Impact of the 2022 Infant Formula Shortage on Breastfeeding and Infant Healthcare Costs

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Abstract

Objective: Suboptimal breastfeeding rates in the U.S. contribute to significant health and economic costs, with structural, social, and policy factors driving persistent socio-demographic disparities. The 2022 infant formula shortage, characterized by widespread supply disruptions and product safety concerns, may have influenced infant feeding practices. This study examines changes in breastfeeding continuity during the shortage and predicts associated reductions in pediatric illness and healthcare costs.

Methods: Using 2017–2022 data from the Pregnancy Risk Assessment Monitoring System (PRAMS), we applied Bayesian structural time-series analysis to assess changes in breastfeeding initiation and duration, including differential effects across subpopulations. We then predicted the corresponding reductions in infant disease incidence and healthcare costs resulting from increased breastfeeding.

Results: During the 2022 formula shortage, the proportion of infants breastfed for at least four months increased by 3.43 percentage points (pp) (95% credible interval [CrI]: 1.12 to 5.70 pp). Statistically significant gains in breastfeeding at one, two, and three months postpartum ranged from 2.49 to 3.55 pp. Breastfeeding initiation rose by 1.54 pp (95% CrI: 0.46 to 2.59 pp). These increases varied by maternal education, race/ethnicity, Medicaid status, WIC participation, rural versus urban residence at delivery, and household income, suggesting a potential narrowing of disparities. Improvements in breastfeeding practices were associated with an estimated $420 million in annual healthcare cost savings (95% CI: $414–$425 million).

Conclusions: These findings highlight the need for policies that sustain breastfeeding gains beyond emergency contexts.

Keywords: Infant Formula Shortage; Breastfeeding; Child Health; Health Disparities; Healthcare Costs

1 Introduction

Breastmilk is the ideal source of nutrition for most infants, offering substantial health benefits for both mothers and children.[1] While some economic studies have questioned its long-term effects due to selection bias or maternal opportunity costs,[2;3] medical and public health experts overwhelmingly support breastfeeding. The American Academy of Pediatrics recommends exclusive breastfeeding for the first six months and continuation for at least two years. Although an estimated 95% of U.S. mothers are physiologically able to produce milk,[4] breastfeeding rates remain suboptimal: one in six mothers does not initiate breastfeeding, and only 25% breastfeed exclusively for six months, with even lower rates in some groups.[5] These shortfalls contribute to an estimated $14.2 billion annually (2014 U.S. dollars) in healthcare costs and premature deaths,[1] likely understating the full economic burden by excluding impacts on cognitive development and productivity.[6]

In 2022, a major recall and the shutdown of Abbott Nutrition's Michigan facility prompted by a federal investigation into foodborne illness led to severe nationwide infant formula shortages. By fall, 34.7% of parents reported difficulty finding formula.[7] In response, breastfeeding initiation increased, particularly among groups historically reliant on formula.[8] However, little research has examined impacts on breastfeeding duration or associated healthcare cost.

This study uses population-based data and causal inference methods to quantify the impact of the infant formula shortage on breastfeeding initiation and duration, including socio-demographic differences. It also predicts the resulting healthcare cost savings from reduced infant illness and mortality. These findings inform policies to support breastfeeding, strengthen formula supply chains, and improve emergency preparedness for infant nutrition.

2 Methodology

2.1 Data and Measures

This study used data from the 2017–2022 Pregnancy Risk Assessment Monitoring System (PRAMS), a nationally representative survey of postpartum women in the United States that links responses to birth certificate records. PRAMS collects information on maternal behaviors, attitudes, and experiences before, during, and after pregnancy.[9] We used data on breastfeeding initiation and duration, with duration originally reported in weeks and converted to months using a four-week-per-month approximation **(Appendix A, Section 1)**. Because PRAMS is conducted 2–6 months postpartum, and most responses are received by four months, many mothers are still breastfeeding at the time of the survey. In these cases, duration is right censored, measured as time since birth, likely underestimating true duration. To ensure consistency and produce a conservative estimate of the shortage's impact, we focus on breastfeeding outcomes within the first four months postpartum.

The sample includes mothers from 19 states and New York City whose infants were alive at the interview and who had no missing data on key covariates. For breastfeeding duration at two, three, and four months, we further limited the sample to participants surveyed at or beyond each time point. The final dataset included 105,228 observations for the two-month duration measure, 100,698 for three months, and 58,259 for four months (**Appendix A**, **Figure A.1**).

The primary variable of interest was the infant formula shortage period, defined as February to December 2022, corresponding to the Abbott plant closure and recall. The pre-shortage period (January 2017 to January 2022) served as the control. To reduce confounding, we adjusted for key predictors of breastfeeding, including WIC participation, maternal education (less than high school, high school, some college, college+), race/ethnicity (Hispanic or non-Hispanic [NH], American Indian or Alaska Native, Black, Asian, White, and other), maternal age (<19 to ≥ 45 years), and marital status (married vs. not). Delivery-related controls included payment source (private insurance, Medicaid, or other) and mode of delivery (spontaneous vaginal, assisted vaginal, or cesarean). Infant characteristics were birth order, gestational age (<32, 33–37, ≥ 38 weeks), and birth weight (<1.5 kg, 1.5–2.5 kg, 2.501–4 kg, 4.001–4.5 kg, >4.5 kg), all from birth certificate data. County of residence was classified as urban or rural using the National Center for Health Statistics (NCHS) urban–rural classification. Additional variables included household income in the 12 months before birth ($<\$50,000$ vs. $\geq \$50,000$) and maternal tobacco use at the time of the survey.

2.2 Statistical Analysis

2.2.1 Estimating the Impact of Formula Shortage on Breastfeeding Rates

We estimated changes in breastfeeding initiation and duration using a Bayesian Structural Time Series (BSTS) model,[10] which required aggregating data by month of birth to construct a monthly time series. We selected the BSTS model as a flexible alternative to interrupted time series (ITS) analysis. It requires fewer assumptions,[10] accounts for temporal dependencies in time series data, and supports unbiased estimation and counterfactual forecasting in synthetic control settings. To validate model assumptions, we conducted placebo tests using hypothetical intervention dates and confirmed that key covariates were not affected by the infant formula shortage. Additional details are provided in **Appendix A, Section 2**.

To examine heterogeneity in the effects, we performed stratified analyses using the BSTS model across subgroups defined by maternal education, race and ethnicity, WIC participation, household income, delivery payment source, and rural or urban county of residence at the time of delivery. Due to sample size limitations, we combined some categories and excluded groups with small sample sizes. We also conducted three sensitivity analyses to address potential sources of bias. First, to account for changes in sample composition due to the exclusion of observations with missing covariates, we replicated all models by retaining those observations and creating separate indicators for each variable with missing values. Second, to address potential confounding from state paid family leave (PFL) policies, which were shown to encourage longer breastfeeding duration,[11;12] we estimated all models while excluding states that adopted PFL policies in 2017–2022. Third, we excluded observed breastfeeding rates for infants born in January–March 2020 to account for the temporary increase linked to shelter-in-place orders,[13] as documented in prior research (**Appendix A, Section 3**). All analyses applied PRAMS survey weights to account for the complex survey design and nonresponse. The University of Connecticut Institutional Review Board (IRB) deemed the study exempt from IRB review (protocol #23-274-910).

2.2.2 Simulating Healthcare Cost Savings

We predicted changes in healthcare costs resulting from increases in breastfeeding initiation and duration following methods outlined by Bartick et al. (2016). Specifically, we calculated the difference in disease incidence between any breastfed and non-breastfed infants using the formula:

$$x = \frac{s}{(b_{\text{any}}\, r_{\text{any}} + 1 - b_{\text{any}})},$$

where x is the incidence of disease in non-breastfed infants, s is the overall disease incidence,

b_{any} is the breastfeeding rate when s was observed, and r_{any} is the relative risk for any breastfed versus non-breastfed infants. Incidence among any breastfed infants was then calculated as $x \times r_{\text{any}}$.

