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Breastfeeding and post-perinatal infant deaths in the United States, A national prospective cohort analysis

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Summary

Background—Reducing infant mortality is a major public health goal. The potential impact of breastfeeding on infant deaths is not well studied in the United States (US).

Methods—We analyzed linked birth–death certificates for 3,230,500 US births that occurred in 2017, including 6,969 post-perinatal deaths from 7–364 days of age as the primary outcome,

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Contributors
RL and JW developed the study protocol and designed the study with input from all authors. RL, JW, AC, JMK, ALM, and CGP developed the analysis strategy. RL, JMN, JC, and CGP obtained the data. RL and JC analyzed the data and created the tables and figure. RL and JW wrote the first draft. All authors reviewed, made inputs to data interpretation, and approved the final paper.

Declaration of Interest
We declare no competing interests.

Disclaimer
The findings and conclusions in this report are those of the authors and do not necessarily represent the official position of the U.S. Centers for Disease Control and Prevention.

further specified as late-neonatal (7–27 days) or post-neonatal (28–364 days) deaths. The primary exposure was 'ever breastfed' obtained from birth certificates. Multiple logistic regression examined associations of ever breastfeeding with post-perinatal deaths and specific causes of deaths, controlling for maternal and infant factors.

Findings—We observed an adjusted reduced odds ratio (AOR)= 0·74 with 95% confidence intervals (CI)=0·70–0·79 for the association of breastfeeding initiation with overall infant deaths (7–364 days), AOR=0·60 (0·54–0·67) for late-neonatal deaths, and AOR=0·81 (0·76–0·87) for post-neonatal deaths. In race/ethnicity-stratified analysis, significant associations of breastfeeding initiation with reduced odds of overall infant deaths were observed for Hispanics [AOR=0·64 (0·55–0·74)], non-Hispanic Whites [AOR=0·75 (0·69–0·81)], non-Hispanic Blacks [AOR=0·83 (0·75–0·91)], and non-Hispanic Asians [AOR=0·51 (0·36–0·72)]. Across racial/ethnic groups, effect sizes for late-neonatal deaths were consistently larger than those for post-neonatal deaths. Significant effects of breastfeeding initiation were observed for deaths due to infection [AOR=0·81(0·69–0·94)], Sudden Unexpected Infant Death [AOR=0·85 (0·78–0·92)], and necrotizing enterocolitis [AOR=0·67 (0·49–0·90)].

Interpretation—Breastfeeding initiation is significantly associated with reduced odds of post-perinatal infant deaths in multiple racial and ethnic groups within the US population. These findings support efforts to improve breastfeeding in infant mortality reduction initiatives.

Keywords

Breastfeeding; Infant mortality; Racial/ethnic disparity

Introduction

Infant mortality, defined as death of a child before the first birthday, is viewed as a measure of infant health and an overall indicator of a nation's well-being.1 The infant mortality rate (IMR) in the United States (US) is higher than in other high-income countries 2 and major disparities exist by race/ethnicity.3 In 2018, there were 5·7 infant deaths per 1,000 live births in the US; leading causes included congenital malformations (21% of deaths), short gestation and low birthweight (17%), maternal complications of pregnancy (6%), sudden infant death syndrome (SIDS) (6%), and unintentional injuries (5%).4 According to 2018 national statistics,[5] non-Hispanic Black infants had the highest IMR (10·8 per 1000 births) and non-Hispanic Asian infants had the lowest IMR (3·6 per 1000 births). As with IMR, racial/ethnic disparities in breastfeeding exist; for infants born in 2017, the lowest breastfeeding initiation rate was among non-Hispanic Black infants (73·7%) and the highest was among non-Hispanic Asian infants (90·0%).6 While the racial/ethnic disparities on infant deaths in the US remain poorly understood, it has been postulated that lower breastfeeding rates in non-Hispanic Black population may partially explain the disparities. Given the high overall IMR and racial inequities in the US, interventions that could decrease the risks for overall infant deaths and reduce the disparities are needed. Examining the associations of breastfeeding with infant deaths could contribute important strategies to decrease infant mortality across the nation.

Breastfeeding is the optimal source of nutrition for infants 7 and is associated with reduced risk of acute otitis media, gastrointestinal and severe lower respiratory infections, type 1 diabetes, necrotizing enterocolitis (NEC), SIDS, asthma, and childhood obesity.[8,9] Protective effects of breastfeeding against infectious diseases play an important role in reducing infant mortality in low- and middle-income countries.[10,11] However, studies are limited in high-income countries where infectious diseases account for a smaller portion of infant deaths, due to better resources of hygiene and control of infectious diseases.12

Analyzing a representative sample of US infants born in 1988, Chen and Rogan13 reported an adjusted odds ratio (AOR)=0·79 with 95% confidence intervals (CI)=0·67–0·93 for the association between initiation of breastfeeding and post-neonatal mortality, defined as deaths between 28 and 364 days. More recently in Shelby County, Tennessee, Ware and colleagues[14] found that breastfeeding initiation was significantly associated with reductions in total post-perinatal mortality, defined as deaths between 7–364 days [AOR=0·81 (0·68–0·97)] and late-neonatal mortality, defined as deaths between 7–27 days [AOR=0·49 (0·34–0·72)]. Based on risk reductions associated with breastfeeding, it has been estimated that if 90% of US infants exclusively breastfed for 6 months, more than 700 deaths among infants <1 year of age could be prevented annually.15 Breastfeeding may reduce infant mortality through optimized nutrition, improved feeding hygiene, enhanced maternal-infant bonding, and the unique immunological properties of breast milk with development of a healthy gut microbiome.[16,17] However, no large US studies have examined breastfeeding and all-cause infant mortality.

