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Assessing the Impact of Breastfeeding Cessation on the Reported Incidence of Diarrhea in

Infants Between the Ages of 7 to 12 Months: A Secondary Data Analysis

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To Ruben and my family for their unconditional love and support.

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Abstract

Background: Diarrheal diseases remain a major cause of childhood morbidity in the United States. Optimal breastfeeding has been identified as one of the most effective measure to prevent diarrheal diseases in childhood.

Purpose: To evaluate the impact of breastfeeding duration during the first 6 months on the incidence of diarrhea in infants between 7 and 12 months in the United States.

Method: A secondary data analysis was performed using mothers and infants participating in the Infant Feeding Practices Study II (2005-2007).

Results: Compared to those who breastfed for 6 months or more, infants who discontinued breastfeeding between 0 and 3 months were at 48.4% greater risk of having diarrhea at 7 and 12 months and those who discontinued breastfeeding between 3 and 6 months were at 31% greater risk of having diarrhea between 7 and 12 months.

Conclusion: Breastfeeding cessation before the first 6 months is a significant predictor of diarrhea between 7 and 12 months.

1. Introduction

Diarrhea is a symptom often associated with gastrointestinal infections and is characterized by an abrupt onset of three or more loose stools per day.[1] Approximately 578 000 children die from diarrhea each year in both developed and under-developed countries.[2] Worldwide, it is estimated that 4.7 million episodes of childhood diarrhea are reported each year and approximately 1,600 deaths associated with diarrhea occur daily. Poverty and unsanitary environment are two factors that significantly increase the frequency and severity of diarrheal episodes.[3] So geographically, the poorest regions of the world, South Asia and Sub Saharan Africa, alone account for 90% of the total childhood mortality rate due to diarrhea.[2] In these parts of the world, the immediate cause of death related to diarrheal diseases is dehydration; therefore, preventing and treating dehydration with oral rehydration solutions has been the major focus of diarrheal management.[3]

The major burden of diarrheal related morbidity and mortality is reported to be in the developing regions of the world. However, children living in richer countries are also affected by diarrheal diseases.[4] While accounting for fewer deaths in developed countries, diarrheal infections are associated with high rates of doctors and emergency hospital visits, hospital admissions and medical costs. In the US, diarrheal related infections account for approximately 300 deaths each year in children under the age of 5.[4] Causing approximately 200, 000 hospitalizations, it is estimated that diarrhea cost about $250 million in direct medical expenses each year.[4-5] Low birth weight, being male and black are all factors that have been found to significantly increase the risks of dying from diarrheal diseases in the US.[6] Preventive measures to control and reduce the impact of diarrhea in the US includes the promotion of rotavirus vaccines and optimal breastfeeding for the first 6 months of life are among the key strategies to prevent diarrhea.[5]

Before the introduction of rotavirus vaccines, the pathogen was reported to cause the most frequent episodes of diarrhea in US children with 55,000 to 70,000 hospital admissions each year and approximately $1 billion to the US government in medical cost.[7] Following its introduction between 2007 and 2009, the rotavirus vaccine was estimated to reduce gastroenteritis hospitalizations by at least 53% in US infants living in the Western part of the country.[7] The vaccine reduced by more than 70% diarrheal related infections among children between 1 to 4 years old in the Southern, Northeastern and Midwest regions of the US.[7] Besides the rotavirus vaccine, the promotion of breastfeeding for the first 6 months of life has been another cost-effective preventive measure against diarrheal diseases in the US.

Given the extensive evidence, the health advantages of breastfeeding are undisputable. Multiple studies have shown that breastfeeding, the recommended source of nutrition for at least the first six months of life, is essential for the nutritional, immunologic, neurobehavioral and social development of the infant and young child.[8-9] Following the 1984 Surgeon General's Workshop on breastfeeding practices; the rates of breastfeeding initiation and continuation increased three-fold from the 1970's to the mid 1980's. However, this significant progress decreased in the 1990's before rising slowly again in the 2000s.[8] A major recommendation of the Workshop was the provision of exclusive breastfeeding, which means the infant receives only breastmilk, during the first 6 months of life. It has been estimated that optimal (exclusive) breastfeeding could prevent the death of 823,000 children per year worldwide.[10] Less optimal breastfeeding has been associated with the increased occurrence of diarrhea. The prevention of persistent diarrhea through the promotion of optimal breastfeeding is imperative in reducing the burden of diarrhea and infectious diseases in early infancy in both developed and less developed countries.