We used a conservative approach, focusing on four pediatric conditions occurring before age one that have well-documented lower incidence among breastfed infants: acute otitis media (AOM), gastrointestinal infection (GII), lower respiratory tract infections (LRTI), and sudden infant death syndrome (SIDS).[14–17] **Table 1** summarizes published associations between breastfeeding and these outcomes. To estimate expected incidence rates, we used the most recent studies.[18–21] For conditions with mortality, we incorporated published mortality rates for LRTI and SIDS to estimate infant death risk.[21;22]

Cost estimates for each condition were derived from published sources and adjusted to 2024 U.S. dollars using the Consumer Price Index for medical care.[23] The cost of premature death was calculated using the Value of a Statistical Life (VSL), set at $12.5 million for the base year 2022.[24] This figure likely understates the full cost, as VSL may be higher for children due to greater parental willingness to pay for risk reductions and longer life expectancy.[25] To maintain a conservative estimate, we included only direct healthcare and death-related costs (**Table 1**). The study does not account for potential long-term cost savings associated with breastfeeding, such as reduced risks of childhood asthma, obesity, and maternal breast and ovarian cancers.

Using a Monte Carlo simulation with 1,000 iterations, we extrapolated the observed increase in breastfeeding initiation and duration to the national level based on 3,667,758 births in 2022.[26] This simulation incorporated uncertainty in the breastfeeding rate increase to estimate the additional number of breastfed infants, along with a 95% confidence interval. We then used the previously published estimates of disease incidence differences between any breastfed and non-breastfed infants to calculate the total reduction in disease cases. Finally, we estimated associated healthcare cost savings by multiplying the reduction in disease cases by the cost per case.

3 Results

Table 2 summarizes maternal and infant characteristics from 2017 to 2022, showing increases in maternal education, the proportion of Hispanic mothers, maternal age at birth, and the proportion of preterm babies. At the same time, there was a decline in WIC participation and the proportion of mothers with low income.

Prior to the formula shortage, unadjusted breastfeeding rates remained relatively stable, with some seasonal fluctuations (**Figure 1**). During the pre-shortage period (January 2017–January 2022), average rates were 89.66% for breastfeeding initiation, 79.50% for breastfeeding at one month, 71.07% at two months, 64.45% at three months, and 56.64% at four months postpartum. Following the shortage onset in February 2022, breastfeeding rates increased across all indicators. From February to December 2022, the average initiation rate rose to 91.99%, while duration rates also improved, increasing by 3.56–5.65 percentage points (pp). Although breastfeeding rates declined slightly in the last quarter of 2022, they remained above pre-shortage levels. From October to December 2022, average rates were 91.20% for initiation, 80.41% at one month, 72.56% at two months, 67.27% at three months, and 59.88% at four months.

3.1 Impact of Infant Formula Shortage on Breastfeeding Practices

During the 2022 formula shortage, breastfeeding initiation increased by 1.54 pp (95% credible interval [CrI]: 0.46 to 2.59 pp; **Appendix A**, **Figure A.2** and **Table A.1**). Increases in breastfeeding duration were larger: the share of mothers breastfeeding for at least one month rose by 2.49 pp (95% CrI: 1.03 to 3.88 pp), with continued gains at two (3.55 pp), three (3.38 pp), and four months postpartum (3.43 pp), all 95% CrIs statistically significant (**Appendix A**, **Figure A.2** and **Table A.1**)).

Subgroup analyses showed variation in response (**Figure 2**). The largest and most consistent gains in duration occurred among mothers with some college education, ranging from 5.27 pp at one month to 8.06 pp at two months postpartum. College graduates showed no significant changes, while mothers with high school or less improved only at one and two months. Among racial/ethnic groups, Black mothers saw the largest gains, particularly at two months (6.61 pp, 95% CrI: 2.40 to 10.79 pp), but also at one month (4.87 pp, 95% CrI: 1.06 to 8.60 pp). White mothers had smaller but statistically significant increases in initiation and duration. Medicaid-covered births were associated with larger increases in breastfeeding duration than private insurance, particularly beyond one month. Similarly, greater gains were observed among mothers with household incomes below $50,000, especially at two and three months postpartum. Rural mothers also showed the largest gains at two and three months postpartum (4.36 pp and 4.68 pp, respectively).

3.2 Healthcare Cost Savings from Increased Breastfeeding

For the four pediatric conditions examined in this study, we predict that the 2022 infant formula shortage led to meaningful annual healthcare cost savings, totaling $420 million in 2024 U.S. dollars (95% confidence interval [CI]: $414–$425 million) (**Appendix A**, **Table A.2**). Most of these savings, $395 million, resulted from avoided premature deaths due to LRTI and SIDS. Additional savings came from reduced healthcare utilization, including outpatient visits ($10 million), emergency department visits ($4 million), and hospitalizations ($10 million).

4 Discussion

Breastfeeding initiation and duration both increased significantly during the 2022 infant formula shortage, with a more pronounced impact on duration. This likely reflects lower baseline rates of sustained breastfeeding, which allowed for greater relative gains. The increase in initiation of 1.54 percentage points (pp) observed in this study of 19 states and New York City aligns with national studies, which reported gains in initiation of 1.88 to 1.95 pp sustained through the end of 2022.[8]

The 2.49 to 3.55 pp increases in breastfeeding duration during the shortage exceed the effects of many interventions aimed at promoting breastfeeding. For example, earlier longitudinal evaluations of paid family leave (PFL) laws in California and New Jersey found no overall increase in breastfeeding duration, and some gains in exclusive breastfeeding.[27] Similarly, a study in New York found no significant overall changes in initiation or duration through 12 weeks postpartum, though it did identify increases in initiation and duration at 4 and 8 weeks among Black women.[11] A national study using shelter-in-place orders during the COVID-19 pandemic as a proxy for PFL policies found a 17.5% increase in breastfeeding duration, from 12.6 weeks in January 2020 to 14.8 weeks in April–May 2020. However, these gains were concentrated among White and high-income respondents with the flexibility to work remotely, further widening disparities.[13] To our knowledge, the most recent multistate analysis of PFL programs found a modest 0.53 week increase in breastfeeding duration, with no significant effect on initiation. This small increase was driven primarily by New Jersey, while the District of Columbia and Massachusetts, where PFL had only recently been implemented, showed no or even negative effects on breastfeeding initiation.[12] In contrast, research on state-mandated postpartum hospital care regulations (2003–2017) found these policies increased breastfeeding initiation by 3.8 pp and improved duration as well.[28]

To facilitate comparison with studies that measure changes in average breastfeeding duration, we used weeks of breastfeeding as the outcome. This analysis yielded a statistically significant increase of 0.46 weeks (95% credible interval [CrI]: 0.04 to 0.99 weeks), closely aligning with the 0.53 week increase attributed to PFL policies in a recent multistate study.[12]

The most pronounced increases in breastfeeding initiation and duration were observed in households that previously relied more heavily on infant formula and had greater room for improvement. The largest gains in breastfeeding initiation were observed among mothers with lower education (2.64 pp) and those with lower household income (2.17 pp). The largest gains in duration at four months postpartum were among mothers with some college (6.48 pp) and in the Medicaid group (4.74 pp), with similar results at three months postpartum. These improvements were likely influenced by the adaptive strategies families used to cope with the formula shortage, such as purchasing from multiple retailers, stockpiling, or relying on social networks for access.[7] For many families, breastfeeding offered a more stable and secure alternative during this period of uncertainty.