Methods

Data source

The National Vital Statistics System (NVSS) led by the National Center for Health Statistics (NCHS) is a census of all live births and deaths in the US, derived from the Standard Certificates for Live Birth and Death.[18,19] Starting in 2016, all 50 states and District of Columbia (DC) adopted the 2003 revision of the birth certificates, which includes breastfeeding initiation, allowing us to analyze US national data to examine the impact of breastfeeding initiation on infant death using linked birth and infant death files. Using NVSS data, we created the “2017 birth cohort” consisting of birth data from infants born in 2017 linked to infant death data occurring in 2017 or 2018 (up to one year after birth).[20] Only births and deaths occurring in the 50 states and DC were included. Among 3,864,754 births in 2017, a total of 22,197 died before 365 days of life, yielding an IMR of 5·74 per 1000 live births in this cohort. Exclusion criteria included infants born to mothers who were foreign residents (n=9,254), birth weight <500 grams (n=6,187), death <7 days (n=6,913), and death due to malignant neoplasms (n=42) or congenital anomalies (n=1,843), which limited the study to the US birth population and reduced the possibility of reverse causality. Births in California and Michigan were also excluded, as California did not report breastfeeding data to NCHS during the study period and Michigan collected breastfeeding data inconsistently. After excluding California (470,225), Michigan (109,886), and infants with missing breastfeeding data from other states (29,904), the final analytical population included 3,230,500 births delivered in 2017, of which 6,969 infants died between 7–364 days (Figure 1).

Outcome variables

Among 6,969 total post-perinatal deaths (7–364 days), there were 1,722 late-neonatal deaths (7–27 days) and 5,247 post-neonatal deaths (28–364 days). Cause of death was certified according to the International Classification of Diseases, Tenth Revision21 as follows: Causes due to infection included diarrhea and gastroenteritis of infectious origin (A09), whooping cough (A37), meningococcal infection (A39), septicemia (A40 to A41), meningitis (G00, G03), acute upper respiratory infections (J00 to J06), influenza and pneumonia (J10 to J18), acute bronchitis and bronchiolitis (J20 to J21), chronic and unspecified bronchitis (J40 to J42), congenital pneumonia (P23), and bacterial sepsis of the newborn (P36). Sudden Unexpected Infant Death (SUID) was used to describe the sudden and unexpected death of an infant; this includes SIDS (R95), accidental suffocation and strangulation in bed (ASSB, W75) and unknown (other ill-defined and unspecified cause of mortality, R99). Cause due to NEC is categorized by P77. Cause due to injuries are specified by unintentional injuries (V01 to X59) and assaults (*U01, X85 to Y09). All other deaths are coded as “Other” category.

Main exposure variable and covariates

Breastfeeding initiation was collected on the birth certificate with the question “Is the infant being breastfed at discharge?” with a “Yes” or “No” response option. The NCHS provided detailed guidance to assist in completion of the facility worksheet for the birth certificate including instructions that breastfeeding should be determined from medical records, based upon indication of receipt of any breast milk or colostrum during the period between delivery and hospital discharge.[22] There was no information on the birth certificate regarding the duration or exclusivity of breastfeeding or formula supplementation.

All covariates were obtained from the birth certificate. Maternal characteristics included age, education, race and ethnicity, participation in the Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) during pregnancy, marital status, timing of prenatal care initiation, smoking during pregnancy, pre-pregnancy body mass index (BMI), mode of delivery, birth plurality, principal source of payment for this delivery (insurance), and maternal diabetes and hypertension in this pregnancy. Infant characteristics included admission to the neonatal intensive care unit (NICU), gestational age, previous live births to the mother (birth order=1 for no previous children), birth weight, and infant sex.

Statistical Analyses

Breastfeeding initiation was coded as “Ever” versus “Never.” Cochran–Mantel–Haenszel tests were used to examine the associations of each maternal and infant characteristic with the binary outcomes of death (yes/no) and breastfeeding (ever/never). Logistic regression was used to model infant death and subsequently specific causes of death. Because associations between breastfeeding and infant mortality may vary by race/ethnicity, gestational age, and birthweight,[13,14] stratified logistic regression analyses were performed by these factors. Each logistic regression model was adjusted for all covariates listed inTable

1 except for NICU and gestational age due to their high collinearities with birth weight. Covariates in multiple logistic regression analysis included parameters commonly associated with both increased infant mortality and lower breastfeeding rates, including maternal factors (maternal race/ethnicity, age, education, WIC status, marital status, prenatal care, smoking during pregnancy, pre-pregnancy BMI, mode of delivery, birth plurality, insurance, maternal diabetes and hypertension) and infant factors (birth order, sex, and birthweight).14 In addition, birth weight was excluded from the adjusted analysis for specific cause of death due to NEC. This approach avoided overfitting the model because almost all infant deaths due to NEC were either preterm (<37 weeks) or had low birth weight (<2500 grams).

SAS Version 9·4 (Cary, NC) was used for all data analyses and results were considered statistically significant at $p < 0{\cdot}05$. The Centers for Disease Control and Prevention (CDC) determined that this study was not subject to Institutional Review Board review because only deidentified secondary data were analyzed.

Results

Table 1 lists the maternal and infant characteristics in this study. Of all live births included in this study, 20·5% were among mothers who were Hispanic, 54·8% non-Hispanic White, 15·7% non-Hispanic Black, 5·3% non-Hispanic Asian, 0·2% non-Hispanic Hawaiian/Pacific Islander, and 0·9% non-Hispanic American Indian/Alaska Native. Although most mothers sought prenatal care during their first trimester (74·1%) and did not smoke during pregnancy (92·1%), a large proportion were classified as either having overweight (25·5%) or obesity (26·6%) based on BMI calculated from self-reported pre-pregnancy height and weight or had a Caesarean delivery (32·0%). Among the infants, 8·9% required NICU admission, 11·6% were preterm (<37 weeks), and 8·1% had low birth weight (<2500g). This study excluded neonatal death within 7 days (6913), malignancy death (42) and congenital anomaly death (1843). Comparing with included death for this study, those excluded deaths were more likely to be infants born among mothers who were older than 35 years of age (12% vs. 20%), had a college education (13% vs. 22%) and of Hispanic origin (15% vs. 24%).

