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Journal

Pediatric Obesity, 12(4)

ISSN

2047-6302

Authors

Modrek, S
Basu, S
Harding, M
et al.

Publication Date

2017-08-01

DOI

10.1111/ijpo.12143

Peer reviewed

HHS Public Access
Author manuscript
Pediatr Obes. Author manuscript; available in PMC 2019 June 21.

Published in final edited form as:
Pediatr Obes. 2017 August ; 12(4): 304–311. doi:10.1111/ijpo.12143.

Does breastfeeding duration decrease child obesity? An instrumental variables analysis

S. Modrek[1], **S. Basu**[1], **M. Harding**[2], **J. S. White**[3], **M.C. Bartick**[4], **E. Rodriguez**[5], and **K. D. Rosenberg**[6]

[1]Stanford University School of Medicine Palo Alto, CA, USA

[2]Sanford School of Public Policy, Duke University, Durham, NC, USA

[3]University of California, San Francisco, San Francisco, CA, USA

[4]Cambridge Health Alliance Somerville Hospital Somerville, MA, USA

[5]School of Medicine, Stanford University, Palo Alto, CA, USA

[6]Oregon Health & Science University, Portland, OR, USA

Summary

Background—Many studies have documented that breastfeeding is associated with a significant reduction in child obesity risk. However, a persistent problem in this literature is that unobservable confounders may drive the correlations between breastfeeding behaviors and child weight outcomes.

Objective—This study examines the effect of breastfeeding practices on child weight outcomes at age 2.

Methods—This study relied on population-based data for all births in Oregon in 2009 followed for two years. We used instrumental variables methods to exploit variations in breastfeeding by mothers immediately after delivery and the degree to which hospitals encouraged mothers to breastfeed in order to isolate the effect of breastfeeding practices on child weight outcomes.

Results—We found that for every extra week that the child was breastfed, the likelihood of the child being obese at age 2 declined by 0.82% [95% CI 1.8% to 0.1%]. Likewise, for every extra week that the child was exclusively breastfed, the likelihood of being obese declined by 0.66% [95% CI 1.4 to 0.06%]. While the magnitudes of effects were modest and marginally significant, the results were robust in a variety of specifications.

Address for correspondence: S Modrek, Stanford University School of Medicine, 1070 Arastradero Road, Rm 257, Palo Alto, CA 94304-1334, USA. smodrek@stanford.edu.

Conflict of interest
The authors have no COI to report.

Ethics
We received de-identified data from the Oregon Health Authority Center for Health Statistics. Our protocol was reviewed by the Oregon Health Authority Center for Health Statistics' internal committee. In addition, Stanford's IRB approved this study. Individual consent was waived because of an epidemiological exemption.

Supporting Information
Additional Supporting Information may be found in the online version of this article at the publisher's web-site:

Conclusion—The results suggest that hospital practices that support breastfeeding may influence childhood weight outcomes.

Keywords

Breastfeeding; child obesity; hospital practices; instrumental variable analysis

Introduction

While breastfeeding has been associated with a significant reduction in child obesity (1,2), the relationship is controversial because women who breastfeed differ from those who do not, often in hard-to-measure ways (e.g. not just in income or maternal weight, but parental teaching of children in nutritional topics). In addition, inconsistent associations between breastfeeding and child obesity have been found in observational studies (3–9), and no association in the only randomized trial (10), which was underpowered with low breastfeeding rates (11% in control and 19% in treatment arms) and no comparison of fully formula-fed to breastfed infants (11). The Centers for Disease Control (CDC) has concluded that the inconsistent findings are potentially because of the widespread reliance on low-quality surveys that fail to have consistent follow-up or measure important socioeconomic confounders (12). Both the Institute of Medicine and CDC have noted that more evidence is needed from longitudinal studies to determine whether breastfeeding strategies actually manifest in significantly lower obesity rates, controlling for critical social confounders that account for selection into breastfeeding (13,14).