Households with fewer resources faced greater challenges during the formula shortage due to financial and time constraints in obtaining formula.[29] For example, WIC participants were limited to purchasing formula only from in-state, authorized retailers and were unable to place online orders using WIC benefits.[30] While the USDA permitted states to relax WIC formula restrictions, the pace and extent of implementation varied, with some states adopting changes more slowly than others.[31] Initiatives like Operation Fly Formula increased formula imports, but higher retail prices kept many of these products out of reach for low-income families.[31]

The 2022 formula shortage highlights how structural, institutional, and policy factors shape breastfeeding patterns in the United States. These include aggressive formula marketing, inadequate paid family leave, and limited workplace support for lactation.[32] Addressing these systemic barriers, such as by strengthening regulations on infant formula marketing in alignment with WHO and UNICEF recommendations,[32] could help reduce persistent disparities in breastfeeding rates. Additional policy changes, such as the 2024 revision of the WIC food packages that introduced a partially breastfeeding option from birth, may also contribute to increased breastfeeding rates by supporting mothers who lack confidence in their ability to produce enough milk.[33;34] Future research should examine whether the breastfeeding gains observed in 2022 will persist beyond the immediate shortage period.

A major contribution of this study is its economic analysis, which quantifies the public health benefits of improved breastfeeding. Despite a conservative approach, limiting the analysis to four infant health conditions, this study estimates social savings of $420 million annually. To put this in perspective, that amount would be sufficient to cover all recommended immunizations for approximately 268,000 infants from birth through one year.[35] The true social benefits of increased breastfeeding are likely much greater.

This study has several key strengths. It draws on a representative sample from PRAMS (2017–2022), enabling the assessment of breastfeeding initiation and duration across 19 states and New York City. The use of a Bayesian Structural Time Series (BSTS) model enhances causal inference by estimating counterfactual trends while preserving seasonal patterns, capturing long-term dynamics through an extended pre-intervention period, and reducing overfitting with spike-and-slab priors.

However, several limitations should be noted. First, this study focuses on the short-term health effects of breastfeeding. Many health outcomes associated with infant feeding, such as Crohn's disease, ulcerative colitis, obesity, and asthma, develop over a longer time horizon and were not included in this analysis. Maternal health benefits, such as reduced risks of breast cancer, premenopausal ovarian cancer, diabetes, hypertension, and myocardial infarction, were excluded, along with the associated cost savings. Second, while the study estimates potential healthcare cost savings due to increased breastfeeding, it does not account for the health risks stemming from certain coping strategies adopted by some families during the 2022 formula shortage. Practices such as homemade formula and formula dilution posed significant risks to infant health.[7] Third, the analysis relies on self-reported data for breastfeeding outcomes and many covariates, which may be subject to misreporting and may introduce error or bias. Finally, while the sample includes mothers from 19 states and New York City, we believe the findings are generalizable to national patterns, based on comparisons with the 2021 National Immunization Survey–Child (results available upon request).

5 Conclusion

This study shows that the 2022 infant formula shortage led to meaningful increases in breastfeeding initiation and duration, resulting in substantial healthcare cost savings from reduced infant illness and mortality. Although not a policy intervention, the shortage triggered a widespread behavioral response that reveals modifiable conditions that policymakers could address. Increased breastfeeding among groups historically more reliant on formula suggests that, with adequate motivation and structural support, breastfeeding rates can improve. These findings highlight the potential of policies such as extended paid family leave, workplace lactation support, and stricter regulation of infant formula marketing to sustain and expand breastfeeding gains beyond emergency contexts.

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Figure 1. Unadjusted Breastfeeding Rates, PRAMS 2017–2022.

Figure 2. Estimated Changes in Breastfeeding Initiation and Duration Across Subpopulations During the 2022 Infant Formula Shortage, Estimates from the Bayesian Structural Time-Series Analysis.

Table 1. Prior Literature on Breastfeeding and Infant Disease: Risk, Incidence, Mortality, and Costs.

Panel A: Morbidity				
Disease	**Disease Risk: Breastfeeding vs Formula [95%CI]**	**Utilization Type**	**Incidence per 100,000 live births**	**Direct medical Cost per case (2024 $)**
AOM	OR 0.67 [0.56, 0.80][1]	Outpatient visits	71,805 [71,703, 71,899]	$401.29
		ED visits	4,997 [4,990, 5,004]	$684.32
		Hospitalizations	76.88 [76.77, 76.98]	$2,562.01
GII	aRR 0.60 [0.48, 0.72][2]	Outpatient visits	9,000	$157.65
		ED visits	1,500	$1,204.16
		Hospitalizations	500	$7,879.02
LRTI	aRR 0.78 [0.63, 0.96][2]	Outpatient visits	10,798 [9,566, 12,214]	$395.63
		ED visits	3,911 [3,454, 4,452]	$1,658.77
		Hospitalizations	1,318 [1,087, 1,573]	$15,880.81
Panel B: Mortality				
Disease	**Disease Risk: Breastfeeding vs Formula [95%CI]**	**Mortality Type**	**Mortality per 100,000 live births**	—
LRTI	aRR 0.78 [0.63, 0.96][2]	Infant mortality	1.32 [1.09, 1.57]	—
SIDS	aOR 0.60 [0.44, 0.82][3]	Sudden infant death	39.8	—

Notes: OR = Odds Ratio; aRR = Adjusted Relative Risk; aOR = Adjusted Odds Ratio. AOM = Acute otitis media; GII = Gastrointestinal infection; LRTI = Lower respiratory tract infection; SIDS = Sudden Infant Death Syndrome; ED = Emergency Department. Confidence intervals [95%] are provided when available. [1] Any breastfeeding. [2] Any breastfeeding for at least 4 months. [3] Any breastfeeding for at least 2 months.

Table 2. Maternal and Infant Characteristics by Year of Birth, PRAMS 2017–2022

Description	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**
Maternal Characteristics:						
Age (years)						
< 19	3.14	3.05	2.90	2.69	2.54	2.47
20–24	17.61	16.78	16.09	15.29	14.72	14.05
25–29	29.87	28.99	29.85	28.18	27.10	28.37
30–34	30.53	31.55	31.28	32.99	34.11	32.76
35–39	15.77	16.38	16.20	16.92	18.07	18.33
≥ 40	3.08	3.25	3.69	3.93	3.46	4.03
Delivery mode						
Spontaneous	66.40	67.84	66.96	67.27	68.15	66.24
Forceps	0.68	0.60	0.72	0.62	0.56	0.60
Vacuum	2.73	2.69	2.87	2.93	2.44	2.99
Cesarean	30.18	28.87	29.45	29.18	28.85	30.16
Prenatal household income (2022 $)						
< $50,000	45.55	44.27	42.16	43.93	40.87	39.18
≥ $50,000	54.45	55.73	57.84	56.07	59.13	60.82
Marital status						
Married	67.18	67.27	66.83	66.98	67.69	69.08
Maternal education						
Less than high school	9.49	8.79	8.76	7.85	7.81	7.49
High school	22.50	23.34	22.64	23.36	21.02	22.41
Some college	28.34	26.95	27.26	26.06	25.64	24.20
College degree or more	39.67	40.92	41.34	42.73	45.53	45.89
Maternal race/ethnicity						
Hispanic, of any race	14.91	14.95	15.41	16.74	16.47	16.13
American Indian	0.84	0.86	0.78	0.85	0.77	0.77
Asian	6.15	6.04	6.46	6.47	5.87	6.01
Black	11.75	11.67	11.87	10.89	10.69	10.90
Other[1]	3.43	3.29	3.16	3.15	3.27	3.77
White	62.93	63.19	62.32	61.90	62.94	62.43