The overall IMR among infants of non-Hispanic Black mothers was more than twice that of non-Hispanic White mothers (3·99 vs. 1·84 per 1000 births). Preterm and low birth weight infants also had a higher IMR compared with term (≥37 weeks) and normal birth weight infants (≥2500 grams) (Table 1). The breastfeeding initiation rate among all births was 83·6% and was significantly associated with each maternal and infant factor examined among all births. Among both late-neonatal and post-neonatal deaths, breastfeeding initiation rates were the highest for mothers with college education, being married, initiating prenatal care during the 1st trimester, non-smoking during pregnancy, and having private insurance (Table 2).

Multiple logistic regression analysis was performed on 2,700,334 breastfed and 530,166 non-breastfed infants, adjusting for covariates (Table 3). Because of a relatively high percentage of missing data on BMI (2·4%) and initial prenatal care (2·6%), “missing” for these two covariates were included as a category in the models to increase the sample size. Analysis revealed AOR=0·74 (95% CI=0·70–0·79, p<0·001) for overall mortality in breastfed infants, 0·60 (0·54–0·67, p<0·001) for late-neonatal mortality, and 0·81 (0·76–0·87, p<0·001) for post-neonatal mortality. In stratified models for overall infant deaths, statistically significant results were noted for all race/ethnicity subgroups except non-Hispanic Hawaiian/Pacific islanders, American Indians/Alaska Natives, and 2 or more races. Compared with AOR among post-neonatal deaths, the effect sizes of breastfeeding for late-neonatal deaths were larger across all race/ethnicity subgroups except for 2 or more races. Although the crude odds ratios indicated stronger associations of breastfeeding with infant deaths in each race/ethnicity, these estimates were attenuated after controlling for confounding factors, but remained significant for Hispanic, non-Hispanic White, non-Hispanic Black, and non-Hispanic Asian infants. Except for birth weight ≥4000 grams, statistically significant AORs were consistently observed for overall infant deaths across different groups of gestational age and birth weight. Similarly, the adjusted analysis showed that the effect size of breastfeeding was consistently larger for late-neonatal deaths than for post-neonatal deaths, regardless of gestational age and birth weight.

Table 4 illustrates the associations of ever breastfeeding with the following causes of deaths: infections, injuries, SUID (including SIDS, ASSB and "unknown"), NEC, Injuries and "other" (including circulatory, short gestation, and all other causes). Statistically significant associations of ever breastfeeding and specific causes of death were observed for infection (AOR=0·81, 0·69 –0·94, p=0·007), SUID (AOR=0·85, 0·78–0·92, p<0·001), NEC (AOR=0·67, 0·49–0·90, p=0·009) and "other" (AOR =0·62, 0·56–0·69, p<0·001).

Discussion

In this study of linked birth-death data from over 3 million US infants born in 2017, we evaluated the associations between breastfeeding initiation and post-perinatal infant deaths. Our analysis revealed a 26% reduction in odds for overall post-perinatal deaths associated with the initiation of breastfeeding (95% CI=21%–30%, p<0·001). For late-neonatal deaths, the reduction in infant mortality was greater at 40% (95% CI=33%–46%, p<0·001), with 19% reduction in post-neonatal deaths associated with the initiation of breastfeeding (95% CI=13%–24%, p<0·001). This large national study is consistent with previous findings in smaller cohorts, where breastfeeding initiation was associated with reduced post-neonatal deaths in a representative US sample of mothers with live births and infant deaths during 1988[13] and with overall post-perinatal deaths in a cohort of infants from 2004 to 2014.14 These significant associations between any breastfeeding and reduced infant mortality, particularly in the neonatal period suggest that efforts to promote, protect, and support breastfeeding may be an important infant mortality reduction strategy to reach Healthy People 2030 goals.23

Notably, our study excluded early neonatal deaths (0–6 days) as a previous study showed such deaths significantly differed from post-perinatal deaths (7–364 days) in the distributions of ICD 10 codes as well as maternal and infant characteristics.24 The exclusion of early neonatal deaths also helps reduce the possibility of reverse causality, since these infants were likely too sick to breastfeed. It is recommended, therefore, to consider early neonatal deaths as a discrete entity from post-perinatal deaths, and further studies on the impact of breastfeeding on infants who died before 7 days are warranted. In addition, we separated infant deaths into late-neonatal and post-neonatal infant death in this study to distinguish patterns in the causes of death and associated maternal and infant risk factors between these two life states.

For the US to achieve the 2030 Healthy People IMR goal of 5·0 deaths per 1000 infants, a 14% overall reduction is needed.23 We found statistically significant associations between any breastfeeding and post-perinatal infant deaths among most racial/ethnic groups, with 25% reductions in overall post-perinatal infant mortality for the non-Hispanic White population, 17% reduction in non-Hispanic Blacks, and even greater protection in association with breastfeeding among Hispanic and non-Hispanic Asian populations (36% and 49% lower death rates, respectively). The reasons for a smaller effect size among non-Hispanic black population cannot be explained by further analysis of our data, but we offer two potential explanations. First, our analysis does not address the impact of breastfeeding duration and exclusivity, which is known to be significantly lower in the non-Hispanic Black population compared to all others except for American Indian and Alaska Natives.[6] Thus, breastfeeding "dose" to the infant whose mother initiates breastfeeding is not equal by race. Second, the small effect size might be explained by other risk factors for which we were not able to fully adjust for. Social and structural determinants of infant death risks, such as poverty and structural racism, are more prevalent among non-Hispanic black population regardless of their breastfeeding status and thus may dilute the effect of breastfeeding. Given the high IMR in the US, any intervention that could reduce infant deaths would be worthwhile, even if itself alone does not reduce disparities proportionately.