2. Background and rationale

Since 1984, breastfeeding has been identified as one of the most important and cost-effective intervention, significantly reducing the incidence of infectious diseases among children, especially diarrhea and pneumonia.[11-13] Human breastmilk contains bioactive molecules, mostly secretory antibodies, lactoferrin and glycans promoting protection and maturation of the gastrointestinal track and immune system during infancy and early childhood.[13-14]

In a systematic review of the literature, Lamberti and colleagues (2011) assessed the protective effect of optimal versus suboptimal breastfeeding practices on diarrhea associated childhood morbidity, mortality and hospitalization in low income countries. The study findings indicated that among infants between 0 and 5 months, those who were partially breastfed had 1.68 times (95% Confidence interval [1.03-2.76]) greater risk of having diarrhea compared to those who were exclusively breastfed. The risk of hospitalization from diarrhea was 6.05 times greater in infants between 6 and 11months who were not breastfed compared to those who were breastfed.[16] Exclusive breastfeeding during the first 6 months of life has been reported to offer the best immune protection against diarrheal diseases.

In the most recent meta-analysis on breastfeeding practices published in the Lancet, it was reported that compared to middle-income and low-income countries, the prevalence of any breastfeeding at 12 months is lower in high-income countries.[17] The weighted prevalence of breastfeeding at 6 months in high income countries was approximately 45% (compared to more than 95% in low income countries) and was 20% at 12 months (compared to more than 90% in low income countries).[17] Breastfeeding practices among US mothers are not an exception. The prevalence of any breastfeeding at 12 months in the US is around 27%.[17]

The 2014 CDC report card on breastfeeding indicates that only 18.8% of US infants are exclusively breastfed at 6 months while 49.4% receive some breastmilk through 6 months.[18] These numbers depict the perpetuation of suboptimal breastfeeding in the US since they remain far from the Healthy People 2020 objectives of 25.5% exclusive breastfeeding at 6 months and 60.6% infants receiving some breastmilk at 6 months.[18-20]

A cost analysis of the impact of suboptimal breastfeeding on infants' health and the US national economy was conducted by Bartick and Reinhold in 2010. The authors used breastfeeding data from the 2005 National Immunization Survey to report that 741 infant deaths per year could have been prevented and $10.5 billion could have been saved if 80% of US families practiced exclusive breastfeeding during the first 6 months of life.[20] In addition, the study reports that exclusive breastfeeding for the first 6 months of life reduced by 36% the risk of developing cases of gastroenteritis.[20] While progress have been made to reduce the gaps surrounding breastfeeding practices as recommended by Healthy People 2020, more coordinated efforts are warranted.

2.1 Protective properties of human breast milk

The human digestive system is described as a complex ecology with diverse species of bacteria also called microbiota.[21] The constitution of a healthy and stable gastrointestinal microbiota is the resultant of: internal and external environmental exposures during the prenatal and perinatal periods; intestinal epithelial cells; as well as, the bacteria of individuals coming in close contact with the infant; and the diet. The protective effects of human breastmilk during the first years of life have been largely attributed to three major classes of factors inhibiting the colonization and growth of certain bacteria and other pathogens in the microbiome.[22] These factors include secretory antibodies, lactoferrin, glycoconjugates and oligosaccharides.[21]

2.1.1 Secretory antibodies. Breastmilk contains antibodies specific to infections and antigens from maternal exposure, hence providing early antigen-specific immunity to breastfed infants.[23] The composition and concentration of human breastmilk mediated immune response is primarily found in the form of secretory immunoglobulin A (SIgA) in colostrum, and are defined by the mother's prior exposure to pathogens found in her environment.[24] This passive immunity of breastmilk provides specific- immune protection against certain pathogens, indirectly influencing the composition of the infant gut microbiota. Additionally, secretory antibodies found in human milk also promote the development and later maturation of the infant's immune system by affecting the permeability function of the intestinal epithelial and dendritic cells.[24]

2.1.2 Lactoferrin. Described as the second most abundant protein in human milk, lactoferrin has been reported to have antimicrobial, anti-inflammatory and immunomodulatory properties.[25-26] The structure of Lactoferrin provides iron binding ability, in doing so it removes an essential substrate required for bacterial growth. In addition, being positively charged also provides the protein with the property to bind to the surface of Gram negative bacterial cells and to degrade their cell membranes.[26] These binding properties afford lactoferrin the ability to inhibit pathogens growth, while at the same time increasing adherence and degradation of host cells.[26]

