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THE BENEFITS OF BREASTFEEDING ACROSS THE EARLY YEARS OF CHILDHOOD

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ABSTRACT

The choice to breastfeed rather than formula-feed an infant as well as the duration of doing so has been scrutinized in more recent times. Yet, key identification issues remain to be resolved, including the array of possible child development benefits, the optimal intensity of breastfeeding versus formula-feeding, and the possibility of confounding with other inputs that promote child health. This study uses the Early Childhood Longitudinal Survey – Birth Cohort to explore the causal effect of breastfeeding on development across the early years of childhood. We examine a range of health, physical, and cognitive outcomes and relate these to a set of breastfeeding and formula-feeding intensities. Adjusting for a very extensive set of potential confounding factors that also promote child development, our empirical method uses simultaneous equations models and propensity score measures to understand the link between breastfeeding and child outcomes. Our results indicate that breastfeeding and not formula-feeding at birth are associated with increased probabilities of being in excellent health at 9 months. Furthermore, they are protective against obesity and improve cognitive outcomes at 24 months and 54 months. Breastfeeding for 6 months or more increases motor scores at 9 months.

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1. INTRODUCTION

Exclusive breastfeeding for the first six months of a child's life has been promoted by the World Health Organization, the American Academy of Pediatrics, the U.S. Department of Health and Human Services, and *Healthy People 2010*. The choice to breastfeed rather than formula-feed an infant as well as the duration of doing so has been scrutinized, with more recent studies showing limited benefits regarding the returns to breastfeeding when cognitive performance is the outcome being analyzed (Ip et al. 2007). Yet *Healthy People 2010* had as its goal a prevalence of 75% for breastfeeding and 50% for breastfeeding at six months (USDHHS, 2000).[1]

Nevertheless, empirically identifying the influence of breastfeeding on child development is challenging for several reasons. Breastfeeding may be the natural preference since it contains all the nutrients a child needs and is designed for human infants. As the primary or single source of sustenance in the first months of life, we might anticipate an array of immediate and or longer-term developmental benefits for the child. Yet understanding the potential mechanism through which breastfeeding affects children's outcomes is important. Is it solely due to the nutrients contained in milk and the lack of preservatives?[2] Is it due to the increased bonding a mother experiences with her child? Or is it due to potential problems with formula?[3] If the quality of

[1] While breastfeeding initiation is now at 75%, the prevalence of breastfeeding at six months is 43% and that of exclusive breastfeeding at six months is 13.3%. See the CDC's Breastfeeding Report Card at http://www.cdc.gov/breastfeeding/data/reportcard2.htm.

[2] According to Campbell (1996): "Human milk is rich in secretory IgA, produced partly in response to specific intestinal and respiratory pathogens encountered by the mother. It also contains other immunoglobulins, lysozyme, lactoferrin, bifidus factor, macrophages, lymphocytes, neutrophil granulocytes, cytokines and complement." A recent study also found that a part of human milk cannot be digested but serves to protect the infant's small intestine (Zivkovic et al., 2010).

[3] Formula is closely monitored, with a bill specifically focusing on infant food, the Infant Formula Act of 1980 (amended in 1986), which amended the Federal Food, Drug, and Cosmetic Act to ensure the safety and nutrition of infant formulas (Woolley and Peters 1980). This bill was passed by President Carter in response to reports in 1979 of soybean-based formulas with an insufficient amount of chloride, resulting in over 100 infants becoming seriously ill (Woolley and Peters 1980). More recently, a fatal case of meningitis in Tennessee was linked to contaminated powdered infant formula (Baker 2002). The Infant Formula Act apparently does not have rigid sterility requirements, although it says that "good manufacturing practice" should be followed (Baker 2002).

the formula is at issue, joint policies to both encourage breastfeeding and tighten regulations on infant formula may be proposed to improve child health outcomes. Moreover, breastfeeding is not a monolithic activity of given duration and intensity, and is often undertaken in conjunction with some formula-feeding. Finally, a potential identification issue that arises in this type of study is that of statistical endogeneity. Unobservable family inputs to child health (such as the mother's education) or circumstances related to the birth of the child (such as prematurity) may be associated with breastfeeding. Such endogeneity may show an effect of breastfeeding on child outcomes in linear probability models when there is no causal effect.

This study attempts to address these issues using the Early Childhood Longitudinal Survey – Birth Cohort. We use several measures of breastfeeding in our analysis: (1) breastfed ever, (2) duration of breastfeeding, (3) breastfed in the week prior to survey, and (4) formula-fed at birth. Specifically, our comprehensive analysis examines a range of developmental outcomes measured at multiple points in time, including health, physical, and cognitive outcomes. With detailed information on the birth circumstance, the family characteristics, and the early development of the child, we are able to take potential confounding factors into account. Our empirical method is based on covariate models, propensity score measures, and instrumental variables models using internally generated instruments to understand the link between breastfeeding and child outcomes. We also exploit the large subsample of twins available in our data to estimate twin fixed effects models.

We believe these estimates are an advance over prior results. Few prior studies simultaneously use longitudinal data where outcomes at multiple points in time are analyzed to gauge duration of effect; explore a range of outcomes relating to health, physical, and cognitive outcomes; and address causality using several econometric methods. In addition, to our

knowledge, this study is the first to assess outcomes pertaining to maternal attachment, motor scores, and physical activity. Our results indicate that breastfeeding and not formula-feeding at birth are associated with increased probabilities of being in excellent health at 9 months. Furthermore, breastfeeding is protective against obesity and improves cognitive outcomes at 24 months and 54 months, but has little effect on respiratory outcomes after 9 months. Breastfeeding for 6 months or more increases motor scores at 9 months. Broadly, these results are not sensitive to model specifications.

2. BACKGROUND LITERATURE

This section focuses on the determinants of breastfeeding and the effect of breastfeeding on child outcomes in developed countries. Our theorized relationships are shown in Figure 1.

2.1 Determinants of Breastfeeding

There are many independent determinants of the decision to breastfeed and, as such, it is necessary to control for many different factors. While difficulty with technique and concern over sufficient food for the child have also been reported as obstacles to breastfeeding, not being able to take time off work is the main reported reason not to breastfeed (Baker and Milligan 2008; Kools et al. 2006; Fein and Roe 1998), causing the marginal cost of breastfeeding to be high if generous maternity leave laws are not in place. Baker and Milligan (2008) use variation in maternity leave mandates across provinces in Canada to show that mother's time away from work is a predictor of breastfeeding duration. Prior to 2000, mothers were allowed a maximum of six months of compensated maternity leave. For those children born after December 21, 2000, compensated maternity leave was extended to one year, generating an exogenous variation across mothers with infants born before and after the policy change.

A higher wage rate implies a higher opportunity cost of time associated with breastfeeding. In light of the higher opportunity cost of breastfeeding for those women with higher incomes, in addition to some evidence that minorities are more likely to breastfeed due to cultural differences (Chapman and Pérez-Escamilla 2009), one might be led to believe that effects of breastfeeding on subsequent cognitive and health outcomes for the child may be downward biased. Interestingly, breastfeeding has been found to be more prevalent among lower SES groups in certain populations (Gibson-Davis and Brooks-Gunn 2006; Victora et al. 2000) and among foreign-born mothers (Gibson-Davis and Brooks-Gunn 2006), even though breastfeeding is more likely among the college educated (Ryan et al. 2002), older mothers, and those not participating in the Women, Infants, and Children (WIC) program (Gibson-Davis and Brooks-Gunn 2006). Very low birth weight (Smith et al. 2003), private insurance (Smith et al. 2003), and delivery via Caesarean section (Pérez-Escamilla et al. 1996) are associated with lower probabilities of breastfeeding. Not being encouraged by a clinician to breastfeed and being depressed are associated with a mother's lower likelihood of breastfeeding (Taveras et al. 2003). Regional differences are observed, with the prevalence of breastfeeding highest in the West and lowest in the South (Ryan et al. 2002). As pointed out in the American Medical Association's *Family Medical Guide*, "[s]ome people prefer the convenience of bottle-feeding because other people can help out with feedings. It also gives the father and older siblings and opportunity to participate in feedings and form their own attachment to the baby" (AMA 2004, p.540).

2.2 Determinants of Child Outcomes

A comprehensive review of scholarly articles on the possible benefits of breastfeeding in developed countries was conducted by the Agency for Healthcare Research and Quality in 2007 (Ip et al. 2007). We draw heavily on this report, which screened over 9000 abstracts and

included 400 studies in their final review. The report concluded that breastfeeding was associated with a reduction in the risk of ear infections, gastroenteritis, lower respiratory tract infections, atopic dermatitis, asthma, obesity, diabetes, childhood leukemia, sudden infant death syndrome (SIDS), and necrotizing enterocolitis.[4] However, little effect was found for cognitive ability as measured by the Peabody individual achievement test (PIAT) administered to 5- to 14-year olds (Der et al. 2006). Moreover, the summary did not provide a comprehensive inventory of possible impacts. Outcomes related to maternal attachment, motor scores, and physical activity were not mentioned in the report, which cautioned that the majority of the articles were based on observational studies, and "one should not infer causality based on these findings."

A summary of the literature on the effects of breastfeeding provided by the American Academy of Pediatrics (1997) reaches similar conclusions. In addition to the aforementioned Baker and Milligan (2008), which primarily focused on determinants of breastfeeding, studies that attempt to address causality from breastfeeding to health outcomes include Kramer et al. (2001), who find effects on gastrointestinal infection and dermatitis using randomly assigned maternity support in Belarus, and Der et al. (2006), who use the 1979 cohort of the National Longitudinal Survey of Youth to analyze sibling pairs and whose study will be discussed in more detail in the next paragraph. Baker and Milligan (2008), relying heavily on variation over time, find little effect of breastfeeding on child health, as measured by health status, nose and ear infections, asthma, allergies, chronic conditions, and injuries. They control for gender, age, province, city size, parents' age and education, immigration status, presence of siblings, and unemployment (to capture labor market changes over time) in their regressions. Mild effects that disappear at older ages are found among 7- to 12-month olds for asthma, allergies, and chronic

[4] A review conducted by the World Health Organization around the same time gave similar results (Horta et al. 2007). This review assessed the effects of breastfeeding on blood pressure, diabetes, cholesterol, obesity, and cognitive outcomes, generally concluding that beneficial effects of breastfeeding could be seen for all outcomes.

conditions. They do note, however, that their main contribution is showing how a mother's increased time at home, through the Canadian maternity leave mandates, affected breastfeeding. Their primary focus is not on the effects of breastfeeding on outcomes. Moreover, their health outcomes analysis is of the mandates and not breastfeeding per se. Research using historical data from Germany (Haines and Kintner 2008) finds that breastfeeding has substantial positive effects on adult stature.