The effect sizes with late-neonatal deaths were consistently larger than those with post-neonatal deaths for each racial/ethnic group, with the largest 67% reduction observed among the non-Hispanic Asian population. These findings further support the promotion of breastfeeding as a potential important strategy to reduce infant mortality, especially neonatal deaths25. Noting that breastfeeding rates vary across American subpopulations and the social determinants of health including workplace support and structural racism must be addressed to mitigate barriers to breastfeeding,26 the Surgeon General has highlighted the need for culturally-appropriate breastfeeding promotion efforts27

This analysis from a high-income country setting adds to the literature already available from low- and middle-income country settings by demonstrating the protective association of breastfeeding initiation on overall post-perinatal deaths for infants, regardless of gestational age and across different birth weights including preterm (<37 weeks) and low birth weight (<2500 grams) infants. Significant reductions in late-neonatal deaths were also identified among all gestational age and birth weight groups examined, as well as reductions in post-neonatal deaths in gestational ages 34–40 weeks, and birthweight 1500–3999 grams. These data support the importance of breast milk for all infants, including preterm and low birth weight infants, and support the recommendation by the American Academy of Pediatrics to use human milk for all infants28

The current study further indicates the causes of death with reductions that are associated with breastfeeding initiation. Specifically, reduced odds for post-perinatal infant mortality from infectious conditions (19%, p = 0·009), SUID (15%, p<0·001), NEC (23%, p = 0·009), and "Other" (38%, p<0·001) was observed (Table 4). The SUID grouping (including R99, R95, W75) is being increasingly used by researchers to produce more accurate comparisons in SUIDs over time.[29] This grouping is important because individual death certifiers have varied preferences and practices with the use of the individual codes making comparisons between the sub-categories of SUID problematic due to "diagnostic shift".30 In addition, the importance of breastfeeding for at least 2 months has been shown to reduce the risk of SIDS,9 but our study only evaluated the initiation of any breastfeeding, which may limit statistical significance for the SIDS subgroup in our findings. Similarly, the crude reduction in deaths due to injuries associated with breastfeeding, when adjusted for possible confounders that included socioeconomic factors such as insurance type, maternal age and education, was no longer statistically significant. This highlights the importance of addressing socio-economic risks for both injury prevention and breastfeeding promotion, protection, and support.

These linked birth–death data provided a unique opportunity to examine post-perinatal infant mortality reduction in relation to breastfeeding initiation. This study has several strengths: all the infants born in the US are included in this study except for those from California and Michigan; this prospective birth cohort followed infants born in 2017 for an entire year to ascertain their death rates and causes; stratified analysis and controlling for a series of maternal and infant factors in the adjusted analysis provide more appropriate estimates for true associations of breastfeeding with post-perinatal infant mortality.

An important limitation of our analysis is the lack of data regarding duration and exclusivity of breastfeeding from birth certificates. Future studies should focus on the duration and intensity of breastfeeding to determine if the significant reductions in infant mortality are further related to timing, exposure, and/or dose response to breast milk. In addition, using the vital statistic data alone, this study could not identify the causal pathway between initiating breastfeeding and infant mortality, such as structural racism and other social determinants of health that impact breastfeeding practices and infant outcomes especially among Black women.31 These upstream factors are recognized as barriers to both initiation and continuation of breastfeeding and should be addressed to support breastfeeding. Lastly, although many social factors that create barriers to breastfeeding such as lack of paid maternity leave and the need to return to work, access to breastfeeding support, and presence of peer role models are not available on the birth certificate data, the socio-demographic characteristics such as type of insurance, WIC participation, maternal age and education, race and ethnicity are proxy of these possible confounding effects. Controlling for these available factors lessened the association in almost all categories and causes of death, which highlights the importance of addressing societal factors in the promotion, protection, and support of breastfeeding to improve health equity. Despite our statistical efforts towards a more robust study design, we may not have completely ruled out the reverse causality and residual confounding effects given the nature of this study. To address how robust our findings are to potential uncontrolled confounding, we have conducted a sensitivity analyses using E-value.32 To explain away the observed associations between breastfeeding and overall infant death, late-neonatal death, and post-neonatal death, the minimum strength of the association (E-value) between the unmeasured confounding and breastfeeding or infant death would be 2.04, 2.73, and 1.76, respectively. These large E-values imply that unmeasured confounding, if existing, needs to be strong to explain away the association observed in this study.

In conclusion, we have identified significant associations between the initiation of any breastfeeding and reduced post-perinatal deaths in the US population, with consistent findings in various stratified analyses representing different demographics and health status. These findings support integrating efforts to promote, protect, and support breastfeeding for US infant mortality reduction efforts.

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Data Sharing Statement

Data is available at http://www.cdc.gov/nchs/data_access/vitalstatsonline.htm.

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Research in context

Evidence before this study

The benefits of breastfeeding on reducing infant and child morbidity and mortality have been well documented for the developing world. The 2016 Breastfeeding Lancet Series continues to provide unequivocal evidence regarding the numerous risk reductions that optimal breastfeeding practices offer to children and women worldwide and the major savings that improving these practices can have due to public health benefits. However, only two small studies in the United States have assessed the associations of breastfeeding with all-cause infant mortality up to now.