2.1.3 Oligosaccharides and glycoconjugates. Present in diverse sizes, charges and sequences in human breastmilk, oligosaccharides (HMOs) are complex structural carbohydrates attached to lactose. They constitute the third largest components in human milk after lactose and lipid[27]. Glycoconjugates on the other hands are carbohydrate molecules attached to glycoproteins, glycolipids, glycosaminoglycan, and mucins.[21] HMOs and glycoconjugates are structurally similar to glycoconjugates present at the surface of human cells, which constitute the means of entry for pathogens into target host cells. Based on this specificity, HMOs and glycoconjugates

are reported to have binding properties with bacterial or viral pathogens and toxins hence preventing these pathogens or toxins from adhering to the surface of target host cells and inhibiting infection or death of the host cells.[22, 26]

In addition HMOs have also been described to have probiotic functions in the gut by promoting the growth of bacterial species beneficial for the health of host cells, mainly the growth of bifidobacteria.[21-22, 26-28] These specific bacteria can partially or entirely metabolize HMOs for growth and proliferation.[29] However, HMO structures and compositions vary between the breastmilk of women so their effects on the intestinal microbiota and immune system might differ from one infant to the other.

While the protective effect of breast milk is undeniable, significant gaps still exist in the promotion and practice of early breastfeeding initiation and continuation for the first 6 months of life, even in countries like the US. Non-exclusive or early interruption of breastfeeding, also known as suboptimal breastfeeding, was ranked in 2010 by the Global Burden of Disease Study as the second leading risk factor of disease burden in children under the age of 5 worldwide regardless of whether the child was in a developed or under-developed country.[30]

2.2 The Infant Feeding Practice II (IFPS II) study

The Infant Feeding Practices Study II (IFPS II) is a longitudinal study performed between 2005 and 2007 by the Center for Diseases Control and Prevention (CDC) and the Food and Drug Administration (FDA).[31] The study explored maternal diet during the last trimester of pregnancy and at four months after delivery as well as infant feeding practices and their health status during the first 12 months of life. Feeding practices included patterns of breastfeeding, formula feeding and intake of solid food.[31] Infant health status included questions related to: weight; length; onset

of symptoms such as fever, diarrhea, vomiting, ear infection, colic and reflux; the use of medicines; stool characteristics. Mothers completed: a prenatal questionnaire; a neonatal questionnaire when their infants were approximately 1 month; and 9 more neonatal questionnaires on infant feeding and health status were completed when the infants were between 2 and 12 months.[32] The IFPS II dataset is accessible to the public upon request via email.

A total of 32 articles were published between 2008 and 2012, reporting study results using the IFPS II dataset.[32] While the majority of the research focused on US mothers' feeding practices during the first year after delivery, none of the published reports have examined the relationship between breastfeeding cessation and the reported onset of diarrhea in infants. One study used the IPFS II dataset and its 6 years follow-up data to evaluate the long term effect of breastfeeding on common infections in children.[33] The authors examined the association between maternal breastfeeding practices and reports of infections such as upper respiratory tract infection/cold, ear, throat, sinus, pneumonia and urinary tract infections.[33] Diarrhea was not counted as a common infection and as such was not a variable included in the study's analysis.

The IFPS II dataset was used in the present study because it is the most recent survey compiling comprehensive information on US mothers and infant feeding practices and their health status.[31] This is the first secondary data analysis study using the IFPS II data to assess the longitudinal effect of breastfeeding duration on the occurrence of diarrhea in the first 12 months of life. The goal of this study is to evaluate the impact of breastfeeding duration during the first 6 months after birth, on the maternal reports of diarrhea episodes in infants during their first year. Providing more evidence on the outcomes related to the immunologic properties of breastfeeding using a national survey data, will strengthen the literature and encourage the promotion of

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optimal breastfeeding practices of US mothers. The prevention of persistent diarrhea through the promotion of optimal breastfeeding is imperative in reducing the burden of the symptoms in early infancy and childhood.

3. Research Question

A secondary data analysis was performed to answer the following research question: **Is the incidence of diarrhea episodes in infants between the ages of 7 to 12 months influenced by mothers' breastfeeding duration between 0 to 6 months?** The research question was based on the hypothesis that compared to infants who discontinued breastfeeding between 0 and 6 months, the infants who were breastfed up to 6 months or longer would have a lower count of diarrheal episodes, reported by mothers within 2 weeks prior to completion of questionnaires at 7, 9, 10, and 12 months.

