NBER WORKING PAPER SERIES

BREASTFEEDING AND CHILD DISABILITY: A COMPARISON OF SIBLINGS FROM THE UNITED STATES

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Working Paper 19940
http://www.nber.org/papers/w19940

NATIONAL BUREAU OF ECONOMIC RESEARCH
1050 Massachusetts Avenue
Cambridge, MA 02138
February 2014

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NBER Working Paper No. 19940
February 2014
JEL No. I12,J13,J24

ABSTRACT

Little is known about whether breastfeeding may prevent disabilities throughout childhood. We evaluate the effects of breastfeeding on child disability using data from the National Survey of Family Growth merged to the National Health Interview Survey for a large nationally representative sample of children aged 1 to 18 years from the U.S. including over 3,000 siblings who are discordant on breastfeeding status/duration. We focus on a mother fixed effect model that compares siblings in order to account for family-level unobservable confounders and employ multiple specifications including a dynamic model that accounts for disability status of the prior child. Breastfeeding the child for a longer duration is associated with a lower risk of child disability, by about 0.2 percentage-points per month of breastfeeding. This effect is only observed on the intensive margin among breastfed children, as any breastfeeding has no effect on the extensive margin. We conclude that very short breastfeeding durations are unlikely to have an effect on reducing disability risk.

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1. Introduction

A wide literature exists on the effects of breastfeeding on infant and child health outcomes. Meta-analyses of previous studies in developed countries have found that breastfeeding is associated with improvement in certain physical health measures including reduced risks of infection, obesity, diabetes, and asthma (Ip et al., 2009). Meta-analyses and randomized studies have also found an improvement in infant's physical growth with prolonged breastfeeding (Kramer and Kakuma, 2002, 2004). Furthermore, breastfeeding for a longer duration has been reported to improve achieving several developmental milestones among infants including gross and fine motor, language, and social adaptation skills (Belfield and Kelly, 2012; Chiu et al., 2011; McCrory and Murray, 2012). Improvement in neurodevelopmental outcomes with breastfeeding has also been reported in other smaller observational studies (McCowan et al., 2002). In addition, some studies that compare siblings to each other have found that breastfeeding may enhance cognitive ability and long-term educational achievement (Belfield and Kelly, 2012; Evenhouse and Reilly, 2005; Rees and Sabia, 2009).

Even with this large literature, there are still important gaps in the knowledge about the effects of breastfeeding on child health and development. In particular, it remains unclear whether breastfeeding may reduce the risk of child disability in the form of physical and cognitive limitations or not. Identifying this effect is important for determining whether breastfeeding, an easily accessible household intervention, may reduce child disability risks and enhance child physical and cognitive development. This is especially relevant given the high and rising prevalence of child disability in the United States over the past few decades, and the fluctuating rates of breastfeeding including a recent increase over the past few years. More than 15% of children in the U.S. are estimated to have one or more of chronic physical or mental

conditions that may eventually result in activity limitations (Boyle et al., 2011). More importantly, the rate of children experiencing these activity limitations in the U.S. has increased from about 1.8% in 1960 to 7% in 2004 (Perrin et al., 2007). The reasons behind this increase remain unknown.

In contrast, breastfeeding rates have been fluctuating significantly over the past few decades including some periods of significant decline. Figure 1 shows the breastfeeding rates between 1965 and 1995, which is the period covered in our study. Breastfeeding rates were very low in the late 1960s through late 1970s – less than 40%. However, after an increase to over 55%, breastfeeding rates declined again in late 1980s but increased after that to about 60% in 1995. In 2007, 75% of mothers breastfed their children, and about 44% were still breastfeeding at age 6 months (CDC, 2011). Changes in certain population-level factors such as maternal employment and awareness of breastfeeding value correlate with these trends (Wright and Schanler, 2001).

The previously reported positive effects of breastfeeding on child health and developmental outcomes and the opposite trends between child disability and breastfeeding over several periods in the past four decades may suggest a potential effect of breastfeeding on child disability. However, this question has not been adequately evaluated, and it is unclear whether the declines in breastfeeding over the past four decades may have contributed to the increase in disability rates and whether the recent increase in breastfeeding rates may reduce future disability rates.

Even though some studies have reported improvements in neurodevelopmental milestones with breastfeeding, these studies do not provide direct evidence for an effect of

breastfeeding on child disability. Most studies were generally limited to infants under 2 years of age and did not provide information on development and disability status later in life. At this very young age, the infant's performance on these milestones may not accurately reflect disability and functional limitations later in childhood as it may under- or over-represent future limitations. A few studies evaluated the effects of breastfeeding on cognitive and motor development later during childhood. For example, Lucas et al. (1992) reported a higher IQ at age 7-8 years among breastfed preterm children. However, the study included a small sample of 300 children, was limited to preterm birth children, and did not report child disability measures. Another limitation of this study is potential bias from maternal self-selection into breastfeeding based on unobservable characteristics related to both the choice of breastfeeding and other maternal behaviors and investments or household or health risk factors that in turn affect child development and disability. Belfield and Kelly (2012) evaluated the effects of breastfeeding on several physical and cognitive outcomes up to 54 months of age. Using instrumental variable and propensity score approaches to account for the endogenous selection into breastfeeding and data from Early Childhood Longitudinal Survey, they reported improvement in several outcomes including in motor and cognitive scores. However, no direct measures of child disability were included in that study. Furthermore, the oldest child age was under 5 years. Given that many disabilities are not diagnosed until later in childhood, it is important to evaluate the effects of breastfeeding on child development and disability throughout childhood and not only during the first few years of life. Other studies evaluated cognitive and non-cognitive outcomes later in childhood, but also had no direct measures of child disability.[1] Therefore, a study that employs