Added value of this study

Our study is the first linking all births in the United States to infant deaths up to one year after birth to evaluate whether the benefits of breastfeeding on reducing infant mortality is also evident in a developed country. We found a 26% reduction in odds for overall post-perinatal deaths from 7 to 364 days associated with the initiation of breastfeeding. For late-neonatal deaths from 7 to 27 days, the reduction in infant mortality was greater at 40%, with 19% reduction in post-neonatal deaths from 28 to 364 days associated with the initiation of breastfeeding. Statistically significant effects of breastfeeding were also observed for infant deaths due to infections (AOR=0·81, 0·69–0·94, p=0·007), Sudden Unexpected Infant Death (AOR=0·85, 0·78–0·92, p<0·001), and necrotizing enterocolitis (AOR=0·67, 0·49–0·90, p=0·009).

Implications of all the available evidence

These findings support integrating efforts to promote, protect, and support breastfeeding as one of the key strategies for US infant mortality reduction efforts.

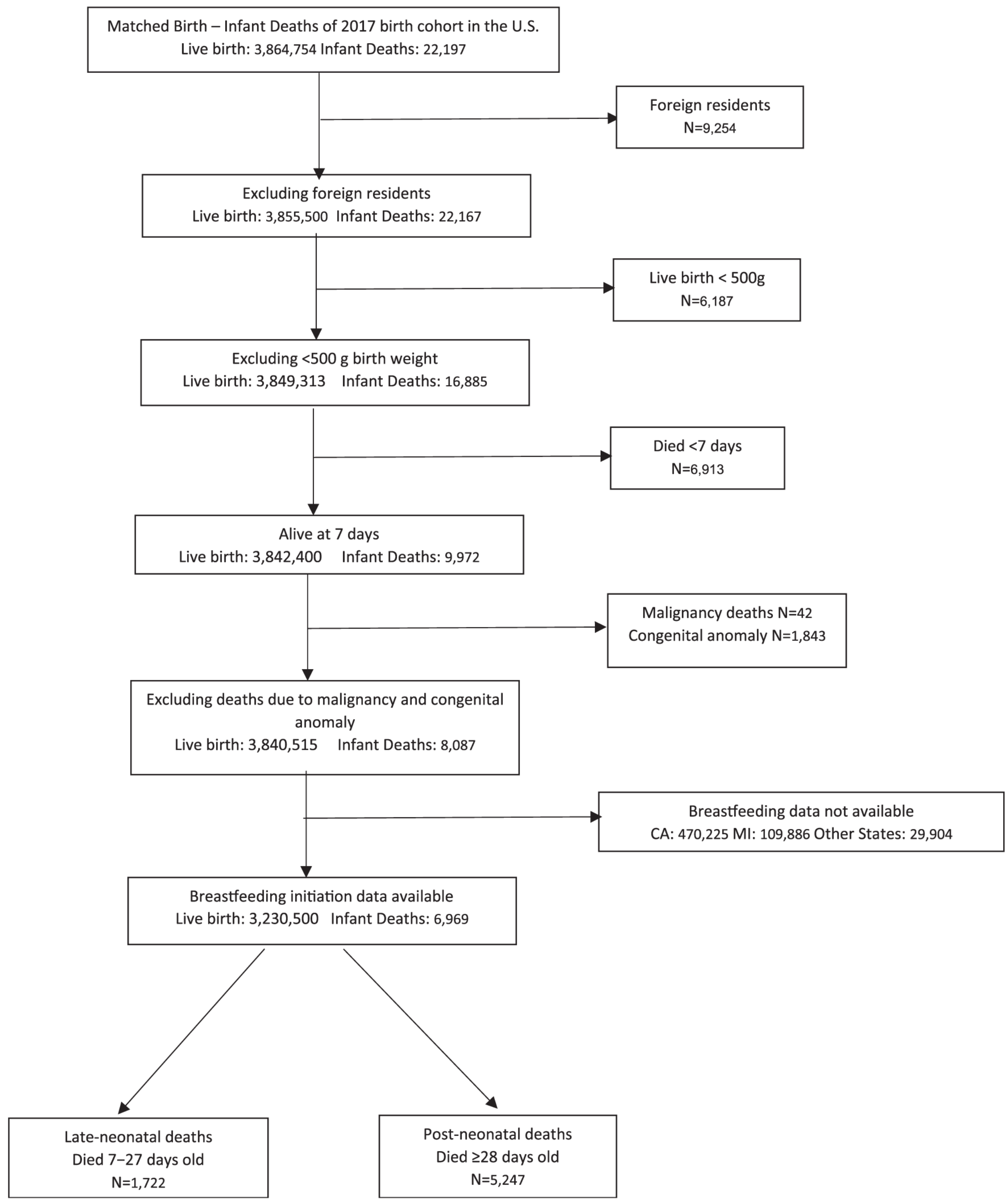

Figure 1.
Sample Flow

Table 1:

Sample characteristics of linked file for live birth in 2017 and post-perinatal infant deaths in 2017 or 2018, United States