In this study, we conducted standard multivariable regressions in addition to a quasi-experimental methodology—an instrumental variables (IV) approach, which uses quasi-random variation in the exposure of interest (breastfeeding duration) to control for unobserved or unmeasured confounders—to examine the causal relationship between breastfeeding and child obesity (15). We used longitudinal data from the 2009 Oregon Pregnancy Risk Assessment Monitoring System (Oregon PRAMS) and the 2011–2012 follow-up survey (Oregon PRAMS-2), which selected a representative sample of children born in Oregon in 2009 to survey their mothers 2–6 months postpartum and again when the child was two years old. We exploited variations in breastfeeding by mothers immediately after delivery and the degree to which different hospitals encouraged women to breastfeed; these quasi-random variations allow us to isolate the effect of breastfeeding practices on obesity outcomes, without the influence of individual-level unobserved confounders (e.g. cultural and socioeconomic factors). In addition, our analyses controlled for important social and economic confounding variables that were not included in prior analyses, such as participation in the Special Supplemental Nutrition Program for Women, Infants and Children (WIC).

Methods

Data

Sampling—Data were obtained from three linked sources: PRAMS for 2009 births; the follow-up survey, Oregon PRAMS-2 and the birth certificates of the respondents' infants.

PRAMS is a state-based system of surveys of postpartum women (2–6 months after a live birth) established by the CDC and conducted by many state health departments (http://www.cdc.gov/prams/). Women were selected by stratified random sampling from birth certificates every month. Oregon oversampled mothers who identify themselves as belonging to a racial/ethnic minority. PRAMS respondents were surveyed again when their child was two years old (16). These mothers received a second survey, PRAMS-2, shortly after the index child's second birthday. Oregon PRAMS-2 was administered to all mothers who responded to the Oregon PRAMS survey, except those who indicated that they did not wish to be contacted again or whose babies were deceased. This analysis is based on data from women who had a live birth in 2009 and completed both PRAMS surveys. The data are weighted for non-response and oversampling to provide a population-based, representative sample of all Oregon births in 2009 (see Supplemental Appendix 2 for details on weighting and sample selection).

Variables used in the analyses are detailed below. Supplemental Table 1 shows the analytic sample size and number of missing observations, and Supplemental Table 2 compares the means of the analytic and overall samples.

Outcome variables: child weight categories—The primary outcome variables include two measures of a child's weight status at age 2: whether a child is overweight or not, and whether the child is obese or not. For each child we calculated BMI based on parent-reported weight and height. We then classified each child's BMI as an indicator variable of whether the child is overweight or obese, based on the child's gender and age in months using international cut-offs (17).

Breastfeeding variable—Using maternal self-reported responses from the PRAMS-2 survey, we examined three breastfeeding variables: ever breastfed, number of weeks of breastfeeding and number of weeks of exclusive breastfeeding (no other liquids or foods). Previous studies suggest that maternal recall is a valid and reliable measure of breastfeeding practices, especially when recall is less than 3 years (18). In Supplemental Table 3, we present data on our breastfeeding variables by child weight categories. Although previous studies used dichotomous measures such as breastfeeding exclusivity at three or six months, we use a continuous measure in weeks to facilitate the IV analysis.

Control variables—In each regression model, we included a series of control variables to account for differences in breastfeeding behavior and child obesity outcomes. We included several socio-demographic variables for the mother: household income, education level, employment, marital status, age and insurance status. In addition, we controlled for mothers' weight and health characteristics: weight, height, weight gain during pregnancy, parity at time of birth, number of prenatal visits grouped into three levels (≤8 visits, 9–11 visits, ≥12 visits), and whether she experienced gestational diabetes during her pregnancy. (19) We also controlled for the mother's race/ethnicity, paternal education level, child's birth weight and whether the child ever received WIC benefits. Finally we included county of residence fixed effects (i.e. indicator variables) to account for differences in breastfeeding norms across counties and in rural vs. urban areas. Supplemental Table 4 details the data source from which each variable was derived.

Instrumental variables: hospital breastfeeding—As part of the initial Oregon PRAMS survey, mothers were asked about their breastfeeding experience during the newborn hospitalization. The events of the immediate postpartum period have been shown to be highly associated with initiation, duration and exclusivity of breastfeeding (20,21).