Of these studies, we focus on two that use data from the United States – namely, those of Der et al. (2006) and Rees and Sabia (2009). Using the 1979 cohort of the National Longitudinal Survey of Youth, Der et al. (2006) analyze sibling pairs and conclude that family background explains much of the observed correlation between breastfeeding and cognitive outcomes. They use the *total* PIAT scores, even though the test was administered biennially to respondents between the ages of 5 and 14. It is unsurprising that no effect in general is found using their methods. Their analysis relies on sibling pairs and controlling for maternal intelligence, which has the potential to soak up most variation that can be found, particularly due to the potential endogeneity of mother's IQ itself. The authors also exclude low birth weight and premature babies. That being said, the authors do find significant effects of the duration of breastfeeding on cognitive outcomes, yet dismiss the effects as being too small. However, combined with the benefits of breastfeeding on physical and health outcomes, the overall effects may not be insubstantial.

Rees and Sabia (2009) use a similar method (sibling fixed effects) and find a positive and significant effect of breastfeeding on educational attainment, as measured by high school GPA and college attendance. Using data from the National Longitudinal Survey of Adolescent Health and controlling for measures of cognitive ability and maternal attachment, they also conduct

falsification tests, using outcomes relating to drunkenness, smoking, television watching, and having been in a physical fight. They acknowledge that while comparing siblings accounts for family-level unobservable factors, it reduces sample size and identifying variation, may not be generalizable to all children, and, perhaps most importantly, does not account for "unmeasured within-family heterogeneity resulting from the fact that the decision to breast-feed is not random" (Rees and Sabia 2009).

Our analysis builds on these studies in that we are able to use more recent data, younger children, multiple time points, and various methods to address potential confounding factors. We estimate the relationship between formula-feeding and child outcomes, largely missing in most studies carefully accounting for causality.[5] We analyze a rich set of outcomes at 9, 24 and 54 months, so we are not concerned with disentangling factors that may affect the child at later stages in life.

3. THEORETICAL FRAMEWORK

We apply an economic framework to modeling both the determinants of breastfeeding and its outcomes. While there has been some opposition by economists to the use of utility functions to discuss the economics of the family (such as Samuelson 1976), this may serve as a useful tool originally posed by Becker (1965, 1981) and modified by Pollak (1988), with assumptions that may be relaxed.[6] However, the economic approach that an individual

[5] Although some studies in the health literature analyzing asthma, gastrointestinal infection, lower respiratory tract disease, and cognitive outcomes use exclusive breastfeeding in their models (Ip et al. 2007), these studies largely suffer from methodological issues such as not adjusting for confounding factors, as found, for example, in a meta-analysis of studies analyzing the effects of breastfeeding on asthma (Gdalevich 2001). Der et al. (2006) and Rees and Sabia (2009) do not analyze exclusive breastfeeding. Baker and Milligan (2008) only analyze exclusive breastfeeding as an outcome.

[6] For example, Pollak has "long been a critic of the Stigler-Becker view that preferences are fixed and exogenous" (Pollak 2003). Habit formation and interdependent preferences that change over time are fundamental to his models.

maximizes utility subject to constraints and thus reaches an equilibrium is taken here (Pollak 2003).

Investment in a child's health is presented in the context of a household production function with one parent for simplicity (the mother in the context of breastfeeding),[7] whose child's health (commodity Z_H) enters into the parent's utility function in a paternalistic fashion.[8] A child's health may thus enter directly into parent's utility function but may also increase a future income stream, leading it to be both a consumption and investment good (Grossman 1972).

$$U = U(Z_H, Z_V, U_C(Z_H)) \qquad (1)$$

where Z_H is a child's health, Z_V is a vector of other commodities entering the parent's utility function, and U_C represents the child's utility function. If a child's health is largely a function of breastfeeding, as many studies show, but does not enter directly into the child's utility function, we can rewrite equation (1) as:

$$U = U(B, F, Z_V, U_C) \qquad (2)$$

where B is the length of time breastfeeding and F is the length of time formula-feeding. The above utility function is simplified in that breastfeeding and formula-feeding are not functions of one another, whereas in reality they may be substitutes or complements. If breastfeeding promotes the mother's health, then the assumption of paternalistic preferences is not required, as breastfeeding will enter into the parent's utility function directly through its effects on a parent's

[7] If another parent is present, that parent may work, thus freeing up time for the mother to breastfeed, and additionally contributing to the child's cognitive and physical development.

[8] This allows for the parent's utility function to not only depend on the child's utility function but also the child's consumption. This implies that, for example, a parent may prefer that a child do her homework rather than watching television. If preferences were purely altruistic, the child's consumption would only appear in her utility function and not directly in the parent's, and television watching may be preferred to doing homework.

health; moreover, it may enter into it directly through the pleasure associated with bonding with the child.

Breastfeeding is mainly a time-intensive activity, with few direct monetary costs. Formula-feeding, on the other hand, may be less time-intensive if another individual formula-feeds the baby, although it carries with it monetary costs. If breastfeeding is only a function of the time it takes to breastfeed an infant (t_B), and we assume that all income is earned income, the full income constraint is:[9]

$$Income = wt_W + wt_B + wt_F + wt_{Zv} \qquad (3)$$

$$Income = p_F x_F + p_Z x_Z + wt_B + wt_F + wt_{Zv} \qquad (4)$$

where w is the mother's wage rate (assumed to be constant), t_W represents time spent at work, t_F is time spent formula-feeding, x_F represents inputs into formula-feeding, p_F is the price of the inputs into formula-feeding, x_Z represents inputs into the consumption of other commodities, p_Z is a vector of prices of inputs x_Z, and t_{Zv} represents time spent in producing or enjoying other commodities Z_V. Maximizing utility subject to the full income constraint, we obtain the simple first order condition, which equates the marginal benefit of breastfeeding with its marginal cost, equal to the time cost associated with breastfeeding ($w\frac{\partial t_B}{\partial B}$) multiplied by the marginal utility of full income (λ):

$$\frac{\partial U}{\partial B} = \lambda(w\frac{\partial t_B}{\partial B}) \qquad (5)$$

The RHS represents the opportunity cost of breastfeeding; the higher the wage rate, the greater the opportunity cost. Also, the more time-intensive breastfeeding is, the higher its cost.

A similar first-order condition for formula-feeding is:

$$\frac{\partial U}{\partial F} = \lambda(p_F\frac{\partial x_F}{\partial F} + w\frac{\partial t_F}{\partial F}) \qquad (6)$$

[9] Breastfeeding is likely to be a function of many factors, which we explore in the empirical section.

Here the RHS suggests that the higher the monetary cost of formula-feeding, the higher the marginal cost. Formula-feeding is likely less time-intensive than breastfeeding for the mother, and so $\frac{\partial t_F}{\partial F} < \frac{\partial t_B}{\partial B}$. However, if the marginal benefit of breastfeeding is higher than the marginal benefit of formula-feeding, which we empirically test in this paper, then $\frac{\partial U}{\partial F} < \frac{\partial U}{\partial B}$. We hypothesize that this is the case for most individuals, and therefore the marginal utility subject to the full price of breastfeeding is substantially greater than the marginal utility subject to the full price of formula-feeding.

4. DATA

Our analysis relies on the Birth Cohort of the Early Childhood Longitudinal Survey (ECLS-B). The ECLS-B follows a sample of 14,000 children born in 2001 through until kindergarten. Nationally representative, the study also oversamples for twins, low birth weight children, and racial minority subgroups. Data were collected at four points of the children's early lives, although we restrict our analysis to the first three waves, when the children are 9 months old, 24 months, and 4 years old (preschool age). A series of survey instruments were applied at each wave, along with direct tests and observations of the children. At each wave, the primary care parent (almost all biological mothers) was surveyed with information collected on both the mother and the child. From these respondents we obtain data on the characteristics of the mother and the child at each point in time. The 9-month wave is especially useful: it includes information on the mother's prenatal experiences, as we several questions related to breastfeeding practices and the circumstances of the birth of the child. The surveys to the primary care parent included questions on the health status of the children; these parent-reported measures are used as indicators of children's health development. As well, independent cognitive and motor tests were administered to the children at each wave; and body mass index

(BMI) measures for the child were also collected at the 24 month and preschool waves. At 9-months and 24-months general mental ability was measured using a modified Bayley Short Form to estimate BSID-II scores; for the pre-school wave a range of instruments were used to measure language, literacy, and math skills. Gross and fine motor skills were also measured using the Bayley Short Form. Collectively, this data is used to capture cognitive and physical development. Finally, the ECLS-B includes information from birth certificate records; these records yield further information on complications associated with birth and some maternal data.

The ECLS-B data is high quality and well-suited to the purposes of our analysis. There is detailed information on each family over time; this information includes self-report and independent evidence on the child across multiple time periods. This allows us to investigate an array of possible developmental outcomes for the child. For breastfeeding, there is a series of questions, allowing us to check the validity of parental responses.[10] The survey response rates are high.[11] For the 9-month wave, there are 10,500 usable responses, although this falls to approximately 8,900 by the pre-school wave. These correspond to response rates of 76% and 64%, respectively, from the initial total sample. To ensure our analytical results are nationally representative, we apply survey weights. Finally, there is an oversample of twins, with information collected on each twin; this allows us to compare across twins.

Tables 1a and 1b provide ECLS-B summary statistics for our sample (unweighted). The incidence of ever breastfeeding is 67% (Table 1a), which is comparable to reported estimates of 73% from the 2005 National Immunization Survey of U.S. (Ip et al., 2007) and 72% from Li et al. (2005). Our estimate of breastfeeding for at least six months is 12%, which is also close to

[10] To the biological mother, the questions are: "Did you ever breastfeed child?"; "For how many months did you breast-feed him/her?"; "During the past seven days, was child breast-fed, formula-fed, or fed regular cow's milk?"; "How old was child in months when you began feeding him/her formula?"

