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Global Epidemiology

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Bachelor of Science

Mississippi State University

2009

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An abstract of

A thesis submitted to the Faculty of the
Rollins School of Public Health of Emory University

in partial fulfillment of the requirements for the degree of
Master of Public Health
in Global Epidemiology

2012

Abstract

Breastfeeding is not an independent predictor of inter-pregnancy interval in a population with high prevalence of contraception

By Melissa Larkin

Objectives: The objective of this study is to investigate the relationship between breastfeeding and subsequent inter-pregnancy interval (IPI) in a cohort of Georgia mothers. This study aims to supplement the existing literature on breastfeeding and IPI by investigating a population in which contraception use is high and by controlling for various potential confounders not included in previous studies. **Methods:** Two commonly available maternal and child health databases were linked by a common identifier to create a population-based cohort of mothers with index and subsequent births in Georgia. Two models, one including ever breastfeeding after an index pregnancy with covariates, and one including exclusive breastfeeding after an index pregnancy with covariates were assessed for association with subsequent IPI. Ideal IPI was considered greater than 18 months. **Results:** No significant association was found between ever breastfeeding or exclusive breastfeeding and IPI. African American race was significantly associated with shorter IPIs, and contraception use was significantly associated with longer IPIs. **Conclusion:** While increasing the prevalence of breastfeeding, especially exclusive breastfeeding, is an important public health goal, interventions to lengthen IPI should focus on other exposures, such as health education, access to and utilization of family planning services and contraception for underserved populations.

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Acknowledgements

I would like to acknowledge my advisor, Michael Kramer, for his superb guidance and critique of this work. He is largely responsible for the innovative design of this study, for obtaining the data, and for devising the linkage and analysis process. Many thanks to him for the wise and timely help that made this project possible.

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Chapter I. Background

Introduction

In recent years breastfeeding has been promoted for a variety of reasons, some beneficial for the mother and some for the child. Some benefits proposed include reduced risk of breast cancer for mothers, longer birth intervals due to longer period of infertility, better nutrition outcomes, and even increased IQ scores for children who were breastfed. The percent of women breastfeeding their child at six months of age has been included by the U.S. department of Health and Human Services as a national health performance measure. It has also been identified by the Georgia Department of Public Health's Maternal and Child Health Office as a priority area for fiscal year 2011 activities. Georgia's Women Infants and Children (WIC) program has been promoting breastfeeding, which has been identified by WIC as a cost effective strategy for their participants, since 1996. They provide breastfeeding counseling and education, and they are always looking for new ways to promote breastfeeding (1). This study will investigate another potential benefit of breastfeeding – prolonging the interval between birth of one child and conception of another. This interval between pregnancies is called inter-pregnancy interval (IPI). The length of IPI has been associated in many studies with perinatal and postnatal complications and health outcomes. Some examples include preterm birth, low birth weight, and stillbirth. Generally, a longer IPI is preferred to a shorter one. Most studies categorize IPI into at least 3 groups, but there is no standard categorization. In the most common schemes, very short IPI is less than 6 months, short is between 6 and 12 months, moderate is between 12 and 18 months, and long is greater than 18 months. Very long IPIs, greater than 60 months, in some studies have actually been linked to adverse outcomes (2). Length of IPI tends to vary across races, with socioeconomic status, age, and other factors.

Determining whether or not breastfeeding increases IPI, independent of contraception, which may have positive effects on subsequent pregnancy outcomes among Georgia women could be helpful in promoting breastfeeding in the future (3).

Epidemiology of Breastfeeding in the U.S.

The many benefits of breastfeeding have caused it to be recognized and promoted by stakeholders at international, national, and community levels. Exclusive breastfeeding for at least six months is recommended by WHO, followed by breastfeeding with complimentary feeding for up to two years (4). The U.S. government's Healthy People 2020 goals include increasing the proportion of babies who were ever breastfed from 74% in 2006 to 82% in 2020 and increasing the proportion of babies who were breastfed exclusively for six months from 14% in 2006 to 25% in 2020(5).

Breastfeeding behavior is difficult to measure at the population scale. Methods for measuring breastfeeding practices include 24-hour recall and 7-day recall. In the 24-hour recall method, exclusive breastfeeding is assessed based on whether or not the baby was given anything other than breast milk in the last 24 hours. This approach may misclassify many mothers who have breastfed exclusively for one day but do not do so consistently as practicing exclusive breastfeeding. Likewise, the 7-day recall method, which asks if mothers have given anything other than breast milk in the last seven days, has been criticized because of ambivalence between simply giving some complimentary foods occasionally or regularly giving such foods(6). Some common categories associated with breastfeeding practices are defined here. Exclusive breast feeding is defined as giving breast milk only, with no other liquids or foods (7). Complimentary feeding is defined as supplementing breast milk with appropriate (nutritious and easily digestible) foods. In Georgia in 2011, 71.6% of infants were ever breastfed, 36.7% were breastfed at six months, and 10.1% were exclusively breastfed until six months(8).

Short term benefits for children

There is evidence of an inverse dose response relationship between breastfeeding and odds of infectious illness in infancy. Infants who were exclusively breast fed were consistently and significantly less likely to have diarrhea, ear infections, cold, and fever than infants who were not breastfed. Those who were exclusively breastfed had lower odds ratios for diarrhea, cough, and ear infection compared to those who were breastfed only most of the time. Further, those who were breastfed most of the time had lower odds ratios for the same illnesses than those who were not breastfed (9).

Long term benefits for children

The simplest benefits of breastfeeding for both mother and child are that it is free, and that it contains the exact formula of nutrients that infants need for optimum growth and health. There is a dose response relationship between breastfeeding and health benefits(10). Breastfeeding in infancy is inversely associated with blood pressure and LDL cholesterol levels in adulthood. Additionally, adults who were breastfed in infancy were less likely to be overweight or obese than those who were not breastfed [Odds Ratio= 0.78 (95%CI 0.72, 0.84)] (9). A few studies have shown an association between breastfeeding in infancy and risk of type 2 diabetes, with a pooled risk ratio of 0.63 (95% CI 0.45, 0.89)(11). It is also well documented that breastfed infants have improved cognitive function compared to those who were not breastfed, after controlling for a wide range of potential confounders. Children who were breastfed had a cognitive score that was 3.16 points (95% CI 2.35, 3.98) higher than that of children who were formula fed. This difference was larger for low birth weight infants, and it increased linearly with breastfeeding duration (12). Breastfeeding was also significantly associated with increased school achievement, in that children who were breast fed were more likely to achieve a higher grade in school compared to those who were not breastfed in three studies on the topic (11).

Benefits for mothers

The benefits of breastfeeding for mothers have not been well studied compared to benefits for children, excepting cancer risk. However, there is evidence for multiple positive health effects for mothers as well. Women who breastfed for a duration of at least two years during their lifetime had a 23% lower risk of coronary heart disease after adjusting for confounders. Breastfeeding is also associated with a reduced risk of developing type 2 diabetes in the future (13). Breastfeeding can also improve the mental health of mothers. Mothers who breastfeed are less likely to experience stress and post-partum depression compared to mothers who do not breastfeed. This may be due to a reduction in inflammation which is an important risk factor for depression. Additionally, breastfeeding is beneficial because it promotes bonding between mothers and their infants and promotes a healthy social structure for the future of both mother and child (14).