[1] For example, Borra et al. (2012) evaluated the relationship between breastfeeding for at least the first 4 weeks and child cognitive development based on academic achievement tests administered up to age 14 years and non-cognitive (psychosocial and behavioral) outcomes measured up to age 6 using data from the Avon Longitudinal Study of Parents and Children (ALSPAC). They found a positive effect on the

direct measures of child disability and a nationally representative sample of U.S. children at different stages of childhood is still needed to fully understand the long term effects of breastfeeding on functional aspects of the child's wellbeing and development. This is especially important given the intertwined relationship between disability particularly early in life and human capital accumulation and labor outcomes (Kidd et al., 2000; McGee, 2011).

In this study, we evaluate the effects of breastfeeding on child disability based on activity limitations – the standard definition of disability – using a nationally representative sample of U.S. children aged 1 to 18 years that has not been previously studied for this question. We account for self-selection into breastfeeding using a within-mother siblings' comparison that removes maternal time-invariant heterogeneity that may affect breastfeeding and child disability such as maternal preferences for health, time discounting, and risk taking, family history of disability and health problems, and maternal efficiency in health production. Such unobservable factors result in a theoretically ambiguous direction of bias in models that compare mothers who vary on these characteristics.[2] In that regard, our study is the first to provide nationally representative estimates of the effects of breastfeeding on child disability that explicitly account for such unobserved time-invariant maternal heterogeneity in breastfeeding behavior. However, despite their likely advantage over classical models that only account for observable confounders, sibling comparisons do not account for child-specific and time varying

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cognitive outcomes; the effects on non-cognitive outcomes were overall inconsistent. Similarly, Rees and Sabia (2010) reported positive effects of breastfeeding on high school graduation and college attendance by comparing siblings in the AddHealth study.

[2] For example, mothers who are future oriented may breastfeed their children more but also invest more through other ways in their children's health and development than mothers who are present oriented. This may result in overestimating the benefits of breastfeeding. In contrast, mothers who have a family history of disability may face a greater incentive to breastfeed their children as a way to reduce their elevated risk of future disability due to time-invariant heritable factors predisposing to disability such as genetic factors. Such an unobservable effect may result in underestimation of the benefits of breastfeeding.

unobservables that result in variation in breastfeeding between siblings. Most important among these are potential confounders that influence maternal decision to breastfeed *and* child disability risk such as child health status at birth or very early in life.[3] We control for birth weight and gestational age, which are important early indicators for child health and development, child's sex and birth order, pregnancy wantedness, and time varying maternal demographics. However, it is possible that these do not capture all relevant unobservable child-specific factors, which may still bias our estimation.

Consistent with the broad literature summarized above reporting a positive relationship between breastfeeding and child developmental (cognitive and non-cognitive) outcomes, we find that longer breastfeeding is associated with a reduced risk of child disability, by about 0.2 percentage-points per month of breastfeeding. This effect is only observed on the intensive margin among breastfed children, as any breastfeeding has no effect on disability risk. This finding is consistent with the expectation that very short breastfeeding durations are unlikely to have an effect on disability.

2. Methods

2.1 Data and Measures

We employ data from the 1995 National Survey of Family Growth (NSFG) merged with the 1993 National Health Interview Survey (NHIS). The research question we address requires measures on breastfeeding and disability measures for each live birth the mother has had. The

[3] For example, children born with certain congenital malformations (e.g. heart, neural tube, or craniofacial defects) may be less likely to be breastfed or breasted for shorter duration because of difficulty in breastfeeding (Rendon-Macias et al., 2002).

NSFG-NHIS dataset is one of the few data sources that provide these data for all of the children the mother has had. For each child, the NSFG provides the data on breastfeeding and several other maternal and child characteristics such as maternal age at pregnancy and the child's sex and birth outcomes, while the NHIS provides the data on child disability. The NHIS includes a nationally representative sample of all households in the U.S. (NCHS, 1995). The NHIS provides health data on all household members including the presence of activity limitations which we use to define the child disability measures as described below. The NSFG includes a nationally representative sample of women of reproductive age in the U.S. (NCHS, 2000). The NSFG provides data on the women's pregnancy history and pregnancy outcomes. For each child, data are available on whether the child was breastfed and the age of the child when breastfeeding ended as well as on birth outcomes such as birth weight and gestational age. Data are also available on certain maternal characteristics for each pregnancy such as maternal marital status and age. These data are collected through a series of questions that are asked for each pregnancy or live birth.

The fifth cycle of the NSFG in 1995 included as a sampling frame the women who were in the households included in the 1993 NHIS sample. Therefore, the 1993 NHIS data on mothers and their households which include disability measures for the children can be merged to the 1995 NSFG data on the complete pregnancy history and outcomes and breastfeeding.