[11] The ECLS-B are restricted-use data and all analyses must be reported to the nearest 50.

the 13.3% estimate of (exclusive) breastfeeding at six months reported by Li et al. (2005). Slightly different estimates are expected; as Chapman and Pérez-Escamilla (2009) note, the wording of the questions tends to be inconsistent across surveys.[12] For example, Baker and Milligan (2008) find pre-reform (1994-2000) breastfeeding estimates in Canada of 86% but the question included attempts to breastfeed ("Did you breastfeed or try to breastfeed your baby, even if only for a short time?"). Table 1a also shows the prevalence of breastfeeding within last week, with the sample restricted to mothers whose child were 8 or 9 months old at the time of survey; the rate for this group is 19%.[13] Our fourth indicator is of whether the child was formula-fed at birth: this rate is 44%, which indicates considerable overlap between breast and formula-feeding. In fact, one quarter of those who breastfed also formula-fed from birth. This percentage (44%) is comparable to the prevalence of formula-fed infants (including infants also breastfed) in the United States of approximately 50% in 2001 found by Ziegler et al. (2008). Hence, we utilize all these indicators of breastfeeding in our analysis below.

5. METHODS

5.1 Breastfeeding as an Outcome

Prior to examining the effects of breastfeeding on child outcomes, we explore the determinants of breastfeeding (as classified in four ways). We use data from the 9-month wave of the ECLS, with contemporaneous indicators for maternal (M) characteristics and child (C) characteristics, as well as variables measuring the circumstances of the birth. Specifically, we include dummy variables for whether primary care was by mother, center, relative, or non-relative; region; race/ethnicity; gender of child; health insurance status (at 9 months); obese

[12] For example, the question in the ECLS-B is "Did you ever breastfeed (child)?" The question in the National Immunization Survey, which Li et al. (2005) use, is: "Was (child) ever breastfed or fed breast milk?"
[13] This discrepancy with the frequency for 6+ months reinforces the need for validity checks on the phrasing of survey questions.

mother; religiosity; mother's employment status[14]; mother's education; whether child has a twin; number of siblings; father non-resident; mother's age at birth; and mother's marital status. Related to the circumstances of the birth, we include variables for: low and very low birth weight; if the baby was in the Neonatal Intensive Care Unit (NICU); if the mother smoked while pregnant; if the mother consumed alcohol while pregnant; if the mother wanted the child; if mother was not told that breastfeeding was important; if mother had maternity leave; if mother participated in WIC; and county establishments for health/social assistance.

In addition, we investigated a series of local context variables that may influence breastfeeding rates but may be exogenous to the family's utility function or child's birth circumstances, results of which are shown in Appendix Table 1. These variables were measured as availability per 1,000 persons of services related to religious organizations; individual family assistance; physicians; hospitals; and child day care.[15] We also investigated the relationship between breastfeeding and the price of baby food (used as a proxy for the price of formula) and the local unemployment rate (both measured at the county level),[16] and between breastfeeding and the percent of females in the county who are: employed; with a college degree; married; obese; with health insurance; and in excellent or very good health.[17]

5.2 Child Development Outcomes

Using the standard controls on the RHS, we analyzed the following health, physical, and cognitive outcomes at 9 months: Respiratory problems; gastroenteritis; asthma; excellent health; maternal attachment; motor scores; and cognitive scores. The following outcomes were

[14] Anderson et al. (2003) find that a mother's hours of work affect childhood obesity, which may partially indirectly operate through breastfeeding.
[15] These data come from the 2001 County Business Patterns. See http://www.census.gov/econ/cbp.
[16] Including prenatal care, which did not have much variation as almost all mothers in our sample sought it, did not alter the results.
[17] These data come from the 2001 Behavioral Risk Factor Surveillance System. See http://www.cdc.gov/brfss.

analyzed at 24 months: Respiratory problems; gastroenteritis; asthma; excellent health; maternal attachment; motor scores; underweight; overweight; obese; and cognitive scores. The following outcomes were analyzed at 54 months: Respiratory problems; gastroenteritis; asthma; excellent health; motor and copy form skills scores (based on block tower building); high physical activity; underweight; overweight; obese; reading score; math score; and literature score. These outcome measures come from various sources: the health conditions measures are self-report by the parent of diagnosed incidences; the maternal attachment and some of the cognitive and motor measures are based on independent observers' reports within the home; the later cognitive scores are based on tests administered to the children; and the underweight, overweight and obesity indicators are calculated based on measured BMI.

We use basic ordinary least squares and probit specifications, with controls for covariates, as a base case for the results. However, a potential concern with analyzing the effect of breastfeeding on child outcomes using linear probability models is that unobserved characteristics common to both breastfeeding and child outcomes are not controlled for and, as discussed in Section 2 above, these characteristics are many. We attempt to identify the potential causal effect of breastfeeding on outcomes using a variety of techniques.

5.3 Robustness Checks for Development Outcomes

5.3.1 Instrumental Variables

Excluded instruments in our instrumental variables models pertain to Caesarian birth, mother's behavior regarding smoking and alcohol consumption prior to the child's birth, whether the mother wanted to become pregnant, maternity leave, and county-level establishments related to health care and social assistance. In order to be valid, these instruments must jointly predict breastfeeding in addition to passing the appropriate overidentification tests for exclusion

restrictions. However, there may still be concern that these variables cannot theoretically be excluded from the child health equation, in that they may be correlated with the error term in the second stage. We therefore perform several robustness checks and find our external instruments to be invalid as they are not legitimately excludable from the main equations of interest. Results from these models are therefore not reported.

5.3.2 Lewbel Estimation

Lewbel (2007) presents an IV technique that is useful when valid external instruments are weak or not available. This procedure relies on the presence of heteroscedasticity in the error term of the first-stage equation, which is tested using a Breusch-Pagan (1979) test. The Lewbel IV procedure uses $(X - \bar{X}) * \widehat{u_2}$ as the identifying instruments, where X is a vector of independent variables that may include all independent variables or a subset of them, and $\widehat{u_2}$ is the predicted residual from the first-stage (breastfeeding) regression. Both Sabia (2007) and Kelly and Markowitz (2009) successfully use this procedure and find the Lewbel IV results to be more plausible than the IV results that rely on external instruments of questionable validity.

5.3.3 Twins Estimation

In this context, it has been suggested that "[s]ibling analysis provides a method to control for hereditary and household factors that are important in certain outcomes" (Ip et al. 2007). This method is useful is that unobserved heterogeneity arising from genetic factors and family background are largely controlled for. While this has the potential to underestimate the effect that breastfeeding has on outcomes since all characteristics common to both siblings are completely accounted for, it may be illuminating. This regression is estimated by analyzing a fixed effects model where twin identification is controlled for. This model has the disadvantage of washing away any variables that are similar to both twins. Moreover, if a mother makes a

decision about breastfeeding, she is likely to apply that decision to both babies, and thus identifying variation is limited.

5.3.4 Propensity Score Analysis

Propensity score matching may be used to determine the average effect of the treatment (breastfeeding) on the treated (a dichotomous health outcome variable such as obese status). This can be estimated as:[18]

$$\tau \equiv E\{O_1 - O_0|B = 1\}$$

$$= E\{E\{O_1 - O_0|B = 1, p(W)\}\}$$

$$= E\{E\{O_1|B = 1, p(W)\} - E\{O_0|B = 0, p(W)\}|B = 1\} \quad (5)$$

where the propensity score (*p(W)*) is defined as the probability of being obese given pre-treatment characteristics (*W*). We assume that the effect of unobservable characteristics on the propensity score is the same as that of observable characteristics.

5.3.5 Stratified Samples

Low birth weight infants are likely systematically different from other infants; as seen in Table 2, for example, they are both less likely to be breastfed as well as less likely to be formula-fed at birth, possibly due to their presence in the neonatal intensive care unit (NICU). Additional unobserved attributes may render them different, and thus we stratify the sample by birth weight status to ensure that low birth weight babies are not driving the results one way or another.

Moreover, in order to observe for which groups the benefits of breastfeeding, if any, may be realized, we stratify the sample by poverty status, mother's employment status, and marital status. These results are reported in Appendix Tables 2 and 3.

6. RESULTS

6.1 Determinants of Breastfeeding

[18] See Becker and Ichino (2002) and Rosenbaum and Rubin (1983) for more detail.

We present results for the determinants of breastfeeding in Table 2. The first three columns focus on breastfeeding outcomes, with ever breastfed, breastfeeding duration, and breastfed in the week prior to survey (restricted to 8-9 month olds) as dependent variables of interest. The last column focuses on an alternative specification where formula-fed at birth is the outcome of interest. This last specification captures the factors discouraging mothers from breastfeeding exclusively and includes mothers who exclusively formula-feed their infants, and should generally yield coefficients carrying signs opposite to the specifications shown in columns 1-3.

Some notable results emerge in Table 2. While strongest for "breastfed in last week," the results show a significant, negative effect of care other than parental care on breastfeeding practices. This is interesting in light of a study using the Early Childhood Longitudinal Study, Kindergarten cohort (ECLS-K) suggesting that non-parental child care can adversely influence a child's weight outcomes (Herbst and Tekin, forthcoming), in addition to cognitive and behavioral problems (Herbst and Tekin 2010). In terms of region, those in the West are most likely to breastfeed and less likely to formula-feed at birth. Low birth weight babies (<2500 grams) are less likely to be breastfed but more likely to be formula-fed at birth, while very low birth weight babies (<1500 grams) are also less likely to be formula-fed at birth. This may be due to their initial care in the NICU, either because of alternative feeding practices or more restricted access to the child for the mother. Babies with obese mothers, working mothers, or mothers who smoked during pregnancy are less likely to be breastfed and more likely to be formula-fed at birth. Perhaps due to the widespread availability of literature on the benefits of breastfeeding, and because educated individuals are more aware of health-related information (Hammond 2003), education has a consistent strong and significant effect on breastfeeding, with

those with more education more likely to breastfeed and less likely to formula-feed at birth. A mother who has continued with studies obtaining her college degree is 23.2 percentage points more likely to ever breastfeed and 25.6 percentage points less likely to formula-feed at birth than her counterparts with less than a high school degree. There is some evidence that twins are less likely to be breastfed and more likely to be formula-fed at birth, which is consistent with babies in general that may be born prematurely.[19] The negative effect of WIC on breastfeeding (and positive effect on formula-feeding) is in line with WIC's indirect promotion of formula-feeding through the dissemination of free formula (Kent 2006).

