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## Article

## The best of intentions: Prenatal breastfeeding intentions and infant health

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## ABSTRACT

Health organizations recommend that mothers exclusively breastfeed infants for the first six months of life. The current study contributes to a growing body of research that examines whether the purported benefits of breastfeeding are causal. We systematically evaluated the role of an expectant mother's prenatal breastfeeding intentions, which reflect not only demographic characteristics, but also knowledge, attitudes, and social norms about infant feeding, and therefore serve as a proxy for positive maternal selection into breastfeeding. We used the Infant Feeding Practices Study (IFPS) II ( $n = 1008$ ) to examine a heretofore overlooked group of mothers—those who intended to breastfeed but did not actually breastfeed. Results suggest that mothers who intended to breastfeed had infants with fewer ear infections and respiratory syncytial viruses, and used fewer antibiotics in the first year of life compared to infants whose mothers did not intend to breastfeed, irrespective of whether they actually breastfed. Because breastfeeding intention is a confounding characteristic that proxies for positive maternal selection and does not represent a causal mechanism for infant health, we further examined how mothers who intended to breastfeed differed from mothers who did not intend to breastfeed. Results suggest that mothers who intended to breastfeed had more knowledge about potential food contaminants and consulted more sources of information about nutrition and diet than mothers who did not intend to breastfeed. Taken together, our results underscore the need for new policy interventions aimed at improving infant health.

## 1. Introduction

One of the very first decisions a new mother will make is how to feed her newborn infant. This is an important decision, as early nutrition is related to health in infancy and later in life (Almond, Currie, & Duque, *in press*). Given evidence that breastfeeding is associated with positive infant health outcomes, the World Health Organization (WHO) and the American Academy of Pediatrics (AAP) recommend that mothers exclusively breastfeed for six months, and then continue for one year or longer according to the preferences of the mother and infant (American Academy of Pediatrics, 2012; World Health Organization, 2003). The AAP further asserts that breastfeeding “should be considered a public health issue and not only a lifestyle choice” (American Academy of Pediatrics, 2012). This message has been internalized by the medical community and the general public, as evidenced by national, state, and local policies that promote breastfeeding (Naylor, 2001; U.S. Department of Health and Human Services, 2010).

Despite being endorsed as an important factor for infant health, the evidence on the causal effect of breastfeeding is mixed. Although some research suggests that breastfeeding is linked with infant health benefits (Ip et al., 2007; Kramer, 2010), there is also evidence that the benefits

are overstated due to selection bias, a specific type of confounding that can bias statistical estimates if unaddressed (Colen and Ramey, 2014; Der, Batty, & Deary, 2006; Evenhouse & Reilly, 2005). Most studies draw on observational data, and must therefore carefully account for the fact that mothers who breastfeed tend to be more advantaged compared to mothers who formula feed. Without accounting for baseline maternal differences through research design or fully including all confounding variables, statistical models may overstate the positive relationship between breastfeeding and infant health.

The novelty of our study is to critically re-evaluate the relationship between breastfeeding and infant health outcomes by examining a proxy for maternal characteristics and advantage—the mother's prenatal intention to breastfeed. This also allows us to evaluate a heretofore overlooked group: mothers who intended to breastfeed but did not actually breastfeed. Prenatal breastfeeding intentions may capture maternal characteristics that are largely overlooked in existing studies. There is evidence that maternal breastfeeding intentions are a stronger factor in predicting breastfeeding behavior than demographic characteristics alone (Donath & Amir, 2003). Prenatal breastfeeding intentions reflect sociodemographic characteristics and maternal knowledge, attitudes, and social norms about infant feeding methods (Barnes, Stein,

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Smith & Pollock, 1997; Humphreys, Thompson, & Miner, 1998; Mitra, Khoury, Hinton & Carothers, 2004; Persad & Mensinger, 2007), all of which may play a critical role in infant health.

In this study, we draw on longitudinal data from the Infant Feeding Practices Study (IFPS) II, and address two specific research questions: (1) do prenatal breastfeeding intentions serve as a proxy for positive maternal selection into breastfeeding, a specific type of confounding characteristic that lessens or fully accounts for the association between breastfeeding behavior and three infant health outcomes in the first year of life?; (2) how do mothers who intend to breastfeed differ from mothers who do not intend to breastfeed, in terms of their knowledge of nutritional practices and access to information?

By probing these questions, our research makes two important contributions. First, ours is the first study to account for the mother's prenatal intention to breastfeed when estimating the relationship between breastfeeding and infant health. Second, we move beyond regression adjustment to understand how intending and non-intending mothers differ in their health knowledge. Prior research focuses on demographic characteristics as potential confounders and therefore identifies population groups that are less likely to breastfeed, but this strategy does not uncover the mechanisms that account for better health among breastfed babies compared to formula-fed babies. This prior research therefore does little to improve our understanding of how to enhance infant health via program or policy interventions, apart from encouraging breastfeeding among these groups. If intending and non-intending mothers differ in terms of access to information and health knowledge, this may suggest a different course of action than simply promoting breastfeeding in targeted populations to improve health in infancy and throughout the life course.

## 2. Background

### 2.1. Breastfeeding and infant health

There is mounting evidence to support a positive causal relationship between early nutrition and improved individual outcomes throughout the life course (Almond et al., forthcoming; Currie & Rossin-Slater, 2015). The most rapid period of physical growth and neural development is between birth and age 3, making early nutrition an especially important foundation for current and later health (Case & Paxson, 2010). Therefore, an important issue for mothers, doctors, and policymakers is to understand the nutritional value of breastmilk relative to the most likely alternative: infant formula.

Randomized controlled trials, the gold standard for establishing causal relationships, are difficult to implement in breastfeeding studies due to logistical and ethical concerns. Nevertheless, there is one oft-cited randomized controlled trial of a breastfeeding intervention in Belarus that provides some evidence of a causal link between exclusive and prolonged breastfeeding and children's health (Kramer, Chalmers, Hodnett, Sevkovskaya, Dzikovich & Shapiro, 2001). Using a sample of about 17,000 mothers in Belarus from 1996–1997, this study found that breastfeeding reduced the risk of gastrointestinal infections and eczema in the first year of life, but was unrelated to the risk of respiratory infections (Kramer, 2010; Kramer et al., 2001). This study implicitly accounted for prenatal breastfeeding intentions by limiting the sample to mothers who intended to breastfeed, but could not explicitly examine the confounding role of positive selection into breastfeeding. Furthermore, these findings may not be generalizable to an American context. For example, Belarus's drinking water, a crucial ingredient for infant formula, is historically of poor quality (The World Bank, 2013). These conditions may not be generalizable to the United States.

A comprehensive meta-analysis of observational studies in developed countries found evidence that breastfeeding is associated with several health benefits for infants and children, including reduced risk of ear infections (acute otitis media), eczema (atopic dermatitis), severe lower-respiratory tract diseases, diarrhea (non-specific gastroenteritis),

and Sudden Infant Death Syndrome (Ip et al., 2007). The meta-analysis found weak or inconclusive evidence on the link between breastfeeding and asthma, obesity, cardiovascular disease, diabetes, childhood leukemia, infant mortality, and cognitive development. The study also noted that existing research often yields mixed or inconclusive evidence, in part due to the inconsistent quality of the studies, sample selection criteria, and varying ability to adjust for potentially confounding factors (Ip et al., 2007).

A central challenge for observational studies of breastfeeding is addressing selection bias, which is the nonrandom sorting of women who breastfeed or formula feed. Breastfeeding mothers are more likely to be well-educated, white, married, and have higher income than non-breastfeeding mothers (Centers for Disease Control and Prevention, 2013; Forste and Hoffmann, 2008; Jones, Power, Queenan & Schulkin, 2015; Wen, Kong, Eiden, Sharma & Xie, 2014). It is possible that these sociodemographic advantages are related to both successful breastfeeding and better infant health outcomes. Indeed, several studies have found that when these demographic and socioeconomic characteristics are taken into account, the long-term benefits of breastfeeding are weak or insignificant (Cesur, Sabia, Kelly & Yang, 2017; Colen & Ramey, 2014; Der et al., 2006; Evenhouse & Reilly, 2005; Grube, Von Der Lippe, Schlaud & Brettschneider, 2015; Jenkins & Foster, 2013; Jiang, Foster, & Gibson-Davis, 2011; Kramer, 2010; for exceptions see Belfield & Kelly 2012; Rees and Sabia 2015; Wehby 2014). In other words, the nonrandom selection of mothers who successfully breastfeed confounds estimates of infant health outcomes.

Sibling fixed effects studies, which compare a breastfed sibling to a formula-fed sibling, may help to address some concerns about the confounding variables attributable to maternal selection bias. In this quasi-experimental design, the assumption is that many of the time-invariant characteristics of the family, such as genetic endowments or parental quality, are held constant while only the breastfeeding treatment varies. Several studies employing this strategy found that among breast and formula-feeding discordant sibling pairs, outcomes were similar for children regardless of whether they were breast or formula fed. This suggests that most physical health benefits associated with breastfeeding are likely attributable to demographic characteristics such as race and socioeconomic status, and other difficult to measure unobservable characteristics (Cesur et al., 2017; Colen & Ramey, 2014; Evenhouse & Reilly, 2005). While studies that employ sibling fixed-effects have several advantages, they are limited to families with siblings who were fed differently, and cannot evaluate families with only one child or siblings who were fed the same way. In addition to generalizability concerns, these models also assume that the feeding method is randomly assigned and not associated with other factors such as infant or maternal health, or some other omitted time-varying characteristics (Rees & Sabia, 2009), and this assumption may be difficult to justify.