We limit the sample to children older than one year of age at the time of the NHIS interview in 1993 since disability based on functional limitations may not be apparent very early in life. A few children were excluded from the sample due to having a birth weight less than 500 grams or gestational age less than 20 weeks as these might suggest data recording errors in these variables since infants born below these thresholds are expected to be stillbirths. The main

analytical sample includes 8,519 children born to 4,984 mothers who have complete data on the variables in the model comparing siblings including breastfeeding duration.[4] Of these, there are 1,294 siblings who are discordant on ever being breastfed and born to 518 mothers, and 1,990 siblings who are discordant on breastfeeding duration and born to 837 mothers. Therefore, there are 3,284 siblings (born to 1,355 mothers) who are discordant on the main study's measure of breastfeeding duration (described below) that includes a zero for no breastfeeding. The total number of children per mother in the sample that only includes discordant siblings on this breastfeeding duration measure ranges from 2 to 7 with an average of 2.6 children per mother.[5]

The NHIS asks about whether the person is limited in performing their major activities as reported by the household member being interviewed. The major activity is the person's main activity in the past 12 months at the time of the 1993 interview (NCHS, 1995). For children under 5 years of age, the major activity is playing. For children between 5 and 17 years of age, major activities are school attendance and needs, and the limitations include whether the child is unable to attend school, attends (or needs to attend) special school/classes, or is limited in school attendance. Information is also available on whether the child has limitations in performing any other activities.

We define disability based on the presence of limitations in activities that children would be expected to perform at their age. This definition, considered the standard approach for measuring disability based on the NHIS (Perrin et al., 2007), includes both inabilities to participate in activities as well as limitations in activity participation, and is consistent with a

[4] A slightly larger sample is used when evaluating the effect of any breastfeeding (8553 children including 1305 siblings discordant on breastfeeding status) since a few children reported to have been breastfed had missing data on breastfeeding duration.

[5] An average exceeding 2 children is expected in this subsample (by definition) given that only mothers with at least two children are included.

globally accepted definition of disability from the Word Health Organization (WHO, 2002). We study a comprehensive measure of disability that considers children as disabled if they meet any of the following conditions: 1- unable to perform major activity for their age; 2- limited in kind/amount of major activity for their age; and 3- limited in any other activities appropriate for their age. As mentioned above, major activity for children younger than 5 years is playing, while major activity for older children is school attendance. Non-disabled children are those without any limitations in activity participation. Our specification of the disability measure is also consistent with other studies of child disability using this dataset (MacInnes, 2008; Park et al., 2003). An alternative approach may proxy for disability based on the presence of chronic conditions, but such a definition may significantly overestimate disability since many children with chronic conditions may not experience activity limitations (Perrin et al., 2007). As described above, the prevalence rate of these chronic conditions is over twice that of disability.

The mothers were first asked about whether the child was breastfed or not. For each child who was breastfed, the mother was asked about the child's age in days when breastfeeding was stopped, which defines breastfeeding duration in cases that were breastfed. We first evaluate the average effect of breastfeeding duration across the whole sample assigning a zero value to children who were never breastfeed. This measure captures the variation in both initiation and duration of breastfeeding. Next, we decompose this effect over changes in the extensive and intensive margins, by separately estimating the effect of any breastfeeding on disability in the total sample (extensive margin), and the effect of breastfeeding duration conditional on breastfeeding (intensive margin), i.e. only for children who were breastfed. Conceptually, breastfeeding duration is likely more relevant for studying disability than a yes/no measure for any breastfeeding which includes children breastfed for very short times in the same

category as those who were breastfed for much longer durations. For example in this study sample, about 5% of the children were only breastfed for a week or less after birth and about 18% were breastfed for a month or less. Therefore, separating these effects is of interest to understanding the responsiveness of disability to breastfeeding.

We observe several other maternal and child characteristics that we include in our models as described below. The child characteristics include sex, birth order, age at the 1993 NHIS interview, birth weight and gestational age. Except for the NHIS interview date used to calculate the child's age at the 1993 interview, all of these measures are from the NSFG. Maternal characteristics include maternal age and marital status at pregnancy, pregnancy wantedness, maternal education, maternal employment after pregnancy, and family poverty level, all measured from the NSFG.

2.2 Empirical Model and Estimation

Our main model to evaluate the effects of breastfeeding on child disability is based on the following specification:

$$D_{ij} = \alpha_0 + \beta F_{ij} + \mathbf{X}_{ij}\boldsymbol{\lambda} + \mathbf{U}_{\mathbf{j}} + e_{ij} \qquad (1).$$

For child i born to mother j, child disability (D) is modeled as a function of breastfeeding duration (F) or alternatively an indicator for any breastfeeding, its effect (β), and child and maternal characteristics (**X**) that are specific to child i including child's sex, age at the NHIS interview (when disability is measured), number of previous children born to the mother before the current child, birth weight (in grams), gestational age (in weeks), pregnancy wantedness and

enthusiasm, and maternal age and marital status at the time of pregnancy with the child.[6] The model also includes mother fixed effects (**U**) in order to account for unobservable time-invariant characteristics that affect both breastfeeding and child disability such as extended family history of disability and maternal preferences for health, investment in children, risk taking, and present versus future orientedness. This model only utilizes within-mother variation from siblings who are discordant on breastfeeding duration and identifies the effect of breastfeeding duration on disability (β) *only if* the relevant unobservables are *shared* by *all* children born to the same mother, i.e. do not vary between different siblings. This is likely a reasonable assumption for several theoretically relevant unobservables that may be time-invariant such as family history of disability which may be driven by genetic influences or maternal preferences which may associate with rather stable personality traits. However, unobserved child-specific variables such as early indicators of child health problems and developmental risks that may not necessarily be captured by birth weight and gestational age may bias the estimates from this model. We discuss below the implications of these issues for our inference.