4. Methods and materials

The present study is a secondary data analysis evaluating the effect of breastfeeding duration during the first 6 months of life on the reported incidence of diarrhea in infants between the ages of 7 and 12 months. The study population included mothers and their infants enrolled in the IFPS II. Longitudinal study collected between May 2005 and June 2007 through a nationwide consumer opinion panel of 4902 women who were at least 18 years old, in their third trimester of pregnancy and expecting a singleton.[31]

Mothers were excluded from the study if: they refused to participate; did not return the questionnaires; the infant was born before 36 weeks gestational age; the infant was born with a long-term illness. Mothers were also excluded from the original study if they resided in areas where the United States Postal Service could not deliver mail after the 2005 Gulf Coast

hurricanes.[31] Based on these exclusion criteria, a total of 3033 mothers completed all the survey questionnaires.[31]

Among the 3033 mothers who participated in all the IFPS II questionnaires, 61.4% were between 25 and 34 years old, mainly married (79.1%) and majority had some college education (40.2%).[31] More than 80% of the women declared themselves to be white, 6.2% were Hispanic and 4.9% were black.[31] While well distributed in the four regions of the US, the IFPS II dataset is based on a sample of self- selected consumer opinion panel with a majority of the women are white, with a high socio-economic status and educational level. Therefore, the dataset is not nationally representative and the results from the analysis of the IFPS II dataset cannot be generalized to the overall US population.[31]

4.1 Participants

Based on the study's research question and main variables, the sample size for the present study was limited to mother who completed the questionnaires with reports on breastfeeding cessation, last time a questionnaire was retuned and diarrhea episodes between 7 and 12 months after delivery. We excluded mothers with missing data (no survey responses reported) on the study's variables. A total sample of 2344 dyads were included in the final analysis (Figure 1). The following sections described the variables used for the secondary data analysis of the IFPS II.

4.2 Study variables

4.2.1 Breastfeeding duration. Breastfeeding duration was the primary exposure variable and corresponds to the infant's age when the mother reported to completely discontinued breastfeeding and provision of expressed breastmilk. The variable indicates the infant's age when he/she stopped providing breastmilk directly from the breast or through expression

(pumped). The variable was categorized into four subset variables: 1) infants reported to never breastfeed (bfduratn= 0); 2) infants who stopped receiving breast milk between 0 and 3 months (0.1 to 12.0 weeks); 3) infants who stopped receiving breast milk between 3 and 6 months (12.1 to 24 weeks); and 4) infants who received breast milk at 6 month or beyond.

The code 77 also existed in the original dataset as part of the breastfeeding duration variables. The code 77 corresponds to mothers who were still breastfeeding at the last questionnaire they returned, which could be at any time point during the study period and beyond the investigation period (12 months) (n= 917). In the original codebook, there was no clear description of mothers who left the study early, and those records with missing values. So a variable, last questionnaire available in the dataset, was created in the present study to identify the number of mothers who dropped out before the 6 month study period. The last questionnaire received was coded as the last time (in month), mothers were reported to return an IFPS II questionnaire. The variable provided an estimate of the number of mothers who discontinued breastfeeding between 0 and 6 months after delivery. This variable was also used to estimate the sample size of each breastfeeding duration groups.

4.2.2 Reported episodes of diarrhea. The main outcome variable was reported diarrheal episodes within the 2 weeks prior to completing the questionnaire. Data on infants' diarrheal episodes were obtained from the questionnaire by using the following question: "Which of the following problems did your baby have during the past 2 weeks?" Diarrhea was listed as one of the multiple choice options including fever, vomiting and ear infection. Mothers could choose all of the items, none of the items or some of the items. The occurrence of a diarrheal episode was defined as a mother reporting at least one episode of diarrhea within the 2 weeks prior to receiving questionnaires in months 7, 9, 10 and 12. For the purpose of the analysis, the

dependent variable (reported episodes of diarrhea) was recoded into a binary variable: 0 = no episodes of diarrhea; 1 = 1 or more episodes of diarrhea reported at months 7, 9, 10 and 12.

A total of 59 mothers did not respond to the question on diarrhea at least once between months 7 and 12 month questionnaires. A sensitivity analysis was completed to determine whether treating the lack of response as occurrence (condition 1) or non-occurrence (condition 2) of diarrhea would modify the study finding. No statistically significant difference was found. The statistical analysis was completed using the more conservative condition, condition 1.

4.2.3 Offset variable. The number of times a mother reported an episode of diarrhea between 7 and 12 months also depended on the number of questionnaires she returned during that given period. Therefore, the number of questionnaires returned by each mother could affect the total count of reported diarrhea episodes. For this reason a variable "number of questionnaire returned" was created to account for the total number of time mothers returned the survey questionnaire between 7 and 12 months. A value from 0 to 4 was given based on the number of times a mother returned a postnatal questionnaire at months 7, 9, 10 and 12. This variable was considered an offset variable and was used as a control variable during statistical analysis using Poisson regression.

4.2.4 Other variables. Following consultation with a certified lactation specialist and an extensive literature review, a series of mother and infant characteristics were identified as potential confounders and controlled for during the statistical analysis using Poisson regression. The variables included sociodemographic characteristics of the mothers such as age, race, level of education and employment status. Infant characteristics included gender, weight and occurrence/non-occurrence of infant breastfeeding during the neonatal period.