Results from alternative specifications for the determinants of breastfeeding are shown in Appendix Table 1, where the first column is the same as the first column of Table 2. In Column 2 we utilize information from the Birth Certificate record on type of delivery (vaginal versus Caesarean), risk factor at birth, and whether the baby was in the NICU. Of these, vaginal birth emerges are being a strong predictor of breastfeeding, which prior research has found (Pérez-Escamilla et al. 1996). Columns 3 and 4 explore the sensitivity of the coefficients to the inclusion or exclusion of variables on maternal behavior, with few notable differences. In Column 5, information from County Business Patterns on establishments for religious organizations; individual family assistance; physicians; hospitals; and child day care, with religious organizations emerging as a significant *negative* predictor of breastfeeding. While this may seem surprising, this variable on the county level may be correlated with socioeconomic status and geographic characteristics that negatively affect the probability of breastfeeding. (Note that we already control for individual religiosity.) The last column adds county-level information from the Behavioral Risk Factor Surveillance System, a nationally representative

[19] Twins are substantially more likely to be born prematurely, with an estimate of 54% of all twins being born prematurely, according to Gardner et al. (1995).

health survey conducted by the Centers for Disease Control and Prevention. The percent of females in the county with a college degree and the percent of females in the county in excellent or very good health positively affect the probability of breastfeeding, significant at the 5% level.

6.2 Child Development Outcomes from Breastfeeding

Table 3 presents results for the effect of breastfeeding on health (respiratory problems, gastroenteritis, asthma, reported excellent health), physical (maternal attachment, motor scores, physical activity, weight), and cognitive (reading, math, literature) outcomes, as measured at 9 months, 24 months, and 54 months. The inputs for breastfeeding are slightly different from the outcomes in Table 2 with breastfed for 6+ months replacing duration. For outcomes at 9 months, results that are most robust pertain to respiratory problems, excellent health, maternal attachment, and motor scores.[20] For outcomes at 24 months, asthma, weight status, and cognitive scores emerge as being significantly correlated with breastfeeding and formula-feeding, with the expected outcomes. The strongest effects are found for obese as an outcome at 24 months, with being breastfed for 6+ months being associated with a 5.6 percentage-point decrease in the likelihood of being obese, a decrease of about 35% from a mean of 16% (see Table 1b). These protective effects are weaker when analyzing outcomes at 54 months, with cognitive outcomes being the most positively affected by breastfeeding and not formula-feeding at birth. Duration of breastfeeding is marginally associated with increased physical activity at 54 months.

6.3 Robustness Checks on Child Development Outcomes from Breastfeeding

Instrumental variables estimates where internal instruments are generated in the presence of heteroscedasticity are shown in Table 4. Results generally corroborate the findings in Table 3

[20] Body mass index is not measured at 9 months. The equivalent measure used for infants and toddlers is weight-for-recumbent length.

in terms of sign, magnitude, and significance. The most robust results across the various breastfeeding specifications pertain to respiratory problems and excellent health at 9 months, obesity and cognitive outcomes at 24 months, and obesity and cognitive outcomes at 54 months. In particular, children of mothers who have ever breastfed them are 4.7-8.8 percentage points less likely to be obese, and those of mothers who formula-fed them at birth are 2.8-5.4 percentage points more likely to be obese. Children of mothers who have ever breastfed them have improved cognitive outcomes at 24 and 54 months, while those of mothers who formula-fed them at birth appear to have consistently worse cognitive outcomes (although the coefficient is imprecisely measured for math at 54 months).

As expected, twin fixed effects reveal very little in terms of significance and the coefficients are inflated in magnitude, as indicated by the results shown in Table 5. There is mild evidence of positive effects of breastfeeding on reported health (at 9 months) and respiratory problems, asthma, and physical activity, yet these results are not very consistent. Moreover, the assumption that the twins have similar characteristics and are treated similarly is unlikely to hold if one is being breastfed and the other one is not.

Propensity score matching results are presented in Table 6. Results generally remain robust to those in Table 3, often with similar magnitudes, and stronger effects emerging for cognitive outcomes at all ages.

Table 7 reveals results where the sensitivity of the coefficients on breastfeeding from Table 3 (as measured by "ever breastfed") is analyzed. If the coefficients drastically decrease in magnitude with the addition of covariates, then statistical endogeneity is likely problematic in this context. Percentage changes in the coefficients on breastfeeding from the baseline model (which includes controls for child characteristics pertaining to race/ethnicity, gender, twin status,

and number of siblings) are reported. Column 1 includes birth weight status to the baseline model; Column 2 further includes maternal characteristics pertaining to obesity, religion, marital status, father's residency status, and age at birth; Column 3 adds maternal employment and education; and Column 4 includes center based care, region, and health insurance. The lack of consistency in the movement of the coefficients reveals that the coefficients are not systematically decreasing in magnitude with the addition of covariates.

In Appendix Table 2, covariates results for "ever breastfed" (comparable to those shown in Table 3) stratified by birth weight status and poverty status are reported. As expected, results for the "not low birth weight" group are comparable to those shown in Table 3, as low birth weight babies are systematically different. Results by poverty status reveal that the benefits seen at 9 months for maternal attachment and at 24 months for asthma are driven by those below the poverty threshold. In contrast, the beneficial effects of breastfeeding on cognitive outcomes at 24 and 54 months are mainly seen for those above the poverty threshold.

Results stratified by mother's employment status and mother's marital status are shown in Appendix Table 3. These results suggest that the beneficial effects of breastfeeding seen in Table 3 are more precisely measured for mothers who do not work full-time and for married mothers.

7. DISCUSSION

The present study casts some doubt on the limited effects for cognitive performance found by some recent studies analyzing the effects of breastfeeding on various outcomes. While we do not find consistent protective effects of breastfeeding and not formula-feeding on respiratory outcomes post 9 months, our preferred estimates suggest that formula-feeding at birth is positively associated with obesity and negatively associated with cognitive outcomes.

Children of mothers who have ever breastfed them are 4.7-8.8 percentage points less likely to be obese, and those of mothers who formula-fed them at birth are 2.8-5.4 percentage points more likely to be obese. If we were to increase breastfeeding from 67% to 75%, in line with *Healthy People 2010* goals, this implies that obesity among two-year-olds may decrease by 0.38-0.70 percentage points with the initiation of breastfeeding. With the increased likelihood of obesity in adulthood for obese children, and with economic costs of obesity currently estimated at $117 billion per year (USDHHS, 2001), promoting breastfeeding may have the added benefit of decreasing obesity rates in addition to improving cognitive outcomes for children. Preferred estimates further suggest that, at 9 months, motor scores are improved, excellent health is improved, and respiratory problems are reduced through breastfeeding.

Our study is unique in that it explores a rich set of outcomes, addresses potential endogeneity using multiple econometric techniques, analyzes outcomes at multiple time points, and explores effects of breastfeeding on maternal attachment, physical activity, and motor scores. It does, however, suffer from several limitations. The actual amount of milk consumed is not measured, and our duration measure does not capture how intensive the breastfeeding sessions were. Our results are thus only valid on the extensive margin of breastfeeding. As noted, the wording of the questions may be problematic. Moreover, our data come from the U.S., and the generalizability of these results to other countries may be limited.

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Table 1a
Descriptive Frequencies

	Frequency	*N*
Ever breastfed	67%	10,500
Breastfed for 6+ months	12%	10,500
Breast fed in last week [a]	19%	5,350
Formula-fed at birth	44%	10,650
If formula-fed at birth:		
Ever breastfed	38%	4,700
If ever breastfed:		
Formula-fed at birth	25%	7,100

Source: ECLS-B 9-month wave. *Notes:* [a] Sample restricted to respondents when child aged 8-9 months. Unweighted data.

Table 1b
Descriptive Statistics for Outcomes

	9-month		24-month		54-month	
	Mean	**(SD)**	**Mean**	**(SD)**	**Mean**	**(SD)**
Respiratory problem	0.14	(0.35)	0.12	(0.33)	0.12	(0.32)
Gastroenteritis	0.06	(0.24)	0.04	(0.19)	0.03	(0.18)
Asthma	0.06	(0.24)	0.09	(0.28)	0.10	(0.31)
Excellent health	0.53	(0.50)	0.58	(0.49)	0.43	(0.49)
Maternal attachment	0.00	(1.00)	0.00	(1.00)		
Motor scores (standardized)	-0.001	(1.00)	0.002	(1.00)	0.00	(1.00)
High physical activity					0.24	(0.42)
Under weight			0.06	(0.24)	0.04	(0.19)
Overweight or obese			0.31	(0.46)	0.34	(0.47)
Obese			0.16	(0.37)	0.18	(0.38)
Cognitive scores (standardized)	-0.003	(1.00)	0.002	(1.00)	0.00	(1.00)
Reading (standardized)					-0.48	(0.76)
Math (standardized)					-0.47	(0.81)
Literature (standardized)					0.00	(0.92)

Table 2
Determinants of Breastfeeding

VARIABLES	Ever breastfed	Longer duration breastfeeding‡	Breastfed in last week§	Formula-fed at birth
Primary care: center	0.005	0.020	-0.090***	-0.018
	[0.022]	[0.060]	[0.024]	[0.026]
Primary care: relative	-0.044***	-0.091*	-0.101***	0.064***
	[0.017]	[0.047]	[0.019]	[0.020]
Primary care: nonrelative	-0.014	-0.002	-0.065***	0.013
	[0.021]	[0.057]	[0.022]	[0.022]
Region NE	-0.163***	-0.383***	-0.051**	0.146***
	[0.025]	[0.053]	[0.023]	[0.038]
Region MW	-0.124***	-0.332***	-0.032	0.129***
	[0.026]	[0.058]	[0.022]	[0.027]
Region S	-0.163***	-0.394***	-0.095***	0.167***
	[0.026]	[0.056]	[0.019]	[0.023]
Black	-0.065***	-0.136**	-0.030	0.069***
	[0.025]	[0.062]	[0.022]	[0.025]
Hispanic	0.102***	0.181***	0.032	-0.010
	[0.020]	[0.054]	[0.024]	[0.024]
Asian	0.029	0.050	-0.023	0.112***
	[0.023]	[0.067]	[0.030]	[0.030]
Other race (non-white)	0.088***	0.179***	0.062**	0.007
	[0.021]	[0.055]	[0.029]	[0.025]
Female	0.006	0.036	0.021	-0.004
	[0.012]	[0.032]	[0.015]	[0.013]
Birth weight: Low	-0.065***	-0.168***	-0.028	0.064***
	[0.020]	[0.047]	[0.021]	[0.021]
Birth weight: Very Low	-0.055**	-0.111**	-0.095***	-0.117***
	[0.024]	[0.053]	[0.022]	[0.019]
Health Insur.: Private	-0.017	0.063	0.019	-0.022
	[0.032]	[0.078]	[0.045]	[0.039]
Health Insur.: Public	-0.023	0.069	0.022	0.000
	[0.035]	[0.086]	[0.048]	[0.036]
M obese	-0.040***	-0.145***	-0.030**	0.063***
	[0.014]	[0.034]	[0.015]	[0.015]
Religiosity scale: 1	0.014	0.018	-0.030	-0.017
	[0.021]	[0.057]	[0.023]	[0.025]
Religiosity scale: 2	0.056***	0.161***	-0.012	-0.021
	[0.017]	[0.047]	[0.025]	[0.021]
Religiosity scale: 3	0.054***	0.168***	-0.012	-0.045**
	[0.020]	[0.056]	[0.022]	[0.022]
Religiosity scale: 4	0.103***	0.320***	0.057**	-0.066***
	[0.018]	[0.056]	[0.026]	[0.021]
M works full-time	-0.055***	-0.126**	-0.064***	0.058***
	[0.018]	[0.051]	[0.022]	[0.018]
M works part-time	-0.037*	-0.044	0.009	0.048**
	[0.019]	[0.055]	[0.022]	[0.020]
M HS graduate	0.071***	0.163***	0.007	-0.085***
	[0.017]	[0.047]	[0.029]	[0.022]
M some college	0.137***	0.374***	0.055*	-0.142***
	[0.018]	[0.054]	[0.033]	[0.023]
M college degree	0.227***	0.641***	0.121***	-0.250***
	[0.019]	[0.072]	[0.044]	[0.024]
M college plus	0.232***	0.830***	0.209***	-0.256***
	[0.019]	[0.087]	[0.051]	[0.028]
Twin	-0.031	-0.161**	-0.130***	0.160***
	[0.026]	[0.065]	[0.014]	[0.024]