While breastfeeding provides excellent nutrition for infants, mixed research evidence shows the tradeoffs between breastmilk and formula are not well understood. The “breast is best” message has been so deeply internalized that failure to meet breastfeeding recommendations makes many mothers feel inadequate (Shah, 2013), placing them at increased risk for maternal depression (Borra, Iacovou, & Sevilla, 2015). Exclusive breastfeeding for 6 months requires a significant investment from mothers and may be difficult to achieve, particularly for mothers who work outside the home, face physiological challenges, or have little social support. It is important to contextualize breastfeeding research in light of the realistic trade-offs that many mothers face (Colen & Ramey, 2014).

### 2.2. Breastfeeding intentions as a proxy for positive maternal selection

Many mothers make breastfeeding plans when they are pregnant (Lawson & Tulloch, 1995). Prenatal breastfeeding intentions (hereafter “intentions”) are an antecedent to breastfeeding behavior that may provide insight into relevant maternal characteristics. The theory of

planned behavior posits that intentions (i.e., “planned behavior”) arise from a combination of motivation, attitudes, subjective norms, and perceived control (Ajzen, 2002; Manstead, Proffitt, & Smart, 1983; Wambach, 1997). Similarly, breastfeeding self-efficacy theory posits that a mother’s perceived ability to breastfeed, which is informed by past breastfeeding experience, observations of other women breastfeeding, encouragement from friends and family, and physiological responses such as fatigue or stress, is related to breastfeeding intentions (Blyth, Creedy, Dennis, Moyle, Pratt & De Vries, 2002). Intentions are, in turn, predictive of actual behavior.

These theoretical frameworks are useful for understanding the link between prenatal breastfeeding intentions, behavior, and infant health. It is possible that intentions may be related to infant health regardless of the mother’s actual breastfeeding behavior, given evidence that they act as a proxy for other positive maternal characteristics, such as knowledge, attitudes, self-efficacy, and social norms about infant feeding practices (Blyth et al., 2002; Manstead et al., 1983; Wambach, 1997). In addition, studies analyzing samples of low-income and disadvantaged women found that those with higher education, breastfeeding experience, breastfeeding knowledge, self-efficacy, and perceived social support were more likely to intend to breastfeed (Humphreys et al., 1998; Mitra et al., 2004; Persad & Mensinger, 2007). Intentions might also reflect a commitment to children’s overall health. Women who intend to breastfeed may engage in other healthy behaviors related to sleep, nutrition, exercise, and medical care. For example, women may also improve their own health practices, such as improving their diet and exercise, in anticipation of breastfeeding.

Although prenatal intentions are strongly associated with breastfeeding behavior, they are not deterministic (Persad & Mensinger, 2007). Approximately one-third of mothers who intend to exclusively breastfeed are able to achieve this goal (Perrine, Scanlon, Li, Odom & Grummer-Strawn, 2012). There are several exogenous factors that may prevent mothers from fulfilling their intentions. For example, biological barriers include low milk supply, pain, infections (mastitis), or clogged milk ducts (Li, Fein, Chen & Grummer-Strawn, 2008; Thulier & Mercer, 2009). The baby may have a poor latch, be an ineffective nurser, or have food intolerances. Institutional factors, such as hospital policies that do not promote early breastfeeding, or encourage supplemental formula or pacifiers, can also impede breastfeeding goals (Perrine et al., 2012). Some factors may act as both an influence on a mother’s intentions as well as her ability to realize those intentions. For example, maternal employment, lack of social support, limited knowledge, or limited access to professional support such as lactation consultants may first undermine intentions and then breastfeeding success (Chezem, Friesen, & Boettcher, 2003; McInnes & Chambers, 2008; Persad & Mensinger, 2007).

In sum, prenatal breastfeeding intentions may be an important factor in examining the relationship between breastfeeding and infant health as they help us to overcome a key identification challenge in measuring the effect of breastfeeding on infant health: that the same characteristics that lead a mother to breastfeed may also lead to an infant having improved health. While prior research has rigorously examined the role of breastfeeding on infant and child outcomes using various identification strategies, none have accounted for prenatal breastfeeding intentions. Given mixed research evidence and the importance of promoting infant health, we believe a parsimonious strategy, whereby a proxy for maternal selection is included in the models – thereby accounting for or reducing the confounding effects, will be informative.

### 3. Material and methods

#### 3.1. Data and sample

We draw on data from the Infant Feeding Practices Study (IFPS) II, which was designed by the Centers for Disease Control and Prevention

(CDC) and the Food and Drug Administration (FDA) to examine infant feeding practices, maternal dietary selections, and health outcomes. The IFPS II mailed surveys to women during their third trimester of pregnancy in 2005 (referred to as the prenatal module), and surveyed women nearly monthly throughout the infant’s first year. The sampling frame was a nationally distributed consumer opinion panel. Respondents were adult, healthy expectant mothers, who gave birth to a healthy full or near-full term infant (Fein, Labiner-Wolfe, Shealy, Li, Chen & Grummer-Strawn, 2008). The baseline sample included 4902 pregnant women. Our final analytic sample includes 1008 respondents. Respondents were excluded due to attrition (primarily occurring between the prenatal and first postnatal interview) and, to a lesser extent, item non-response. Table A1 compares the analytic and baseline samples, and provides detail about attrition. While the initial sample was not nationally representative, our sample of breastfeeding mothers (described below) is similar – though perhaps still slightly more advantaged – to the nationally representative sample described in the Pediatric Nutrition Handbook (6<sup>th</sup> edition), which is produced by the American Academy of Pediatrics.<sup>1</sup> Our analytic sample of exclusively breastfed infants is also consistent with the exclusively breastfed infant sample in the CDC’s National Immunization Survey from 2009, which was a nationally representative sample when appropriately weighted. All samples show that exclusively breastfed infants are advantaged on socio-economic indicators, though direct comparisons are difficult because of survey-to-survey covariate differences. More convincing to us is that our first models that quantify the association between breastfeeding and infant health are consistent with findings in extant literature, which we take as evidence that our findings are not idiosyncratic to our sample.

#### 3.2. Measures

When the mother was approximately 7 months pregnant – and therefore before the birth of the infant or onset of breast or formula feeding – she was asked, “What method do you plan to use to feed your new baby in the first few weeks?” The response options included: Breastfeed only, Formula feed only, Both breast and formula feed, or Don’t know yet. The variable “intended to breastfeed” is coded 1 if she answered “breastfeed only” and 0 otherwise.<sup>2,3</sup>

Breastfeeding behavior is captured from mothers’ *postnatal* (after the infant’s birth) responses. “Exclusively Breastfed at 2 months” was coded 1 if the infant consumed only breastmilk at two months of age, and 0 otherwise. This is our preferred measure of breastfeeding behavior, but we also created “Supplemented breastfeeding”, which was coded 1 if a mother breastfed her infant at all at the second month and 0 otherwise. Before the 2<sup>nd</sup> month, many mothers switched from supplemented to exclusive breastfeeding, which motivates our decision to examine feeding at 2 months (Fig. 1). We also notice that the proportion of breastfeeding mothers at months 2, 3, and 4 is relatively stable, but declines in the following months. Breastfeeding at 2 months is our preferred measure of breastfeeding because this seems to be a critical timeframe for new mothers to make their feeding decisions. Moreover, according to the National Immunization Survey conducted by the CDC,

<sup>1</sup> The sample referenced by the Pediatric Nutrition Handbook comes from a study that examined a nationally representative sample of mothers published by Ryan, Wenjun & Acosta, (2002).

<sup>2</sup> We also constructed “intended to breastfeed any”, which was equal to 1 if a mother indicated she intended to “breastfeed only” or “both breast and formula feed.” Our results are robust to the choice of intentions measure.

<sup>3</sup> We note that a non-intending mother may state that she intends to breastfeed due to social desirability bias. This kind of measurement error is not problematic in our study, as intentions are simply a proxy for positive maternal selection. If a mother knows that breastfeeding is desirable, then she likely knows about other healthy behaviors, which is the essence of what we hope to capture with the intentions variable. Furthermore, in the event a mother declares a breastfeeding intention but does not have enhanced knowledge of healthy behaviors, this would attenuate the intentions variable in our regressions.

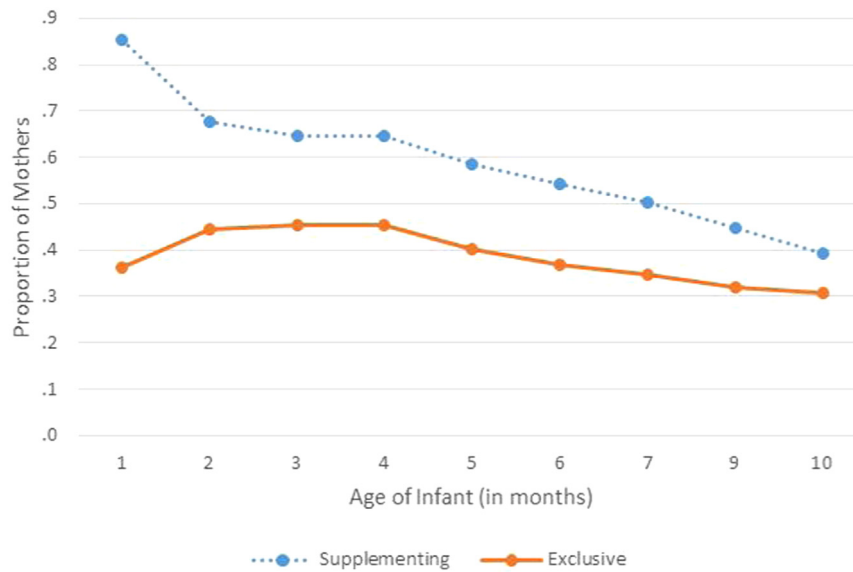


Fig. 1. Proportion of women exclusively breastfeeding (Analytic Sample).