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Table ?? (continued)						
Description	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**
Payment source for delivery						
Private insurance	58.18	57.77	58.40	59.21	60.88	61.20
Medicaid	35.91	36.32	35.31	34.19	32.75	32.57
Other[2]	5.91	5.91	6.29	6.60	6.37	6.23
Prior births living						
0	39.34	38.07	40.05	40.15	39.08	40.58
1	33.06	35.04	33.00	32.57	34.14	32.89
2	16.23	16.22	15.60	16.55	15.75	15.76
3–5	10.16	9.75	10.20	9.80	10.06	9.80
6 or more	1.21	0.92	1.14	0.92	0.97	0.98
County urbanicity						
Urban	85.96	85.72	85.65	86.32	86.13	85.41
Maternal cigarette smoking						
Smoker	10.94	10.45	9.60	8.10	6.44	5.17
Women, Infants and Children (WIC)[3]						
WIC participant	32.33	30.93	28.88	26.50	25.00	24.83
Infant Characteristics:						
Birth Weight						
$<$ 1.5 kg	0.87	0.80	0.87	0.67	0.74	0.94
1.5–2.5 kg	5.71	5.49	5.76	6.11	5.92	5.86
2.501–4 kg	84.51	85.03	85.62	84.71	85.36	85.42
4.001–4.5 kg	7.48	7.54	6.94	7.40	6.73	6.89
$>$ 4.5 kg	1.43	1.13	0.82	1.12	1.25	0.90
Obstetric Estimate (maturity)						
$<$ 32 weeks	1.33	1.16	1.44	1.26	1.27	1.49
33–37 weeks	15.07	15.49	17.55	17.16	17.52	17.67
$\geq$ 38 weeks	83.60	83.35	81.01	81.58	81.21	80.84
Number of observations	**18,716**	**18,081**	**18,292**	**17,386**	**16,352**	**16,401**

Note: Data drawn from the Pregnancy Risk Assessment Monitoring System (PRAMS) years 2017–2022. Estimates are based on the authors' calculations using PRAMS weights to adjust for the complex survey design and nonresponse (n = 105,228). Percentages may not add up to 100% due to rounding. [1] Includes Alaska Native, Native Hawaiian or Pacific Islander, or Multiracial. [2] Includes self-pay, Indian Health Service, CHAMPUS/TRICARE, and Other Government (Federal, State, Local). [3] WIC: Special Supplemental Nutrition Program for Women, Infants, and Children.

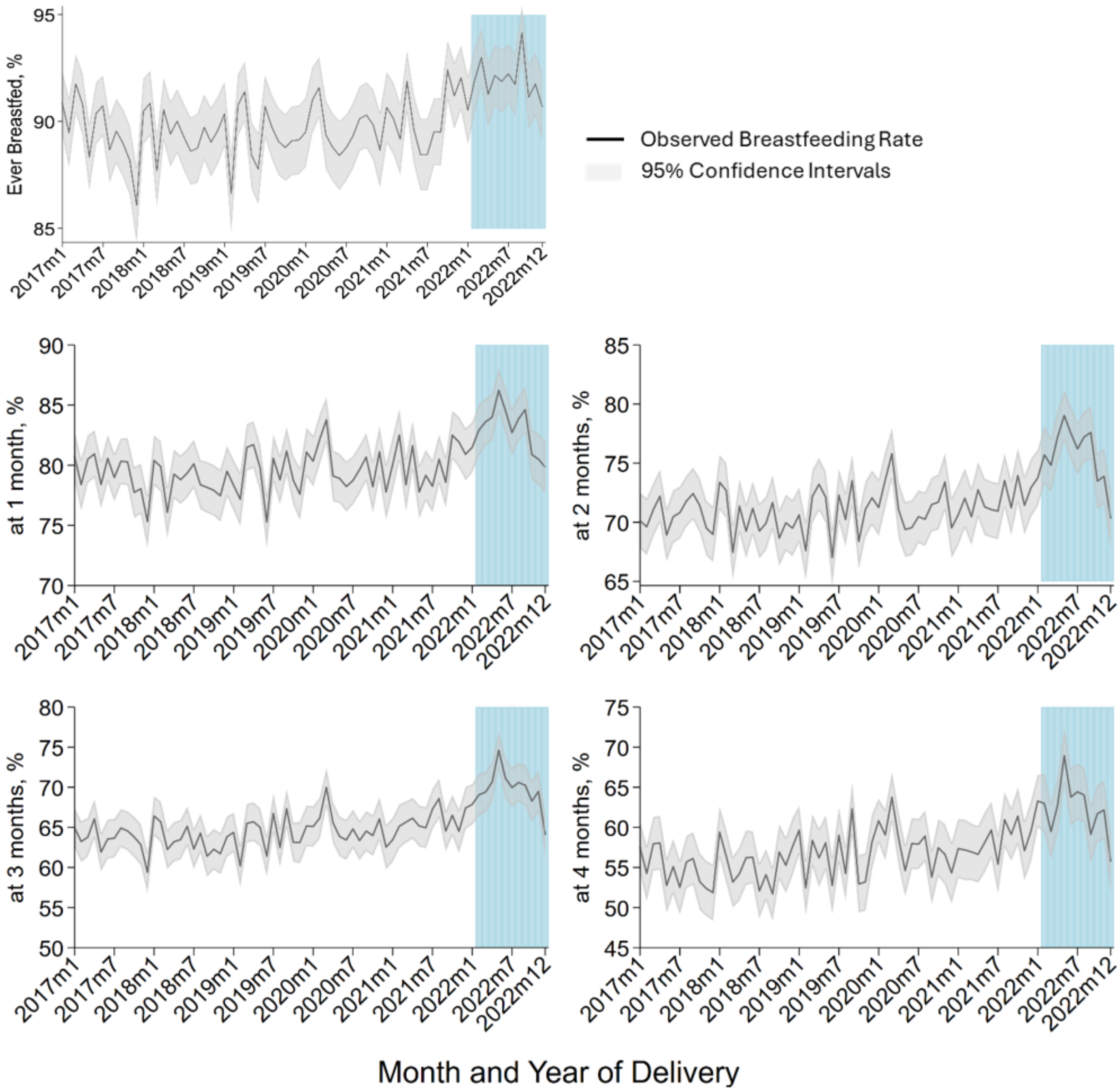
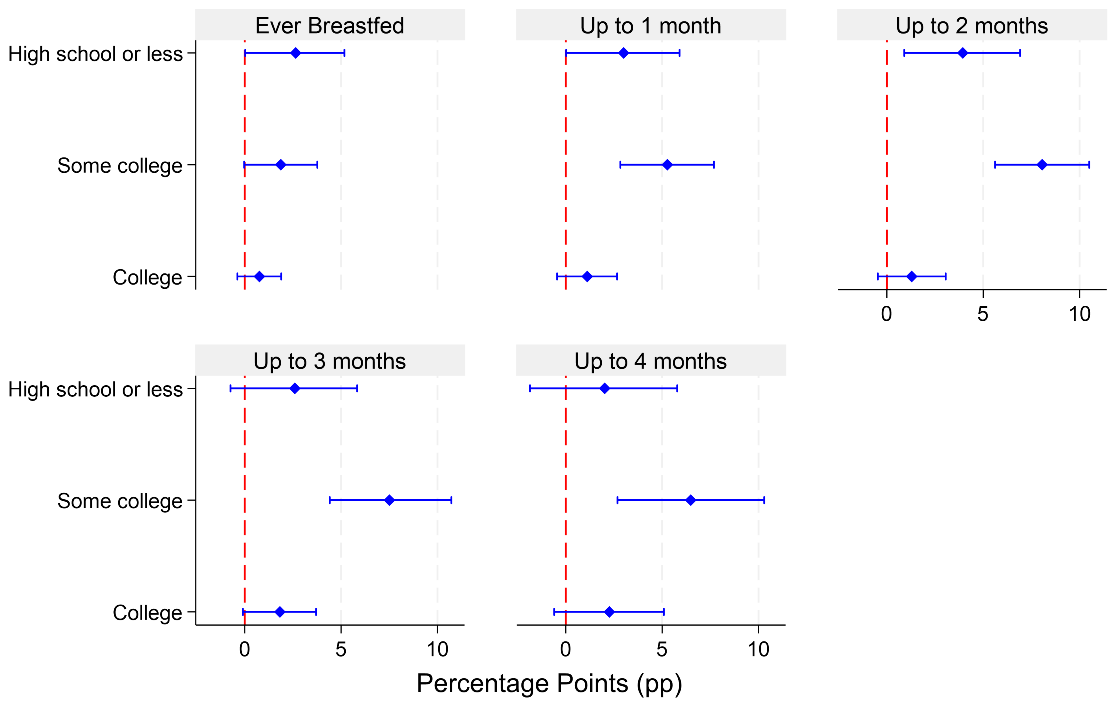


Figure 1. Unadjusted Breastfeeding Rates, PRAMS 2017–2022.