We estimate this function by a linear probability model (OLS) and weighting by the sampling probability weights available for the NHIS-NSFG merged sample in order to obtain nationally representative estimates.[7] We estimate the standard errors using a Huber-type estimator that allows for clustering at the mother level (Wooldridge, 2002).

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[6] We first estimate a specification without controlling for maternal employment since it affects breastfeeding but there is no consistent evidence that it is causally related to child disability. If so, controlling for employment as an "irrelevant variable" would inflate the standard errors of the breastfeeding (Greene, 2003). However, in an additional specification, we control for maternal employment after pregnancy and find the same pattern of results.

[7] We estimate the model using OLS instead of a conditional (fixed-effects) logit model for two reasons. First, conditional logit cannot be estimated with sampling probability weights. Second, conditional logit limits the estimation sample to siblings who are discordant on disability status not on breastfeeding.

Model (1) assumes that maternal investments in future pregnancies and children are not dependent on their behaviors and investments at previous pregnancies and on the health of previously born children. However, this may be restrictive since mothers may update their preferences for children's health and their information about household investments such as breastfeeding based on their experiences with previous children. In order to account for such possible effects of previous children, we estimate another model in which we control for the disability status of the child born to the mother before the current child.

$$D_{ij} = \alpha_0 + \beta F_{ij} + \mathbf{X}_{ij}\boldsymbol{\lambda} + \gamma P_{ij} + \mathbf{U}_{\mathbf{j}} + e_{ij} \qquad (2),$$

where *P* denotes the disability status of the child born before child i; for simplicity, we show similar coefficients in equation (2) as in equation (1) but realize that these are different after including *P*. This dynamic model is expected to account for any "feedback" effects from the previous pregnancy.

In order to empirically evaluate the extent to which the unobservable time-invariant maternal characteristics may bias the effect of breastfeeding if ignored, we also estimate the above two models using OLS without maternal fixed effects and compare the estimate of β from those models to the models with maternal fixed effects.[8] When excluding maternal fixed effects,

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Since disability is relatively rare (6.8%), this significantly reduces the estimation sample size to 834 observations, which may limit the generalizability of the estimates. Even though a linear probability model is generally less preferred than a logit model, the linear probability model should provide a consistent estimate of the "average" effect of breastfeeding duration (or any breastfeeding) on the probability of becoming disabled (β).

[8] The equations for the OLS models without maternal fixed effects are as follows:

$$D_{ij} = \alpha_0 + \beta F_{ij} + \mathbf{X}_{ij}\boldsymbol{\lambda} + \mathbf{M}_{\mathbf{j}}\boldsymbol{\delta} + u_j + e_{ij} \qquad (1a),$$

$$D_{ij} = \alpha_0 + \beta F_{ij} + \mathbf{X}_{ij}\boldsymbol{\lambda} + \mathbf{M}_{\mathbf{j}}\boldsymbol{\delta} + \gamma P_{ij} + u_j + e_{ij} \qquad (2a),$$

we add observed time-invariant maternal characteristics including race, highest educational level and household poverty level, as reported in the 1995 NSFG interview.[9]

3. Results

3.1 Sample description

Table 1 reports the study variables and weighted summary statistics. About 6.7% of the sample children have a disability based on the activity limitation measure described above, which is consistent with previously reported estimates from the NHIS data (Perrin et al., 2007). Average breastfeeding time is 3.5 months when assigning 0s for children who were not breastfed at all and is 6.7 months among breastfed children. The children were about 8 years old on average at the 1993 NHIS survey with a range from 1 to 18 years. Average maternal education is 12.6 schooling years, and average household income is about 280% of the federal poverty line.

3.2 Breastfeeding effects

Table 2 shows the effects of breastfeeding in the child disability regression of equation (1). Column 1 shows a linear probability model including maternal fixed effects, while column 2 shows the same model restricting the sample to siblings who are discordant on the breastfeeding measure; without covariates, the breastfeeding effect would be identical between the two estimations, but may slightly vary when including covariates. We first describe the

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where u is unobservable time-invariant maternal characteristics, and **M** is a vector of observable time-invariant characteristics such as education.

[9] Maternal education and household poverty level may vary at different pregnancies within the same mother. However, these characteristics are only available from the NSFG in 1995 in the NHIS-NSFG merged dataset. Therefore, these measures are considered the same across all children born to the mother in the dataset.

results under Panel A which reports the effects of breastfeeding duration including both breastfed children and those who were not breastfed and were assigned a zero on this measure.[10] In this model, breastfeeding duration has a significant negative effect on child disability; breastfeeding the child for an additional month is associated with a lower probability of disability by about 0.2 percentage-points, or by about 3% relative to the population disability rate. The effect is virtually the same whether all children are included or only siblings discordant on breastfeeding duration.

In column 3 of Table 2, we report the effects of breastfeeding from the linear probability model without maternal fixed effects (which uses both within- and between-mother variation). The effect of breastfeeding duration in that model including all children is very close to that in the model with fixed effects; a one-month increase in breastfeeding duration is associated with a 0.18 percentage-point decrease in the child's probability of having a disability. The relative similarity between the two estimates suggests that unobservable time-invariant characteristics have little influence on the magnitude of estimates in this specification.