There have been numerous studies conducted which sought to determine the effect of breastfeeding on cancer risk. Breastfeeding for at least one year, cumulatively, in the mother's life is associated with a reduced likelihood of breast cancer due to BRAC mutation compared to those who had children but never breastfed[OR=0.55 95% CI(0.38, 0.80)](15). Several studies and a review article agree that breastfeeding for at least one year over a lifetime is associated with a 40% decrease in risk of breast cancer resulting from BRAC 1 mutation compared to women who did not breastfeed for at least one year. In a recent study, breastfeeding was not associated with risk of ovarian cancer due to BRAC mutations (16).

Barriers to Breastfeeding

Given the many benefits of breastfeeding for mothers and children alike, why is the prevalence of breastfeeding in the United States so low? Some social barriers to breastfeeding include poor support for breastfeeding by friends and family, lack of confidence in breastfeeding ability, belief that breast-milk is not as nutritious as formula, short periods of maternity leave at workplaces, stigma, and more. The most cited predictors of breastfeeding are advanced maternal age, higher maternal education, higher parity, previous breastfeeding, being married, higher socio-economic status, white race, and good social support (17).

In a study of Georgia WIC participants, the most common reason listed for deciding not to breastfeed was fear of breastfeeding difficulty or pain. Other common reasons were mother was sick at birth, mother had to return to work, or infant rejected the breast. Reasons for stopping breastfeeding before six months were not enough milk, pain or discomfort, mother had to return to work, infant rejected breast, and mother was sick or on medication. Mothers who had at least a high school education and who were older were significantly more likely to breastfeed. Rates of breastfeeding cessation differed across races. White mothers were more likely to stop breastfeeding earlier than Hispanic mothers [Hazard Ratio = 1.61, 95% CI:(1.15–2.24), $P = 0.005$]. Unadjusted associations included that multiparous mothers and mothers who were employed full time were more likely to stop breastfeeding before other mothers. The authors attributed the higher rates of breastfeeding among Hispanics to culture and social support and the lower rates among lower income women to returning to work sooner (18).

A 2011 study of WIC participants examined breastfeeding exclusivity in the hospital following delivery; this is important because if breastfeeding is not initiated early, it is not likely to be continued consistently. Maternal age, first trimester entry into prenatal care, pre-pregnancy BMI, vaginal delivery, plans to return to work, and prenatal intention to exclusively breastfeed were all significant predictors of exclusive breastfeeding in the hospital. Pre-pregnancy overweight or obesity was associated with a 50% decrease in breastfeeding likelihood [95% CI:(0.26, 0.97)]. Those who entered prenatal care in the first trimester were 2.02 times more likely to exclusively breastfeed [95% CI:(1.07, 3.85)]than those who entered in the second or third trimester. Those who intended to breastfeed before delivery were also more likely to breastfeed than those who did not [OR=3.85 95% CI:(1.70, 8.77)] (10).

In a 2010 Canadian study, factors that influenced the frequency and duration of breastfeeding included household income, marital status, mothers' smoking status, mother's and baby's health, and mother's age at delivery. Those with an annual household income of more than $60,000 were 1.35 times more likely [95%CI: (1.02-1.77)] to exclusively breastfeed at 6 months than those with lower income; those who had a marital partner were 2.79 times more likely [95% CI: (1.86-4.18)] to exclusively breastfeed at 6 months than those who had no partner. The presence of a partner and abundant income probably provides mothers with more freedom to breastfeed, through access to maternity leave, as well as support for breastfeeding if problems arise. Mothers who had good perceived health and those who did not smoke were more likely to exclusively breastfeed at 6 months, with ORs of 2.11 [95%CI:(1.30-3.43)] and 3.15 [95% CI:(2.12-4.68)], respectively. Babies who were admitted to the NICU and babies who were hospitalized were less likely to be exclusively breastfed at 6 months with ORs of 1.83 [95%CI: (1.38-2.44)] and 1.46 [95% CI:(1.03-2.07)], respectively (7).

Breastfeeding and Fertility

There is much biological and epidemiological evidence to suggest that lactation prolongs infertility after birth. At a population level, there is also evidence that prolonged lactation leads to greater average inter-pregnancy intervals. The Bellagio Consensus in 1988 recommended breastfeeding as a method of family planning, and stated that women who exclusively breastfed had 98% protection from getting pregnant in the first six months after delivery (19). The earliest observational studies found that within the same tribal groups in Africa and Asia, those who lived in rural regions breastfed exclusively longer and those who lived in urban regions began complementary feeding earlier. Consequently, perhaps, rural populations had a longer IPI than urban areas. Of course, these early studies had many limitations including confounding by maternal nutritional status and family planning use. Breastfeeding is known to prolong amenorrhea, known as lactational amenorrhea, but whether it actually prolongs infertility is less clear(20). Demographic studies have shown that 2-12% of mothers who breastfeed exclusively become pregnant during the period of lactational amenorrhea. By six months after delivery, amenorrhea is not a good indicator of fertility status (21). The Bellagio Consensus was intended for low-resource settings where other forms of contraception and family planning are hard to access. In the U.S., beginning contraception immediately after birth is considered best practice (22).

Biological Pathway

The hormone primarily responsible for lactational amenorrhea is prolactin. Prolactin concentrations are at least ten times higher at delivery than during the non-pregnant state, and it continues at elevated levels in mothers who breastfeed, but drops to normal levels within 20 days in mothers who do not breastfeed. Prolactin concentrations are only maintained if suckling happens at least four times per day(20). Another hormone necessary for ovulation, and therefore fertility, is Follicle Stimulating Hormone (FSH). FSH is suppressed during pregnancy and returns to normal levels for both mothers who breastfeed and those who don't around 20 days after delivery. Lutenizing hormone (LH) is also necessary for ovulation. It is suppressed in mothers who breastfeed until suckling declines sufficiently, or until suckling occurs less than four times per day. Because of this, return to fertility varies depending on frequency and intensity of breastfeeding and initiation of complementary feeding. It has been suggested that return to fertility is also mediated by maternal nutrition status (23). Studies have shown that mothers with poor nutritional status have a longer period of lactational amenorrhea and infertility than mothers with good nutritional status. In a study of Philippine women, lower BMI and lower fat intake were independently associated with longer IPI (24).

Epidemiological Evidence

A 1991 Australian study showed that, among a group of breastfeeding women who used no other form of contraception, 50% were expected to become pregnant within one year. Whereas, in the comparison group of mothers who did not breastfeed or use contraception, 85% were expected to become pregnant within 6 months (19). A later Australian study of 624 women who breastfed and did not use contraception found that the average length of lactational amenorrhea was 8.5 months. Additionally, no one in the cohort became pregnant within one year of the previous delivery (25). In a study of 2000 Filipinas, 50% of women who breastfed for at least 7 to 12 months had IPIs of at least 1.5 to 2 years. Meanwhile, among women who did not breastfeed, only 30% had IPIs of at least 1.5 to 2 years. The difference was significant – greater than two standard deviations(26). A life table analysis using data from several studies, including Chile, UK, Thailand, and Egypt, found that women who exclusively breastfed had a 6 month rate of pregnancy of 7.2 per 100 women, and the 12-month rate of pregnancy was 17.2 per 100 women regardless of whether or not they had lactational amenorrhea, which was significantly lower than the average rate of pregnancy for all women of reproductive age (27). A Chilean study found that the risk of pregnancy at 6 and 12 months, respectively, for all women who were in amenorrhea was 0.9% and 17%. For those who had resumed normal menstrual cycles, the risk of pregnancy rose to 36% at 6 months and 55% at 12 months, controlling for use of contraception. The risk of pregnancy was significantly higher for women after they began complementary feeding and after they resumed normal menstrual cycles (28).