4.3 Statistical Analysis

To assess the association between breastfeeding cessation and the report of diarrhea episodes in a longitudinal manner, generalized linear modeling using Poisson regression was used. Recoding of the variables of interest was completed using SAS version 9.4.[34] Frequency and descriptive statistics were completed for the demographic characteristics of the sample using SPSS version 22.[35]

Diarrhea episodes were self-reported by the participating mothers and returns of the questionnaires occurred at different time for each participants. Since these variables could not be controlled for, rate ratios rather than relative risk were reported. Poisson regression was applied to estimate the rate ratio (RR) and a *p value* was obtained based on the Wald test and 95% confidence interval of the reported occurrence of diarrhea between months 7 and 12 as it related to breastfeeding cessation between 0 and 6 months. All analyses were completed using SPSS version 22.[35]

5. Results

5.1 Participants demographics

Demographic statistics for maternal and infant characteristics are presented in Table 1. In the infant cohort, the male to female ratio was almost equal with 49.7% male and 50.2% female. A majority of the infants were delivered vaginally (71.3%) with an average birth weight of 7.64 lbs. Mothers (n= 2000, 84.3%) either breastfed or tried breastfeeding their infant. More than a quarter of the infants (25.8%) stopped receiving any breastmilk before 3 months and almost half of the infants (47.3%) were breastfed beyond 6 months. At least one episode of diarrhea was reported in 714 cases between 7 and 12 months.

Descriptive analysis of the maternal participants indicated that mothers' average age was 29 years old with the majority being white (85.5%) and married (77.4%). Most mothers were highly educated (65% had some college education) and 45% lived in a household with an income level higher than $50,000. The present study's maternal and infant characteristics mirror the larger IFPS II sample of 3033 mother- infant dyads. A majority of the mothers in the initial IFPS II study were white (84.4%), between 25 to 34 years old (61.4%) and many had some college education (40.2%).[31]

5.2 Breastfeeding duration and reported episodes of diarrhea

In this study, 14.2% of the infants were never breastfed either directly from the breast or received expressed breastmilk from the bottle while 38.5% stopped being breastfed between 0 and 6 months. A total of 1109 (47.3%) infants were reportedly breastfed for the first 6 months or more. Approximately 28% of these mothers reported one or more episodes of diarrhea within the last 2 weeks after receiving questionnaires in months 7, 9, 10 and 12. The reported episodes of diarrhea increased over time with 6.4% mothers reporting at least one episode at 7 months compared to 12% reported at least one episode at 12 months.

The results from the Poisson regression model assessing the relationship between the four-level breastfeeding cessation variable and reported episodes of diarrhea are described in Table 2. Repetition of the analysis using either condition 1 (considering "no answer on diarrhea occurrence question" as no occurrence of diarrhea) or condition 2 (considering "no answer on diarrhea occurrence question" as occurrence of diarrhea) did not change the rate ratio for breastfeeding cessation. Further analyses were completed using the more conservative approach, condition 1.

The incidence of diarrhea for infants who breastfed for 6 months or more was approximately 93 per 1000 infants ($p = 0.000$). The model results indicate that breastfeeding cessation during the first 6 months of life is a significant factor predicting the number of reported episodes of diarrhea between 7 and 12 months. Infant who were never breastfed had 1.24 times greater risks of having an episode of diarrhea reported between 7 and 12 months compared to the infants who breastfed for 6 months or more ($p= 0.043$, CI [1.007 – 1.52]). Infants who discontinued breastfeeding between 0 and 3 months were 1.48 times at greater risk to have a reported episode of diarrhea at least once between 7 and 12 months compared to the infants who breastfed for 6 months or more ($p = 0.000$ CI [1.18- 1.71]). Infants who stopped receiving any breastmilk between 3 and 6 months were at 1.31 times at greater risk of having a diarrhea episode reported by their mother between 7 and 12 months ($p = 0.016$, CI [1.17- 1.90]) compared to those who breastfed for 6 months or more. Given the fact that in general many mothers stop breastfeeding before the infant is 3 months old these findings are very important.

Wealth related factors such as maternal education and household income have been reported to influence breastfeeding duration.[17,36] In high-income countries, women with higher education and socio-economic status were found to breastfeed more than women in lower income groups.[17] When adjusting for each the wealth related variable separately by adding them as covariates in the Poisson regression modeling, the results indicate maternal household income, maternal age, and maternal education level significantly affected reported episodes of diarrhea. Among the mothers who breastfed their infants, every $1,000 increase in their household income was linked to a 2% decrease in reported episodes of diarrhea at months 7, 9, 10 and 12 ($p = 0.006$). The results also showed that reported episodes of diarrhea decreased with older (RR $= .98$; $p = 0.000$) and more educated (RR$= .92$; $p = 0.02$) mothers (Table 2).