Note: Data drawn from the Pregnancy Risk Assessment Monitoring System (PRAMS), 2017–2022. PRAMS survey weights are applied to account for the complex survey design and nonresponse. Sample size varies by duration: Ever breastfed, 1 month, and 2 months (n = 105,228); 3 months (n = 100,698); and 4 months (n = 58,259). The shaded blue area indicates the intervention period (February–December 2022).

(a) By Maternal Education Level



(b) By Maternal Race and Ethnicity

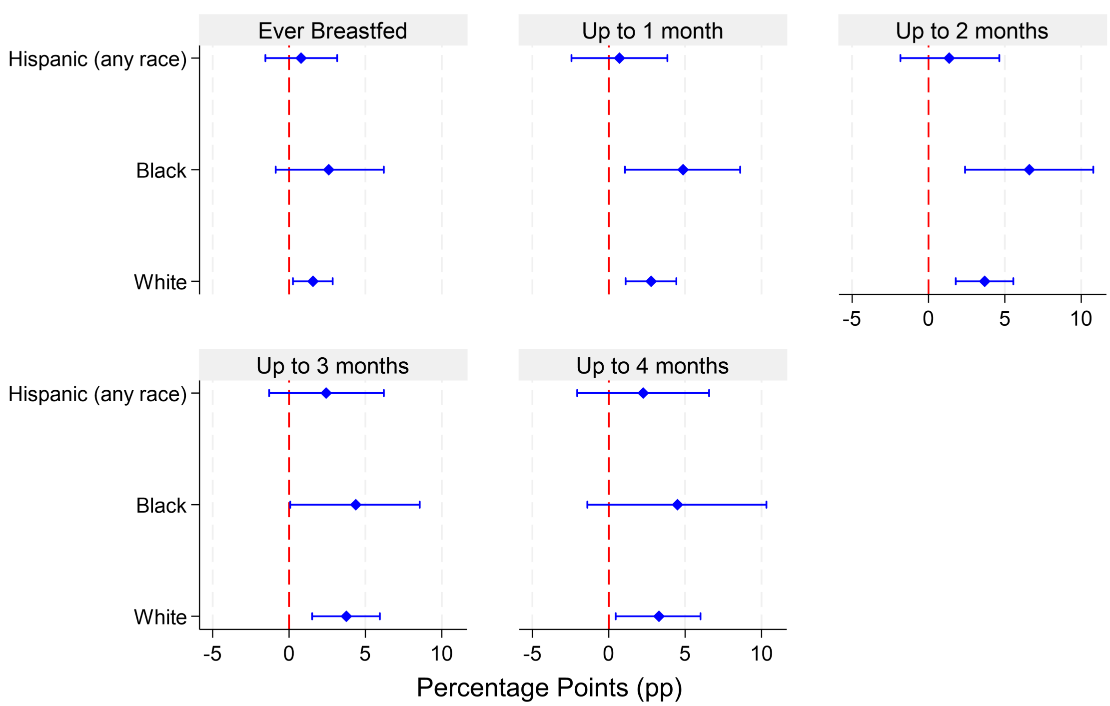
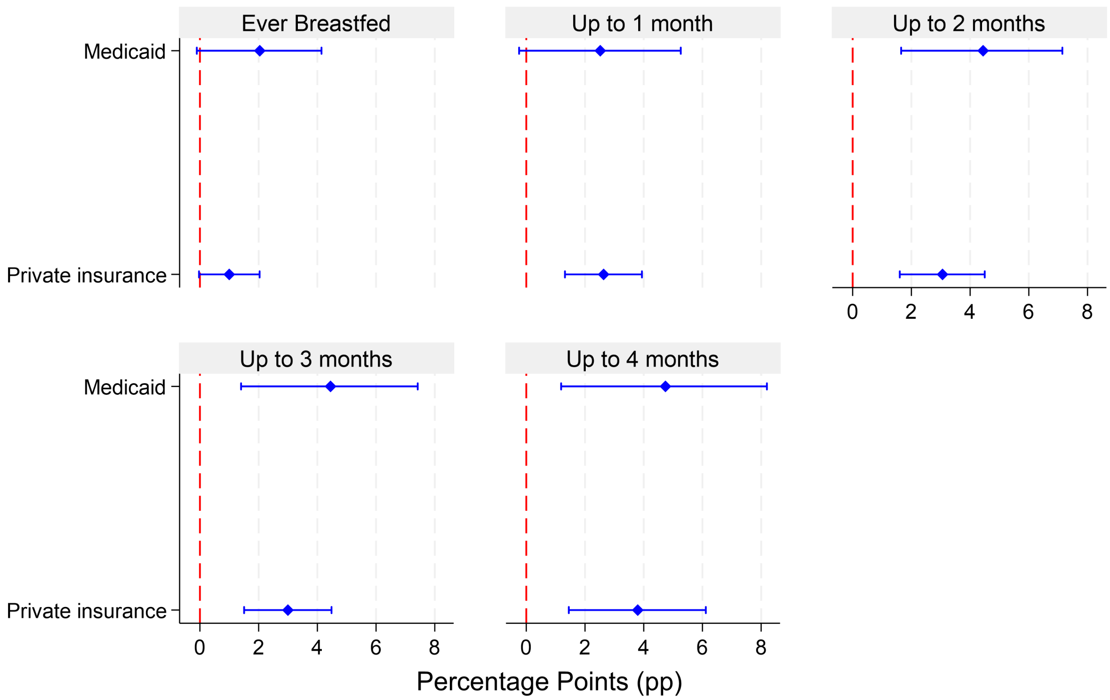


Figure 2. Estimated Changes in Breastfeeding Initiation and Duration Across Subpopulations During the 2022 Infant Formula Shortage, Estimates from the Bayesian Structural Time Series Analysis.