Breastfeeding and Family Planning

Given the biological and epidemiological evidence that breastfeeding, at least exclusive breastfeeding, prolongs lactational amenorrhea and increases time between delivery and return to fertility, it is no surprise that breastfeeding has been touted as a cheap and effective method of family planning. While a few public health institutions have concluded that exclusive breastfeeding is such a good form of contraception that there is no need to use other contraceptive methods until return of normal menstrual cycle or until complementary feeding begins, many others have cautioned that, since there is no reliable way to tell exactly when fertility returns, other methods of contraception should be used immediately following delivery (23, 29). A Cochrane review of the lactational amenorrhea method (LAM) of contraception agreed that due to the uncertainty of when fertility begins, other forms of contraception should be used as soon as possible even among exclusively breastfeeding women, especially those who live in places where contraceptives are hard to access (30).

Predictors of Inter-pregnancy Interval

Length of IPI tends to vary with certain factors, such as race, marital status, and education. A study of almost 90,000 subsequent births in Scotland found that women who were under age 20 and those who were married, as well as those who lived in an economically deprived area were more likely to have an IPI shorter than 6 months compared to other women ($p < 0.001$) (31). In the U.S., IPI varies by race. One study on women in the military found that African American women were 4.4 times as likely as Caucasian women to have an IPI less than 6 months. A larger population based study showed that African Americans were about 1.8 times as likely as Caucasians to have an IPI of less than 6 months. Additionally, 10.5% of African Americans had IPIs of less than 6 months while 5.7% of Caucasians had IPIs of less than 6 months. Although the incidence of short IPIs varied across states, the ratio of short IPIs in African Americans vs. Caucasians remained relatively constant (32). A 2006 study of over 150,000 Missouri women who gave birth to a subsequent child found that younger women, women who were not married, women who smoked, women who had less education, those who had no prenatal care, those who had a previous preterm birth, and those who were on Medicaid were all more likely than others to have an IPI of less than 6 months ($p<0.001$) (3).

IPI and perinatal outcomes

The most common outcome studied in relation to IPI is preterm birth. In general, short IPIs are considered a risk factor for preterm birth, which is birth before 37 weeks gestation. A large population-based study of Missouri births found that IPIs of less than six months were associated with increased likelihood of extremely preterm birth, defined as birth at 20-28 weeks gestation [OR= 1.41 95% CI:(1.13-1.76)]. IPIs of less than 6 months were also associated with increased likelihood of preterm birth [OR=1.48 95% CI:(1.37-1.61)], while IPIs of 6-12 months were just significantly associated with preterm birth (3). A similar study in 2000 showed that IPIs of less than 18 months were significantly associated with 14-47% increased likelihood of birth between 23 and 37 weeks of gestation. In the same study, IPI of greater than 5 years was associated with 12-45% increased likelihood of preterm birth (33). A Scottish study also found an association between IPI and preterm birth. IPIs of less than 6 months were associated with birth between 24 and 32 weeks gestation [OR=2.2 95% CI:(1.3 to 3.6)] and birth between 32 and 36 weeks [OR=1.6 95%CI:(1.3, 2.0)]. Overall, IPI has a J shaped relationship, graphically, with preterm birth. Very short IPIs and very long IPIs both are associated with increased risk of preterm birth (31).

IPI is also associated with other outcomes, such as neonatal death, low birth weight and small for gestational age. In the Scottish study above, births to women with an IPI of less than 6 months were found to be 3.6 [95%CI:(1.2,10.7)] times as likely to end in perinatal death than births to women with longer IPIs, likely due to a higher likelihood of preterm birth and low birth weight (31). However, in a study of over 400,000 women in Sweden, IPIs of less than 3 months were not significantly associated with increased risk of stillbirth or early neonatal death after adjusting for previous perinatal outcomes and other factors (34). Two studies in Utah and Michigan found the same association of IPI with low birth weight. Those with IPI less than 6 months were 1.4 times as likely to have a baby with birth weight less than 2500 grams [OR=1.4 95% CI: (1.3, 1.6)]. The same studies showed that IPIs of less than 6 months were associated with small size for gestational age [OR=1.3 95%CI: (1.2, 1.4)] (35). A meta-analysis of IPI and perinatal outcomes by Conde-Agudelo found associations between IPIs of less than six months and low birth weight, preterm birth, and small size for gestational age. The pooled adjusted odds ratios are as follows: preterm birth [OR=1.4 95%CI: (1.24, 1.58)], low birth weight [OR=1.61 95%CI: (1.39, 1.86)], small size for gestational age [OR=1.26 95%CI: (1.18, 1.23)]. The dose-response relationships were further defined; there was a 1.92 percentage point risk increase for preterm birth, 3.25 point increase for low birth weight, and a 1.52 point increase for small size for gestational age, for every one month shorter than an IPI of 18 months. Similarly, for every one month greater than an IPI of 5 years, there was a .55 point increase in risk of preterm birth, .91 point increase in low birth weight, and .76 point increase in small for gestational age (36).

One popular theory that explains the association between short IPI and adverse perinatal outcomes regards maternal nutrition. The hypothesis states that women with short IPIs do not have time to recover adequate micro and macronutrient stores. The resulting folate and iron deficiencies are said to cause low birth weight, preterm birth, small size for gestational age, and they are even linked to neonatal death. Social and behavioral factors, such as socio-economic status, and inter-pregnancy primary care, are not thought to be part of a biological mechanism, but they are considered proximal determinants and confounders of the association between IPI and perinatal outcomes. The most common theory that explains the association between IPIs longer than 5 years and adverse outcomes states that after delivery the reproductive capacity of women starts to degrade and eventually becomes similar to that of women with a history of previous perinatal complications. Further study is needed to more clearly define these mechanisms and pathways (36).

IPI and maternal health

Length of IPI has consequences for maternal health outcomes as well. Short IPIs have been associated with uterine rupture, while long IPIs have been linked to pre-eclampsia. A recent systematic review by Conde-Agudelo found that there was a significantly increased risk of uterine rupture in women with previous Cesarean delivery who had IPIs of less than 6 months. They also found a significant association between IPIs longer than 5 years and pre-eclampsia and labor dystocia. Dystocia was classified as functional or mechanical obstruction of labor, and it had a dose-response relationship with IPI, such that as IPI increased past 5 years, risk of dystocia increased. Studies on the effect of IPI on maternal death and anemia have yielded conflicting results, mainly due to study design issues. There have been several studies on IPI and maternal nutrition status, but the results were mixed. A systematic review found that IPI was not a good predictor of maternal nutrition status because breastfeeding between pregnancies was more important for maternal nutrition status than IPI (37).

Breastfeeding and IPI

Much of what is known about the relationship between breastfeeding and IPI has been reviewed above. There is substantial evidence that breastfeeding prolongs infertility, therefore, it follows that breastfeeding might also increase IPI. However, many other factors influence conception and IPI. Breastfeeding and birth spacing has been studied for over 20 years, but most studies have not controlled for some important factors, such as use of contraceptives, socio-economic status, duration and exclusivity of breastfeeding, complementary feeding, race, and more. Further, most studies regarding breastfeeding and birth spacing have been conducted in countries other than the U.S., and most have been in settings where contraceptives were not readily available. However, in the U.S. population, the population of interest in this study, the relationship between breastfeeding and IPI is complicated by contraceptive use, return to work, marital status, intendedness of pregnancy, and other factors. After searching PUBMED, OMID, and EBSCO databases, no studies in the U.S. were found that specifically studied breastfeeding and IPI as the main outcome of interest.