**Table 1**  
Cross-Tabs of mothers who breastfeed and mothers who intend to breastfeed when Infant is 2 months old (Analytic Sample).

|                                      | Mother does not breastfeed | Mother does breastfeed | Total        |
|--------------------------------------|----------------------------|------------------------|--------------|
| Mother does not intend to breastfeed | 357                        | 0                      | 357          |
| Mother does intend to breastfeed     | 242                        | 409                    | 651          |
| <b>Total</b>                         | <b>599</b>                 | <b>409</b>             | <b>1,008</b> |

most infants in the United States are exclusively breastfed for only 1–2 months before mothers stop breastfeeding or initiate supplementing (Centers for Disease Control and Prevention, 2017). Therefore, we chose to measure the effect of breastfeeding duration (2 months) that is the most commonly experienced by American infants.

However, in order to evaluate policy alternatives and consider the benefits of extended breastfeeding, we also measured the effect of the AAP’s recommendation to exclusively breastfeed for 6 months; we constructed variables with categories for “breastfed exclusively at 6 months,” “supplemented at or before 6 months,” “never breastfed but intended to do so,” and “never intended and did not breastfeed.”

To examine the overlap between prenatal intentions and behavior, we created a variable with categories for women who intended to exclusively breastfeed and did, women who intended to breastfeed but did not, and women who did not intend to and did not breastfeed. Table 1 shows that in our sample, approximately 60% of women who intended to breastfeed were exclusively breastfeeding at the infant’s 2 month milestone.<sup>4</sup>

We focus on three infant health outcomes: ear infections, respiratory syncytial viruses (RSV), and antibiotic usage in the infant’s first year.<sup>5</sup> As the IFPS II survey relies on mother-reported health information, we examine outcomes that likely involved a medical practitioner’s diagnosis to minimize reporting bias. At near monthly interviews, mothers

<sup>4</sup> We did not examine the women who did not intend to breastfeed but did exclusively breastfeed their infant at 2 months.

<sup>5</sup> Breastmilk’s SIgA antibodies may protect against infections, which would reduce antibiotic use (Hanson & Korotkova, 2002; Slade & Schwartz, 1987). Also, colostrum, which is present in the first hours and days after birth, is thought to be rich in antibodies and is often referred to as “liquid gold”.

were asked if her infant experienced the aforementioned health outcomes in the past 2 weeks. The mother’s reports were summed across the infant’s first year; therefore, outcomes range from 0 (never reported health event) to 10 (always reported health event).

The short interval between surveys and confined time period of the question (within the last two weeks) likely minimizes response error and provides a more accurate measure of infant health than is available in surveys administered with larger time intervals. While these measures capture a rather complete history, some events may be under-reported.<sup>6</sup> Measurement error in the outcome variables should not be correlated with breastfeeding or intentions, and - if present - would simply enlarge our standard errors.

Expectant mothers were asked if they had heard about problems in food related to listeria, mercury, and dioxins. We created variables indicating whether mothers had heard of each contaminant (1 = yes, 0 = no). We also constructed “heard of any contaminants,” which is coded 1 if the mother had heard of any of the contaminants and 0 otherwise. Next, we constructed “number of contaminants heard of” by summing those with positive responses (range: 0–3).

We also examined the dietary information sources mothers consulted. Expectant mothers were asked, “Have you obtained information about your diet or about feeding babies from any of the following sources for this pregnancy or a previous one? For information about feeding babies, please think of breastfeeding, formula feeding, feeding solid foods, or any other infant feeding information.” Mothers could provide a “yes” or “no” response to many information sources for her prenatal diet and/or infant nutrition, respectively. We collapsed the response options into categories for medical professionals, WIC representative, relative or family member, print source (e.g., book or magazine), or government website. We created “any sources,” which is equal to 1 if a mother consulted any sources and 0 if she consulted none. “Number of sources” is equal to the number of positive responses (range 0–6). All measures were created separately for maternal diet and infant feeding.

We control for a host of prenatal demographic characteristics, all of which were captured in the prenatal module, i.e. before the birth of the

<sup>6</sup> Also note that our outcomes undercount the annual prevalence of these outcomes. Respondents are only asked to reflect on a two week period, and surveys were not conducted each month. Likewise, marginal effects generated by our models (presented in the tables), which estimate the change in the number of health events, will also represent an undercount.



**Table 2**  
Descriptive statistics, by intentions and exclusive breastfeeding at 2 months.

|   | Total sample      | Intend & do breastfeed | Intend & don't breastfeed | Don't intend to breastfeed |
|---|-------------------|------------------------|---------------------------|----------------------------|
| Number of ear infections                      | 0.467<br>(0.846)  | 0.396<br>(0.837)       | 0.426<br>(0.802)          | 0.577<br>(0.876)           |
| Number of respiratory syncytial viruses (RSV) | 0.067<br>(0.27)   | 0.042<br>(0.2)         | 0.066<br>(0.265)          | 0.098<br>(0.333)           |
| Number of antibiotics                         | 0.749<br>(1.155)  | 0.653<br>(1.166)       | 0.622<br>(0.957)          | 0.948<br>(1.238)           |
| Age   | 30.501<br>(5.21)  | 30.399<br>(4.642)      | 30.401<br>(5.621)         | 30.686<br>(5.537)          |
| Married                                       | 0.861             | 0.914                  | 0.826                     | 0.824                      |
| Not married, other adult in home              | 0.055             | 0.032                  | 0.066                     | 0.073                      |
| Not married, no other adults in home          | 0.084             | 0.054                  | 0.107                     | 0.104                      |
| Less than high school                         | 0.019             | 0.012                  | 0.017                     | 0.028                      |
| High school                                   | 0.145             | 0.103                  | 0.132                     | 0.202                      |
| Some college                                  | 0.335             | 0.291                  | 0.372                     | 0.361                      |
| College plus                                  | 0.501             | 0.594                  | 0.479                     | 0.409                      |
| White, Non-Hispanic                           | 0.891             | 0.914                  | 0.876                     | 0.874                      |
| African American, Non-Hispanic                | 0.026             | 0.02                   | 0.021                     | 0.036                      |
| Other, Non-Hispanic                           | 0.038             | 0.037                  | 0.05                      | 0.031                      |
| Hispanic                                      | 0.046             | 0.029                  | 0.054                     | 0.059                      |
| Non-Family provides care                      | 0.345             | 0.335                  | 0.372                     | 0.339                      |
| Family member provides care                   | 0.214             | 0.161                  | 0.252                     | 0.249                      |
| Mother provides care                          | 0.44              | 0.504                  | 0.376                     | 0.412                      |
| Number of smokers in home                     | 0.124<br>(0.425)  | 0.051<br>(0.242)       | 0.12<br>(0.415)           | 0.21<br>(0.559)            |
| Mom Pre-Pregnancy BMI                         | 26.561<br>(6.538) | 25.412<br>(5.711)      | 27.229<br>(6.825)         | 27.426<br>(7.03)           |
| Prenatal began by week 4                      | 0.107             | 0.088                  | 0.095                     | 0.137                      |
| Prenatal began weeks 5–8                      | 0.535             | 0.516                  | 0.529                     | 0.56                       |
| Prenatal began weeks 9–12                     | 0.264             | 0.301                  | 0.273                     | 0.216                      |
| Prenatal began weeks 13–15                    | 0.048             | 0.046                  | 0.045                     | 0.05                       |
| Prenatal began weeks 16–20                    | 0.047             | 0.049                  | 0.058                     | 0.036                      |
| Number of children in home                    | 1.13<br>(1.06)    | 1.186<br>(1.04)        | 0.992<br>(1.05)           | 1.16<br>(1.07)             |
| Household income                              | 55,340<br>(33578) | 54,499<br>(33210)      | 59,768<br>(34248)         | 53,302<br>(33362)          |
| WIC recipient                                 | 0.223             | 0.193                  | 0.219                     | 0.261                      |
| North   | 0.206             | 0.186                  | 0.182                     | 0.246                      |
| South   | 0.284             | 0.257                  | 0.318                     | 0.291                      |
| Midwest                                       | 0.325             | 0.315                  | 0.314                     | 0.345                      |
| Pacific West                                  | 0.185             | 0.242                  | 0.186                     | 0.118                      |
| Sample size                                   | 1008              | 409                    | 242                       | 357                        |

child or any breastfeeding has occurred: mother's age, marital status and household composition (married, not married and not living with another adult, or not married but living with another adult<sup>7</sup>), education (less than high school, high school, some college, or college graduate), race/ethnicity (white, non-Hispanic; black, non-Hispanic; other, non-Hispanic; or Hispanic), and the number of children in the home<sup>8</sup>. Annual household income was measured with the midpoint value of 26 categories that ranged from less than \$5,000 to over \$300,000. We also adjust for the type of intended child care (the mother herself, a relative, or non-family care), the number of smokers in the home, and the mother's pre-pregnancy Body Mass Index (BMI). Initiation of prenatal care is captured with variables that indicate whether she began by week 4, in weeks 5–8, in weeks 9–12, in weeks 13–15, or in weeks 16–20 of her pregnancy. Finally, we control for the mother's enrollment in the Special Supplemental Nutrition Program for Women, Infants, and Children (WIC), and region of the country (North, South, Midwest, and West).