Number of siblings	-0.028***	-0.029	0.012	0.010
	[0.006]	[0.020]	[0.007]	[0.007]
F non-resident	-0.064***	-0.140**	-0.038	0.024
	[0.023]	[0.058]	[0.027]	[0.023]
M age at birth	0.021**	0.074***	-0.003	-0.006
	[0.010]	[0.028]	[0.013]	[0.009]
M age at birth sqd	-0.000*	-0.001**	0.000	0.000
	[0.000]	[0.000]	[0.000]	[0.000]
M divorced/separated	-0.002	0.014	-0.014	0.015
	[0.030]	[0.078]	[0.041]	[0.033]
M single	-0.022	-0.075	-0.019	0.031
	[0.020]	[0.050]	[0.027]	[0.022]
M other marital status	0.158**	0.137	0.009	-0.061
	[0.064]	[0.229]	[0.105]	[0.117]
M smoked pregnant	-0.101***	-0.297***	-0.101***	0.071***
	[0.022]	[0.056]	[0.021]	[0.024]
M alcohol pregnant	0.033	0.109	0.094**	-0.005
	[0.036]	[0.100]	[0.046]	[0.040]
M wanted baby	0.013	0.088**	0.039***	-0.018
	[0.016]	[0.043]	[0.014]	[0.016]
M not told BF important	-0.026	-0.121**	0.045**	0.036
	[0.021]	[0.059]	[0.022]	[0.023]
M no maternity leave	0.029*	0.073	0.009	-0.003
	[0.015]	[0.048]	[0.019]	[0.016]
M in WIC	-0.035**	-0.072	-0.067***	0.046***
	[0.017]	[0.046]	[0.023]	[0.017]
Health Social Assistance [b]	28.134**	64.514**	24.766	-27.217*
	[12.301]	[31.252]	[15.520]	[15.276]
Observations	9800	8150	4800	9800

Notes: [‡] Duration of breastfeeding categorized: 0 months, 1-2 months, 3-5 months, or 6+ months. [§] Sample restricted to respondents when child aged 8 or 9 months. Data weighted using W1R0. Probit specifications (columns 1, 3 and 4); ordered probit specification (column 2). M denotes mother; F denotes father. All variables measured at 9 months from response by mother except indicated by superscripts a, b and c. [a] Variables taken from Birth Certificate record. [b] Variables measured as availability per 1000 persons in the county; data as classified by the NAICS system from the 2001 County Business Patterns. [c] Variables measured at the county level. Age of child in months at survey date also included. Robust standard errors given in brackets. *** p<0.01, ** p<0.05, * p<0.1.

Table 3. Influence of Breastfeeding on Health, Physical, and Cognitive Outcomes (Specification: Covariates)

	Outcomes at 9 months				Outcomes at 24 months				Outcomes at 54 months			
	Ever breastfed	Breast fed in last week	Breast fed for 6+ months	Formula-fed at birth	Ever breastfed	Breast fed in last week	Breast fed for 6+ months	Formula-fed at birth	Ever breastfed	Breast fed in last week	Breast fed for 6+ months	Formula-fed at birth
Respiratory problem	-0.012	-0.044***	-0.017	0.025***	-0.009	-0.009	-0.012	0.011	-0.000	-0.032*	-0.005	0.008
	[0.011]	[0.015]	[0.015]	[0.010]	[0.010]	[0.016]	[0.014]	[0.009]	[0.011]	[0.017]	[0.015]	[0.011]
Gastroenteritis	0.014**	-0.007	-0.009	0.005	0.010*	0.015*	-0.003	-0.007	-0.002	-0.015*	0.010	0.004
	[0.006]	[0.011]	[0.009]	[0.006]	[0.005]	[0.010]	[0.007]	[0.005]	[0.006]	[0.007]	[0.009]	[0.005]
Asthma	-0.005	-0.011	0.002	0.011**	-0.013*	-0.024*	-0.008	0.016**	-0.005	-0.024*	-0.020	0.014
	[0.007]	[0.007]	[0.009]	[0.005]	[0.008]	[0.011]	[0.011]	[0.007]	[0.010]	[0.015]	[0.013]	[0.010]
Excellent health	0.012	0.049**	0.011	-0.044***	-0.001	0.011	0.031	-0.021	0.000	-0.009	0.019	-0.005
	[0.015]	[0.024]	[0.022]	[0.014]	[0.016]	[0.025]	[0.022]	[0.014]	[0.017]	[0.026]	[0.024]	[0.016]
Maternal attachment	0.062*	0.076	0.035	-0.056*	-0.009	-0.004	0.070	-0.010				
	[0.033]	[0.050]	[0.044]	[0.030]	[0.030]	[0.042]	[0.050]	[0.028]				
Motor scores (std) [a]	0.049**	0.043	0.059**	-0.026	0.004	0.015	0.042	-0.083***	0.044	0.035	0.051	-0.071**
	[0.021]	[0.028]	[0.029]	[0.019]	[0.030]	[0.045]	[0.041]	[0.027]	[0.034]	[0.052]	[0.046]	[0.031]
High physical activity									-0.002	-0.071***	0.048*	-0.003
									[0.019]	[0.026]	[0.026]	[0.017]
Under weight					0.017***	0.011	0.005	-0.012**	-0.002	0.003	-0.000	0.004
					[0.006]	[0.011]	[0.010]	[0.006]	[0.004]	[0.007]	[0.006]	[0.004]
Overweight or obese					-0.065***	-0.100***	-0.024	0.043***	-0.004	-0.039	-0.004	0.003
					[0.017]	[0.023]	[0.022]	[0.015]	[0.017]	[0.025]	[0.024]	[0.016]
Obese					-0.077***	-0.053***	-0.056***	0.045***	-0.023	-0.045**	-0.005	0.023*
					[0.014]	[0.018]	[0.016]	[0.012]	[0.014]	[0.021]	[0.019]	[0.013]
Cognitive scores (std) [b]	0.029*	0.027	0.032	-0.001	0.093***	0.173***	0.056	-0.160***	0.123***	-0.022	0.132***	-0.087**
	[0.017]	[0.022]	[0.024]	[0.015]	0.029	[0.043]	[0.039]	[0.003]	[0.031]	[0.049]	[0.046]	[0.029]
Reading (std)									0.043**	0.104***	0.044	-0.063***
									[0.022]	[0.036]	[0.031]	[0.020]
Math (std)									0.067***	0.093**	0.087***	-0.067***
									[0.024]	[0.037]	[0.032]	[0.020]

Literature (std)		0.071***	0.109**	0.073*	-0.070***
		[0.027]	[0.044]	[0.039]	[0.025]

Source: ECLS-B, birth to pre-school waves. *Notes:* Each cell is coefficient of breastfeeding variable on dependent variable in column (1). Estimations with probit and OLS, survey weights applied (W1R0-W3R0). Estimation controls for: early care variables; maternal characteristics; race; region; and socioeconomic status (as per Table 2). Estimations for breastfed for 6+ months include dummy variables for breastfed at 1-2 months and 3-5 months. Coefficient for breastfed for 6+ months relative to default category of never breastfed. Estimations using 9-month cohort include interviewer fixed effects for cognitive scores and motor scores. [a] The 54-month motor score is based on a block building exercise, with motor skills derived as a standardized composite variable based on ten motor skill tasks. [b] The 54-month cognitive score is a copy forms score: this is a standardized composite variable based on the child's score on eight copy form tasks (e.g. draw vertical line from the Bruininks-Oseretsky test). Sample sizes vary per estimation. Sample for 'breastfed in last week' restricted to children aged 8 or 9 months at first survey date. ***, **, * denotes significance at 1%, 5%, 10%.