Chapter II. Manuscript

Abstract

Objectives: The objective of this study is to investigate the relationship between breastfeeding and subsequent inter-pregnancy interval (IPI) in a cohort of Georgia mothers. This study aims to supplement the existing literature on breastfeeding and IPI by investigating a population in which contraception use is high and by controlling for various potential confounders not included in previous studies. **Methods:** Two commonly available maternal and child health databases were linked by a common identifier to create a population-based cohort of mothers with index and subsequent births in Georgia. Two models, one including ever breastfeeding after an index pregnancy with covariates, and one including exclusive breastfeeding after an index pregnancy with covariates were assessed for association with subsequent IPI. Ideal IPI was considered greater than 18 months. **Results:** No significant association was found between ever breastfeeding or exclusive breastfeeding and IPI. African American race was significantly associated with shorter IPIs, and contraception use was significantly associated with longer IPIs. **Conclusion:** While increasing the prevalence of breastfeeding, especially exclusive breastfeeding, is an important public health goal, interventions to lengthen IPI should focus on other exposures, such as health education, access to and utilization of family planning services and contraception for underserved populations.

Key words: breastfeeding, inter-pregnancy interval, birth spacing, contraception

Objective

The objective of this study is to investigate the relationship between breastfeeding and subsequent inter-pregnancy interval in a cohort of Georgia mothers.

Introduction

The relationship between breastfeeding and inter-pregnancy interval (IPI) has important implications for maternal and perinatal health. IPI, the time between the birth of one child and conception of a subsequent pregnancy, has only recently been recognized as an important factor in maternal and perinatal outcomes. Short IPIs have been associated in various studies with preterm birth, low birth weight, neonatal death, and adverse maternal outcomes (3, 31, 35, 37) . Strong evidence links breastfeeding to prolonged infertility, which may lead to increased IPI in some populations. However, many studies on the subject have limitations and may be confounded by birth control use or other covariates or be biased by poor measurement of breastfeeding or exclusion of mothers using birth control. Studies that do not consider birth control use do not reflect the real experience of women in the study and may produce a biased result (26-28). The relationship between breastfeeding and IPI has not been well studied in the United States, where there is high coverage of contraception.

The benefits of breastfeeding have led stakeholders at all levels to promote it as an important part of maternal and perinatal care. The World Health Organization recommends exclusive breastfeeding for at least six months, followed by breastfeeding with complimentary feeding for up to two years (4). Georgia does not meet the U.S. government's Healthy People 2020 initiative goals for breastfeeding. In 2011, 71.6% of newborns were ever-breastfed, 36.7% were breastfed at six months, and 10.1% were exclusively breastfed until six months (8). Breastfeeding has short and long-term benefits for infants, including lower risk of obesity and chronic disease in adulthood, increased cognitive scores and school achievement, and decreased likelihood of infectious diseases in infancy (9, 11, 12).

Many studies have identified predictors of and barriers to breastfeeding. A 2011 study of WIC participants found that maternal age, first trimester entry into prenatal care, low pre-

pregnancy BMI, vaginal delivery, no plans to return to work, and prenatal intention to exclusively breastfeed were all significant predictors of exclusive breastfeeding in the hospital (10). In another WIC study, mothers who had at least a high school education and who were older were significantly more likely to breastfeed (18). In a 2010 Canadian study, factors that influenced the frequency and duration of breastfeeding included household income, marital status, mothers' smoking status, mother's and baby's health, and mother's age at delivery. Those with an annual household income of more than $60,000 were 1.35 times more likely [95%CI: 1.02-1.77] to exclusively breastfeed at 6 months than those with lower income; those who had a marital partner were 2.79 times more likely [95% CI: 1.86-4.18] to exclusively breastfeed at 6 months than those who had no partner. Mothers who had good perceived health and those who did not smoke were significantly more likely to exclusively breastfeed at 6 months (7).

There is much evidence that breastfeeding prolongs infertility after birth. At a population level, there is also evidence that prolonged lactation leads to longer average IPIs. The earliest observational studies found that within the same tribal groups in Africa and Asia, those who lived in rural regions exclusively breastfed longer and had longer average IPIs than those who lived in urban regions and began complementary feeding earlier. Breastfeeding is known to prolong amenorrhea, known as lactational amenorrhea, but whether it actually prolongs infertility is less clear(20). Demographic studies have shown that 2-12% of mothers who breastfeed exclusively become pregnant during the period of lactational amenorrhea. By six months after delivery, amenorrhea is not a good indicator of fertility status (21). In the United States, beginning contraception immediately after birth is considered best practice for family planning (22).

Many predictors of breastfeeding are also predictors of IPI length. A large study in Scotland found that women who were under age 20 and those who were married, as well as those who lived in an economically deprived area were more likely to have an IPI shorter than 6 months compared to other women ($p < 0.001$) (31). In the U.S., African Americans were about 1.8 times as likely as Caucasians to have an IPI of less than 6 months (32). Younger women, women who were not married, women who smoked, women who had less education, those who had no prenatal care, those who had a previous preterm birth, and those who were on Medicaid were all more likely than others to have an IPI of less than 6 months ($p<0.001$) (3).

Short IPI is a risk factor for many adverse perinatal outcomes. In a U.S. study, IPIs of less than six months were significantly associated with increased likelihood of extremely preterm birth (20-28 weeks gestation) and preterm birth (3). A similar study in 2000 showed that IPIs of less than 18 months were significantly associated with 14-47% increased likelihood of birth between 23 and 37 weeks of gestation. In the same study, IPIs of greater than 5 years were associated with 12-45% increased likelihood of preterm birth (33). Very short IPIs and very long IPIs both are associated with increased risk of preterm birth (31). A meta-analysis of IPI and perinatal outcomes found associations between IPIs of less than six months and low birth weight, preterm birth, and small size for gestational age. There were dose-response relationships between IPI and preterm birth and low birth weight (36). Length of IPI has consequences for maternal health as well. Short IPIs have been associated with uterine rupture, while long IPIs have been linked to pre-eclampsia (38).

Breastfeeding and birth spacing has been studied for over 20 years, but most studies have not controlled for some important factors, such as use of contraceptives, socio-economic status, duration and exclusivity of breastfeeding, complementary feeding, race, and more. Further, most studies regarding breastfeeding and birth spacing have been conducted in countries other than the U.S., and many have been in settings where contraceptives were not readily available or have excluded women who used contraception. However, in the U.S. population, the population of interest in this study, the relationship between breastfeeding and IPI is complicated by contraceptive use, socio-economic status, marital status, race, education, and other factors. The purpose of this study is to understand whether breastfeeding has an effect on IPI in a population that has high contraceptive use, controlling for multiple confounders. The authors hypothesized that ever vs. never breastfeeding would be associated with longer IPI and exclusive breastfeeding vs. non-exclusive or never breastfeeding would be associated with longer IPI. In each hypothesis, dichotomous and categorical IPI was tested separately.