Table 2 shows descriptive statistics. Mothers were approximately 30 years of age and relatively advantaged: 86% were married, over 80% obtained some college education, 90% were white, non-Hispanic, and

the annual average household income was \$55,000. We disaggregate the descriptive statistics into 3 groups by breastfeeding intentions and behavior at two months. Consistent with the literature, breastfeeding mothers were more advantaged relative to non-breastfeeding mothers. Notably, mothers who simply intend to breastfeed are also more advantaged than mothers who do not share this intention, which further justifies intentions as a potential proxy for positive maternal selection into breastfeeding.

### 3.3. Analytic strategy

Our study will first seek to replicate the conventional finding in the literature that breastfeeding reduces adverse infant health outcomes. We will then see if this effect persists after accounting for a rich set of prenatal maternal characteristics, many of which are used in other studies that seek to address selection on observables. Our main objective is to directly examine the confounding role of positive maternal selection, as proxied by prenatal intentions, in the association between breastfeeding and infant health. If prenatal intentions account for the protective relationship between breastfeeding and infant health, this provides new evidence that the benefits of breastfeeding are overstated. We do not interpret that intentions alone have a causal role in producing infant health, but rather, the bundle of maternal characteristics

<sup>7</sup> We cannot identify the relationship between the mother and the other household adult (e.g., romantic, familial, etc.).

<sup>8</sup> The specific relationship (e.g., own children, relatives, etc.) is unknown.

that are captured with prenatal breastfeeding intentions would be linked to infant health. Then, we examine how mothers who intend to breastfeed differ from mothers who do not intend to breastfeed, in terms of their knowledge of nutritional practices and access to information.

We hypothesize that the omission of maternal selection likely confounds estimates of breastfeeding on infant health. Therefore, we simply incorporate the prenatal breastfeeding intention measure, which is a proxy for maternal advantage, into regression models estimating the association between breastfeeding and infant health. Due to the count nature of the outcome variables we use negative binomial regression models to examine the effect of early breastfeeding and prenatal intentions on infant health<sup>9</sup>.

We illustrate the importance of including breastfeeding intentions by first estimating a naïve model. In Eq. (1), which represents Model 1,  $Y_i$  represents the health outcome for respondent  $i$ 's infant. "Breastfed Exclusively<sub>2m</sub>" indicates whether the mother breastfed exclusively at two months.

$$Y_i = \alpha_0 + \alpha_1(\text{Breastfed Exclusively}_{2m})_i + \varepsilon_i \tag{1}$$

Model 2 adds the described prenatal demographic and health controls that were collected in the 7<sup>th</sup> month of pregnancy.

$$Y_i = \alpha_0 + \alpha_1(\text{Breastfed Exclusively}_{2m})_i + \Gamma(\text{Demographic Characteristics}_{\text{Prenatal}})_i + \varepsilon_i \tag{2}$$

Model 3 adds breastfeeding intentions, our proxy for maternal advantage.

$$Y_i = \alpha_0 + \alpha_1(\text{Breastfed Exclusively}_{2m})_i + \beta_2(\text{Breastfeeding Intentions}_{\text{Prenatal}})_i + \Gamma(\text{Demographic Characteristics}_{\text{Prenatal}})_i + \varepsilon_i \tag{3}$$

Next, in Model 4 we group women by their breastfeeding behavior and intentions to highlight the effect of prenatal intentions and to promote a clear analysis of the role of maternal selection as proxied by intentions in infant health (Eq. (4)):

$$Y_i = \lambda_0 + \lambda_1(\text{Intended, Breastfed}_{2m})_i + \lambda_2(\text{Intended, Not Breastfed}_{2m})_i + \Gamma(\text{Demographic Characteristics}_{\text{Prenatal}})_i + \varepsilon_i \tag{4}$$

In Eq. (4), the coefficients  $\lambda_1$  and  $\lambda_2$  represent the average difference in the infant health relative to mothers who did not intend to breastfeed and did not breastfeed. We also perform T-tests to evaluate the null hypothesis that  $\lambda_1$  and  $\lambda_2$  are equal.

Supplemental analyses evaluate whether exclusive or supplemented breastfeeding at 6 months is linked with infant health. In the 6 month models, we expand our analytic strategy to incorporate exclusive breastfeeding, supplemented breastfeeding, and exclusive formula feeding. We run the same sequential analysis outlined in Eqs. (1)–(4), but expand our breastfeeding behaviors to acknowledge that infants may be both breast and formula fed and to understand if the relationship between maternal advantage and infant outcomes is weakened if breastmilk is persistently consumed by the infant.

Finally, we examine whether information asymmetries exist between intending and non-intending mothers. Models 5 and 6 (Eq. (5)) show the statistical relationship between a mother's prenatal breastfeeding intentions and her knowledge of dietary contaminants or the sources of nutritional information she consulted while pregnant. The prenatal demographic controls are unchanged from the previous analyses. We used a linear probability model for binary outcomes, and a negative binomial regression model for count variables.

<sup>9</sup> Results are robust to Poisson and OLS regression models. Poisson models show evidence of overdispersion. Results available upon request.

**Table 3**  
Exclusive breastfeeding at 2 months on infant health coefficient, (Standard Error), [Marginal Effect].

|  | Ear infections                   | Respiratory syncytial viruses    | Antibiotics                      |
|--|----------------------------------|----------------------------------|----------------------------------|
| <b>Model 1: Bivariate Model.</b>   |                                  |                                  |                                  |
| Breastfed at 2 Months  | -0.273**<br>(0.115)<br>[-0.128]  | -0.567**<br>(0.268)<br>[-0.038]  | -0.235**<br>(0.100)<br>[-0.180]  |
| <b>Model 2: Demographics and Maternal Health Controls.</b>                                       |                                  |                                  |                                  |
| Breastfed at 2 Months  | -0.265**<br>(0.116)<br>[0-.123]  | -0.506+<br>(0.278)<br>[-0.034]   | -0.255**<br>(0.101)<br>[-0.187]  |
| <b>Model 3: Adds "Intended to Breastfeed" as Regressor.</b>                                      |                                  |                                  |                                  |
| Breastfed at 2 Months  | -0.143<br>(0.130)<br>[-0.068]    | -0.268<br>(0.314)<br>[-0.018]    | -0.102<br>(0.112)<br>[-0.074]    |
| Intended to Breastfeed   | -0.264**<br>(0.127)<br>[-0.123]  | -0.503+<br>(0.289)<br>[-0.034]   | -0.340***<br>(0.111)<br>[-0.250] |
| <b>Model 4: Mothers Categorized by Intent and Breastfeeding. Non-Intenders Omitted Category.</b> |                                  |                                  |                                  |
| Intended to and breastfed through 2 months   | -0.351***<br>(0.130)<br>[-0.165] | -0.838***<br>(0.314)<br>[-0.056] | -0.376***<br>(0.112)<br>[-0.276] |
| Intended to but did not breastfeed through 2 months  | -0.293**<br>(0.144)<br>[-0.136]  | -0.365<br>(0.311)<br>[-0.024]    | -0.399***<br>(0.126)<br>[-0.293] |
| P Value from T-test  | 0.6988                           | 0.1891                           | 0.8591                           |
| Sample size  | 1,008                            | 1,008                            | 977                              |
| Average dependent variable   | 0.467                            | 0.067                            | 0.749                            |

Coefficients provide the average percent difference in the outcome between the indicator variable and omitted group. The marginal effect provides the average difference in the number of reported outcome events between the indicator variable and omitted group. For example, in the first set of results, a coefficient of -0.273 implies that exclusively breastfed infants experienced 27.3% fewer ear infections compared to non-exclusively breastfed babies, while the marginal effect implies breastfed infants experienced -0.128 fewer ear infections compared to non-exclusively within our sampled timeframe.

Models 2–4 contain controls for mother's marital or household arrangement, educational attainment, race, age, household income, WIC status, number of children in the home, the number of people in the home who smoke, intended childcare arrangement, pre-pregnancy BMI, gestational age at which mother started prenatal care, and regional dummies. Variables are described in text + p < 0.10, \* p < 0.05, \*\* p < 0.01, \*\*\* p < 0.001

$$\text{Knowledge}_i = \beta_0 + \beta_1(\text{Breastfeeding Intentions}_{\text{Prenatal}})_i + \Gamma_1(\text{Demographic Characteristics}_{\text{Prenatal}})_i + \varepsilon_i \tag{5}$$

## 4. Results

### 4.1. Main results

In the tables and the discussion that follows, we present both the coefficients, which represent the percent change in the health outcome between the indicator category and the reference group, as well as the marginal effects, which represent the change in the number of incidents. Recall that the marginal effects are likely an undercount of the actual change in health outcomes, and therefore represent a particularly conservative estimate. Table 3 presents results from models estimating the associations between breastfeeding and infant health outcomes. Model 1 (bivariate model) suggests that exclusively breastfed

infants had 27% fewer ear infections (on average 0.128 fewer ear infections), over 56% fewer episodes of RSV (0.038 fewer episodes), and 23% fewer incidents where antibiotics were prescribed (0.18 fewer antibiotic prescriptions) compared to formula-fed infants. Model 2 adds the previously described demographic and health covariates to the regression. Even with a full array of controls, the breastfeeding coefficients are largely unchanged from Model 1. These results are consistent with prior research linking breastfeeding with improved infant health (American Academy of Pediatrics, 2012; Ip et al., 2007).