(c) By Payment Source for Delivery



(d) By Women, Infants, and Children (WIC) Participation

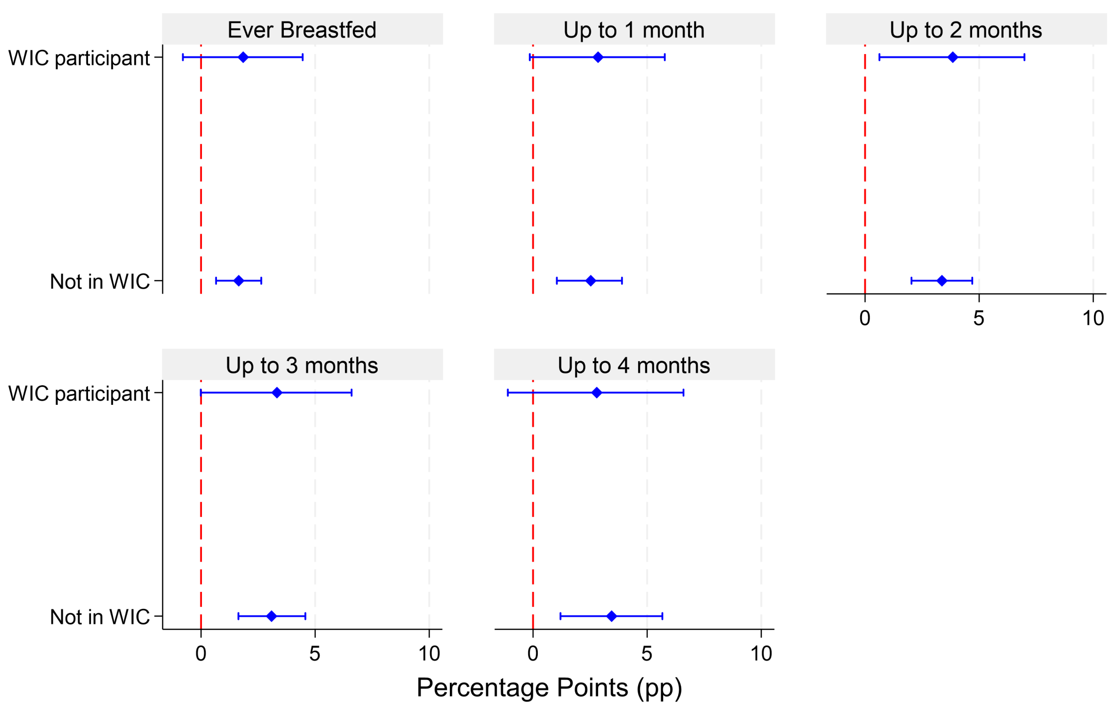
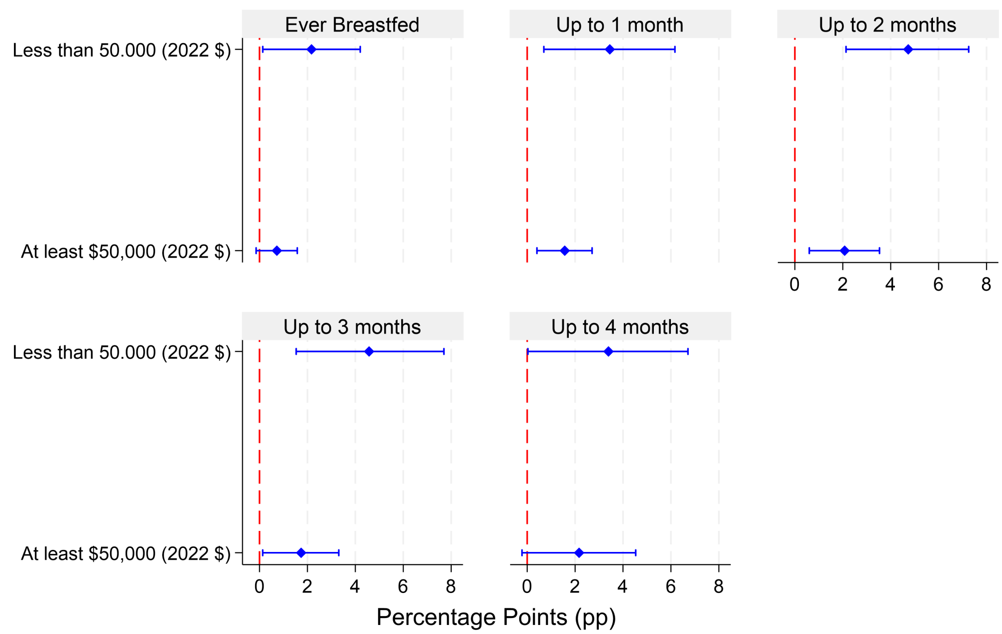


Figure 2. Estimated Changes in Breastfeeding Initiation and Duration Across Subpopulations During the 2022 Infant Formula Shortage, Estimates from the Bayesian Structural Time Series Analysis *(continued)*.

Figure 3

(e) By Prenatal Household Income (2022 $)



(f) By Rural or Urban County of Residence at Delivery

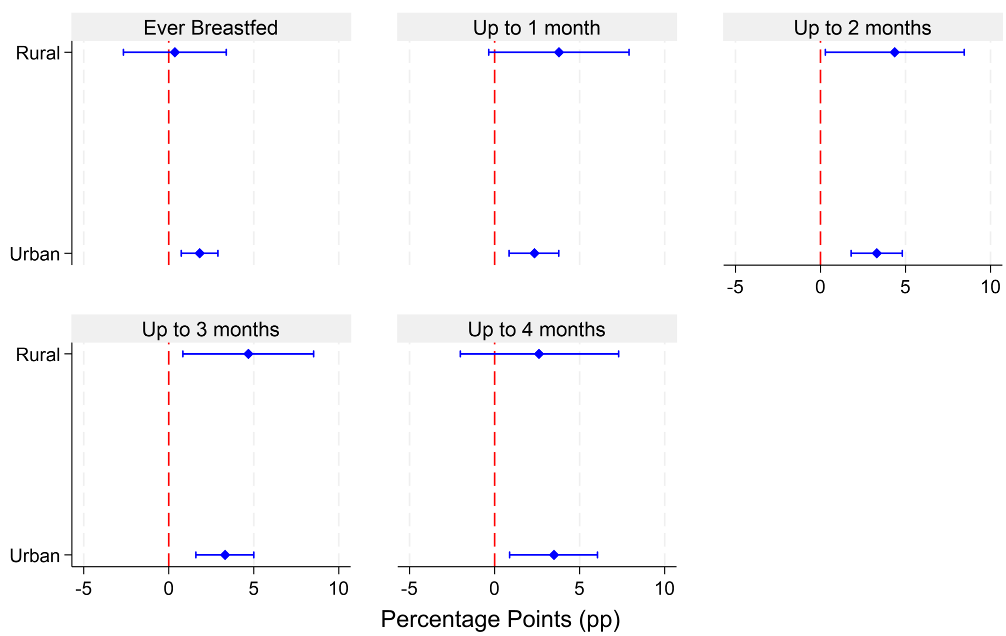


Figure 3. Estimated Changes in Breastfeeding Initiation and Duration Across Subpopulations During the 2022 Infant Formula Shortage, Estimates from the Bayesian Structural Time Series Analysis *(continued)*.

Note: PRAMS survey weights are applied to account for complex survey design and nonresponse. Sample size varies by duration: Ever breastfed, 1 month, and 2 months (n = 105,228); 3 months (n = 100,698); and 4 months (n = 58,259). These estimates denote the change in the rate of breastfeeding for the reference group during the infant formula crisis.

Appendix A: Additional Details

A1. Breastfeeding initiation and duration

Breastfeeding initiation and duration were examined based on the PRAMS survey questions: "Did you ever breastfeed or pump breast milk to feed your new baby, even for a short period of time?" and "How many weeks or months did you breastfeed or feed pumped milk to your baby?" Women who responded "Yes" to the first question were categorized as having initiated breastfeeding.

For respondents who were still breastfeeding at the time of the survey, duration was measured as the time since birth. Consequently, these estimates may understate true breastfeeding duration, as some respondents likely continued breastfeeding beyond the survey date.

Among women who initiated breastfeeding, duration was categorized into four groups based on the reported number of weeks of breastfeeding or feeding pumped milk: 4 weeks (1 month), 8 weeks (2 months), 12 weeks (3 months), and 16 weeks (4 months). The sample was limited to mothers who completed the survey at or beyond the relevant postpartum period. For example, when examining breastfeeding rates at three months postpartum, only mothers who completed the interview at three months or later were included.

A2. Bayesian Structural Time Series Analysis (BSTS)

The data were organized by aggregating the outcomes of interest and covariates by the infant's month and year of birth. PRAMS survey weights were applied to adjust for the complex survey design and nonresponse. The pre-intervention period, extending from January 2017 to January 2022, captured long-term breastfeeding dynamics and ensured sufficient variation in the predictors.