	Total live births n (%)	Overall infant deaths (7–364 days) n (%)	Overall death rate per 1,000 birth	Late-neonatal deaths (7–27 days) n (%)	Late-neonatal death rate per 1,000 birth	Post-neonatal deaths (28–364 days) n (%)	Post-neonatal death rate per 1,000 birth
Overall	3,230,500 (100)	6,969(100)	2·16	1,722 (100)	0·53	5,247(100)	1·62
Maternal Characteristics							
Age							
<20years	169,080 (5·2)	695 (10·0)	4·11	142 (8·2)	0·84	553 (10·5)	3·27
20–24 years	655,222 (20·3)	2,049 (29·4)	3·13	443 (25·7)	0·68	1,606 (30·6)	2·45
25–29 years	950,586 (29·4)	1,944 (27·9)	2·05	436 (25·3)	0·46	1,508 (28·7)	1·59
30–34 years	908,176 (28·1)	1,417(20·3)	1·56	417 (24·2)	0·46	1,000 (19·1)	1·10
>=35 years	547,436 (16·9)	864 (12·4)	1·58	284 (16·5)	0·52	580(11·1)	1·06
P value			< 0·001		< 0·001		< 0·001
Education							
<High school	425,061 (13·2)	1,465 (21·0)	3·45	315 (18·3)	0·74	1,150 (21·9)	2·71
High school	819,782 (25·4)	2,524 (36·2)	3·08	564 (32·8)	0·69	1,960 (37·4)	2·39
Some college	925,198 (28·6)	2,004 (28·8)	2·17	517 (30·0)	0·56	1,487 (28·3)	1·61
≥College	1,037,888 (32·1)	906 (13·0)	0·87	306 (17·8)	0·29	600(11·4)	0·58
Missing	22,571 (0·7)	70(1·0)	3·10	20 (1·2)	0·89	50(1·0)	2·22
P value			< 0·001		< 0·001		< 0·001
Race							
Hispanic	663,545 (20·5)	1,067(15·3)	1·61	268 (15·6)	0·40	799(15·2)	1·20
Non-Hispanic white	1,769,279 (54·8)	3,252 (46·7)	1·84	824 (47·9)	0·47	2,428 (46·3)	1·37
Non-Hispanic black	506,440 (15·7)	2,022 (29·0)	3·99	463 (26·9)	0·91	1,559 (29·7)	3·08
Non-Hispanic Asian	171,023 (5·3)	187 (2·7)	1·09	64 (3·7)	0·37	123 (2·3)	0·72
Non-Hispanic Hawaiian/Pacific Islander	7,430 (0·2)	20 (0·3)	2·69	NA	NA	16(0·3)	2·15
Non-Hispanic American Indian/Alaska Native	27,757 (0·9)	129 (1·9)	4·65	22 (1·3)	0·79	107 (2·0)	3·85
2 or more races	67,490 (2·1)	251 (3·6)	3·72	60 (3·5)	0·89	191 (3·6)	2·83
Missing	17,536 (0·5)	41 (0·6)	2·34	17 (1·0)	0·97	24 (0·5)	1·37
P value			< 0·001		< 0·001		< 0·001

	Total live births n (%)	Overall infant deaths (7–364 days) n (%)	Overall death rate per 1,000 birth	Late-neonatal deaths (7–27 days) n (%)	Late-neonatal death rate per 1,000 birth	Post-neonatal deaths (28–364 days) n (%)	Post-neonatal death rate per 1,000 birth
WIC[a]							
Yes	1,187,674 (36·8)	3,459 (49·6)	2·91	690 (40·1)	0·58	2,769 (52·8)	2·33
No	2,004,960 (62·1)	3,411 (48·9)	1·70	1,005 (58·4)	0·50	2,406 (45·9)	1·20
Missing	37,866 (1·2)	99(1·4)	2·61	27 (1·6)	0·71	72(1·4)	1·90
P value			< 0·001		0·0037		< 0·001
Married							
Yes	1,940,199 (60·1)	2,500 (35·9)	1·29	733 (42·6)	0·38	1,767 (33·7)	0·91
No	1,290,301 (39·9)	4,469 (64·1)	3·46	989 (57·4)	0·77	3,480 (66·3)	2·70
P value			< 0·001		< 0·001		< 0·001
Prenatal Care							
1st trimester	2,394,102 (74·1)	4,208 (60·4)	1·76	1,099 (63·8)	0·46	3,109 (59·3)	1·30
2nd trimester	544,709 (16·9)	1,582 (22·7)	2·90	300 (17·4)	0·55	1,282 (24·4)	2·35
3rd trimester	150,397 (4·7)	386 (5·5)	2·57	53 (3·1)	0·35	333 (6·3)	2·21
No prenatal care	57,928 (1·8)	435 (6·2)	7·51	156 (9·1)	2·69	279 (5·3)	4·82
Missing	83,364 (2·6)	358 (5·1)	4·29	114 (6·6)	1·37	244 (4·7)	2·93
P value			< 0·001		< 0·001		< 0·001
Smoking during pregnancy							
Yes	241,322 (7·5)	1,363 (19·6)	5·65	269 (15·6)	1·11	1,094 (20·9)	4·53
No	2,974,973 (92·1)	5,541 (79·5)	1·86	1,435 (83·3)	0·48	4,106 (78·3)	1·38
Missing	14,205 (0·4)	65 (0·9)	4·58	18 (1·0)	1·27	47 (0·9)	3·31
P value			< 0·001		< 0·001		< 0·001
Pre-pregnancy BMI (kg/m^2)[b]							
<18·5	105,999 (3·3)	282 (4·0)	2·66	69 (4·0)	0·65	213 (4·1)	2·01
18·5–24·9	1,363,789 (42·2)	2,528 (36·3)	1·85	584 (33·9)	0·43	1,944 (37·0)	1·43
25·0–29·9	824,681 (25·5)	1,598 (22·9)	1·94	421 (24·4)	0·51	1,177 (22·4)	1·43
>=30·0	858,255 (26·6)	2,280 (32·7)	2·66	561 (32·6)	0·65	1,719(32·8)	2·00
Missing	77,776 (2·4)	281 (4·0)	3·61	87(5·1)	1·12	194 (3·7)	2·49
P value			< 0·001		< 0·001		< 0·001
Delivery							
C-section	1,033,321 (32·0)	3,156 (45·3)	3·05	929 (53·9)	0·90	2,227 (42·4)	2·16