To examine positive maternal selection, we account for prenatal intentions in Model 3. While the coefficients for exclusive breastfeeding remain negative, they shrink by approximately half and become statistically insignificant. The intentions coefficient is comparable to the magnitude of the breastfeeding coefficient from Models 1 and 2: it is negatively associated with all health outcomes and statistically significant. This suggests that breastfeeding intentions are an important consideration in estimating the relationship between breastfeeding and infant health. This set of results also strongly suggests that there is something important about the “type” of mother who intends to breastfeed rather than actual breastfeeding that stimulates infant health, and this latent variable was not fully accounted for by the demographic characteristics employed in Model 2. Maternal breastfeeding intentions are a unique measure that is independently associated with infant health, even after controlling for breastfeeding behavior and a rich set of sociodemographic characteristics.

Model 4 compares three distinct groups of mothers: mothers who did not intend to breastfeed and did not breastfeed (the omitted group), mothers who intended to breastfeed and did breastfeed exclusively at the 2<sup>nd</sup> month, and mothers who intended to breastfeed but did not breastfeed exclusively at the 2<sup>nd</sup> month. An infant born to a mother who intended and did breastfeed had approximately 35% (or 0.165) fewer ear infections than infants born to mothers who had no intention of breastfeeding, but an infant born to a mother who intended and did *not* breastfeed had approximately 29% (or 0.136) fewer ear infections compared to the same omitted group. There is no statistically significant difference in ear infections between intending mothers who did and did not breastfeed.

Next, we examine the RSV outcome. Compared to infants whose mothers did not breastfeed and did not intend to do so, infants with mothers who intend and do breastfeed are 83% less likely to have an episode of RSV in their first year of life (a marginal effect of 0.056 fewer episodes). The coefficient for infants born to mothers who intended but did not breastfeed is not significant but suggests a qualitatively large difference (36% less likely to have an RSV diagnosis, which is 0.024 fewer diagnoses). This substantial percent difference (83% vs 36%) is likely due to RSV being a rare outcome; only 7% of mothers in our sample reported RSV.

Finally, we focus on antibiotic usage, and our analysis suggests that prenatal intentions are negatively linked to incidents of antibiotic use. The infants whose mothers intended and did breastfeed had 38% fewer incidents where antibiotics were used, compared to infants of non-intending mothers, while infants whose mothers intended but did not breastfeed had 40% (or 0.293) fewer incidents where antibiotics were used compared to infants of non-intending mothers. Both coefficients are statistically different from the omitted group, but the difference between breastfeeding and formula-feeding mothers who intended to breastfeed is insignificant.

#### 4.2. Robustness and specification checks

The AAP and WHO recommend exclusive breastfeeding for 6 months, so we also examined how this longer-term exclusive or supplemented breastfeeding is related to infant health. The results are very similar (Table C1). Infants who were exclusively breastfed for 6 months had significantly fewer ear infections, RSV episodes, and incidents of antibiotic usage even when accounting for a robust set of demographic

controls. Yet again, after adjusting for intentions, the breastfeeding coefficients shrink and become statistically insignificant. We also limit the sample of mothers who intended to breastfeed but did not to those who reported a physiological barrier to breastfeeding (pain, inadequate milk supply, etc.). This examines a subset of mothers who intended to breastfeed but did not breastfeed due to factors that are plausibly exogenous. The results (found in Table D1) are consistent with the main results. Finally, our main results do not include a measure for maternal employment. The prenatal module questions regarding employment suffered from high item-nonresponse and including this variable results in an additional sample reduction of 13%. Nevertheless, Appendix E includes a variable for the mother’s prenatal employment, and the results are robust to its inclusion. We do not include the mother’s post-natal employment as this could be influenced by infant health (for example, if the infant is sick a mother may choose not to work) and is therefore not an appropriate regressor (Angrist & Pischke, 2009). We also note that maternal employment is likely highly collinear with other controls in the model: maternal education, family income, and the mother’s intended childcare arrangement (herself, a family member, or institutional care), which mitigates concerns about omitted variable bias from the omission of maternal employment in the main results.

#### 4.3. Intentions and knowledge gaps

The previous analyses demonstrate that prenatal intentions have a strong and independent link with infant health regardless of the duration or exclusivity of breastfeeding. However, simply intending to engage in healthy behaviors should not alone result in better health outcomes. Our hypothesis is that our measure of breastfeeding intentions is capturing one or more crucial and previously omitted variables that are difficult to obtain in most types of survey data. Therefore, we examined one of the underlying mechanisms potentially driving the association between breastfeeding and infant health: knowledge about nutrition and diet. In probing the differences between mothers who intended versus did not intend to breastfeed, we see that there are significant knowledge gaps (Table 4). Intending mothers were 9.6

**Table 4**  
Expectant mother’s knowledge of contaminants (N = 1008).

|                            | Listeria                         | Mercury                          | Dioxins & Polychlorinated biphenyls (PCBs) | Heard of any?                    | Total number                     |
|----------------------------|----------------------------------|----------------------------------|--|----------------------------------|----------------------------------|
| Intended to breastfeed     | 0.096 <sup>***</sup><br>(0.0330) | 0.115 <sup>***</sup><br>(0.0228) | 0.062 <sup>**</sup><br>(0.0293)            | 0.010 <sup>***</sup><br>(0.0279) | 0.189 <sup>***</sup><br>(0.0474) |
| Percent difference         | 21.1%                            | 14.6%                            | 21.7%                                      | 12.4%                            | 18.9%                            |
| Average dependent variable | 0.456                            | 0.788                            | 0.287                                      | 0.805                            | 1.518                            |

Mothers who did not intend to breastfeed are the omitted category. Models contain controls for mother’s marital or household arrangement, educational attainment, race, age, household income, WIC status, number of children in the home, the number of people in the home who smoke, intended childcare arrangement, pre-pregnancy BMI, gestational age at which mother started prenatal care, and regional dummies. Variables are described in text. Coefficients in columns 1–4 provide the average percentage point difference in the likelihood an intending to breastfeed mother has heard of a particular contaminant, relative to a non-intending to breastfeed mother, all else equal. For example, intending to breastfeed mothers were 9.6 percentage points (or 21.1%) more likely to report knowing that listeria was a contaminant. The coefficient in column 5 provides the average percent difference in the outcome between the indicator variable and omitted group. For example, on average intending to breastfeed mothers had heard of 18.9% (or 1.52) more contaminants relative to non-intending to breastfeed mothers, all else equal. + p < 0.10, \* p < 0.05, \*\* p < 0.01, \*\*\* p < 0.001

**Table 5**  
Expectant mothers' sources of information (N = 1008).

|                                 | Medical professional             | WIC representative              | Relative                         | Print source                     | Government website | Any sources consulted           | Number                           |
|---------------------------------|----------------------------------|---------------------------------|----------------------------------|----------------------------------|--------------------|---------------------------------|----------------------------------|
| <b>Regarding Mother's Diet</b>  |                                  |                                 |                                  |                                  |                    |                                 |                                  |
| Intended to breastfeed          | 0.0410<br>(0.0337)               | -0.032 <sup>+</sup><br>(0.0190) | 0.073 <sup>**</sup><br>(0.0324)  | 0.101 <sup>***</sup><br>(0.0310) | 0.006<br>(0.0111)  | 0.048 <sup>**</sup><br>(0.0206) | 0.206 <sup>***</sup><br>(0.0761) |
| Percent difference              | 5.0%                             | -14.3%                          | 15.3%                            | 31.0%                            | 23.7%              | 5.3%                            | 20.6%                            |
| Average dependent variable      | 0.823                            | 0.224                           | 0.476                            | 0.326                            | 0.025              | 0.914                           | 1.863                            |
| <b>Regarding Baby's Feeding</b> |                                  |                                 |                                  |                                  |                    |                                 |                                  |
| Intended to breastfeed          | 0.0544 <sup>**</sup><br>(0.0268) | 0.036 <sup>**</sup><br>(0.0170) | 0.097 <sup>***</sup><br>(0.0335) | 0.130 <sup>***</sup><br>(0.0300) | 0.008<br>(0.0114)  | 0.045 <sup>+</sup><br>(0.0249)  | 0.328 <sup>***</sup><br>(0.0671) |
| Percent difference              | 9.4%                             | 14.9%                           | 14.9%                            | 37.4%                            | 30.4%              | 5.3%                            | 32.8%                            |
| Average dependent variable      | 0.579                            | 0.238                           | 0.649                            | 0.348                            | 0.024              | 0.850                           | 1.819                            |

Mothers who did not intend to breastfeed are the omitted category. Models contain controls for mother's marital or household arrangement, educational attainment, race, age, household income, WIC status, number of children in the home, the number of people in the home who smoke, intended childcare arrangement, pre-pregnancy BMI, gestational age at which mother started prenatal care, and regional dummies. Variables are described in text

Coefficients in columns 1–6 provide the average percentage point difference in the likelihood an intending to breastfeed mother consulted a particular knowledge source, relative to a non-intending to breastfeed mother, all else equal. For example, intending to breastfeed mothers were 7.3 percentage points (or 15.3%) more likely to report consulting a relative about their own diet.