No significant differences were noted on the relationship between breastfeeding duration and the reported episodes of diarrhea based on maternal race, marital, and employment status. When introducing maternal race as a covariate in the regression model, the rate ratio between breastfeeding cessation and the reported onset of diarrhea episodes was 1.007 ($p = 0.874$). Marital status also did not have an impact on the relationship between breastfeeding duration during the first 6 months after birth and the report of diarrhea episodes at age 7 to 12 months (RR= 1.03, $p = .227$). Similarly, mothers' employment status during the duration of the study, did not impact the relationship between breastfeeding duration and reported episodes of diarrhea (RR= .993, $p = .612$).

Importantly, none of the reported infant demographic characteristics were found to significantly influence the reported episodes of diarrhea between 7 and 12 months. When infant birth weight was added as a covariate in the regression model, the estimate rate ratio was .970 ($p = .367$). Gender or delivery method also did not show a statistical significant impact on the relationship between breastfeeding duration and report of diarrhea episodes ($p = .143$ and $p = .684$ respectively). In other words, inclusion or exclusion of the infants' demographic variables in the regression model did not change the rate ratio estimates of reported episodes of diarrhea between 7 and 12 months based on breastfeeding duration before the age of 6 months.

6. Discussion

Breastfeeding is considered the most cost effective intervention to assist in preventing diarrhea in early infancy and childhood. In a 2011 meta-analysis of studies performed in developing countries between 1980 and 2009, Lamberti et al., reported that no breastfeeding increased by 26% the risk of incidence of diarrhea in infants between the ages 0 to 5 months.[16] While exclusive breastfeeding is the recommended practice for infants up to 6 months of age, the

authors reported that any breastfeeding for more than 6 months had a protective effect on outcomes such as diarrhea. Increasing evidence indicates that antibodies and glycobiome found in breastmilk provide an important source of protection against infectious diseases.[15] These breastmilk components are reported to provide protection against diarrhea by decreasing the incidence and duration of diarrheal episodes.[16]

Consistent with the previous research, the present study demonstrates that breastfeeding for 6 months or more could significantly decrease the incidence of diarrhea for infants younger than 12 months. The results of the secondary data analysis indicated that approximately 93 in 1000 infants who breastfed for 6 months or more had at least one episode of diarrhea reported by their mothers between 7 and 12 months. The number of infants experiencing an episode of diarrhea increased by 48.4% if they stopped receiving breastmilk before 3 months and by 31.1% if they stopped receiving any breastmilk between the first 3 to 6 months of life. The findings showed that infants who breastfed for less than 3 months had the highest risk of diarrhea prior to 12 months of age.

This could be due to the decrease in breastfeeding intensity and introduction of solid foods. In a previous secondary analysis of the IFPSII , Grummer-Strawnn et al. (2008) reported that by 3 months, majority of the infants (80%) were either fed breastmilk or formula milk. By 4 and 5 months, 61% of the infants were fed with formula.[36] Supplementation and early introduction of food other than breastmilk have been linked with suboptimal breastfeed and increase likelihood of infections like diarrhea- related diseases.[14]

When adjusting for mothers' age, education and household income, breastfeeding duration was significantly associated with reported episodes of diarrhea. Adding each of these variables individually in the regression model was associated with variation in the event of having a

reported episode of diarrhea varied statistically significantly. Higher income households decreased the likelihood of reporting an episode of diarrhea by 2%. Infants whose mothers had a higher level of education decreased the risk of reporting an episode of diarrhea by 8%. These results are consistent with previous research and publications reporting that higher income and more educated mothers tend to breastfeed longer and thus, have healthier infants with less risks of diarrheal symptoms.[37-40]

Jones et al, assessed the factors associated with breastfeeding practices in US infants using the 2007 National Survey of Children's Health. The authors reported that children living in families with a household poverty status between 200% and 399% of the federal poverty level were 85% less likely to ever breastfeed compared to their counterparts living in household with a poverty level higher than 400% the federal poverty level.[37] In addition, the authors also found that 20 years old or younger mothers are .88 times less likely to ever breastfeed compare to 30 years old or older mothers.[37] Results from Jones' study and the present study reflect the 2011 "Surgeon General's Call to Action to Support Breastfeeding", the US Department of Health and Human Services noted the significant disparities in breastfeeding based on race and ethnicity, socioeconomic characteristics and geographical location.[41]

This study is the first to explore a longitudinal relationship between breastfeeding duration and diarrhea episodes using the IFPSII dataset. Using a more current database to explore the protective effect of breastfeeding strengthens the literature and provides more evidence for the promotion of breastfeeding in early infancy at the clinical practice and community level.