Methods

Data Sources

This study was conducted using a retrospective cohort created by linking two separate datasets: Georgia's Pregnancy Risk Assessment and Monitoring System (PRAMS), which contained information on breastfeeding in the form of survey data from births in 2004 to 2008, and Georgia's maternally linked longitudinal dataset (GMLLDS), which contained information on IPI in the form of birth certificate records of all Georgia births from 2004 to 2008. PRAMS collects data on women in Georgia using a systematic stratified sampling method. The sampling frame is stratified on race, and low weight births are oversampled in order to have enough observations for risk estimates. PRAMS initially contacts the sampled mothers two to four months after delivery with a letter introducing the survey. They then mail a questionnaire up to three times and follow up with a telephone interview for non-responders. Linkage of the index birth in the PRAMS cohort to a woman's subsequent birth in the GMLLDS was achieved by matching on a unique maternal identifier present in both datasets. The final cohort included women who responded to PRAMS regarding an 'index birth' and who had a subsequent birth recorded in GMLLDS. Index and subsequent births were limited to singleton live births. If women had more than one subsequent birth, only the first one was included. Not all PRAMS respondents were linked to a subsequent birth. Possible reasons for absent links are that a woman had no additional births during follow-up, that she had a subsequent birth out of the state of Georgia, or that there was an incorrect non-linkage of a true follow-up birth.

Definition of variables

PRAMS questions evaluating breastfeeding are as follows, "Did you ever breastfeed or pump breast milk to feed your new baby, even for a short period of time?" "How many weeks or months did you breastfeed or pump milk to feed your baby?" "How old was your baby the first time you fed him or her anything besides breast milk?" Ever breastfeeding was answered yes or no. Due to excess missing data, duration of breastfeeding was not included in analysis. If the respondent indicated they had never fed their baby anything other than breast milk, they were categorized as exclusive breastfeeding; otherwise, they were considered not to have exclusive breastfed. IPI was defined as the number of months between the index date of birth and the subsequent date of birth minus gestational age of the subsequent birth. IPI was categorized as less than 12 months, 12 months to 18 months, or greater than 18 months. It was also dichotomized as less than 18 months and 18 months or longer. The following variables were considered for confounding based on the literature: maternal age at index birth, maternal race according to birth certificate for subsequent birth, tobacco use at subsequent birth, yearly household income at index birth, marital status at subsequent birth, maternal education at index birth, and contraception use at the time of PRAMS survey. Contraception use included use of condoms, oral contraceptives, injectable or patch-contraceptives, diaphragm, vaginal ring, or intra-uterine device. Marital status was categorized as married or unmarried. Maternal race was classified as Hispanic, non-Hispanic white, non-Hispanic black, or non-Hispanic other. Maternal education was classified as less than high school graduate, high school graduate, and some college. Household income was categorized as less than $20,000, $20,000 to $34,999, and $35,000 or greater.

Analysis

All analyses were completed using SAS survey procedures accounting for complex sample design. Alpha was 0.05 for all tests. Bivariate analyses were carried out for all variables by outcome and exposure. Simple logistic regression was used to obtain unadjusted effect estimates. Four logistic regression models were specified: Dichotomous IPI with ever breastfed as the main exposure, dichotomous IPI with exclusive breastfeeding as the main exposure, categorical IPI and ever breastfed as the main exposure, and categorical IPI and exclusive breastfeeding as the main exposure. Polytomous logistic regression was used to model categorical IPI. Logistic regression models were fit that contained all of the predictor variables and potential confounders named above along with two-way interaction terms of the potential confounders with exposure. The potential confounders based on the literature were assessed for any crude association with the exposure and IPI. If there was a significant association between both exposure and IPI, then the covariate was added to the initial model. All variables were categorized except age, and age-squared was included with age in the models. Interaction terms were assessed for significance using backward elimination and individual Wald tests. There was some evidence of interaction between income, education, and marital status in the model. However, since there was no reasonable pathway for these interactions, and having multiple interaction terms hindered interpretation, the interaction terms were dropped from the model. No collinearity problems were found in the models. Confounding was then assessed using an all-subsets approach. All possible models created by dropping potential confounders were compared to the full initial model. If dropping a covariate or subset of covariates resulted in greater than 10% change in the crude effect estimate, that variable or set of variables was considered a confounder. Models that had an estimated effect within 10% of the estimate of the full model were considered eligible models. Among these eligible models, confidence intervals around each effect estimate for the main exposure were compared to the gold standard. None of the reduced models had more precise confidence intervals than the full models, so the full models were considered the final models.

Results

There were 6,214 eligible PRAMS respondents. Of these, 778 mothers, or 10.68% were identified as having a subsequent birth in the state of Georgia from 2004 to 2008. This is in comparison to 11.42% of births in the GMLLDS dataset that were second or higher order births. Table 1 shows characteristics of women by whether or not they had a recorded subsequent birth in Georgia during follow up, and therefore were included in the analysis dataset. In the study population the average IPI was 10.1 months (95%CI: 8.9, 11.4). 13.9% of women had an IPI less than 12 months, 29.2% had an IPI between 12 and 18 months, and 56.9% had an IPI 18 months or longer. 69.9% reported ever breastfeeding and 11.1% reported breastfeeding exclusively. Average maternal age was 26.9. Table 2 shows characteristics of the study population by IPI category. Chi square tests and unadjusted simple logistic regression results showed that marital status, contraceptive use, race, education, income, ever breastfeeding, and exclusive breastfeeding were different across IPI categories. In addition, unadjusted models showed that marital status, education, income, and race were significantly associated with ever or never breastfeeding and exclusive breastfeeding. Contraceptive use was only significantly associated with exclusive breastfeeding. Significant unadjusted associations were found between ever breastfeeding vs. never breastfeeding and exclusive vs. non-exclusive breastfeeding and IPI using both categorization schemes. Those who ever breastfed were less likely to have an IPI of less than 12 months compared to at least 12 months [OR=0.45; 95%CI: 0.25, 0.80] and less likely to have an IPI of 12 to 18 months compared to at least 18 months [OR=0.63; 95%CI: 0.40, 1.0] (data not shown in table). Those who breastfed exclusively were less likely to have an IPI of less than 12 months compared to at least 12 months [OR=0.13; 95%CI: 0.04, 0.49] and less likely to have an IPI of 12 to 18 months compared to at least 18 months [OR=0.45; 95%CI: 0.20, 1.00] (data not shown in table). Similarly, those who ever breastfed and those who exclusively breastfed were less likely to have an IPI of less than 18 months compared to at least 18 months [OR=0.56; 95%CI: 0.37, 0.84] and [OR=0.34; 95%CI:0.17, 0.70], respectively (data not shown in table). Contraceptive use and being married had significant unadjusted association with longer IPIs. African American race, tobacco use, less than high school diploma, and income categories less than $35,000 were significantly associated with shorter IPIs in unadjusted calculations.

The final adjusted models that regressed IPI on ever or never breastfeeding showed no significant association using either categorization of IPI. The final models with exclusive breastfeeding as exposures did not show a significant association with either IPI categorization. Tables 3 and 4 show the results of the latter two models. The only significant predictors of IPI were birth control use and African American race. African Americans were 1.71 (95%CI: 1.02, 2.88) times as likely to have an IPI of less than 18 months compared to at least 18 months and 2.27 (95%CI: 1.01, 5.11) times as likely to have an IPI of less than 12 months compared to at least 12 months when compared to whites. Those who did not use birth control were 2.08 (95%CI: 1.20, 3.70) times as likely to have an IPI of less than 18 months compared to at least 18 months and 3.57 (95%CI: 1.67, 7.69) times as likely to have an IPI of less than 12 months compared to at least 12 months. Also, less than high school graduation was significantly associated with IPIs of less than 12 months compared to at least 12 months [OR=4.28; 95%CI: 1.32, 13.92).