Table 4. Influence of Breastfeeding on Health, Physical, and Cognitive Outcomes (Specification: Lewbel Instrumentation)

	Outcomes at 9 months				Outcomes at 24 months				Outcomes at 54 months			
	Ever breastfed	**Breast fed in last week**	**Breast fed for 6+ months**	**Formula-fed at birth**	**Ever breastfed**	**Breast fed in last week**	**Breast fed for 6+ months**	**Formula-fed at birth**	**Ever breastfed**	**Breast fed in last week**	**Breast fed for 6+ months**	**Formula-fed at birth**
Respiratory problem	-0.015	-0.041**	-0.038*	0.033***	-0.009	-0.004	-0.018	0.018	-0.001	-0.039*	-0.011	0.012
	[0.014]	[0.017]	[0.021]	[0.013]	[0.014]	[0.018]	[0.201]	[0.012]	[0.016]	[0.021]	[0.022]	[0.014]
Gastroenteritis	0.020*	-0.005	-0.003	0.002	0.008	0.020	0.008	-0.005	0.001	-0.028**	0.014	0.006
	[0.010]	[0.013]	[0.013]	[0.009]	[0.007]	[0.014]	[0.012]	[0.007]	[0.008]	[0.013]	[0.014]	[0.008]
Asthma	-0.002	-0.002	-0.001	0.015*	-0.018	-0.017	-0.010	0.017	-0.001	-0.026	-0.016	0.014
	[0.010]	[0.008]	[0.011]	[0.008]	[0.012]	[0.012]	[0.013]	[0.010]	[0.013]	[0.017]	[0.018]	[0.012]
Excellent health	0.012	0.070**	0.042	-0.051***	-0.002	0.005	0.043	-0.015	-0.004	-0.005	0.019	-0.011
	[0.019]	[0.025]	[0.029]	[0.017]	[0.020]	[0.027]	[0.029]	[0.018]	[0.022]	[0.028]	[0.033]	[0.019]
Motor scores (std)	0.018	0.018	0.204***	-0.020	-0.014	0.034	0.021	-0.070*	0.019	0.033	0.087	-0.032
	[0.039]	[0.034]	[0.067]	[0.035]	[0.039]	[0.052]	[0.060]	[0.036]	[0.044]	[0.064]	[0.058]	[0.039]
Maternal attachment	0.018	0.051	0.045	-0.042	0.001	0.007	0.090	-0.018				
	[0.041]	[0.058]	[0.054]	[0.037]	[0.034]	[0.040]	[0.055]	[0.033]				
High physical activity									-0.002	-0.071***	0.022	-0.002
									[0.019]	[0.026]	[0.031]	[0.017]
Under weight					0.019**	0.017	0.017	-0.016*	-0.003	0.011	0.002	0.002
					[0.008]	[0.013]	[0.013]	[0.008]	[0.007]	[0.010]	[0.009]	[0.005]
Overweight or obese					-0.075**	-0.113***	-0.112***	0.053***	-0.033*	-0.044	-0.030	0.000
					[0.021]	[0.026]	[0.031]	[0.019]	[0.018]	[0.030]	[0.033]	[0.018]
Obese					-0.088***	-0.058***	-0.125***	0.054***	-0.030**	-0.050**	-0.045*	0.038**
					[0.018]	[0.021]	[0.026]	[0.016]	[0.014]	[0.023]	[0.026]	[0.015]
Cognitive scores (std)	-0.012	0.029	0.194***	0.016	0.103***	0.206***	0.184***	-0.156**	0.108***	-0.086	0.190***	-0.046
	[0.039]	[0.030]	[0.067]	[0.036]	[0.037]	[0.049]	[0.056]	[0.034]	[0.038]	[0.060]	[0.057]	[0.035]
Reading (std)									0.068	0.088**	0.126***	-0.067***
									[0.054]	[0.043]	[0.044]	[0.025]
Math (std)									0.178***	0.043	0.146***	-0.034
									[0.058]	[0.044]	[0.044]	[0.027]
Literature (std)									0.089	0.084	0.175***	-0.073**

		[0.066]	[0.054]	[0.057]	[0.031]

Source: ECLS-B, birth to pre-school waves. *Notes:* Each cell is coefficient of breastfeeding variable on dependent variable in column (1). Estimations with probit and OLS, survey weights applied. Estimation controls for: early care variables; maternal characteristics; race; region; and socioeconomic status (as per Table 2). Estimations using 9-month cohort include interviewer fixed effects for cognitive and motor scores. Sample sizes vary per estimation. Sample for 'breastfed in last week' restricted to children aged 8 or 9 months at first survey date. Sample for '6 months plus' restricted to '6 months plus' and 'no months breastfeeding'. ***, **, * denotes significance at 1%, 5%, 10%.

Table 5. Influence of Breastfeeding on Health, Physical, and Cognitive Outcomes (Specification: Twins Fixed Effects)

	Outcomes at 9 months				Outcomes at 24 months				Outcomes at 54 months			
	Ever breastfed	Breast fed in last week	Breast fed for 6+ months	Formula-fed at birth	Ever breastfed	Breast fed in last week	Breast fed for 6+ months	Formula-fed at birth	Ever breastfed	Breast fed in last week	Breast fed for 6+ months	Formula-fed at birth
Respiratory problem	-0.018	-0.479*	-0.044	0.000	0.058	-0.221	0.059	-0.072	-0.003	0.003	-0.195**	0.017
	[0.040]	[0.263]	[0.063]	[0.018]	[0.072]	[0.196]	[0.087]	[0.051]	[0.037]	[0.027]	[0.093]	[0.050]
Gastroenteritis	-0.025	-0.000	-0.004	0.098*	-0.095	-0.014	-0.069	0.047	-0.075	0.009	-0.024	0.043
	[0.070]	[0.020]	[0.067]	[0.051]	[0.068]	[0.019]	[0.047]	[0.042]	[0.010]	[0.010]	[0.064]	[0.040]
Asthma	-0.100	0.369	-0.091	-0.003	-0.096*	0.038	0.008	-0.105**	-0.119**	0.040	-0.012	-0.024
	[0.063]	[0.258]	[0.069]	[0.037]	[0.051]	[0.027]	[0.031]	[0.051]	[0.060]	[0.029]	[0.048]	[0.050]
Excellent health	0.154*	-0.043	0.253**	0.007	0.086	-0.053	0.006	0.109	0.011	-0.084	0.090	0.076
	[0.092]	[0.037]	[0.122]	[0.075]	[0.064]	[0.041]	[0.078]	[0.059]	[0.074]	[0.054]	[0.101]	[0.071]
Maternal attachment	-0.045	0.082	0.210	-0.072	0.049	-0.011	0.196	-0.016				
	[0.285]	[0.451]	[0.336]	[0.184]	[0.160]	[0.012]	[0.201]	[0.053]				
Motor scores (std)	0.039	-0.174	0.162	0.064	0.017	-0.112	0.041	-0.039	0.225	0.421	0.098	0.116
	[0.088]	[0.280]	[0.147]	[0.156]	[0.168]	[0.285]	[0.175]	[0.151]	[0.229]	[0.423]	[0.356]	[0.177]
High physical activity									0.111	0.080	0.275**	0.018
									[0.076]	[0.093]	[0.133]	[0.078]
Under weight					0.005	0.046	0.061	0.033	0.030	0.011	-0.009	-0.003
					[0.005]	[0.040]	[0.070]	[0.040]	[0.027]	[0.016]	[0.045]	[0.023]
Overweight or obese					0.014	0.000	-0.020	-0.181**	-0.070	0.011	-0.026	-0.055
					[0.086]	[0.038]	[0.062]	[0.078]	[0.119]	[0.035]	[0.063]	[0.084]
Obese					0.104	-0.016	0.079	-0.036	-0.070	0.029	0.033	-0.025
					[0.075]	[0.036]	[0.084]	[0.077]	[0.070]	[0.033]	[0.066]	[0.067]
Cognitive scores (std)	0.078	-0.151	0.247*	0.091	0.061	0.216	-0.109	-0.045	0.215	-1.144**	-0.195	-0.188
	[0.169]	[0.151]	[0.142]	[0.102]	[0.120]	[0.283]	[0.140]	[0.109]	[0.184]	[0.507]	[0.246]	[0.150]
Reading (std)									0.078	-0.117	0.068	-0.027
									[0.123]	[0.147]	[0.082]	[0.084]
Math (std)									0.118	0.062	0.088	-0.011
									[0.092]	[0.357]	[0.152]	[0.086]

Literature (std)		0.144	-0.145	0.163	0.016
		[0.103]	[0.158]	[0.126]	[0.104]

Source: ECLS-B, birth to pre-school wave*s*. *Notes:* Each cell is coefficient of breastfeeding variable on dependent variable in column (1). Estimations with survey weights applied. Twins estimation using twin fixed effects. OLS specifications. Estimation controls for: sex and birth weight (low or very low). Sample sizes vary per estimation. Sample for 'breastfed in last week' restricted to children aged 8 or 9 months at first survey date. ***, **, * denotes significance at 1%, 5%, 10%.

Table 6. Influence of Breastfeeding on Health, Physical, and Cognitive Outcomes (Specification: Propensity Score Matching, Stratification)

	Outcomes at 9 months				Outcomes at 24 months				Outcomes at 54 months			
	Ever breastfed	Breast fed in last week	Breast fed for 6+ months	Formula-fed at birth	Ever breastfed	Breast fed in last week	Breast fed for 6+ months	Formula-fed at birth	Ever breastfed	Breast fed in last week	Breast fed for 6+ months	Formula-fed at birth
Respiratory problem	-0.023***	-0.041***	-0.011	0.010	-0.008	-0.010	-0.021	-0.001	0.007	-0.016	-0.000	0.001
	[0.008]	[0.011]	[0.013]	[0.009]	[0.008]	[0.012]	[0.012]	[0.008]	[0.007]	[0.011]	[0.012]	[0.008]
Gastroenteritis	-0.000	-0.016**	-0.006	-0.001	0.008*	0.014*	-0.006	-0.010**	0.005	-0.003	0.013	0.000
	[0.006]	[0.007]	[0.009]	[0.006]	[0.004]	[0.007]	[0.007]	[0.005]	[0.004]	[0.006]	[0.007]	[0.005]
Asthma	-0.024***	-0.025***	-0.011	0.004	-0.029***	-0.039***	-0.021**	0.019	-0.021***	-0.018*	-0.027**	0.006
	[0.005]	[0.006]	[0.008]	[0.006]	[0.006]	[0.008]	[0.010]	[0.007]	[0.007]	[0.010]	[0.011]	[0.008]
Excellent health	0.040	0.079***	0.046**	-0.024*	0.018	0.049***	0.035*	-0.003	0.037***	0.058***	0.065***	0.010
	[0.012]	[0.017]	[0.019]	[0.013]	[0.012]	[0.018]	[0.019]	[0.013]	[0.012]	[0.018]	[0.019]	[0.013]
Maternal attachment	0.219***	0.251***	0.251***	-0.107***	-0.046	0.006	0.026	0.006				
	[0.032]	[0.037]	[0.031]	[0.025]	[0.033]	[0.035]	[0.035]	[0.026]				
Motor scores (std)	0.022	0.065***	0.250***	-0.008	0.050**	0.061*	0.025	-0.069**	0.108***	0.136***	0.097***	-0.074***
	[0.023	[0.025]	[0.039]	[0.025]	[0.023]	[0.034]	[0.039]	[0.025]	[0.033]	[0.035]	[0.031]	[0.026]
High physical activity									-0.016	-0.043**	0.027*	-0.006
									[0.010]	[0.015]	[0.016]	[0.011]
Under weight					0.014***	0.002	0.004	-0.018***	-0.007	-0.001	0.002	0.002
					[0.005]	[0.009]	[0.009]	[0.006]	[0.004]	[0.006]	[0.007]	[0.005]
Overweight or obese					-0.045***	-0.083***	0.000	0.030**	-0.014	-0.041**	-0.017	0.016
					[0.011]	[0.016]	[0.018]	[0.012]	[0.011]	[0.017]	[0.018]	[0.012]
Obese					-0.047***	-0.051***	-0.023*	0.028***	-0.024***	-0.047***	-0.012	0.042***
					[0.009]	[0.012]	[0.014]	[0.009]	[0.009]	[0.013]	[0.015]	[0.010]
Cognitive scores (std)	0.052**	0.081***	0.287***	-0.059**	0.200***	0.287***	0.098***	-0.158***	0.134***	0.075**	0.237***	-0.085***
	[0.023]	[0.021]	[0.039]	[0.025]	[0.023]	[0.035]	[0.038]	[0.025]	[0.031]	[0.035]	[0.032]	[0.026]
Reading (std)									0.179***	0.165***	0.149**	-0.104***
									[0.017]	[0.028]	[0.030]	[0.020]
Math (std)									0.198***	0.177***	0.153***	-0.129***
									[0.018]	[0.028]	[0.031]	[0.021]