Mothers were asked 10 questions about hospital support of breastfeeding in the newborn hospitalization (Supplemental Table 5). Previous research has documented associations between hospital support for breastfeeding and subsequent maternal breastfeeding practices (21–23). We examined each variable's relationship with breastfeeding behavior after controlling for the covariates listed above. Two hospital support variables were most strongly associated with breastfeeding duration and exclusivity behavior: (i) 'My baby was fed only breast milk at the hospital,' and (ii) 'Hospital staff gave me information about breastfeeding,' (Supplemental Table 6).

Statistical methods

We conducted two sets of statistical analyses. First, we estimated logistic regressions to assess the associations between ever breastfeeding, breastfeeding duration and breastfeeding duration exclusivity and child obesity status at age 2. We used an indicator variable to capture whether a child was ever breastfed. We measured breastfeeding duration and breastfeeding exclusivity in weeks and used the continuous variables throughout the analyses. We then employed an IV analysis to estimate the effect of breastfeeding on child obesity outcomes. IV analysis is a quasi-experimental method that addresses the challenge in which the relationship between a predictor (Breastfeeding duration) and an outcome (Child obesity) is confounded by unobserved characteristics (U), and in which the predictor is not randomized (Supplemental Fig. 1). IV analysis relies on the existence of a quasi-randomly assigned variable (Z), which impacts the outcome (Y) only through the exposure (X). We assume that the variation on whether a mother exclusively breastfed her newborn while in the hospital—influenced by hospital support policies—affects childhood obesity at age 2 through its impact on the duration of breastfeeding and breastfeeding exclusivity. In the first stage of the IV model, we use variation on whether a mother exclusively breastfed her newborn while in the hospital to predict duration of breastfeeding and breastfeeding exclusivity. In the second stage, this predicted breastfeeding duration is used as the key independent variable to examine the effects on child obesity outcomes at age 2. While this addresses the probable confounding present in the associations between breastfeeding and obesity in the first set of models, residual confounding may persist in the case of an imperfect instrument; the covariates described above are therefore included in these IV models as well.

The IV analysis relies on two key assumptions about the instrument. First, there is a strong association between the IV and outcome variable—in our case initial hospital breastfeeding experience strongly predicts breastfeeding duration and exclusivity. Second, the exclusion restriction holds, meaning that the IV only impacts child weight status at age 2 through breastfeeding practices (See Wooldridge 2013 for estimation methods) (24).

We empirically test whether we have satisfied the first assumption. As shown in Supplemental Table 6, mothers who indicated that their baby was fed only breast milk in the hospital breastfed longer and exclusively longer. In Supplemental Fig. 2 we present the survival plot of duration and exclusivity duration of breastfeeding by whether a child was fed only breast milk in the hospital. It confirms that women who only fed their baby breast milk in the hospital breastfed longer and were more likely to exclusively breastfeed longer, especially in the first few weeks postpartum.

Establishment of early breastfeeding during the newborn hospitalization is conceptually related to breastfeeding duration and exclusivity through three main pathways: whether the mother wants to breastfeed; the latch between mom and child immediately postpartum and whether the hospital and its staff have policies and practices in place to support the mother and child in initial attempts to establish breastfeeding (20). In Oregon, 91% of mothers initiate breastfeeding (25), and in our sample 96% of mothers initiate breastfeeding. Therefore, there is likely little selection on the kind of mother who wants to breastfeed (poor/rich, working/not working, educated/ not educated, parity) because most mothers want to and do indeed breastfeed, and those who do not tend to have breastfeeding difficulties (see Supplemental Appendix 1 for more details). Whether a child is fed only breast milk in the hospital is dependent on the initial attempts to latch between the mother and the child and the hospital support for these early breastfeeding attempts. For example, hospitals policies support early breastfeeding by (i) ensuring that newborns do not receive formula when he/she has a good latch, (ii) supporting positioning mother and child to find a good latch and (iii) avoid giving formula to newborns when it is not medically indicated. We control for many socioeconomic and child health characteristics that may be related to this initial latch, such as birth weight.

In sensitivity analyses, we conducted over-identification tests where we present regressions using other hospital experience variables as an additional instrument (24). This analysis can indicate how sensitive our estimates are to the selection of a particular instrument. We also present regressions where we examine the relationship between hospital breastfeeding experience and child weight outcomes directly; this is referred to as the reduced form regression.