Turning next to the results for any breastfeeding shown in panel B of Table 2, we find insignificant effects on child disability in all models with or without maternal fixed effects. The breastfeeding coefficient is of the positive (unexpected) sign when including maternal fixed effects.[11]

In contrast, we find significant negative effects of breastfeeding duration among breastfed children in all models (panel C of Table 2) that are slightly bigger than those for breastfeeding

[10] Full regression results of this specification are in Appendix Table A1.
[11] This may be partly driven by the smaller number of siblings that are discordant on breastfeeding status than duration (1305 versus 2152 children) and potentially limited variation in within-mother estimation in this model.

duration across the entire sample (panel A). Combined with the results for any breastfeeding, these results suggest that child disability is likely sensitive to prolonged breastfeeding but not to very short durations of breastfeeding. The effect of breastfeeding duration conditional on breastfeeding is slightly bigger when including maternal fixed effects than in the model excluding these effects; an additional month of breastfeeding is associated with a decrease in child disability risk by about 0.28 percentage-points, compared to 0.22 percentage-points when excluding maternal fixed effects. However, the relatively small difference between these estimates again suggests that unobservable time-invariant characteristics are unlikely to substantially bias the effects of breastfeeding on child disability.

In order to account for feedback effects from the previous pregnancy, we re-estimate the child disability regression controlling for the disability status of the previous child as mentioned above (equation 2). The results from this regression, shown in Table 3, are consistent with the previous results. Despite the decrease in the sample size, the estimates of breastfeeding duration conditional on breastfeeding are identical to those excluding the disability status of the next older sibling and are significant in all specifications (panel C). In contrast to the earlier specification ignoring effects from the prior child, the effects of any breastfeeding when allowing for these effects switch to negative in the model including maternal fixed effects but remain insignificant (panel B). The effects of breastfeeding duration across the entire sample (when assigning 0 on duration for non-breastfed children) are all significant and slightly bigger with maternal fixed effects in this specification (equation 2) than the earlier one excluding effects from disability status of prior child (equation 1).

3.3 Additional specifications

Our main disability measure combines both moderate and severe disabilities. This measure allows for a potential effect of breastfeeding on risk of any disability and avoids a potential sample-selection bias from selecting the sample based on disability level. However, it is possible that the risk of severe disabilities is less sensitive to breastfeeding than moderate disabilities. Our sample includes a very small number of children with severe disabilities (defined by being *unable* to perform the major activity appropriate for their age including attending school for children 5 years and older) representing about 10% of the children with disabilities and 0.6% of the total sample. In order to evaluate the sensitivity of the results to different levels of disability, we re-estimate the main model (equation 1) excluding children with severe disabilities. We find an overall similar pattern of results (Appendix Table A2), suggesting that the estimates are mainly driven by moderate or less than severe disability (*limited* in performing the major activity but still able to perform it).

We also evaluate a specification that controls for maternal employment after pregnancy. As mentioned above, we exclude employment from the main specification since there is no consistent evidence that it is causally related to child disability and to avoid inflated standard errors from including an "irrelevant variable" (Greene, 2003). Adding maternal employment has no effect on the pattern of results described above. Being employed has insignificant effects on child disability in the mother fixed effect models but is associated with a decrease in disability risk in the model without fixed effects.[12]

[12] Employment is associated with shorter breastfeeding duration by about 1 month (based on comparing employment changes within the same mother).

4. Conclusions

We find that prolonged breastfeeding is associated with reduced risk of child disability and activity limitations across multiple specifications. Our estimates suggest that breastfeeding for six months compared to no breastfeeding is associated with a lower risk of disability by 1.3 percentage-points or 19% relative to the population disability rate of 6.7%. Very short breastfeeding durations are unlikely to have an effect on reducing disability risk. To the best of our knowledge, this is the first study to shed light on a potential effect of breastfeeding on direct measures of child disability in a nationally representative U.S. sample.[13] Several studies using U.S. data suggest benefits to multiple infant and child health and development outcomes from breastfeeding, but none includes direct measures of disability. Our findings complement this literature and lend further support to the potential value of breastfeeding as an input for a broad range of child health and development outcomes that in addition to cognitive and non-cognitive skill development may include outcomes such as disability and activity limitations that may be thought of as less sensitive to such household activities.

[13] All our estimations use the sampling probability weights for this survey sample to obtain nationally representative estimates; therefore the estimates should be well generalizable to the population. The overall similarity of the estimates across all models (maternal fixed effects in entire sample, fixed effects from discordant sibling sample, and classical estimation without fixed effects using entire sample) suggests that estimates are generalizable across different sources of variation. The similarity of the disability rate in this study to the population rate using similar disability definitions also supports the generalizability of the results. Appendix Table A4 compares the subsample with discordant siblings on breastfeeding duration (with 0 assigned to non-breastfed children) to the entire sample on both maternal and child characteristics. The subsample of discordant siblings is comparable to the entire sample on most child and maternal characteristics including child disability, sex, age at interview, and gestational age, maternal age, pregnancy wantedness, and maternal education and employment. The discordant sibling subsample has higher breastfeeding rates and slightly longer breastfeeding durations conditional on breastfeeding, more children in the family, slightly higher birth weight on average, fewer single mothers, and a smaller proportion of black mothers. Most of these differences are driven by the rule for constructing this subsample requiring that only mothers with at least two children discordant on breastfeeding duration are included. However, these differences have no real impact on the generalizability of the results from the discordant sibling subsample given the similarity of the estimates obtained from this subsample to the model with maternal fixed effects using the entire sample and to the model without fixed effects (using both within- and between-mother variation in the entire sample).