6.1 Limitations

While consistent with the current literature, the results are subject to certain limitations. Because the IFPS-II dataset is derived from a self-selected consumer opinion panel rather than random sampling, it is not a representative sample of the US population. Participating mothers were predominantly white, medium to high income with higher levels of education. Therefore, the study findings cannot be generalized to the entire US population.

Second, breastfeeding cessation was a composite variable that did not distinguish between infants who were exclusively breastfed and those who were partially breastfed. Had these items been available in more precise variables, it would have allowed testing related to whether there was a stronger relationship between exclusive breastfeeding duration and the occurrence of diarrhea. More specific information on the breastfeeding type would have allowed for exploration of the differences between the effects of exclusive versus any breastfeeding duration on reported onset of diarrhea episodes.

Thirdly, the use of the code 77 for both mothers who left the study early and those who continued breastfeeding beyond the study period, did not allow a clear distinction between the mothers who dropped out early during the study and when did they leave the study versus the mothers who continued breastfeeding beyond the 12 months study period. Finally, the reported episodes of diarrhea were self-reported by the mothers, so the definition of diarrhea might have varied based on mothers' knowledge and perceptions.

6.2 Implication for practice and research

The study's findings support US and WHO clinical practice guidelines regarding breastfeeding during infancy. The results also highlight the issue of suboptimal breastfeeding continuation

during the first 6 months of life and its impact on the increased incidence of diarrhea later during the first year of life. By providing statistically significant evidence of the protective effect of breastfeeding continuation for 6 months or more, the study adds to the existing research and evidence-based policies for the promotion of optimal breastfeeding at the clinical and community level.

While already established and practiced, these strategies ought to be re-evaluated to identify and address the factors that limit adherence to optimal breastfeeding during this critical period in infancy. The study sample did not include many minority mothers. So further studies using prospective longitudinal design with over-sampling of these groups must be attempted to better capture breastfeeding cessation and diarrhea incidence across a nationally representative sample reflecting the racial/ethnic and economic diversity of the US population.

7. Conclusion

Diarrhea related infections remain an issue for children under the age of 5 worldwide. Optimal breastfeeding for at least the first 6 months of life has been considered one of the most effective interventions for protecting infants against diarrhea. The findings from the present secondary data analysis using a nationwide dataset provides increasing evidence for the protective effect of breastfeeding against diarrhea. While this has fact been well-known for the last three decades, adherence to optimal breastfeeding for the first 6 months of life remains limited, even in more developed countries like the US and even within a subgroup of the population with higher income, education level and better access to healthcare services and support. Further research leading to evidence-based health promotion programs are warranted to identify and address factors predicting early breastfeeding cessation. Additionally, these programs need to offer healthcare providers the means to detect early in the post-partum period (during hospitalization)

and follow-up periods, mothers at-risk for suboptimal breastfeeding practices to provide targeted

interventions to best protect their children.

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Table 1 Maternal and Infants demographics

	Total N= 2344 (%)
Mother's Characteristics	
Race	
White	2003 (85.5)
Black	89 (3.8)
Asian/Pacific Islander	64 (2.7)
Other/ Missing	188 (8.0)
Age (average)	
18 - 28	1092 (46.5)
29 – 39	1158 (49.4)
40 or older	94 (4.1)
Marital Status	
Married	1811 (77.3)
Unmarried	402 (17.15)
Missing	131 (5.6)
Household Income	
less than 5000	47 (2.0)
5000-24999	428 (18.3)
25000- 49999	819 (34.9)
50000-74999	591 (25.2)
75000-99999	271 (11.6)
100000 or over	188 (8.1)

Education Level	
High-school or less	435 (18.6)
Some college	827 (35.3)
College graduate or higher	940 (40.1)
Missing	142 (6.1)
Employment Status	
Full time	864 (37)
Part time	271 (11.6)
Unemployed/missing	1209 (52)
Infant's characteristics	
Sex	
Male	1165 (49.7)
Female	1177 (50.2)
Weight (average) at birth	7.64 lbs
Delivery Method	
Vaginal	1671 (71.3)
Cesarean section	673 (28.7)
Ever breastfed or tried breastfeeding	
Yes	2000 (85.3)
No	344 (14.7)

Table 2 Effect of breastfeeding duration before 6 months and other variables on reported

episodes of diarrhea in months 7, 9, 10 and 12.