We present marginal effects for the logistic regression so that they can be directly compared to the IV regression. All regression models correct the standard errors for clustering at the county level and the PRAMS sample weights (26). The PRAMS sample weights adjust for oversampling of underrepresented racial and ethnic populations, low birth weight infants and non-response across waves.

Results

Table 1 presents the summary statistics for the analytic sample, showing the weighted mean and 95% confidence interval for each variable. The sample consists mostly of white children, 76%. Thirty percent of the children’s mothers were employed full-time during pregnancy, and 73% were married. One-quarter of the children were categorized as overweight at age 2 and 11% were categorized as obese. Among these children, 96% were ever breastfed. The median duration of breastfeeding was 40 weeks and median duration of breastfeeding exclusivity was 20 weeks. Approximately 74% of the children were fed only breast milk during the newborn hospitalization.

Table 2 presents the marginal effects of breastfeeding practices on the probability the child is overweight or obese at age 2, derived from a logistic regression. The marginal effects give the difference in predicted probability for a one-unit change in the independent variable of interest. The results show that breastfed children were 13% less likely to be overweight [95% CI–28%, 1.4%, $p = 0.08$] and 17% less likely to be obese [95% CI–26%, 7.4%] at age 2. The association between the duration of breastfeeding and whether a child was overweight at age 2 was also statistically significant. The results suggest that for every extra week a child is breastfed, the probability that the child is overweight at age 2 declined by 0.19% [95% CI–0.31%, 0.07%]. There is no statistically significant association between the duration of exclusive breastfeeding and whether the child is overweight or obese at age 2. Supplemental Table 7 presents the full regression results.

Table 3 presents the estimated effects of breastfeeding practices on child weight using the IV approach. The first and second columns present the first-stage regressions where we use the hospital experience variable to predict breastfeeding duration and exclusivity (extended results presented in Supplemental Table 8). Controlling for child's and mother's characteristics, women whose child was fed only breast milk at the hospital increases their breastfeeding duration by 7 weeks and breastfeeding exclusivity by 8.8 weeks. Hospital experience is a strong predictor for breastfeeding exclusivity, as indicated by an F-statistic on the excluded instrument greater than 10 (27).

In the third column, we observe no significant relationship between breastfeeding duration and exclusivity on whether a child is overweight at age 2, based on two separate IV regressions. In the fourth column, we find that for every extra week that the child was breastfed, the likelihood of the child being obese declined by 0.82% points [95% CI 1.8% to 0.1%]. The magnitude is similar for breastfeeding exclusivity: 0.66% points [95% CI–1.3% to 0.06%]. Given that the obesity rate in the sample is 11%, the estimated magnitudes translate to a clinically significant reduction of 7.4% and 6.6% per week, respectively.

In Supplemental Table 9, we present sensitivity analyses using an extra instrument to check the robustness of the IV results. Regardless of whether we use one or two instruments to predict breastfeeding practices, the likelihood of the child being overweight declined for every extra week a child was breastfed exclusively. Estimates of the likelihood that a child was overweight at age 2 varied between −0.8% and 1.0% points across models, and none of these estimates were significantly different from each other. We also found that for every extra week a child was breastfed exclusively, the likelihood of the child being obese declined and estimates were consistent at −0.6% points across models. The additional instrument did not substantially change the estimated coefficients suggesting that our IV results are robust.

In Supplemental Table 10, we present the reduced form regression between hospital breastfeeding experience and policies and child obesity outcomes at age 2 directly. Children who were fed only breast milk during the newborn hospitalization were 6.7% points less likely to be overweight and 5.1% points less likely to be obese at age 2.

Discussion

We found a marginally significant relationship between duration of breastfeeding and duration of breastfeeding exclusivity and whether a child was obese at age 2, and between duration of breastfeeding exclusivity and whether a child was overweight at age 2. While logistic regression models indicate a modest negative association between breastfeeding and child obesity, IV methods estimate a larger magnitude of the effect. Based on the reduced form model, the overall impact of the hospital policies that encourage breastfeeding during the newborn hospitalization decrease obesity by 5.1% points, a substantial amount given that the overall obesity rate is 11%. Our findings are consistent with the idea that breastfeeding may reduce the propensity for children to become obese.