Discussion

The data show that breastfeeding was not associated with IPI after controlling for factors like contraceptive use, SES, education, and race. This agrees with most of the literature, which recognizes the benefits of breastfeeding at a population level, including lengthening IPI, but recommends beginning other methods of contraception very soon after delivery as the best method of family planning (21, 22). This study showed an association between shorter IPIs and both African American race and low level of education. However, the most significant predictor of IPI in our study was birth control use (3, 32). Breastfeeding may, in fact, prolong IPI for some women, but it is most likely to be among high SES women who already have access and utilize family planning and are more likely to breastfeed. While increasing the prevalence of breastfeeding, especially exclusive breastfeeding, is an important public health goal, interventions to lengthen IPI should focus on other exposures, such as health education, access to and utilization of family planning services and contraception for underserved populations.

Some strengths of the study include innovative use of basic maternal and child health data, population-based design, and the ability to control for potential confounders. First, an innovative retrospective cohort design was used for this study. The exposure and outcome variables were captured from two different datasets routinely collected by the Georgia Department of Public Health. Information on breastfeeding and the index pregnancy was collected using the PRAMS survey, and information on subsequent births was collected using a maternally linked longitudinal dataset that contains all Georgia births and a maternal identifier enabling all births to the same woman to be linked. This design could prove useful for many maternal and child health research questions. Second, this study was population-based, reducing participation bias present in some early IPI studies. Also, IPI has been studied most heavily in resource-poor countries; this study provides information on a very different population than has been traditionally studied. Third, the inability of earlier studies on breastfeeding and IPI to control for confounding by factors like contraceptive use and SES or education was noted earlier. This study allowed for control of many potential confounders, and indeed found different effects of breastfeeding on IPI when confounders were included.

Strengths and Weaknesses

The authors recognize several weaknesses in study design. Most obvious is that some variables differ between mothers who were sampled by PRAMS and had a subsequent birth in Georgia, and thus included in the study and those who were not, which may indicate selection bias or may reflect real differences between women who have completed childbearing and those who have not. Younger mothers were more likely to have a subsequent birth and therefore to be included in our study than older mothers who may be less likely to have subsequent births. Higher income mothers were less likely to be included, which could be bias, or it could be that income and age are highly correlated, so if fewer older women were included, fewer high income women would be included. The difference in contraceptive use and exclusive breastfeeding limit the ability to generalize the findings of the study to the wider population of Georgia women. Also, the mean IPI in the study population was shorter than the mean IPI in the GMLLDS dataset because the GMLLDS dataset held 8 possible years of follow up, but the linked PRAMS and GMLLDS set limited follow up to 4 possible years. This may have led to attenuation of the effects found in this study. Additionally, there may be misclassification of IPI length since there was no information on miscarriages, fetal deaths, or abortions that may have occurred between the index and subsequent live births. Further, because the study population included subsequent births in Georgia only, there may be selective loss to follow up. Misclassification of IPI is also possible because some women could have had an index birth in Georgia, moved away where they had another birth, and then moved back to Georgia where they had a subsequent birth. Further, emigration from Georgia after an index birth may be differential by SES or income, which could have led to overestimation of the prevalence of certain IPI lengths, breastfeeding, and covariates and may have caused an underestimation of effect size.

The original data sources, PRAMS and GMLLDS also have limitations. PRAMS uses both a self-administered paper survey and a telephone survey if no response is received from the paper survey. It is possible that the accuracy of responses differ between the two types of surveys. The main limitation of PRAMS variables for this study has to do with timing of the survey administration, and this is discussed below. GMLLDS holds birth certificate data, which has been criticized for its reliability. However, the main variable used in this study, birth date, is very accurate in birth certificate data (39).

The measurement of certain variables also warrants some discussion. Exclusive breastfeeding was measured as never having given anything besides breast milk up to the point of the survey. Since the PRAMS survey is administered at two to four months after delivery, the duration of exclusive breastfeeding varies from mother to mother. Similarly, birth control use reflects only use at the time of the PRAMS survey. We have no information on timing or type of contraception. Yearly household income as an indicator of SES is limited because it does not account for resources outside of income, such as property ownership, debt, or savings, which could influence health outcomes. Also, income is variable over time but only measured at the index birth. Marital status as married or unmarried is flawed, for someone with a committed partner who is not married may share the same benefits as a married person. Possible unmeasured confounders include stress and social support, both of which have been shown to influence breastfeeding, perinatal outcomes, and IPI (40, 41). The external validity of the study is enhanced because the race distribution of the study population is similar to that of Georgia and the fact that breastfeeding prevalence in Georgia is also similar to the United States as a whole (42).

Overall, this study contributes to the literature because it studied IPI in a population in which contraception use is widespread and allowed for the control of important confounders. The findings support the consensus that breastfeeding is not an adequate method of family planning. However, the finding that breastfeeding had no independent effect on IPI is new and allows a deeper understanding of the determinants of IPI. In addition, this study introduces a useful and innovative retrospective cohort design that could be used to study a wide variety of maternal, perinatal, and pediatric outcomes. The method could also be adapted to link other data sources to longitudinal birth datasets in the future using common identifiers.

Chapter III. Discussion

The data show that breastfeeding is not associated with IPI after controlling for factors like contraceptive use, SES, education, and race. These results are in agreement with most of the literature, which recognizes the benefits of breastfeeding at a population level, including lengthening IPI, but recommends beginning other methods of contraception very soon after delivery as the best method of family planning (21, 22). This study showed an association between shorter IPIs and both African American race and low level of education. Other studies have shown that income also influences IPI in many populations. However, the most significant predictor of IPI in our study was birth control use. Given this information, a possible explanation is that women with higher socio-economic status have better access to and utilization of family planning and very effective contraception (3, 32). Breastfeeding may, in fact, prolong IPI for some women, but it is most likely to be among women who already have access to and utilize family planning, because more women who breastfeed have high SES and education. While increasing the prevalence of breastfeeding, especially exclusive breastfeeding, is an important public health goal, interventions to lengthen IPI should focus on other exposures, such as health education, access to and utilization of family planning services and contraception for underserved populations.

Some strengths of the study include the innovative use of basic maternal and child health data, the population of interest in the study, and the ability to control for potential confounders. First, an innovative retrospective cohort design was used for this study. The exposure and outcome variables were captured from two different datasets already collected by the Georgia Department of Public Health. Information on breastfeeding and the index pregnancy was collected using the PRAMS survey, and information on subsequent births was collected using a maternally linked longitudinal dataset that contains all Georgia births and a maternal identifier enabling all births to one woman to be linked. A cohort of mothers that had births in both datasets were followed forward from their index births in PRAMS to subsequent births in GMLLDS. This design could prove useful for many maternal and child health research questions. Any survey dataset, such as BRFSS, which has some kind of maternal identifier or birth certificate number, could be linked to a longitudinal birth dataset in a retrospective cohort design. Second, this study was population-based, eliminating participation bias present in some early IPI studies. Also, IPI has been studied most heavily in resource-poor countries; this study provides information on a very different population than has been traditionally studied. This study population was made up of U.S. women, most of whom have ready access to family planning and contraception. Third, the inability of earlier studies of breastfeeding and IPI to control for confounding by factors like contraceptive use and SES or education was noted earlier. This study allowed for control of many potential confounders, and indeed found different effects on IPI when confounders were dropped.