	Total live births n (%)	Overall infant deaths (7–364 days) n (%)	Overall death rate per 1,000 birth	Late-neonatal deaths (7–27 days) n (%)	Late-neonatal death rate per 1,000 birth	Post-neonatal deaths (28–364 days) n (%)	Post-neonatal death rate per 1,000 birth
Vaginal	2,195,848 (68·0)	3,807 (54·6)	1·73	792 (46·0)	0·36	3,015 (57·5)	1·37
Missing	1,331 (0)	6(0·1)	4·51	1 (0·1)	0·75	5(0·1)	3·76
P value			< 0·001		< 0·001		< 0·001
Plurality							
Singleton	3,121,438 (96·6)	6,279 (90·1)	2·01	1,444 (83·9)	0·46	4,835 (92·1)	1·55
Multiple	109,062 (3·4)	690 (9·9)	6·33	278(16·1)	2·55	412 (7·9)	3·78
P value			< 0·001		< 0·001		< 0·001
Insurance							
Private	1,574,667 (48·7)	1,959 (28·1)	1·24	618(35·9)	0·39	1,341 (25·6)	0·85
Medicaid	1,378,337 (42·7)	4,416 (63·4)	3·20	955 (55·5)	0·69	3,461 (66·0)	2·51
Self-pay	134,020 (4·1)	293 (4·2)	2·19	84 (4·9)	0·63	209 (4·0)	1·56
Other	124,158 (3·8)	254 (3·6)	2·05	50 (2·9)	0·40	204 (3·9)	1·64
Missing	19,318 (0·6)	47 (0·7)	2·43	15 (0·9)	0·78	32 (0·6)	1·66
P value			< 0·001		< 0·001		< 0·001
Maternal Diabetes							
Yes	236,464 (7·3)	445 (6·4)	1·88	105 (6·1)	0·44	340 (6·5)	1·44
No	2,991,619 (92·6)	6,510 (93·4)	2·18	1,612 (93·6)	0·54	4,898 (93·3)	1·64
Missing	2,417 (0·1)	14 (0·2)	5·79	5 (0·3)	2·07	9 (0·2)	3·72
P value			< 0·001		0·001		< 0·001
Maternal Hypertension							
Yes	289,223 (9·0)	870 (12·5)	3·01	230(13·4)	0·8	640 (12·2)	2·21
No	2,938,860 (90·9)	6,085 (87·3)	2·07	1,487 (86·4)	0·51	4,598 (87·6)	1·56
Missing	2,417 (0·1)	14 (0·2)	5·79	5 (0·3)	2·07	9 (0·2)	3·72
P value			< 0·001		< 0·001		< 0·001
Infant Characteristics							
Breastfeeding							
Ever	2,700,334 (83·6)	4,603 (66·0)	1·70	1,076 (62·5)	0·40	3,527 (67·2)	1·31
Never	530,166(16·4)	2,366 (34·0)	4·46	646 (37·5)	1·22	1,720 (32·8)	3·24
P value			< 0·001		< 0·001		< 0·001
NICU[c]							

	Total live births n (%)	Overall infant deaths (7–364 days) n (%)	Overall death rate per 1,000 birth	Late-neonatal deaths (7–27 days) n (%)	Late-neonatal death rate per 1,000 birth	Post-neonatal deaths (28–364 days) n (%)	Post-neonatal death rate per 1,000 birth
Yes	289,056 (8·9)	2,941 (42·2)	10·17	1,202 (69·8)	4·16	1,739 (33·1)	6·02
No	2,939,185 (91·0)	4,014 (57·6)	1·37	515 (29·9)	0·18	3,499 (66·7)	1·19
Missing	2,259 (0·1)	14 (0·2)	6·20	5 (0·3)	2·21	9 (0·2)	3·98
P value			< 0·001		< 0·001		< 0·001
Gestational Age (weeks)							
<34	103,042 (3·2)	2,120 (30·4)	20·57	1,009 (58·6)	9·79	1,111 (21·2)	10·78
34·36	272,468 (8·4)	892 (12·8)	3·27	157(9·1)	0·58	735 (14·0)	2·70
37·38	828,963 (25·7)	1,469 (21·1)	1·77	208(12·1)	0·25	1,261 (24·0)	1·52
39·40	1,584,870 (49·1)	1,875 (26·9)	1·18	245 (14·2)	0·15	1,630 (31·1)	1·03
≥41	439,725 (13·6)	606 (8·7)	1·38	99 (5·7)	0·23	507 (9·7)	1·15
Missing	1,432 (0)	7(0·1)	4·89	4 (0·2)	2·79	3(0·1)	2·09
P value			< 0·001		< 0·001		< 0·001
Birth Order							
1	1,218,766 (37·7)	2,240 (32·1)	1·84	668 (38·8)	0·55	1,572 (30·0)	1·29
2	1,033,548 (32·0)	1,986 (28·5)	1·92	456 (26·5)	0·44	1,530 (29·2)	1·48
>=3	970,561 (30·0)	2,711 (38·9)	2·79	590 (34·3)	0·61	2,121 (40·4)	2·19
Missing	7,625 (0·2)	32 (0·5)	4·2	8 (0·5)	1·05	24 (0·5)	3·15
P value			< 0·001		< 0·001		< 0·001
Birth Weight (grams)							
500–1499	37,518(1·2)	1,811 (26·0)	48·27	935 (54·3)	24·92	876(16·7)	23·35
1500–2499	223,364 (6·9)	1,121 (16·1)	5·02	236 (13·7)	1·06	885 (16·9)	3·96
2500–3999	2,717,184 (84·1)	3,810(54·7)	1·40	520 (30·2)	0·19	3,290 (62·7)	1·21
≥4000	251,317 (7·8)	221 (3·2)	0·88	29 (1·7)	0·12	192 (3·7)	0·76
Missing	1,117 (0)	6(0·1)	5·37	2(0·1)	1·79	4(0·1)	3·58
P value			< 0·001		< 0·001		< 0·001
Sex							
Male	1,651,917 (51·1)	3,925 (56·3)	2·38	978 (56·8)	0·59	2,947 (56·2)	1·78
Female	1,578,583 (48·9)	3,044 (43·7)	1·93	744 (43·2)	0·47	2,300 (43·8)	1·46
P value			< 0·001		< 0·001		< 0·001