Several recent studies have used longitudinal data and rigorous quasi-experimental methods to examine the relationship between breastfeeding and child obesity outcome (5,28). The study most similar to ours showed that children who are born on the weekend or just before are less likely to be breastfed in the UK, owing to poorer breastfeeding support services in hospitals on weekends (5). That study finds that breastfeeding for at least 90 days leads to a 15% decline in the probability of a child being obese at age 3. The magnitude of their result is similar to ours. Our results suggest a 10–13% decline over 90d at age 2. However, in other studies the effects of breastfeeding on obesity diminish over time, suggesting that the food environment at older ages is a more important factor on child weight outcomes in the long run (5,6,19).

Notably, our data only include mothers who remained in the study and agreed to be contacted. We account for non-response using the sample weights and compared our outcome, exposure and control variables in the analytic sample to the sample that responded to both PRAMS surveys. We find no difference in child weight, breastfeeding or hospital experience variables. However, the least educated and poorest groups are underrepresented in the sample. Second, our measures of child BMI are based on parental reports of height and weight, which may be subject to measurement error (29). While we exclude biologically implausible values, this may not fully remove the bias in BMI based on parental measures. We also do not have a measure for birth height, which may be an important covariate. Third, our modest sample size contributes to imprecise estimates. Finally, we used data from Oregon to reduce selection bias into breastfeeding. Oregon mothers ranked second among all states in breastfeeding initiation rate and longest duration of breastfeeding (25). The breastfeeding norms in Oregon support the notion that the breastfeeding experience and support of women in hospital are capturing ease and support for the initiation of breastfeeding between mother and child as opposed to breastfeeding intentions.

In sum, our results suggest that hospital practices that support breastfeeding (i.e. encouraging immediate skin-to-skin contact, in rooming the newborn with mother, supporting breastfeeding positioning, limiting access to formula when not medically indicated, banning formula samples and discharging women with information for continued breastfeeding) may be effective in promoting breastfeeding duration, and particularly exclusivity, and thereby have the capacity to influence rates of childhood obesity, especially at young ages. Our study suggests that it is worthwhile to further explore this relationship and promote hospital policies that encourage the establishment of breastfeeding as a way to improve child weight outcomes.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgements

This project was funded in part by a seed grant from the Child Health Research Institute, Lucile Packard Foundation for Children's Health, as well as the Stanford CTSA grant (ULI TR001085). Justin White's participation was funded by a NIH training grant (T32-HL 007034).

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Table 1

Sample descriptive statistics (All means are weighted to reflect final sample weights)

	Mean	95% CI	
Weight and breastfeeding variables			
Child BMI	17.1	16.8	17.4
Child overweight	24.4%	18.7%	30.1%
Child obese	11.3%	6.9%	15.7%
Ever Breastfed	96.4%	93.8%	99.0%
Weeks Breastfed	40.8	37.0	44.5
Weeks breastfed exclusively	17.7	15.9	19.5
Pregnancy health			
Gestational diabetes during pregnancy	10.3%	6.1%	14.5%
Income groups			
Less than $20 000	22.2%	16.0%	28.2%
$20 000 to $34 999	19.2%	14.0%	24.5%
$35 000 to $69 999	25.7%	20.3%	31.2%
$70 000 or more	32.9%	26.9%	38.8%
Maternal employment status during pregnancy			
Full-time	30.3%	24.4%	36.2%
Part-time	20.9%	15.9%	25.8%
No, Looking	18.5%	12.8%	24.2%
No, Not Looking	30.3%	24.2%	36.3%
Maternal race/ethnicity			
Non-Hispanic White	75.8%	71.8%	79.8%
Hispanic	14.3%	11.1%	17.6%
Non-Hispanic Asian/PI	6.1%	4.8%	7.5%
Non-Hispanic Black	1.5%	0.9%	2.0%
Non-Hispanic AI/AN	2.3%	1.8%	2.9%
Marital status			
Married	73%	66%	79%
Maternal anthropometric measures			
Maternal weight gain during pregnancy (lb)	30	28	32
Mother's weight (lb)	158	153	164
Maternal height (cm)	161	158	164
Maternal age at birth			
Less than 20	3.4%	0.8%	6.0%
20–29	49.3%	42.7%	55.8%
30–39	43.8%	37.4%	50.2%
40+	3.5%	1.3%	5.8%
Maternal education			
Less than high school graduate	9.7%	5.8%	13.5%
High school graduate	22.5%	16.7%	28.4%

