2010 Level II #1114 Workshop, Western University Oct 2014

SAS data coding workshop (additional training), Western University May 2014

Clubs

Participated in summer book club from the Dept. of Epidemiology and Biostatistics, Summer 2013

Read and discussed “The Ghost Map: The Story of London’s Most Terrifying Epidemic by Steven Berlin Johnson”, Western University

SKILLS and QUALIFICATIONS:

- Knowledge of SAS statistical program, Microsoft Word, Microsoft Excel, Endnote
- Fluent in English and Cantonese

VOLUNTEER EXPERIENCE:

- Volunteer for the Toronto East General Hospital in the emergency and long-term care department
- Ambassador for the University of Guelph
- Veterinarian technician assistant at the Woodland Pet Hospital

PERSONAL INTERESTS:

- Completed the diploma of The Associate of The Royal Conservatory (ARCT) Piano Performer level
- Competitor in the University Bouldering Series (inter-university rock climbing competitions)