The authors recognize several weaknesses in study design. Most obvious is that some variables differ between mothers who were included in the study and those who were not, which may indicate selection bias or may reflect a real difference between mothers who have completed childbearing and those who have not. Younger mothers were more likely to have a subsequent birth and therefore to be included in our study than older mothers who may be less likely to have subsequent births. Higher income mothers were less likely to be included, which could be bias, or it could be that income and age are highly correlated, so if fewer older women were included, fewer high income women would be included. The difference in contraceptive use and exclusive breastfeeding may limit the ability to generalize the findings of the study to the wider population of Georgia women. Also, the mean IPI in the study population was shorter than the mean IPI in the GMLLDS dataset because the GMLLDS dataset held 8 possible years of follow up, but the linked PRAMS and GMLLDS set limited follow up to 4 possible years. The proportion of IPIs that were less than 18 months was probably greater in the final dataset than in the GMLLDS dataset. This may have led to attenuation of the effects found in this study. Additionally, the term IPI may not be true for every woman in the study since we did not have information on miscarriages, fetal deaths, or abortions that may have occurred between the index and subsequent births. This is important because IPI may have an effect on each of these outcomes, and these outcomes may have an effect on later IPIs; future study should include them. Further, because the study population included subsequent births in Georgia only, there may be selective loss to follow up. Misclassification of IPI is also possible because some women could have had an index birth in Georgia, moved away where they had another birth, and then moved back to Georgia where they had a subsequent birth. In this case, the IPI calculation would be incorrect in the study dataset. However, this probably did not occur often enough to bias the results. A bigger concern is that emigration from Georgia after an index birth may be differential by SES or income. This could have led to overestimation of the prevalence of certain IPI lengths, breastfeeding, and covariates and may have caused an underestimation of effect size.

The original data sources, PRAMS and GMLLDS also have limitations. PRAMS is a stratified sample that includes higher numbers of women from certain risk groups, but using complex survey methods in analysis accounted for the stratification. PRAMS uses both a self-administered paper survey and a telephone survey if no response is received from the paper survey. It is possible that the accuracy of responses differ between the two types of surveys. The main limitation of PRAMS variables for this study has to do with timing of the survey administration, and this is discussed below. GMLLDS holds birth certificate data, which has been criticized for its reliability. However, the main variable used in this study, birth date, is very accurate in birth certificate data (39).

The measurement of certain variables also warrants some discussion. Exclusive breastfeeding was measured as never having given anything besides breast milk up to the point of the survey. Since the PRAMS survey is administered at two to four months after delivery, the duration of exclusive breastfeeding varies from mother to mother. Similarly, birth control use reflects only use at the time of the PRAMS survey. There was no information available on when contraception was started after birth or whether it was continued during the IPI. There was also no information on the type of contraception used. The PRAMS survey considers everything from the rhythm method to intra-uterine devices as birth control. This is problematic because some methods are vastly more reliable than others. Yearly household income was used as an indicator of SES, but it is limited. It does not account for resources outside of income, such as property ownership, debt, or savings, which could have an influence on predictors of health outcomes, such as health care access and utilization. Also, income is variable over time but only measured at the index birth. Marital status as married or unmarried is not a perfect measurement, for someone with a committed partner who is not married may share the same benefits as a married person. Possible unmeasured confounders include stress, which has been shown to influence breastfeeding and perinatal outcomes, and a measure of social support, which may influence breastfeeding and IPI (40, 41).

While there are limitations to internal validity, the external validity of the study is solid. The race distribution of the study population is similar to that of Georgia. Georgia does have a proportionately larger African American population than the United States as a whole, but the age distribution of the state is similar to the nation as a whole (42). While Georgia differs from the rest of the United States in many health outcomes, breastfeeding prevalence is similar to the United States as a whole. Further, while it can be argued that the quality of available health care varies widely across the country, standardization of care and national guidelines allow for the comparison of outcomes across states. Since the exposure data is available in many states, and the birth certificate data is available in all states, this study could be easily reproduced in other settings.

Overall, this study contributes to the literature because it studied IPI in a population in which contraception use is widespread, and it allowed for the control of various important confounders. Previously, most studies on IPI have been among non-contracepting populations. According to this study, breastfeeding was not an independent predictor of IPI length. These findings support the consensus that contraception should be started soon after birth, even in women who breastfeed, in order to ensure optimal IPI. In addition, the finding that breastfeeding has no independent effect on IPI is new and allows a deeper understanding of the determinants of IPI. This study also introduces a useful and innovative retrospective cohort design that could be used to study a wide variety of maternal, perinatal, and pediatric outcomes. The method could also be adapted to link other data sources, such as BRFSS, to longitudinal birth datasets in the future using common identifiers.

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Table 1. Comparison of baseline cohort (PRAMS respondents 2004-2008) and those linked or unlinked to subsequent live births in Georgia (N=6,214)

	All Mothers (n=6,214)			Linked Follow-up Birth (n=778)			No linked follow-up Birth (n=5,436)			χ² P Value
	No.	%	SE(%)	No.	%	SE(%)	No.	%	SE(%)	
Maternal Age										
10-15 years	56	0.44	0.09	44	0.52	0.21	12	0.43	0.10	<.001
16-20 years	1229	17.57	0.76	225	25.22	2.10	1004	16.65	0.81	
21-25 years	1745	29.01	0.91	249	32.12	2.26	1496	28.64	0.98	
26-30 years	1492	24.71	0.84	160	22.75	2.06	1332	24.94	0.91	
31-35 years	1151	19.18	0.76	106	15.71	0.21	1045	19.60	0.75	
36-40 years	461	8.10	0.54	25	3.65	0.89	436	8.63	0.60	
41-45 years	80	1.00	0.19	1	0.02	0.02	79	1.11	0.21	
Marital Status										
Not Married	3215	58.15	0.96	377	55.84	2.39	2838	58.42	1.05	0.327
Married	2991	41.85	0.96	399	44.16	2.39	2592	41.58	2.39	
Missing	8									
Maternal Education										
Less than High School Graduate	1294	22.34	0.85	189	23.06	2.18	1105	22.25	0.92	0.432

High School Graduate	2060	32.27	0.94	281	34.63	2.31	1779	31.99	1.02	
Some College or Higher	2686	45.39	0.99	278	42.31	2.44	2408	45.76	1.07	
Missing	174									
Contraceptive use										
Yes	5028	83.45	0.72	570	73.55	2.20	4458	84.64	0.76	<.001
No	1079	16.55	0.72	198	26.45	2.20	881	15.36	0.76	
Maternal Tobacco Use										
Yes	457	6.25	0.49	72	7.35	1.33	385	6.12	0.52	0.336
No	5736	93.75	0.49	702	92.65	1.33	5034	93.88	0.52	
Maternal Race/Ethnicity										
Non-Hispanic White	2322	51.14	0.89	275	50.34	2.32	2047	51.24	0.99	0.005
Non-Hispanic African American	3201	31.76	0.63	444	37.72	1.95	2757	31.05	0.74	
Hispanic	532	13.59	0.74	45	10.63	1.85	487	13.94	0.80	
Non-Hispanic Other	159	3.52	0.43	14	1.32	0.55	145	3.78	0.48	
Income										0.003
Less than $19,999	2366	40.83	1.04	338	48.48	2.68	2028	39.92	1.12	
$20,000-$34,999	896	18.47	0.87	94	13.00	1.77	802	19.12	0.95	
$35,000 and greater	1797	40.70	1.05	192	38.53	0.35	1605	40.95	1.13	
Ever Breastfed										