The covariates included a comprehensive set of maternal characteristics: age group (<19, 20–24, 25–29, 30–34, 35–39, 40–44, and 45 years), mode of delivery (spontaneous, forceps, vacuum, and cesarean), prenatal household income in 2022 dollars (<$50,000 vs. $50,000), and marital status (married vs. not married). Maternal education was categorized as less than a high school diploma, high school diploma, some college, or a college degree or more. Maternal race and ethnicity were classified as Hispanic (any race), American Indian, Asian, Black, Other, and White. We also accounted for delivery payment source (private insurance, Medicaid, and other), number of prior living births (0, 1, 2, 3–5, and 6), and urban–rural county classification. Behavioral factors included tobacco smoking and participation in the Women, Infants, and Children (WIC) program. Infant characteristics were birth weight (<1.5 kg, 1.5–2.5 kg, 2.501–4 kg, 4.001–4.5 kg, and >4.5 kg) and obstetric estimate of maturity (<32 weeks, 33–37 weeks, and 38 weeks). The spike-and-slab variable selection method was used to address potential multicollinearity among predictors.

The analysis relied on two critical assumptions: (1) that the event (the formula crisis) did not affect the control covariates, and (2) that the relationship between the covariates and the treated time series, established during the pre-crisis period, remained stable throughout the crisis period. To test the first assumption, we re-estimated the model using each covariate as the dependent variable and found no systematic changes. To test the second assumption, we conducted falsification exercises by simulating hypothetical interventions in December 2019 and December 2020. For these tests, the pre-intervention period was defined from January 2017 to the respective hypothetical intervention month, and the post-intervention period extended from that month to February 2022, excluding the 2022 formula crisis. In both cases, predicted breastfeeding initiation showed no meaningful deviation from observed rates following the simulated intervention.

Finally, to assess the sensitivity of the results to prior specification, we tested two values for the standard deviation of the Gaussian random walk at the local level: the default 0.01, typically used for stable datasets, and 0.1, a more conservative value appropriate for higher residual volatility. Results were robust to this specification. Forecasts and 95% credible intervals (CrIs) were generated using Markov Chain Monte Carlo estimation with 50,000 iterations.

A3. Sensitivity Analysis

We conducted several sensitivity analyses to assess the robustness of the estimated changes in breastfeeding initiation and duration associated with the 2022 infant formula shortage.

a. Excluding States with Fully Implemented Paid Family Leave Policies

We replicated analyses excluding Massachusetts, New York, and Washington, states that fully implemented paid family leave policies with benefits available during 2017–2022, since these policies are known to increase breastfeeding rates.

Infant's Age (months)	β [95% CrI]	N
0	1.68 [0.44, 2.88]	85,991
1	2.61 [1.06, 4.12]	85,991
2	3.83 [2.19, 5.44]	85,991
3	3.80 [2.04, 5.54]	81,708
4	3.91 [1.27, 6.49]	47,025

Note: These estimates are based on the authors' calculations using PRAMS weights to adjust for the complex survey design and nonresponse. CrI: 95% credible interval.

Results align with the main findings, showing larger effects, reflecting higher pre-crisis breastfeeding rates in states that implemented paid maternity leave policies during the study period.

b. Excluding Q1 2020 Due to COVID-19 Shelter-in-Place Effects on Breastfeeding Duration

We replicated the analysis accounting for the increase in breastfeeding duration observed after the shelter-in-place orders in April and May 2020, as documented by Hamda et al. (*AJPH*, 2023). Since breastfeeding duration averaged about 12 weeks, infants surveyed in April and May 2020 were likely born in January and February. Therefore, births during January and February 2020 are considered the most strongly affected. Although this increase persisted through infants born in August 2020, the magnitude of the change declined abruptly after March 2020.

We exclude the observed breastfeeding rates for infants born in January, February, and March 2020 from the estimation by setting them as missing. The model imputes these months using the state-space structure and covariates, but they don't influence the counterfactual estimation.

Infant's Age (months)	β [95% CrI]	N
0	1.51 [0.46, 2.55]	105,228
1	2.56 [1.16, 3.87]	105,228
2	3.64 [2.29, 4.93]	105,228
3	3.16 [1.64, 4.72]	100,698
4	3.51 [1.30, 5.68]	58,259

Note: These estimates are based on the authors' calculations using PRAMS weights to adjust for the complex survey design and nonresponse. CrI: 95% credible interval.

The results are consistent with the main findings, though they show a slightly larger increase in breastfeeding rates, likely due to excluding the higher rates observed in the first quarter of 2020.

c. Including Observations with Missing Covariates

We replicated the analysis including observations with missing data by creating separate categories for each variable with missing values. This allowed us to expand the sample and assess whether excluding those observations introduced any bias in the main results.

Infant's Age (months)	β [95% CrI]	N
0	1.77 [0.62, 2.86]	125,384
1	2.51 [1.03, 3.93]	125,384
2	3.58 [2.10, 5.02]	125,384
3	3.59 [2.11, 5.02]	119,935
4	3.20 [0.99, 5.39]	73,651

Note: Estimates are based on the authors' calculations using PRAMS survey weights to adjust for the complex survey design and nonresponse. CrI = 95% credible interval.

The results are consistent with the main findings, addressing any concerns about potential bias from excluding observations with missing covariates.

Table A.1. Estimated Changes in Breastfeeding Rates by Infant's Age During the 2022 Infant Formula Shortage.

Infant's Age (months)	β **[95% CrI]**	**N**
Initiation	1.54 [0.46, 2.59]	105,228
1	2.49 [1.03, 3.88]	105,228
2	3.55 [2.10, 4.95]	105,228
3	3.38 [1.71, 5.01]	100,698
4	3.43 [1.12, 5.70]	58,259

Note: These estimates are based on the authors' calculations. PRAMS weights were used to adjust for the complex survey design and nonresponse. CrI: 95% credible interval.

Table A.2. Estimated Savings from Reduced Healthcare Utilization and Avoided Deaths Based on Increased Breastfeeding Rates During the 2022 Infant Formula Shortage.

	Cases [95% CI]	**Cost (in million 2024 $) [95% CI]**
Total	33,499 [32,995, 34,002]	420 [414, 425]
By Healthcare Utilization & Avoided Deaths		
Outpatient visits	28,872 [28,428, 29,316]	10 [10, 10]
ED visits	3,747 [3,689, 3,805]	4 [4, 5]
Hospitalizations	847 [830, 865]	10 [10, 10]
LRTI – SIDS Deaths	32 [31, 32]	395 [390, 400]
By Disease		
AOM	19,672 [19,257, 20,088]	8 [8, 9]
GII	8,338 [8,164, 8,512]	5 [5, 6]
LRTI	5,457 [5,343, 5,571]	16 [16, 17]
SIDS	31 [31, 32]	389 [384, 394]

Note: Acute otitis media (AOM), gastrointestinal infection (GII), lower respiratory tract infection (LRTI), sudden infant death syndrome (SIDS). ED = Emergency department.

Figure A1. Construction Flowchart Any Breastfeeding, PRAMS 2017- 2022.

Figure A2. Breastfeeding Rates Before and During the 2022 Infant Formula Shortage, Estimates from the Bayesian Structural Time-Series Analysis.