Our estimation relies on comparing the disability status between siblings who differ on breastfeeding duration, which removes the effect of unobservable time-invariant maternal and family-level confounders. We find that these estimates are very close to those that also compare children across different families, suggesting that family-level unobservables do not substantially bias those estimates.[14] However, as mentioned above, sibling comparisons are still limited by unobservable child-specific and time-varying family/maternal characteristics relevant to both breastfeeding choices and child health and development. Early manifestations of child health problems are examples of such factors. For example, breastfeeding may be difficult (but not impossible) for children with certain congenital anomalies (end n - ac as et al., 2002), even though breastfeeding is encouraged among children with such anomalies (Barbas and Kelleher, 2004). Such cases may bias the estimates towards suggesting greater (more beneficial) breastfeeding effects. However, congenital malformations are overall rare, collectively affecting around 3% of children (CDC, 2013). A similar bias may result from breastfeeding being likely one of many other household activities and investments toward child development such as educational investments and avoiding risk behaviors such as smoking during pregnancy (Wehby et al., 2012; Wehby et al., 2011). In contrast, an opposite bias could occur if mothers choose to breastfeed children with a higher disability risk for a longer duration. Therefore, it is unclear based on theory alone whether the breastfeeding effect may be over or underestimated from

[14] The slightly larger effects of breastfeeding duration conditional on breastfeeding when maternal fixed effects are included may suggest as small bias towards underestimating the effect in analyses comparing children across families. This may be explained by family history of disability if mothers who have a positive disability history in their extended family (such as due to genetic influences) perceive a stronger incentive to breastfeed their children as a safeguard to reduce their risk of having a disabled child and if positive family history of disability increases the risk of child disability. Indeed, we find that the disability status of the prior child is positively related to that of the currently child excluding maternal fixed effects. However, again our results suggest that any potential bias from unobservable time-invariant confounders is rather small.

child-specific and time-varying unobservables as the net bias may be a function of opposite biases.

We control as much as possible with this dataset for observable child-specific and time-varying maternal factors, several of which were related to breastfeeding.[15] Among these are indicators for birth weight and gestational age, which are important early markers for child health. It is also possible that bias from unobservable child-specific factors is larger for any breastfeeding than for breastfeeding duration among breastfed children which only applies to mothers who breastfed all their children (albeit for different durations) and may therefore represent a group that is more selective of breastfeeding and possibly less influenced by child-specific factors in their choice of breastfeeding. However, we cannot rule out an influence from such unobservables on the observed results for either of the breastfeeding measures. We leave this question for future research with data that provide child-specific instruments for breastfeeding status and duration which are unavailable in this dataset.

[15] In a descriptive regression for breastfeeding status over child-specific and time-varying maternal characteristics and maternal fixed effects, we find that the likelihood of any breastfeeding increases with maternal age but decreases with birth order, not wanting the pregnancy, and being unenthusiastic about the pregnancy. The birth weight and gestational age coefficients are positive but insignificant (p=0.11 and 0.13, respectively). Similar differences are observed when regressing breastfeeding duration among breastfed children over these variables (decline with birth order marginally significant); a decline in breastfeeding duration is also observed among employed mothers. The birth weight and gestational age coefficients are positive and insignificant (p values of 0.38 and 0.94) in the regression of breastfeeding duration conditional on breastfeeding, but they are significant in the total sample when assigning a zero value on breastfeeding duration to children who were not breastfed.

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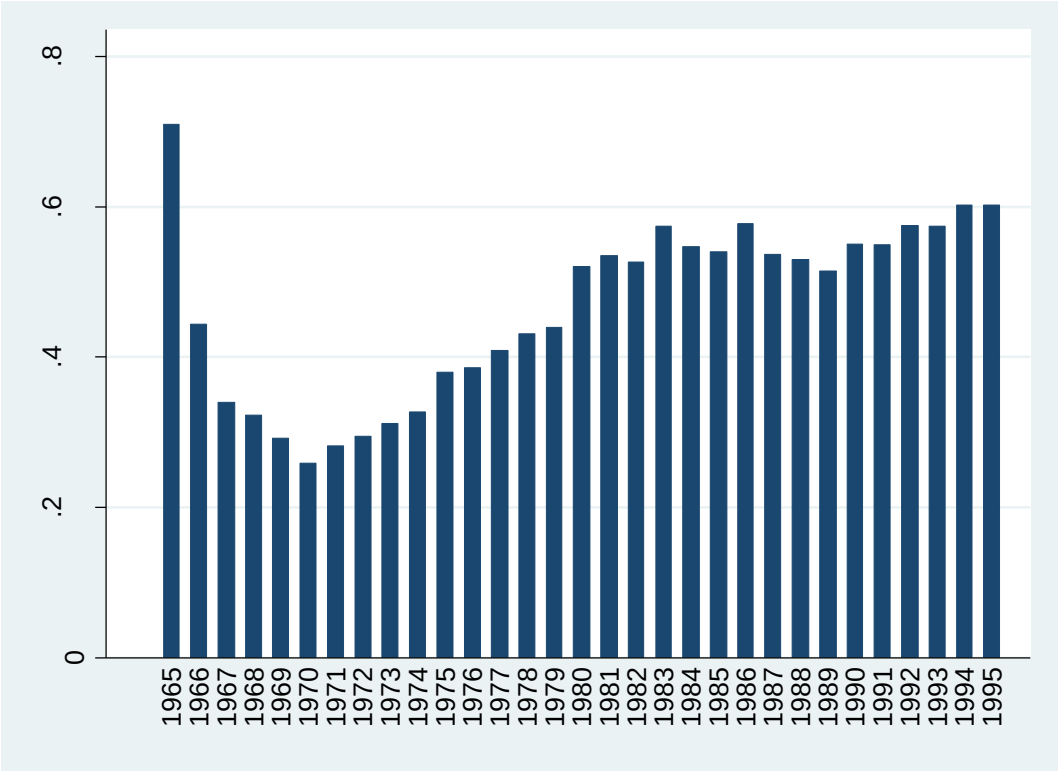
Figure 1: Breastfeeding rates between 1965 and 1995