Literature (std)		0.218***	0.153***	0.194***	-0.114***
		[0.020]	[0.034]	[0.036]	[0.024]

Source: ECLS-B, birth to pre-school wave*s. Notes:* Each cell is coefficient of breastfeeding variable on dependent variable in column (1). Estimations with survey weights applied. Propensity score derived using instrument covariates. Balancing property satisfied. Estimation controls for: early care variables; maternal characteristics; race; region; and socioeconomic status (as per Table 2). Estimations using 9-month cohort include interviewer fixed effects for cognitive and motor scores. Sample sizes vary per estimation. Sample for 'breastfed in last week' restricted to children aged 8 or 9 months at first survey date. Sample for breastfed for 6+ months restricted to either 0 months or 6+ months. ***, **, * denotes significance at 1%, 5%, 10%.

Table 7. Change in Coefficients for Ever Breastfed (Covariate Specifications)

	Percentage change in coefficients from base model														
	Outcomes at 9 months					Outcomes at 24 months					Outcomes at 54 months				
	Base sig.	[1]	[2]	[3]	[4]	Base sig.	[1]	[2]	[3]	[4]	Base sig.	[1]	[2]	[3]	[4]
Respiratory problem	***	-4%	-42%	0%	-13%	**	-5%	-35%	23%	-44%		-14%	-83%	400%	-98%
Gastroenteritis		10%	18%	-8%	17%	**	0%	-9%	-20%	25%		100%	-200%	50%	-33%
Asthma	***	-6%	-67%	-40%	-33%	***	-6%	-41%	-10%	-28%	*	-11%	-75%	50%	-17%
Excellent health	***	-6%	-58%	-53%	33%	*	-7%	-76%	-67%	-101%	***	-5%	-50%	-81%	-95%
Motor scores (std)	**	-33%	67%	7%	2%	***	-16%	-51%	-38%	-75%	***	-5%	-26%	-39%	-15%
High physical activity												0%	-30%	-29%	-60%
Under weight						**	0%	7%	7%	6%	*	-1100%	-200%	100%	0%
Overweight or obese						***	2%	-19%	-6%	-3%	***	13%	-57%	-67%	-180%
Obese						***	1%	-10%	-6%	-1%	***	2%	-26%	-24%	-28%
Cognitive scores (std)	***	-20%	-35%	-15%	4%	***	-4%	-30%	-33%	-6%	***	-2%	-24%	-18%	-3%
Attachment	***	-1%	-40%	-47%	-6%		-8%	118%	0%	-138%					
Reading (std)											***	-2%	-40%	-61%	-9%
Math (std)											***	-3%	-36%	-46%	-14%
Literature (std)											***	-2%	-37%	-52%	-9%

Notes: Specification as per Table 3 for breastfed ever. All models control for age of child at survey date. 9-month responses control for interviewer fixed effects. Baseline model controls for child characteristics: race, sex, twin status, number of siblings. Base sig. refers to statistical significance of breastfeeding coefficient using the baseline model, ***1%, **5%, and *1%. Model [1] adds to the baseline: birth weight status. Model [2] is [1] plus maternal characteristics: obesity, religion, marital status, father non-resident, age at birth. Model [3] is [2] plus maternal employment and education. Model [4] is [3] plus center based care, region, and health insurance.

Appendix Table 1
Determinants of Ever Breastfeeding

	(1)	(2)	(3)	(4)	(5)	(6)
Primary care: center	0.005	0.004	0.003	0.005	0.002	0.002
	[0.022]	[0.022]	[0.022]	[0.022]	[0.023]	[0.024]
Primary care: relative	-0.044***	-0.047***	-0.048***	-0.044***	-0.042**	-0.033*
	[0.017]	[0.017]	[0.017]	[0.017]	[0.017]	[0.018]
Primary care: nonrelative	-0.014	-0.014	-0.016	-0.015	-0.022	0.007
	[0.021]	[0.021]	[0.021]	[0.021]	[0.022]	[0.023]
Region NE	-0.163***	-0.157***	-0.155***	-0.163***	-0.155***	-0.153**
	[0.025]	[0.025]	[0.025]	[0.025]	[0.027]	[0.026]
Region MW	-0.124***	-0.125***	-0.118***	-0.128***	-0.102***	-0.116***
	[0.026]	[0.026]	[0.026]	[0.026]	[0.029]	[0.026]
Region S	-0.163***	-0.164***	-0.161***	-0.167***	-0.113***	-0.152***
	[0.026]	[0.026]	[0.026]	[0.026]	[0.032]	[0.025]
Black	-0.065***	-0.051**	-0.067***	-0.047*	-0.058**	-0.025
	[0.025]	[0.024]	[0.025]	[0.024]	[0.025]	[0.026]
Hispanic	0.102***	0.107***	0.096***	0.112***	0.095***	0.115***
	[0.020]	[0.020]	[0.021]	[0.020]	[0.022]	[0.021]
Asian	0.029	0.037*	0.029	0.040*	0.020	0.025
	[0.023]	[0.021]	[0.023]	[0.020]	[0.022]	[0.022]
Other race (non-white)	0.088***	0.095***	0.085***	0.098***	0.086***	0.106***
	[0.021]	[0.021]	[0.021]	[0.021]	[0.021]	[0.020]
Female	0.006	0.002	0.005	0.004	0.004	0.006
	[0.012]	[0.012]	[0.012]	[0.012]	[0.012]	[0.012]
Birth weight: Low	-0.065***	-0.065***	-0.063***	-0.073***	-0.070***	-0.073***
	[0.020]	[0.022]	[0.020]	[0.020]	[0.021]	[0.022]
Birth weight: Very Low	-0.055**	-0.030	-0.047**	-0.056**	-0.057**	-0.058**
	[0.024]	[0.033]	[0.024]	[0.024]	[0.025]	[0.026]
Health Insur.: Private	-0.017	-0.009	-0.013	-0.014	-0.014	-0.001
	[0.032]	[0.032]	[0.032]	[0.032]	[0.032]	[0.034]
Health Insur.: Public	-0.023	-0.033	-0.031	-0.026	-0.034	-0.019
	[0.035]	[0.035]	[0.035]	[0.035]	[0.035]	[0.037]
M obese	-0.040***	-0.038***	-0.041***	-0.039***	-0.038***	-0.037***
	[0.014]	[0.013]	[0.014]	[0.014]	[0.014]	[0.014]
Religiosity scale: 1	0.014	0.019	0.014	0.018	0.022	0.023
	[0.021]	[0.020]	[0.021]	[0.021]	[0.021]	[0.022]
Religiosity scale: 2	0.056***	0.067***	0.056***	0.066***	0.070***	0.064***
	[0.017]	[0.016]	[0.017]	[0.016]	[0.016]	[0.017]
Religiosity scale: 3	0.054***	0.061***	0.054***	0.061***	0.067***	0.064***
	[0.020]	[0.019]	[0.020]	[0.019]	[0.020]	[0.021]
Religiosity scale: 4	0.103***	0.115***	0.103***	0.113***	0.115***	0.117***
	[0.018]	[0.018]	[0.018]	[0.018]	[0.018]	[0.019]
M works full-time	-0.055***	-0.055***	-0.056***	-0.054***	-0.055***	-0.071***
	[0.018]	[0.018]	[0.018]	[0.018]	[0.019]	[0.020]
M works part-time	-0.037*	-0.038*	-0.037*	-0.036*	-0.036*	-0.046**
	[0.019]	[0.020]	[0.019]	[0.019]	[0.020]	[0.022]
M HS graduate	0.071***	0.074***	0.074***	0.073***	0.069***	0.080***
	[0.017]	[0.017]	[0.017]	[0.017]	[0.018]	[0.019]
M some college	0.137***	0.147***	0.142***	0.143***	0.144***	0.142***
	[0.018]	[0.017]	[0.017]	[0.018]	[0.017]	[0.018]
M college degree	0.227***	0.240***	0.233***	0.236***	0.237***	0.224***
	[0.019]	[0.018]	[0.018]	[0.018]	[0.018]	[0.019]
M college plus	0.232***	0.243***	0.238***	0.240***	0.242***	0.227***
	[0.019]	[0.018]	[0.018]	[0.018]	[0.018]	[0.019]
Twin	-0.031	-0.010	-0.031	-0.023	-0.031	-0.020
	[0.026]	[0.024]	[0.026]	[0.025]	[0.026]	[0.026]
Number of siblings	-0.028***	-0.034***	-0.030***	-0.031***	-0.029***	-0.031***
	[0.006]	[0.006]	[0.006]	[0.006]	[0.006]	[0.007]
F non-resident	-0.064***	-0.062***	-0.063***	-0.063***	-0.066***	-0.059**