The coefficient in column 7 provides the average percent difference in the outcome between the indicator variable and omitted group. For example, on average intending to breastfeed mothers consulted 20.6% (or 1.86) more knowledge sources (as measured in our data) relative to non-intending to breastfeed mothers, all else equal.

+  $p < 0.10$ , \*  $p < 0.05$ , \*\*  $p < 0.01$ , \*\*\*  $p < 0.001$

percentage points (21%) more likely to have heard of listeria, 11.5 percentage points (14.6%) more likely to have heard of mercury, and 6.2 percentage points (21.7%) more likely to have heard of dioxins. Moreover, intending mothers were also nearly 10 percentage points (12%) more likely to have heard of any of these contaminants, and they had heard of 18% more contaminants on average (on average, mothers had heard of 1.52 contaminants).

We next analyze where expectant mothers obtained information about their prenatal diet and their baby's diet. Table 5 suggests that intending mothers have more points of information regarding both their own diet and their baby's feeding. The top panel of Table 5 relates to the mother's information sources for her own diet. Intending mothers are 7.3 percentage points (15.3%) more likely to obtain information from a relative and 10 percentage points (31%) more likely to obtain information from a print source. Furthermore, they are 4.8 percentage points (5.3%) more likely to have consulted any of the sources asked about in the survey, and they had consulted 20.6% more sources of information on average (on average, mothers had consulted 1.86 sources).

Similarly, when seeking information about their baby's feeding, intending mothers were 5.4 percentage points (9.4%) more likely to have consulted a medical professional's advice, 3.6 percentage points (14.9%) more likely to have obtained information from a WIC representative, 9.7 percentage points (14.9%) more likely to have received advice from a relative, and 13 percentage points (37.4%) more likely to have obtained information from a print source. We also note that intending mothers obtained information from an average of 32.8% more sources than non-intending mothers.

These results are likely a conservative estimate of the informational disparities between intending and non-intending mothers. For example, it is likely that a mother who sought advice from a medical professional may have had several conversations with her provider throughout her pregnancy, but the binary nature of the variable essentially "top codes" at 1. Each interaction may have yielded increased knowledge and confidence about dietary practices. Notably, mothers who did not obtain information from a particular source entered their third trimester of pregnancy without ever doing so.

Finally, it is important to state that these coefficients represent descriptive differences in the average outcomes between intending and non-intending mothers. As all of the measures were collected in the prenatal module, we cannot establish a temporal ordering of events.

Therefore, we do not know if the mother sought out information from a particular source and that increased her desire to breastfeed, if she intended to breastfeed and therefore sought out information to help with that process, or if there are other variables that influence both of these processes. We therefore rely on a descriptive interpretation which simply states that on average there are differences between intending and non-intending mothers, and in many cases the difference is statistically significant.

## 5. Discussion and conclusion

The slogan "breast is best" has been popularized by public health campaigns and is deeply internalized by medical professionals, policy-makers, and parents. However, the benefits of breastfeeding may be partially or wholly attributed to the type of mother who intends to breastfeed. To shed light on if and how estimates are confounded by previously omitted positive maternal selection, we evaluated the role of prenatal breastfeeding intentions in the link between breastfeeding and infant health. We examined a heretofore overlooked group of mothers—those who intended to breastfeed but did not.

Our study yielded two central findings. We were able to replicate findings from prior research that linked breastfeeding with positive infant health outcomes (Ip et al., 2007), and this finding persisted even when controlling for a rich set of observable characteristics. However, the inclusion of the prenatal intentions variable fully accounted for this initial association. Mothers who intended to breastfeed but did not actually breastfeed had infants with statistically equivalent ear infections, RSV episodes, and incidents of antibiotic usage in the first year of life compared to infants who were breastfed. It is particularly striking that prenatal intentions were strongly linked with infant health irrespective of whether the infant was actually breastfed. This indicates that the omission of this variable from models quantifying the "effect" of breastfeeding on infant health outcomes make breastfeeding appear overly protective, and further suggests the importance of accounting for maternal advantage in future research. This finding is consistent with a growing body of literature suggesting that the benefits of breastfeeding are overstated due to positive maternal selection bias (Colen & Ramey, 2014; Der et al., 2006; Evenhouse & Reilly, 2005).

We stress that the attendant policy prescription is not to promote breastfeeding intentions. Rather, it is to understand how intending and non-intending mothers differ. We therefore evaluated the link between



breastfeeding intentions and self-reported prenatal and infant dietary knowledge, which yielded our second key finding: women who intended to breastfeed had greater knowledge about prenatal nutritional recommendations, and accessed more sources of information about prenatal and infant nutrition compared to their non-intending counterparts. This suggests that limited knowledge is one potential mechanism that accounts for the increased likelihood of adverse health outcomes among infants whose mothers did not intend to breastfeed and those whose mothers did. Logical next steps include understanding whether other information gaps exist and creating systems to address the needs of non-intending mothers and their infants.

Our study is not without limitations. Respondents in the IFPS II and our analytic sample are more advantaged than the baseline sample (see Table A1), and more likely to breastfeed than the national average, which is an important consideration when interpreting results. In some respects, this study re-examines the effect of breastfeeding on the infants of relatively advantaged children, and once a mother’s prenatal intentions are controlled for, the purported benefits of breastfeeding diminish for this group. Our study implicitly assumes that breastfeeding has a similar effect across all populations, but differential effects are possible. For instance, breastfeeding may be more or less protective among relatively disadvantaged populations with fewer economic resources, but the relative homogeneity of our sample does not allow us to explore this question. This represents an avenue for future research.

We also note that if a mother intends to breastfeed, she may engage in a host of healthy behaviors during her pregnancy – including those that could ward off infections and help her child during fetal development. She may also seek out more supportive environments, or simply engage more with healthcare providers. Mothers who intend to breastfeed but are unable to actualize those intentions may further engage in compensating behaviors to overcome any perceived or real disadvantages of not breastfeeding. For example, if a mother with a high level of knowledge about healthy behaviors is unable to breastfeed, she may compensate in other ways, such as using specialized formula or homemade baby food, to bolster her infant’s health. We do not know the extent to which either of these (or other) scenarios occurs

among the mothers in our sample, and though these endogenous measures would not be appropriate controls in our models, these potential health pathways are important considerations for future research. If compensating behaviors do exist and are the mechanism by which infants of intending, non-breastfeeding mothers have infants with similar health outcomes to breastfed babies, it would be important to raise awareness of these substitutes among the health community and among mothers who do not wish to or are unable to breastfeed.

We provide a preliminary- though important- examination regarding the informational differences that might explain the link between intentions and infant health. If intending mothers have access to more and higher quality health information, then it is no surprise that their children have fewer adverse health events. It further demonstrates that the relationship between breastfeeding and infant health may be explained by other factors. A more in-depth analysis of the mechanisms that link intentions with health outcomes deserves future consideration.

Taken together, our findings help to contextualize the finding that “breast is best,” and add nuance to a body of literature on the benefits of breastfeeding for infant health. Although we do not dispute that breastmilk is an excellent source of nutrition, our results suggest that formula offers similar health benefits for our relatively advantaged sample of infants, once we take prenatal intentions into account. Policymakers and health professionals wishing to promote infant health should consider remedying maternal – and likely other environmental – disadvantage.

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**Appendix A**

see Appendix Table A1.

**Table A1**  
Missing data analysis.

|                                       | Full prenatal module | Only in prenatal module (Dropped) | 12 Month wave (Analytic Sample) | Difference between 12 month & prenatal |
|---------------------------------------|----------------------|-----------------------------------|---------------------------------|--|
| Exclusively Breastfeeding at 2 months | –                    |                                   | 0.457                           | –                                      |
| Intention to Breastfeed               | 0.596                | 0.580                             | 0.645                           | 0.065***                               |
| Age                                   | 28.693<br>(5.552)    | 28.094<br>(5.532)                 | 30.501<br>(5.210)               | 2.407**                                |
| Married                               | 0.760                | 0.726                             | 0.861                           | 0.135***                               |
| Not Married, Other Adult in Home      | 0.064                | 0.067                             | 0.055                           | – 0.013                                |
| Not Married, No Other Adults in Home  | 0.176                | 0.207                             | 0.084                           | – 0.122***                             |
| Less than High School                 | 0.047                | 0.056                             | 0.019                           | – 0.037**                              |
| High School                           | 0.197                | 0.215                             | 0.145                           | – 0.070***                             |
| Some College                          | 0.410                | 0.434                             | 0.335                           | – 0.099***                             |
| College Plus                          | 0.346                | 0.294                             | 0.501                           | 0.207***                               |
| White, Non-Hispanic                   | 0.828                | 0.807                             | 0.891                           | 0.008**                                |
| African American, Non-Hispanic        | 0.054                | 0.064                             | 0.026                           | – 0.038***                             |
| Other, Non-Hispanic                   | 0.049                | 0.053                             | 0.038                           | – 0.016*                               |
| Hispanic                              | 0.068                | 0.076                             | 0.046                           | – 0.030***                             |
| Non-Family Provides Care              | 0.344                | 0.343                             | 0.345                           | 0.002                                  |
| Family Member Provides Care           | 0.266                | 0.283                             | 0.214                           | – 0.069***                             |
| Mother Provides Care                  | 0.390                | 0.374                             | 0.440                           | 0.067***                               |
| Number of Smokers in Home             | 0.212<br>(0.574)     | 0.241<br>(0.613)                  | 0.124<br>(0.425)                | – 0.117***                             |

(continued on next page)