Parameter	Rate Ratio (RR) estimate for reported episode of diarrhea	
	RR (*p value*)	95% CI
Intercept	0.093 (.000)	[0.083-0.103]
Breastfeeding cessation		
Never breastfed	1.24 (.043)	[1.007 - 1.52]
Breastfed between 0-3 months	1.48 (.000)	[1.26 - 1.74]
Breastfed between 3-6 months	1.31 (.016)	[1.05 - 1.64]
Household income	.98 (.003)	[.97 - .99]
Mother's age	.98 (0.000)	[.96 - .99]
Education	.92 (.02)	[.86 – 0.99]

Figure 1 Participants Selection Process
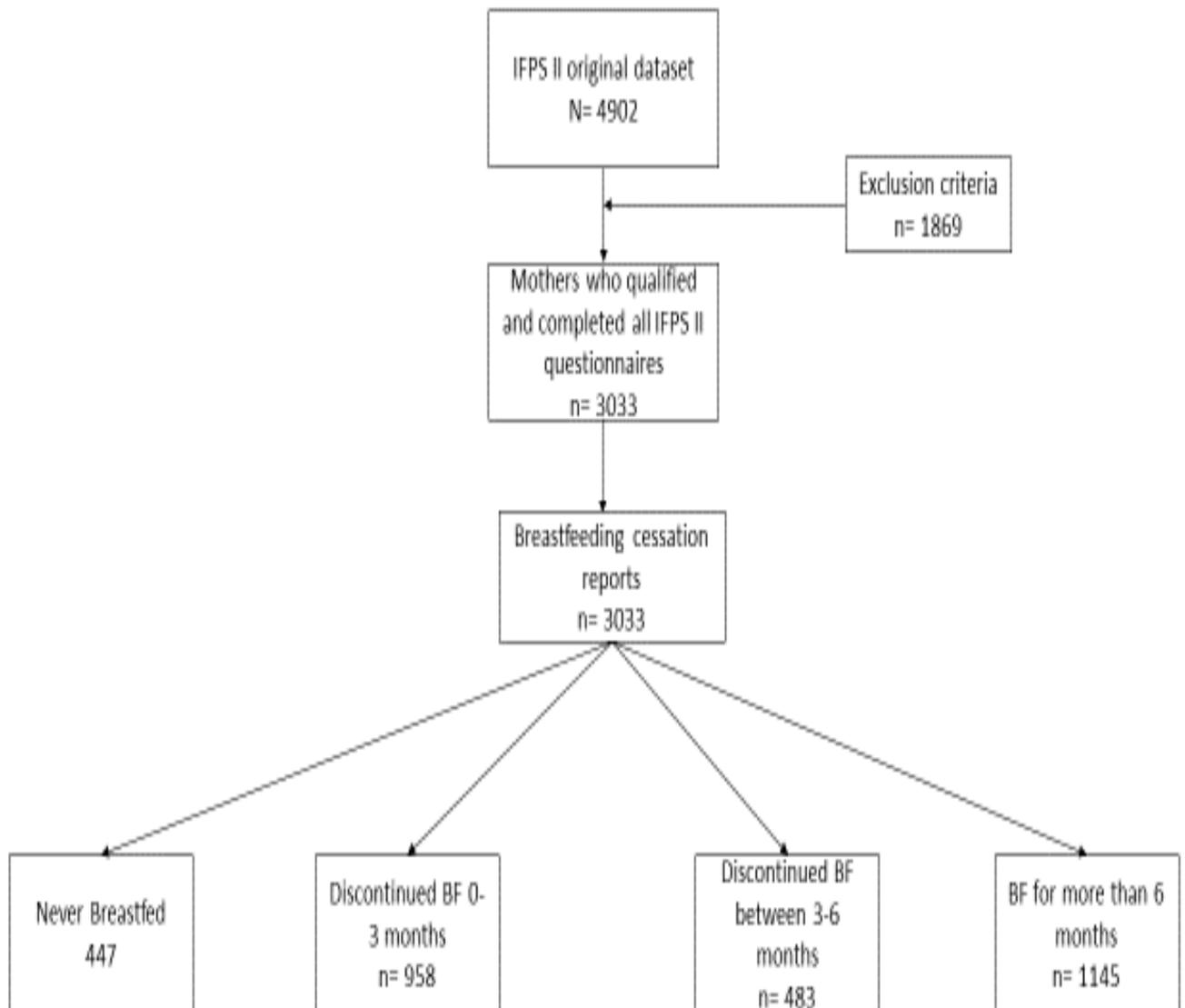
Figure 2 Percentage of reported number of diarrhea episodes at 7,9,10 and 12 months based on breastfeeding du ration.