Yes	4099	68.65	0.91	501	69.89	2.15	3598	68.50	0.99	0.563
No	2115	31.35	0.91	277	30.11	2.15	1838	31.50	0.99	
Exclusive Breastfeeding										
Yes	411	7.78	0.48	58	11.12	0.18	353	10.68	0.46	0.012
No	5803	92.22	0.48	720	88.88	0.45	5083	89.32	0.62	

*a - compared to non-Hispanic white
b - compared to some college education
c - compared to at least $35,000

Table 2. Characteristics of a retrospective cohort of Georgia mothers of live births who responded to PRAMS survey and had a subsequent live birth in Georgia between 2004 and 2008 by IPI category (n=778)

	Total (n=778)			**IPI < 12 months (n=132)**			**IPI 12-18 months (n=239)**			**IPI > 18 months (n=407)**			**χ^2 P value**
	No.	**%**	**SE(%)**	**No.**	**%**	**SE(%)**	**No.**	**%**	**SE(%)**	**No.**	**%**	**SE(%)**	
Maternal Age Category													<.001
10-15 years	12	0.52	0.21	0			6	1.28	0.70	6	0.25	0.10	
16-20 years	225	25.22	2.10	48	31.30	5.89	82	37.47	4.36	95	17.44	2.36	
21-25 years	249	32.12	2.26	52	39.58	6.30	84	30.40	3.84	113	31.18	3.09	
26-30 years	160	22.75	2.06	22	15.87	4.42	36	15.74	3.26	102	28.05	2.98	
31-35 years	106	15.71	1.82	8	10.45	5.34	27	13.10	2.92	71	18.35	2.50	

36-40 years	25	3.65	0.89	2	2.80	2.11	4	2.02	1.33	19	4.70	1.30	
41-45 years	1	0.02	0.02	0			0			1	0.04	0.03	
Marital Status													
Not Married	399	44.16	2.39	84	55.36	6.64	134	52.66	4.39	181	37.05	3.15	0.004
Married	377	55.84	2.39	48	44.64	6.64	104	47.34	4.39	225	62.95	3.15	
Missing	2												
Maternal Education													
Did not graduate High School	189	23.06	2.18	54	48.88	6.71	60	24.85	3.94	75	15.76	2.54	<.001
High School Graduate	281	34.63	2.31	49	34.44	6.05	103	41.64	4.31	129	30.94	3.06	
Some College or Higher	278	42.31	2.44	25	16.67	4.52	71	33.52	4.18	182	53.30	3.35	
Missing	30												
Contraceptive use													
Yes	570	73.55	2.20	78	50.72	6.66	160	70.03	3.93	332	80.67	2.68	< .001
No	198	26.45	2.20	49	49.28	6.66	77	29.97	3.93	72	19.33	2.68	
Missing	10												
Maternal Tobacco Use													
Yes	72	7.35	1.33	13	10.40	4.24	24	8.12	2.56	35	6.21	1.62	0.583
No	702	92.65	1.33	199	89.60	4.24	213	91.88	2.56	370	93.79	1.62	
Maternal Race/Ethnicity													

Non-Hispanic White	275	50.34	2.32	34	35.07	6.47	73	41.89	4.47	168	58.42	2.99	0.008
Non-Hispanic African American	444	37.72	1.95	87	47.26	6.31	149	45.51	4.12	208	31.38	2.44	
Hispanic	45	10.63	1.85	10	17.42	6.59	12	10.48	3.33	23	9.04	2.20	
Non-Hispanic Other	14	1.32	0.55	1	0.25	0.24	5	2.12	1.33	8	1.16	0.68	
Income													
Less than $19,999	338	48.48	2.68	74	75.69	6.18	106	50.75	4.85	158	41.56	3.53	<.001
$20,000-$34,999	94	13.00	1.77	12	10.21	4.25	37	19.14	3.87	45	10.42	2.08	
$35,000 and greater	192	38.53	2.63	13	14.11	4.96	48	30.11	4.52	131	48.02	3.59	
Ever Breastfed													
Yes	501	69.89	2.15	70	57.66	6.31	148	65.44	4.13	283	75.18	2.70	0.018
No	277	30.11	2.15	62	42.34	6.31	91	34.56	4.13	124	24.82	2.70	
Exclusive Breastfeeding													
Yes	58	11.12	1.61	4	2.33	1.43	14	7.38	2.37	40	15.20	2.50	0.002
No	720	88.88	1.61	128	97.67	1.43	225	92.62	2.37	367	84.80	2.50	

*a - compared to non-Hispanic white
b - compared to some college education
c - compared to at least $35.000

Table 3. Logistic regression results for model comparing IPI less than 18 months compared to at least 18 months with exclusive breastfeeding as exposure (n=778)

	IPI less than 18 months			
Parameter	**P value**	**Adjusted OR**	**95% CI**	
Exclusively Breastfed (0=no 1=yes)	0.256	0.61	0.26	1.44
Maternal age in years	0.211	0.98	0.67	1.44
Hispanic ethnicity (0=no 1=yes)[a]	0.953	1.03	0.37	2.84
African American (0=no 1=yes)[a]	0.042	1.71	1.02	2.88
Less than high school graduate (0=no 1=yes)[b]	0.079	2.27	0.93	5.52
High school graduate (0=no 1=yes)[b]	0.702	1.36	0.72	2.59
Less than $20,000[c]	0.504	1.15	0.56	2.38
$20,000 to $34,999[c]	0.074	1.98	0.87	4.49
Birth control use (0=no 1=yes)	0.009	0.48	0.27	0.83
Married (0=no 1=yes)	0.601	0.85	0.45	1.59

Table 4. Polytomous logistic regression results for model comparing IPI less than 12 months and 12 to 18 months compared to at least 18 months with exclusive breastfeeding as exposure (N=778)

	IPI less than 12 months				IPI 12 to 18 months			
Parameter	P value	Adjusted OR	95% CI		P value	Adjusted OR	95% CI	
Exclusively Breastfed (0=no 1=yes)	0.170	0.37	0.09	1.54	0.383	0.67	0.27	1.65
Maternal age in years	0.694	0.86	0.63	1.97	0.130	0.70	0.58	0.85
Hispanic Ethnicity (0=no 1=yes)[a]	0.822	0.86	0.22	3.30	0.843	1.12	0.36	3.52
African American (0=no 1=yes)[a]	0.048	2.27	1.01	5.11	0.112	1.56	0.90	2.73
Less than High school graduate (0=no 1=yes)[b]	0.006	4.28	1.32	13.92	0.432	1.63	0.60	4.45
High school graduate (0=no 1=yes)[b]	0.236	1.33	0.50	3.51	0.851	1.35	0.66	2.75
Less than $20,000[c]	0.193	3.31	0.95	11.55	0.161	0.84	0.38	1.87
$20,000 to $34,999[c]	0.346	3.08	0.76	12.42	0.067	1.77	0.75	4.20
Birth control use (0=no 1=yes)	0.001	0.28	0.13	0.60	0.087	0.59	0.32	1.08
Married (0=no 1=yes)	0.157	0.55	0.24	1.26	0.984	0.99	0.49	2.03