Note: The Figure shows weighted breastfeeding rates for children born in 1965 through 1995 from the 1995 National Survey of Family Growth (NSFG).

Table 1. Study Variables

Variable	Description	Mean	Standard Deviation
Child disability	0/1 indicator for a disabled child based on activity limitations	0.069	0.254
Any breastfeeding [a]	0/1 indicator for any breastfeeding	0.521	0.5
Breastfeeding duration	Breastfeeding duration in months based on child's age when breastfeeding stopped (including 0 for no breastfeeding)	3.532	5.79
Breastfeeding duration | duration>0[b]	Breastfeeding duration in months among breastfed children	6.68	6.459
Female	0/1 indicator for a female child	0.486	0.5
Child age	hild's age in years at the NHIS 1993 survey	8.426	4.63
Previous children	Number of previously born children	0.806	0.969
Birth weight	child's birth weight in grams	3382.4	570.5
Gestational age	Child's gestational age in weeks	38.9	2.0
Maternal age	Maternal age at pregnancy with the child in years	25.298	4.808
Single	0/1 indicator for a single mother at pregnancy with the child	0.286	0.452
Unwanted[c]	0/1 indicator for mother reporting that pregnancy was unwanted	0.091	0.288
Unenthusiastic[c]	0/1 indicator for mother being unenthusiastic about the pregnancy	0.251	0.434
Previous child disabled[d]	0/1 indicator for the child born before the current child being disabled	0.038	0.191
Black[e]	0/1 indicator for black mother	0.139	0.346
Other race[e]	0/1 indicator for mother being of other race	0.061	0.24
Maternal education	Highest maternal education at 1995 NSFG interview based on total schooling years	12.601	2.716
Household poverty	Total household income at 1995 NSFG as a percentage of the federal poverty line	279.265	187.925
Work[f]	0/1 indicator for mother being employed after pregnancy with current child	0.389	0.488

Notes: Means and standard deviations are weighted by sampling probability weights. Lack of enthusiasm is defined as mother reporting that pregnancy was too soon or mistimed, that she did not care or was indifferent, or did not know or was not sure if pregnancy was wanted. The descriptive statistics are based on 8505 children with data on breastfeeding duration and other child and maternal characteristics except where noted.

[a] Based on 8539 observations (a few children had data that they were breastfed but missing data on breastfeeding duration).

[b] 4185 children were breastfed.

[c] Reference category is wanted pregnancy.

[d] Applicable to 7604 children.

[e] Reference category is White.

[f] Available for 8306 observations.

Table 2. Breastfeeding Effects on Disability

Sample	Any child	SB	Any child
Maternal fixed effects	Yes	Yes	No[a]
A. Breastfeeding duration (including 0 for non-breastfed children)	-0.0021**	-0.0019*	-0.0018***
	(0.001)	(0.001)	(0.0004)
N	8519	3284	8505
R^2	0.015	0.018	0.017
B. Any breastfeeding (0/1) [b]	0.0108	0.0107	-0.0059
	(0.017)	(0.0172)	(0.0068)
N	8553	1305	8539
R^2	0.014	0.023	0.016
C. Breastfeeding duration among breastfed children	-0.0028**	-0.0027**	-0.0022***
	(0.0013)	(0.0013)	(0.0005)
N	4192	2152	4185
R^2	0.020	0.029	0.022

Notes: The Table reports the effects of breastfeeding on probability of child disability under different estimations (standard errors in parentheses).
SB = siblings discordant on breastfeeding measure
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.
[a] The sample size is slightly lower when excluding maternal fixed effects since additional time-invariant covariates (maternal education, race, and family income level are included); therefore the few observations with missing data on these additional covariates are dropped.
[b] The sample sizes in panel B when including all children are slightly larger than those in panel A because they include a few children with data that they were breastfed but with missing data on breastfeeding duration.

Table 3. Breastfeeding Effects on Disability Controlling for Disability Status of Prior Sibling

Sample	Any child	SB	Any child
Maternal fixed effects	Yes	Yes	No
A. Breastfeeding duration (including 0 for non-breastfed children)	-0.0024**	-0.0022**	-0.0017***
	(0.001)	(0.001)	(0.0004)
N	7617	2979	7604
R^2	0.293	0.295	0.028
B. Any breastfeeding (0/1)	-0.0026	-0.0033	-0.0032
	(0.0151)	(0.0153)	(0.007)
N	7651	1185	7638
R^2	0.293	0.268	0.027
C. Breastfeeding duration among breastfed children	-0.0028**	-0.0027**	-0.0022***
	(0.0012)	(0.0012)	(0.0005)
N	3845	1951	3838
R^2	0.306	0.318	0.034

Notes: The Table reports the effects of breastfeeding on probability of child disability under different estimations (standard errors in parentheses).
SB = siblings discordant on breastfeeding measure
** $p < 0.05$, *** $p < 0.01$.
The explanations for differences in sample sizes between models are the same as in Table 2 footnotes.