Table A1 (continued)

|                                     | Full prenatal module   | Only in prenatal module (Dropped) | 12 Month wave (Analytic Sample) | Difference between 12 month & prenatal |
|-------------------------------------|------------------------|-----------------------------------|---------------------------------|--|
| Mom Pre-Pregnancy BMI               | 26.593<br>(6.847)      | 26.604<br>(6.947)                 | 26.561<br>(6.538)               | - 0.042                                |
| Prenatal began by week 4            | 0.125                  | 0.130                             | 0.107                           | - 0.023 <sup>+</sup>                   |
| Prenatal began by week 8            | 0.528                  | 0.526                             | 0.535                           | 0.009                                  |
| Prenatal began by week 12           | 0.240                  | 0.232                             | 0.264                           | 0.032 <sup>†</sup>                     |
| Prenatal began by week 15           | 0.052                  | 0.054                             | 0.048                           | - 0.006                                |
| Prenatal began by week 20           | 0.055                  | 0.058                             | 0.047                           | - 0.012                                |
| Number of Children in Home          | 1.188<br>(1.124)       | 1.208<br>(1.146)                  | 1.130<br>(1.056)                | - 0.078 <sup>+</sup>                   |
| Household Income                    | \$50,169<br>(\$35,432) | \$48,456<br>(\$35,865)            | \$55,340<br>(\$33,578)          | \$6,883 <sup>***</sup>                 |
| WIC Recipient                       | 0.327                  | 0.361                             | 0.223                           | - 0.138 <sup>***</sup>                 |
| North                               | 0.167                  | 0.153                             | 0.206                           | 0.053 <sup>***</sup>                   |
| South                               | 0.342                  | 0.361                             | 0.284                           | - 0.077 <sup>***</sup>                 |
| Midwest                             | 0.291                  | 0.280                             | 0.325                           | 0.046 <sup>†</sup>                     |
| Pacific                             | 0.200                  | 0.206                             | 0.185                           | - 0.021                                |
| Number remaining in analytic sample | 4051                   | 3043                              | 1008                            |  |

\* p < 0.05.  
 \*\* p < 0.01.  
 \*\*\* p < 0.001.  
 † p < 0.10.

Appendix B

see Appendix Table B1.

Table B1  
 Exclusive and/ or Supplemented Breastfeeding at 2 Months on Infant Health Coefficient, (Standard Error), [Marginal Effect].

|  | Ear infections                                 | Respiratory Syncytial viruses                 | Antibiotics                                    |
|--|--|---|--|
| <b>Model 1: Bivariate Model.</b>   |  |   |  |
| Breastfed Any at 2 Months  | - 0.340 <sup>***</sup><br>(0.118)<br>[- 0.158] | - 0.506 <sup>**</sup><br>(0.256)<br>[- 0.034] | - 0.323 <sup>***</sup><br>(0.104)<br>[- 0.242] |
| <b>Model 2: Demographics and Maternal Health Controls.</b>                                       |  |   |  |
| Breastfed Any at 2 Months  | - 0.297 <sup>**</sup><br>(0.121)<br>[- 0.139]  | - 0.393<br>(0.277)<br>[- 0.026]               | - 0.306 <sup>***</sup><br>(0.106)<br>[- 0.23]  |
| <b>Model 3: Adds "Intended to Breastfeed" as Regressor.</b>                                      |  |   |  |
| Breastfed Any at 2 Months  | - 0.161<br>(0.141)<br>[- 0.075]                | - 0.0778<br>(0.318)<br>[- 0.006]              | - 0.130<br>(0.123)<br>[- 0.097]                |
| Intended to Breastfeed   | - 0.248 <sup>+</sup><br>(0.133)<br>[- 0.116]   | - 0.586 <sup>**</sup><br>(0.296)<br>[- 0.039] | - 0.322 <sup>***</sup><br>(0.116)<br>[- 0.241] |
| <b>Model 4: Mothers Categorized by Intent and Breastfeeding. Non-Intenders Omitted Category.</b> |  |   |  |
| Intended to and breastfed any through 2 months   | - 0.326 <sup>***</sup><br>(0.119)<br>[- 0.152] | - 0.668 <sup>**</sup><br>(0.274)<br>[- 0.045] | - 0.373 <sup>***</sup><br>(0.103)<br>[- 0.279] |
| Intended to but did not any breastfeed through 2 months  | - 0.331<br>(0.213)<br>[- 0.155]                | - 0.415<br>(0.459)<br>[- 0.028]               | - 0.457 <sup>**</sup><br>(0.189)<br>[- 0.342]  |
| P Value from T-test  | 0.9846   | 0.5957  | 0.6565   |
| Sample size  | 1008   | 1008  | 977  |

(continued on next page)

**Table B1** (continued)

|                            | Ear infections | Respiratory Syncytial viruses | Antibiotics |
|----------------------------|----------------|-------------------------------|-------------|
| Average dependent variable | 0.467          | 0.067                         | 0.749       |

\* p < 0.05,

Coefficients provide the average percent difference in the outcome between the indicator variable and omitted group. The marginal effect provides the average difference in the number of reported outcome events between the indicator variable and omitted group. For example, in the first set of results, a coefficient of -0.340 implies that exclusively breastfed infants experienced 34% fewer ear infections compared to those who were not exclusively breastfed, while the marginal effect implies breastfed infants experienced 0.158 fewer ear infections compared to those who were not exclusively breastfed within our sampled timeframe.

Models 2–4 contain controls for mother’s marital or household arrangement, educational attainment, race, age, household income, WIC status, number of children in the home, the number of people in the home who smoke, intended childcare arrangement, pre-pregnancy BMI, gestational age at which mother started prenatal care, and regional dummies. Variables are described in text

\*\* p < 0.01.

\*\*\* p < 0.001.

+ p < 0.10.

**Appendix C**

see Appendix [Table C1](#).

**Table C1**

Exclusive and supplemented breastfeeding at 6 months on infant health coefficient, (Standard Error), [Marginal Effect].

|  | Ear infections                   | Respiratory Syncytial viruses   | Antibiotics                      |
|--|----------------------------------|---------------------------------|----------------------------------|
| <b>Model 1: Bivariate Model.</b>                                 |                                  |                                 |                                  |
| Breastfed Exclusively at 6 Months                                | -0.404**<br>(0.169)<br>[-0.189]  | -0.533<br>(0.370)<br>[-0.036]   | -0.452***<br>(0.151)<br>[-0.339] |
| Breastfed Any Before 6 Months                                    | -0.312+<br>(0.161)<br>[-0.146]   | -0.321<br>(0.343)<br>[-0.021]   | -0.312**<br>(0.144)<br>[-0.234]  |
| <b>Model 2: Demographics and Maternal Health Controls.</b>       |                                  |                                 |                                  |
| Breastfed Exclusively at 6 Months                                | -0.339**<br>(0.169)<br>[-0.158]  | -0.420<br>(0.389)<br>[-0.028]   | -0.436***<br>(0.150)<br>[-0.327] |
| Breastfed Any Before 6 Months                                    | -0.251<br>(0.157)<br>[-0.117]    | -0.170<br>(0.345)<br>[-0.011]   | -0.308**<br>(0.141)<br>[-0.231]  |
| <b>Model 3: Adds “Intended to Breastfeed” as Regressor.</b>      |                                  |                                 |                                  |
| Breastfed Exclusively at 6 Months                                | -0.081<br>(0.208)<br>[-0.038]    | 0.133<br>(0.455)<br>[0.009]     | -0.152<br>(0.182)<br>[-0.114]    |
| Breastfed Any Before 6 Months                                    | -0.0837<br>(0.175)<br>[-0.039]   | 0.165<br>(0.368)<br>[0.011]     | -0.124<br>(0.155)<br>[-0.124]    |
| Intended to Breastfeed   | -0.297**<br>(0.141)<br>[-0.139]  | -0.669**<br>(0.302)<br>[-0.045] | -0.330***<br>(0.120)<br>[-0.247] |
| <b>Model 4: Mothers Categorized by Intent and Breastfeeding.</b> |                                  |                                 |                                  |
| Intended to and breastfed exclusively through 6 months (1)       | -0.518***<br>(0.171)<br>[-0.242] | -0.496<br>(0.309)<br>[-0.033]   | -0.396***<br>(0.116)<br>[-0.297] |

(continued on next page)

**Table C1** (continued)

|   | Ear infections                     | Respiratory<br>Syncytial viruses | Antibiotics                        |
|---|------------------------------------|----------------------------------|------------------------------------|
| Intended to and breastfed<br>some through 6 months<br>(2)         | − 0.446**<br>(0.183)<br>[− 0.208]  | − 0.798<br>(0.495)<br>[− 0.053]  | − 0.350**<br>(0.152)<br>[− 0.262]  |
| Intended to but did not<br>breastfeed any through<br>6 months (3) | − 0.518***<br>(0.171)<br>[− 0.242] | − 0.231<br>(0.353)<br>[− 0.015]  | − 0.526***<br>(0.149)<br>[− 0.394] |
| P Value from T-test (1 = 3)                                       | 0.3821                             | 0.4876                           | 0.3999                             |
| P Value from T-test (3 = 2)                                       | 0.7399                             | 0.3008                           | 0.3339                             |
| P Value from T-test (2 = 3)                                       | 0.6473                             | 0.5493                           | 0.7574                             |
| Sample size   | 1008                               | 1008                             | 977                                |
| Average dependent variable  | 0.467                              | 0.067                            | 0.749                              |

\* p < 0.05,

Coefficients provide the average percent difference in the outcome between the omitted group and indicator variable groups. The marginal effect provides the average difference in the number of reported outcome events between the omitted group and indicator variable groups. For example, in the first set of results, a coefficient of − 0.404 implies that exclusively breastfed infants experienced 40.4% fewer ear infections compared to those who were never breastfed, while the marginal effect implies exclusively breastfed infants experienced 0.189 fewer ear infections compared to never breastfed infants within our sampled timeframe. The coefficient of − 0.312 implies that infants who received any breastmilk in their first 6 months of life experienced 31.2% fewer ear infections compared to those who were never breastfed, while the marginal effect implies infants receiving any breastmilk experienced 0.146 fewer ear infections compared to those who were never breastfed within our sampled timeframe.