	Mean	95% CI	
Some college	29.8%	23.7%	36.0%
Bachelors or more	37.9%	31.8%	44.1%
Paternal education			
Less than high school graduate	12.3%	8.1%	16.6%
High school graduate	21.0%	15.1%	27.0%
Some college	32.9%	26.7%	39.2%
Bachelors or more	33.7%	27.8%	39.6%
Child birth weight			
Birth weight (g)	3361	3286	3436
Prenatal visits (three groups)			
Less than or equal to eight visits	11.5%	7.3%	15.8%
Between 9 and 11 visits	42.9%	36.4%	49.4%
More than or equal to 12 visits	45.6%	39.0%	52.1%
Number of previous live births			
0	42.4%	35.9%	49.0%
1	34.5%	28.3%	40.8%
2	15.9%	11.0%	20.8%
3	6.7%	3.7%	9.6%
4	0.4%	0.0%	1.2%
Financial support			
No insurance	24.5%	18.3%	30.7%
Child ever on WIC	46.9%	40.3%	53.5%
Main hospital experience and support variables			
Baby had only breast milk at the hospital	73.5%	67.7%	79.3%
Hospital staff gave mom information about breastfeeding	94.4%	90.7%	98.1%

Table 2

Association between breastfeeding practices and obesity status at age 2

Marginal effects presented	Overweight			Child obese		
Ever breastfed	−.131 [−.276 – .014]		−.1651 ** [−.256 – −.742]			
Weeks breastfed		−.0019 * [−.0031 – −.0007]		−.0008 [−.0017 – .0002]		
Weeks breastfed exclusively			−.0034 [−.0077 – .0009]			0.02 [−.0017 – .0022]
Observations	486	456	451	436	436	433
County FE	Yes	Yes	Yes	Yes	Yes	Yes
Model	Logistic regression	Logistic regression	Logistic regression	Logistic regression	Logistic regression	Logistic regression

Models control for mother's income, mother's education, mother's employment, mother's marital status, mother's age, mother's weight, mother's height, mother's weight gain during pregnancy, mother's parity, number of prenatal visits, mother's insurance status, mother's gestational diabetes, child's race, child's birth weight, child's ever being on WIC, father's education and county of residence fixed-effects. Fuller model presented in appendix Table 7.

Weighted 95% confidence intervals clustered at the county level in brackets.

** $p < 0.01$.

* $p < 0.05$.

Table 3

Instrumental variable estimate of the effect of breastfeeding exclusivity on child obesity status at age 2

	First stage Weeks breastfed	First stage Weeks Breastfed Exclusively	IV estimates Child overweight	IV estimates Child obese
Weeks breastfed		−0.01	−0.008 * [−.024 – .004]	[−.018 – .001]
Weeks breastfed exclusively		−0.008	−0.0066 * [−.019 – .003]	[−.014 – .001]
My baby was fed only breast milk at the hospital	7.18 * [1.04–13.33]	8.85 ** [5.00–12.78]		
Observations	447	441	447	441
County FE	Yes	Yes	Yes	Yes
F-statistic of excluded instrument	5.73	21.94		

Estimates from instrumental variables linear probability models.

Models control for mother's income, mother's education, mother's employment, mother's marital status, mother's age, mother's weight, mother's height, mother's weight gain during pregnancy, mother's parity, number of prenatal visits, mother's insurance status, mother's gestational diabetes, child's race, child's birth weight, child's ever being on WIC, father's education and county of residence fixed-effects.

Weighted standard errors clustered at the county level in brackets.

*** $p < 0.01$.

** $p < 0.05$.

* $p < 0.1$.