	[0.023]	[0.023]	[0.023]	[0.023]	[0.024]	[0.026]
M age at birth	0.021**	0.020**	0.021**	0.020*	0.018*	0.022*
	[0.010]	[0.010]	[0.010]	[0.010]	[0.010]	[0.011]
M age at birth sqd	-0.000*	-0.000*	-0.000*	-0.000*	-0.000	-0.000
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
M divorced/separated	-0.002	-0.021	-0.005	-0.018	-0.021	0.002
	[0.030]	[0.031]	[0.031]	[0.031]	[0.032]	[0.035]
M single	-0.022	-0.030	-0.023	-0.026	-0.031	-0.050**
	[0.020]	[0.020]	[0.020]	[0.020]	[0.021]	[0.022]
M other marital status	0.158**	0.151**	0.155**	0.160**	0.151**	0.138**
	[0.064]	[0.067]	[0.065]	[0.064]	[0.068]	[0.068]
M smoked pregnant	-0.101***		-0.103***			
	[0.022]		[0.022]			
M alcohol pregnant	0.033		0.034			
	[0.036]		[0.036]			
M wanted baby	0.013		0.012			
	[0.016]		[0.016]			
M not told BF important	-0.026		-0.024			
	[0.021]		[0.021]			
M no maternity leave	0.029*			0.027*		
	[0.015]			[0.015]		
M in WIC	-0.035**			-0.041**		
	[0.017]			[0.017]		
Health Social Assistance [b]	28.134**				37.195	
	[12.301]				[41.198]	
Vaginal birth[a]		0.039***				
		[0.015]				
Risk factor at birth[a]		-0.011				
		[0.014]				
Baby in NICU[a]		-0.007				
		[0.027]				
Religious organizations[b]					-157.076***	
					[45.847]	
Ind. Family Assistance[b]					161.831	
					[157.247]	
Physicians[b]					-45.665	
					[66.712]	
Hospitals[b]					-68.876	
					[552.713]	
Child day care[b]					87.733	
					[114.985]	
Baby food price [c]					-0.019	
					[0.147]	
Unemployment Rate[c]					-0.010	
					[0.006]	
Percent females: [d]						
18+ who are employed						-0.001
						[0.001]
With college degree						0.004***
						[0.001]
Married						0.001
						[0.001]
Obese						-0.001
						[0.002]
With health insurance						-0.000
						[0.002]
In excell/v. good health						0.002**
						[0.001]
Observations	9800	9800	9800	9800	9300	8200

Source: ECLS-B, birth cohort. *Notes:* Probit specifications. Data weighted using W1R0. Age of child in months at survey date

included. M denotes mother; F denotes father. All variables measured at 9 months from response by mother except indicated by superscripts a, b and c. [a] From Birth Certificate record. [b] Availability per 1000 persons in the county; data as classified by the NAICS system from the 2001 County Business Patterns. [c] Measured at the county level from ACCRA. [d] County-level variables from the Behavioral Risk Factor Surveillance System, 2001. Robust standard errors given in brackets. *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

Appendix Table 2. Influence of Ever Breastfeeding on Health, Physical, and Cognitive Outcomes: Split by Birth Weight Status and Poverty Status (Specification: Covariates)

	Outcomes at 9 months				Outcomes at 24 months				Outcomes at 54 months			
	Ever breastfed				Ever breastfed				Ever breastfed			
	Low birth weight	Not low birth weight	Below poverty threshold	Above poverty threshold	Low birth weight	Not low birth weight	Below poverty threshold	Above poverty threshold	Low birth weight	Not low birth weight	Below poverty threshold	Above poverty threshold
Respiratory problem	-0.015	-0.012	-0.16	-0.012	0.022	-0.012	0.006	-0.014	0.000	0.001	0.023	-0.007
	[0.021]	[0.012]	[0.020]	[0.013]	[0.020]	[0.011]	[0.020]	[0.012]	[0.023]	[0.024]	[0.021]	[0.013]
Gastroenteritis	-0.030**	0.018**	0.035***	0.004	0.005	0.010*	0.012**	0.007	-0.010	-0.000	0.005	-0.004
	[0.015]	[0.007]	[0.010]	[0.007]	[0.008]	[0.005]	[0.006]	[0.006]	[0.012]	[0.006]	[0.006]	[0.007]
Asthma	-0.006	-0.002	0.008	-0.005	-0.017	-0.013	-0.029*	-0.008	-0.045*	-0.002	0.000	-0.005
	[0.013]	[0.005]	[0.014]	[0.005]	[0.018]	[0.009]	[0.017]	[0.008]	[0.024]	[0.011]	[0.020]	[0.012]
Excellent health	0.026	0.011	-0.015	0.021	0.036	-0.004	-0.023	0.010	0.008	-0.000	-0.027	0.009
	[0.028]	[0.017]	[0.029]	[0.018]	[0.029]	[0.017]	[0.031]	[0.019]	[0.031]	[0.019]	[0.032]	[0.021]
Maternal attachment	0.057	0.067	0.133**	0.051	-0.045	-0.005	-0.133*	0.037				
	[0.036]	[0.046]	[0.059]	[0.039]	[0.040]	[0.033]	[0.070]	[0.032]				
Motor scores (std)	0.158***	0.039*	0.029	0.048*	0.148**	-0.008	-0.014	0.016	-0.002	0.049	0.110*	0.020
	[0.046]	[0.022]	[0.037]	[0.025]	[0.059]	[0.033]	[0.059]	[0.036]	[0.062]	[0.037]	[0.065]	[0.040]
High physical activity									-0.017	-0.000	-0.045	0.008
									[0.031]	[0.020]	[0.037]	[0.021]
Under weight					0.005	0.018***	0.011	0.016**	-0.008	-0.002	0.003	-0.004
					[0.013]	[0.006]	[0.009]	[0.007]	[0.012]	[0.004]	[0.004]	[0.005]
Overweight or obese					-0.027	-0.068***	-0.075**	-0.062***	-0.060**	0.011	-0.003	0.005
					[0.026]	[0.018]	[0.033]	[0.020]	[0.027]	[0.019]	[0.033]	[0.020]
Obese					-0.008	-0.083***	-0.117***	-0.063***	-0.045**	-0.020	-0.056**	-0.012
					[0.020]	[0.016]	[0.028]	[0.017]	[0.020]	[0.016]	[0.027]	[0.016]
Cognitive scores (std)	0.128***	0.018	0.048	0.017	0.084	0.092***	0.004	0.125***	0.003	0.134***	0.083	0.143***
	[0.041]	[0.018]	[0.033]	[0.020]	[0.055]	[0.031]	[0.055]	[0.033]	[0.054]	[0.034]	[0.056]	[0.038]
Reading (std)									0.026	0.045**	0.039	0.042
									[0.041]	[0.024]	[0.044]	[0.026]
Math (std)									0.047	0.069**	0.055	0.074***

		[0.043]	[0.026]	[0.046]	[0.028]
Literature (std)		0.046	0.074**	0.102**	0.053
		[0.047]	[0.029]	[0.048]	[0.033]

Appendix Table 3. Influence of Ever Breastfeeding on Health, Physical, and Cognitive Outcomes: Split by Mother Works Full Time and Marital Status (Specification: Covariates)

	Outcomes at 9 months				Outcomes at 24 months				Outcomes at 54 months			
	Ever breastfed				Ever breastfed				Ever breastfed			
	Mother works full-time	Mother not at work (or part-time)	Married	Not married	Mother works full-time	Mother not at work (or part-time)	Married	Not married	Mother works full-time	Mother not at work (or part-time)	Married	Not married
Respiratory problem	-0.004	0.012	-0.019	-0.000	0.006	-0.016	-0.017	0.005	0.009	-0.003	-0.009	0.015
	[0.019]	[0.013]	[0.014]	[0.017]	[0.018]	[0.013]	[0.014]	[0.017]	[0.020]	[0.014]	[0.015]	[0.018]
Gastroenteritis	0.013	0.015*	0.012	0.017*	0.010	0.007	0.009	0.007	-0.005	0.002	-0.001	-0.001
	[0.010]	[0.007]	[0.008]	[0.009]	[0.010]	[0.006]	[0.007]	[0.005]	[0.010]	[0.006]	[0.008]	[0.007]
Asthma	-0.008	0.000	-0.006	0.003	-0.020	-0.010	-0.003	-0.035**	0.017	-0.014	-0.004	-0.005
	[0.008]	[0.006]	[0.006]	[0.011]	[0.014]	[0.009]	[0.009]	[0.015]	[0.017]	[0.012]	[0.012]	[0.019]
Excellent health	0.026	0.003	0.042**	-0.041*	0.025	-0.013	0.014	-0.019	0.004	0.002	0.019	-0.024
	[0.027]	[0.019]	[0.020]	[0.024]	[0.028]	[0.020]	[0.021]	[0.025]	[0.030]	[0.021]	[0.023]	[0.027]
Maternal attachment	0.017	0.106***	0.050	0.083	-0.055	0.012	0.003	-0.038				
	[0.054]	[0.041]	[0.042]	[0.053]	[0.051]	[0.037]	[0.037]	[0.052]				
Motor scores (std)	0.010	0.072***	0.057**	0.052	0.033	-0.009	-0.006	0.032	-0.002	0.067	0.015	0.097
	[0.035]	[0.026]	[0.027]	[0.032]	[0.054]	[0.037]	[0.040]	[0.045]	[0.060]	[0.041]	[0.044]	[0.053]
High physical activity									0.031	-0.017	0.000	-0.014
									[0.031]	[0.023]	[0.024]	[0.029]
Under weight					0.015	0.016**	0.013	0.021***	-0.000	-0.004	-0.003	-0.001
					[0.008]	[0.007]	[0.008]	[0.008]	[0.004]	[0.006]	[0.005]	[0.005]
Overweight or obese					-0.086***	-0.055***	-0.082***	-0.038	-0.013	0.013	-0.001	0.006
					[0.030]	[0.021]	[0.022]	[0.027]	[0.030]	[0.021]	[0.022]	[0.028]
Obese					-0.068***	-0.081***	-0.080***	-0.067***	-0.041	-0.016	-0.012	-0.045*
					[0.024]	[0.018]	[0.019]	[0.022]	[0.025]	[0.017]	[0.017]	[0.024]
Cognitive scores (std)	0.023	0.046**	0.038*	0.027	0.108**	0.087**	0.131***	0.045	0.166***	0.094**	0.168***	0.056
	[0.027]	[0.021]	[0.022]	[0.027]	[0.049]	[0.035]	[0.038]	[0.043]	[0.054]	[0.038]	[0.041]	[0.047]
Reading (std)									-0.003	0.065**	0.058**	0.015
									[0.038]	[0.027]	[0.028]	[0.036]
Math (std)									0.040	0.078*	0.081**	0.041

		[0.041]	[0.031]	[0.031]	[0.039]
Literature (std)		-0.006	0.108***	0.094***	0.027
		[0.047]	[0.033]	[0.035]	[0.042]

Figure 1. Theorized Relationships