Models 2–4 contain controls for mother’s marital or household arrangement, educational attainment, race, age, household income, WIC status, number of children in the home, the number of people in the home who smoke, intended childcare arrangement, pre-pregnancy BMI, gestational age at which mother started prenatal care, and regional dummies. Variables are described in text

\*\* p < 0.01.

\*\*\* p < 0.001.

+ p < 0.10.

**Appendix D. Dropping mothers without a physiological barrier to breastfeeding**

see Appendix [Table D1](#).

Mothers may not realize their prenatal breastfeeding intentions for a host of reasons – some of which are likely exogenous to infant health while others are endogenous. Therefore, we employ a robustness check to limit the sample of mothers who “intended to breastfeed but did not” to those who reported a physiological barrier to breastfeeding.

We use data from the Month 1 and Month 2 survey waves to determine which mothers experienced a physiological barrier to breastfeeding. At the infant’s first month of life (Month 1 Wave), mothers were asked, “Did you have any of the following problems breastfeeding your baby during your first 2 weeks of breastfeeding?” If a mother responded “yes” to the following reasons, we coded her as having a physiological barrier:

- My baby had trouble sucking or latching on
- My baby choked
- My baby wouldn’t wake up to nurse regularly enough
- My baby was not interested in nursing
- My baby got distracted
- It took too long for my milk to come in
- I had trouble getting the milk flow to start
- My baby didn’t gain enough weight or lost too much weight
- I didn’t have enough milk
- My nipples were sore, cracked, or bleeding
- I had a yeast infection of the breast
- I had a clogged milk duct
- My breasts were infected or abscessed

At the infant’s second month of life (Month 2 Wave), mothers were asked, “How important was each of the following reasons for your decision to stop breastfeeding your baby?”: (1) Not at all important, (2) Not very important, (3) Somewhat important, or (4) Very important. If a mother responded somewhat important or very important to the following reasons, we coded her as having a physiological barrier:

*Barriers that are repeated from Month 1 Wave:*

- My baby had trouble sucking or latching on
- My baby choked
- My baby wouldn’t wake up to nurse regularly enough
- My baby was not interested in nursing



**Table D1**  
Exclusive breastfeeding at 2 months on infant health, dropping mothers without physiological barrier.

|   | Ear infections      | Respiratory syncytial viruses | Antibiotics |
|---|---------------------|-------------------------------|-------------|
| <b>Model 4: Drops Mothers Who Did Not Report a Biological Barrier</b> |                     |                               |             |
| Intended to and breastfed through 2 months                            | -0.354**            | -0.859**                      | -0.375**    |
|   | -0.13               | -0.317                        | -0.112      |
| Intended to but did not breastfeed through 2 months                   | -0.244 <sup>+</sup> | -0.431                        | -0.377**    |
|   | -0.141              | -0.307                        | -0.123      |
| P Value from T-test   | 0.4837              | 0.2318                        | 0.9859      |
| Sample size   | 979                 | 979                           | 949         |

Average dependent variable

Coefficients provide the average percent difference in the outcome between the indicator variable and omitted group. The marginal effect provides the average difference in the number of reported outcome events between the indicator variable and omitted group. For example, in the first set of results, a coefficient of -0.318 implies that exclusively breastfed infants whose mothers intended to breastfeed experienced 31.8% fewer ear infections compared to those who were not exclusively breastfed, while the marginal effect implies breastfed infants experienced 0.158 fewer ear infections compared to those who were not exclusively breastfed within our sampled timeframe.

Models contain controls for mother’s marital or household arrangement, educational attainment, race, age, household income, WIC status, number of children in the home, the number of people in the home who smoke, intended childcare arrangement, pre-pregnancy BMI, gestational age at which mother started prenatal care, and regional dummies. Variables are described in text

+ p < 0.10, \* p < 0.05, \*\* p < 0.01, \*\*\* p < 0.001

- My baby got distracted
- It took too long for my milk to come in
- I had trouble getting the milk flow to start
- My baby didn’t gain enough weight or lost too much weight
- I didn’t have enough milk
- My nipples were sore, cracked, or bleeding
- I had a yeast infection of the breast
- I had a clogged milk duct
- My breasts were infected or abscessed

*New barriers in Month 2 Wave*

- My baby became sick and could not breastfeed
- My baby began to bite
- Breast milk alone did not satisfy my baby
- I had trouble getting the milk flow to start
- Breastfeeding was too painful

This robustness check modifies the results presented in Model 4 of the paper. Eq. D1 groups women by their breastfeeding behavior and intentions to highlight the effect of prenatal intentions on health outcomes. However, unlike the paper, the “Intended, Not Breastfed” group only includes mothers who stated that they intended to breastfeed, did not breastfeed, and reported one of the above described physiological barriers in waves 1 or 2. The coefficients  $\lambda_1$  and  $\lambda_2$  represent the average difference in the infant health relative to mothers who did not intend to breastfeed and did not breastfeed. We also perform T-tests to evaluate the null hypothesis that  $\lambda_1$  and  $\lambda_2$  are equal.

$$Y_i = \lambda_0 + \lambda_1(\text{Intended, Breastfed}_{2m})_i + \lambda_2(\text{Intended, Not Breastfed, Barrier})_i + \lambda X_i + \epsilon_i \tag{D1}$$

**Appendix E**

see Appendix [Table E1](#)

**Table E1**  
Exclusive breastfeeding at 2 months on infant health including maternal employment measure coefficient, (Standard Error), [Marginal Effect].

|                                  | Ear infections                 | Respiratory Syncytial viruses  | Antibiotics                    |
|----------------------------------|--------------------------------|--------------------------------|--------------------------------|
| <b>Model 1: Bivariate Model.</b> |                                |                                |                                |
| Breastfed at 2 Months            | -0.282*<br>(0.126)<br>[-0.133] | -0.580*<br>(0.273)<br>[-0.040] | -0.262*<br>(0.191)<br>[-0.193] |

(continued on next page)

Table E1 (continued)

|  | Ear infections                             | Respiratory<br>Syncytial viruses           | Antibiotics                                 |
|--|--|--|---|
| <b>Model 2: Demographics and Maternal Health Controls.</b>                                       |  |  |   |
| Breastfed at 2 Months  | −0.279 <sup>+</sup><br>(0.125)<br>[−0.132] | −0.507 <sup>+</sup><br>(0.280)<br>[−0.035] | −0.283 <sup>+</sup><br>(0.105)<br>[−0.208]  |
| <b>Model 3: Adds "Intended to Breastfeed" as Regressor.</b>                                      |  |  |   |
| Breastfed at 2 Months  | −0.157<br>(0.137)<br>[−0.074]              | −0.292<br>(0.331)<br>[−0.020]              | −0.145<br>(0.106)<br>[−0.107]               |
| Intended to Breastfeed   | −0.264 <sup>+</sup><br>(0.128)<br>[−0.124] | −0.447<br>(0.305)<br>[−0.030]              | −0.313 <sup>**</sup><br>(0.107)<br>[−0.230] |
| <b>Model 4: Mothers Categorized by Intent and Breastfeeding. Non-Intenders Omitted Category.</b> |  |  |   |
| Intended to and breastfed<br>through 2 months  | −0.368 <sup>+</sup><br>(0.136)<br>[−0.174] | −0.833 <sup>+</sup><br>(0.328)<br>[−0.057] | −0.384 <sup>**</sup><br>(0.120)<br>[−0.268] |
| Intended to but <u>did not</u><br>breastfeed through 2<br>months                                 | −0.286 <sup>+</sup><br>(0.149)<br>[−0.135] | −0.265<br>(0.292)<br>[−0.018]              | −0.364 <sup>**</sup><br>(0.129)<br>[−0.268] |
| P Value from T-test  | 0.615                                      | 0.103                                      | 0.880                                       |
| Sample size  | 873  | 873  | 851   |
| Average dependent<br>variable  | 0.472                                      | 0.068                                      | 0.735                                       |

Coefficients provide the average percent difference in the outcome between the indicator variable group and omitted group. The marginal effect provides the average difference in the number of reported outcome events between the indicator variable and omitted group. For example, in the first set of results, a coefficient of −0.282 implies that exclusively breastfed infants experienced 28.2% fewer ear infections compared to those who were not exclusively breastfed, while the marginal effect implies breastfed infants experienced 0.158 fewer ear infections compared to those who were not exclusively breastfed within our sampled timeframe

Models 2–4 contain controls for mother's marital or household arrangement, educational attainment, race, age, household income, WIC status, number of children in the home, the number of people in the home who smoke, intended childcare arrangement, pre-pregnancy BMI, gestational age at which mother started prenatal care, and regional dummies. Variables are described in text

+ p < 0.10, \* p < 0.05, \*\* p < 0.01, \*\*\* p < 0.001

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