Appendix

Table A1. Disability Regression Results

Maternal fixed effects	Yes	No
Breastfeeding duration	-0.002**	-0.002***
	(0.001)	(0.000)
Female	-0.037***	-0.027***
	(0.009)	(0.006)
Child age	-0.017	0.005***
	(0.015)	(0.001)
Birth order	-0.004	-0.002
	(0.009)	(0.003)
Birth weight	-9.8×10^{-06}	-3.8×10^{-06}
	(1.2×10^{-05})	(6.6×10^{-06})
Gestational age	-0.002	-0.003
	(0.004)	(0.002)
Maternal age	-0.019	-0.001
	(0.015)	(0.001)
Single	0.038**	0.011
	(0.016)	(0.009)
Unwanted	-0.018	0.010
	(0.018)	(0.012)
Unenthusiastic	-0.005	-0.006
	(0.011)	(0.008)
Black		-0.001
		(0.010)
Other race		-0.003
		(0.014)
Maternal education		-0.001
		(0.001)
Household poverty		-0.000
		(0.000)
Constant	0.857*	0.205**
	(0.506)	(0.086)
Observations	8519	8505
R^2	0.015	0.017

Notes: The Table reports the effects of the study variables on child disability under different estimations (standard errors in parentheses).
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table A2. Breastfeeding Effects on Disability Excluding Children with Severe Disability

Sample	Any child	SB	Any child
Maternal fixed effects	Yes	Yes	No
A. Breastfeeding duration (including 0 for non-breastfed children)	-0.0018*	-0.0016*	-0.0015***
	(0.001)	(0.001)	(0.0004)
N	8468	3258	8454
R^2	0.015	0.018	0.017
B. Any breastfeeding (0/1)	0.021	0.020	-0.0027
	(0.016)	(0.017)	(0.0067)
N	8502	1285	8488
R^2	0.015	0.022	0.016
C. Breastfeeding duration among breastfed children	-0.0029**	-0.0028**	-0.002***
	(0.0013)	(0.0013)	(0.0005)
N	4181	2141	4174
R^2	0.018	0.028	0.0005

Notes: The Table reports the effects of breastfeeding on probability of child disability under different estimations (standard errors in parentheses).
SB = siblings discordant on breastfeeding measure
* p < 0.1, ** $p < 0.05$, *** $p < 0.01$.
The explanations for differences in sample sizes between models are the same as in Table 2 footnotes.

Table 3A. Breastfeeding Effects on Disability Controlling for Maternal Employment

Sample		Any child	SB	Any child
Maternal fixed effects		Yes	Yes	No
A. Breastfeeding duration (including 0 for non-breastfed children)		-0.0020*	-0.0018*	-0.0019***
		(0.001)	(0.001)	(0.0004)
	N	8320	3166	8306
	R^2	0.016	0.019	0.018
B. Any breastfeeding (0/1)		0.0121	0.0137	-0.0056
		(0.0177)	(0.0179)	(0.007)
	N	8353	1241	8339
	R^2	0.015	0.031	0.017
C. Breastfeeding duration among breastfed children		-0.0028**	-0.0028**	-0.0023***
		(0.0013)	(0.0013)	(0.0005)
	N	4100	2088	4093
	R^2	0.019	0.028	0.023

Notes: The Table reports the effects of breastfeeding on probability of child disability under different estimations (standard errors in parentheses).
SB = siblings discordant on breastfeeding measure
* p < 0.1, ** p < 0.05, *** p < 0.01.
The explanations for differences in sample sizes between models are the same as in Table 2 footnotes.

Table A4. A Comparison of Study Variables between Total Sample and Subsample of Siblings Discordant on Breastfeeding

Variable	Total Sample	Discordant Siblings
Child disability	0.069	0.07
	(0.254)	(0.255)
Any breastfeeding	0.52	0.807
	(0.5)	(0.395)
Breastfeeding duration	3.543	5.919
	(5.8)	(6.831)
Breastfeeding duration | duration>0	6.81	7.34
	(6.51)	(6.89)
Female	0.485	0.477
	(0.5)	(0.5)
Child age	8.419	8.696
	(4.622)	(4.308)
Previous children	0.809	0.982
	(0.968)	(1.01)
Birth weight	3385.1	3436.2
	(568.9)	(551.5)
Gestational age	38.877	38.978
	(2.009)	(1.939)
Maternal age	25.325	25.935
	(4.809)	(4.659)
Single	0.282	0.185
	(0.45)	(0.388)
Unwanted	0.087	0.076
	(0.281)	(0.265)
Unenthusiastic	0.247	0.236
	(0.432)	(0.425)
Black	0.137	0.073
	(0.344)	(0.259)
Other race	0.06	0.071
	(0.237)	(0.256)
Maternal education	12.603	12.966
	(2.718)	(2.707)
Household poverty	279.599	283.547
	(187.482)	(169.807)
Work	0.379	0.352
	(0.485)	(0.478)

Notes: Means and standard deviations (in parentheses) are weighted by sampling probability weights. Variable definitions are the same as in Table 1. The total sample includes 8306 children with complete data on all variables. The discordant sibling sample includes 3208 siblings who are discordant on breastfeeding duration (with zero values assigned to non-breastfed children) and have complete data on all variables.