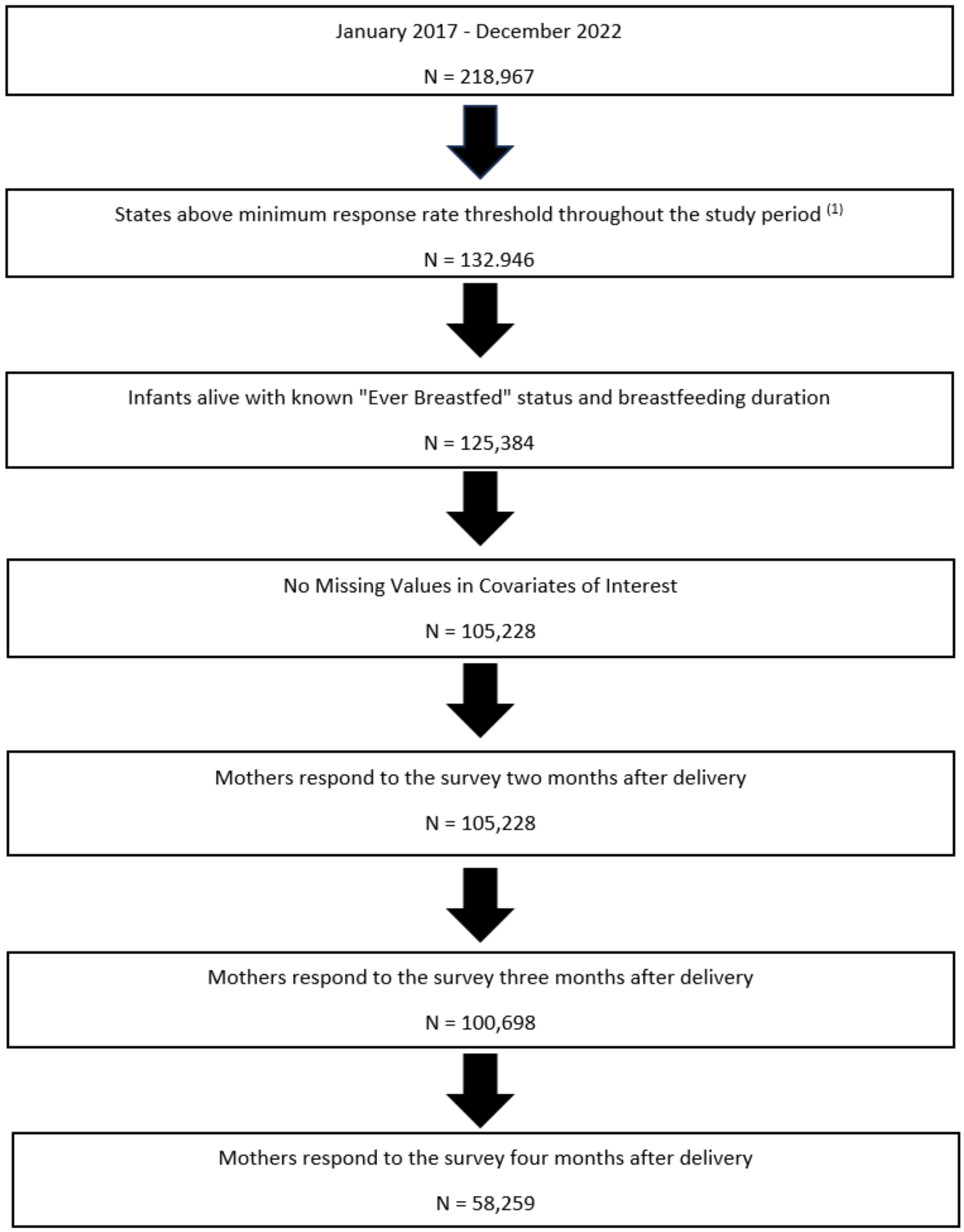


Figure A.1. Construction Flowchart Any Breastfeeding, PRAMS 2017- 2022.

Note: (1) The sample included 19 states and New York City, all meeting the minimum response rate threshold of 50%–55% throughout the study period: The states included are Alabama, Colorado, Delaware, Kansas, Massachusetts, Maine, Michigan, Missouri, Montana, North Dakota, New Jersey, New Mexico, Pennsylvania, South Dakota, Utah, Virginia, Washington, Wisconsin, Wyoming, and the city of New York. While Connecticut met the threshold, it did not participate in the PRAMS ARF. Vermont was excluded because it suppresses the month of birth due to the small number of participants.

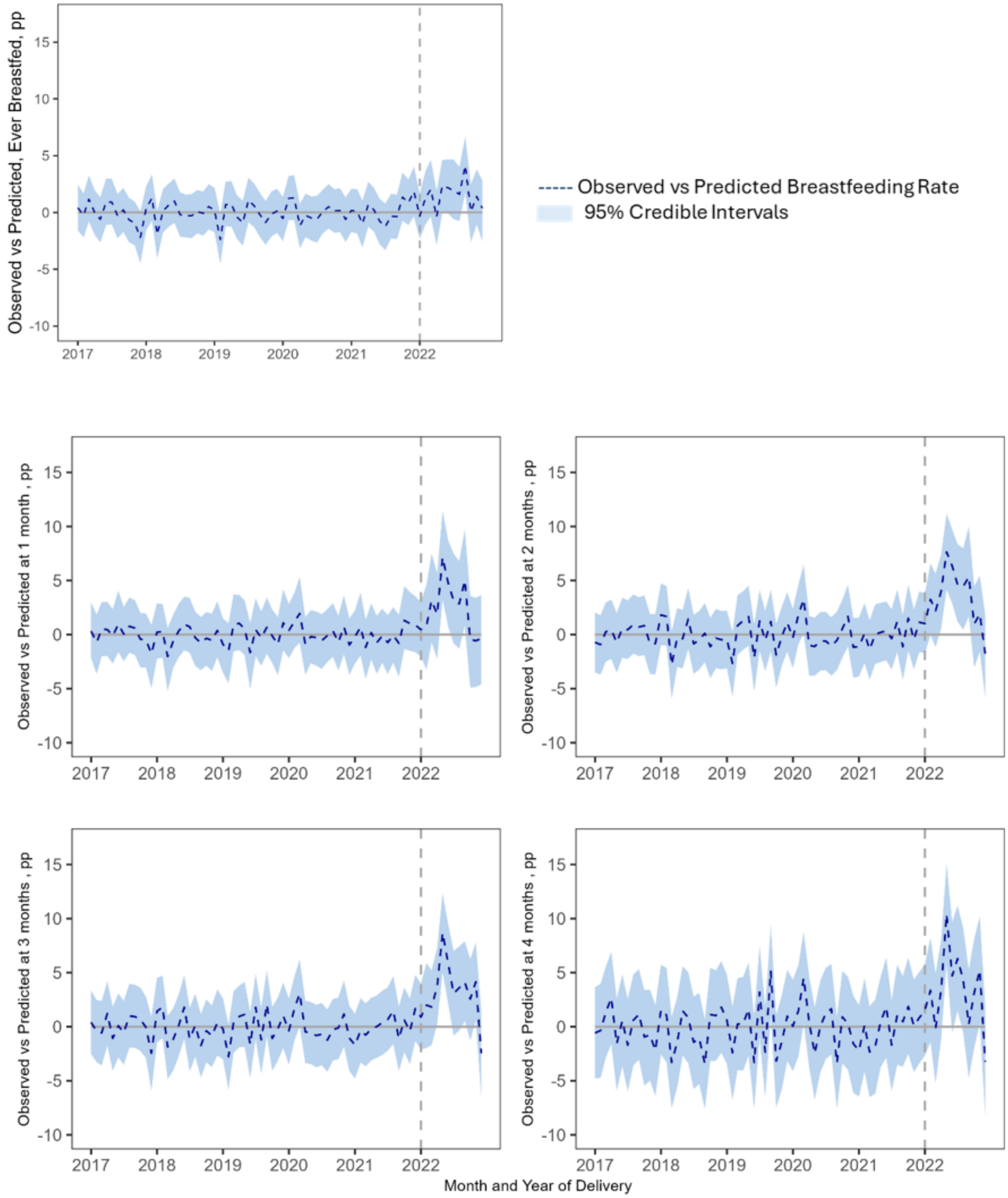


Figure A.2. Breastfeeding Rates Before and During the 2022 Infant Formula Shortage, Estimates from the Bayesian Structural Time-Series Analysis.

Note: Data drawn from the Pregnancy Risk Assessment Monitoring System 2017-2022. PRAMS survey weights are applied to account for complex survey design and nonresponse. Sample size varies by duration: Ever breastfed, 1 month, and 2 months (n = 105,228); 3 months (n = 100,698); and 4 months (n = 58,259). The graph shows the difference between observed and predicted breastfeeding rates by birth month. The vertical dashed line denotes the last month of the pre-intervention period (January 2022) and the beginning of the infant formula crisis. Percentage points (pp).