[a]WIC=Special Supplemental Nutrition Program for Women, Infants, and Children

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[b] BMI= Body Mass Index

[c] NICU=Neonatal Intensive Care Unit

[d] Results not available because of less than 10 observations in display

Table 2:

Ever breastfeeding rates among 2017 birth cohort, United States

	Total live births Breastfed n (% breastfed of total)	Infant deaths 7–364 days Breastfed n (% breastfed oftotal)	Late-neonatal deaths 7–27 days Breastfed n (% breastfed of total)	Post-neonatal death 28–364 days Breastfed n (% breastfed of total)
Overall	2,700,334 (83·6)	4,603 (66·0)	1,076 (62·5)	3,527 (67·2)
Maternal Characteristics				
Age				
<20years	123,371 (73·0)	454 (65·3)	81 (57·0)	373 (67·5)
20–24 years	513,062 (78·3)	1,346 (65·7)	293 (66·1)	1,053 (65·6)
25–29 years	793,570 (83·5)	1,247 (64·1)	257 (58·9)	990 (65·6)
30–34 years	793,608 (87·4)	974 (68·7)	273 (65·5)	701 (70·1)
>=35 years	476,723 (87·1)	582 (67·4)	172 (60·6)	410 (70·7)
P value	<0·001	0·094	0·974	0·018
Education				
<High school	308,369 (72·5)	818 (55·8)	159 (50·5)	659 (57·3)
High school	619,067 (75·5)	1,567 (62·1)	340 (60·3)	1,227(62·6)
Some college	784,324 (84·8)	1,455 (72·6)	353 (68·3)	1,102 (74·1)
≥College	971,033 (93·6)	729 (80·5)	216 (70·6)	513 (85·5)
P value	<0·001	<0·001	<0·001	<0·001
Race				
Hispanic	580,921 (87·5)	782 (73·3)	173 (64·6)	609 (76·2)
Non-Hispanic white	1,500,110 (84·8)	2,181 (67·1)	534 (64·8)	1,647 (67·8)
Non-Hispanic black	365,640 (72·2)	1,202 (59·4)	263 (56·8)	939 (60·2)
Non-Hispanic Asian	156,016 (91 ·2)	136 (72·7)	41 (64·1)	95 (77·2)
Non-Hispanic Hawaiian/Pacific Islander	6,130 (82·5)	15 (75·0)	NA	12 (75·0)
Non-Hispanic American Indian/Alaska Native	20,967 (75·5)	80 (62·0)	12 (54·5)	68 (63·6)
2 or more races	55,962 (82·9)	182 (72·5)	43 (71·7)	139 (72·8)
P value	<0·001	0·014	0·704	0·008
WIC[a]				
Yes	905,258 (76·2)	2,198 (63·5)	427(61·9)	1,771 (64·0)

	Total live births Breastfed n (% breastfed of total)	Infant deaths 7–364 days Breastfed n (% breastfed oftotal)	Late-neonatal deaths 7–27 days Breastfed n (% breastfed of total)	Post-neonatal death 28–364 days Breastfed n (% breastfed of total)
No	1,764,716(88·0)	2,348 (68·8)	636 (63·3)	1,712 (71·2)
P value	<0·001	<0·001	0·558	<0·001
Married				
Yes	1,741,571 (89·8)	1,826 (73·0)	488 (66·6)	1,338 (75·7)
No	958,763 (74·3)	2,777 (62·1)	588 (59·5)	2,189 (62·9)
P value	<0·001	<0·001	0·003	<0·001
Prenatal Care				
1st trimester	2,046,682 (85·5)	2,966 (70·5)	736 (67·0)	2,230 (71·7)
2nd trimester	432,865 (79·5)	989 (62·5)	172 (57·3)	817(63·7)
3rd trimester	117,516(78·1)	230 (59·6)	30 (56·6)	200 (60·1)
No prenatal care	37,072 (64·0)	221 (50·8)	81 (51·9)	140 (50·2)
P value	<0·001	<0·001	<0·001	<0·001
Smoking during pregnancy				
Yes	145,304 (60·2)	734 (53·9)	147 (54·6)	587 (53·7)
No	2,544,846 (85·5)	3,838 (69·3)	922 (64·3)	2,916(71·0)
P value	<0·001	<0·001	0·003	<0·001
Prepregnancy BMI (kg/m^2)^b				
<18·5	85,136 (80·3)	172 (61·0)	36 (52·2)	136 (63·8)
18·5–24·9	1,172,740 (86·0)	1,690 (66·9)	378 (64·7)	1,312 (67·5)
25·0–29·9	696,153 (84·4)	1,075 (67·3)	262 (62·2)	813 (69·1)
>=30·0	685,399 (79·9)	1,513 (66·4)	357 (63·6)	1,156 (67·2)
P value	<0·001	0·593	0·630	0·695
Delivery				
C-section	843,990 (81·7)	2,093 (66·3)	592 (63·7)	1,501 (67·4)
Vaginal	1,855,242 (84·5)	2,505 (65·8)	483 (61·0)	2,022 (67·1)
P value	<0·001	0·649	0·242	0·798
Plurality				
Singleton	2,614,365 (83·8)	4,150 (66·1)	898 (62·2)	3,252 (67·3)
Multiple	85,969 (78·8)	453 (65·7)	178 (64·0)	275 (66·7)
P value	<0·001	0·816	0·562	0·832

	Total live births Breastfed n (% breastfed of total)	**Infant deaths 7–364 days Breastfed n (% breastfed oftotal)**	**Late-neonatal deaths 7–27 days Breastfed n (% breastfed of total)**	**Post-neonatal death 28–364 days Breastfed n (% breastfed of total)**
Insurance				
Private	1,418,370 (90·1)	1,479 (75·5)	434 (70·2)	1,045 (77·9)
Medicaid	1,040,425 (75·5)	2,718(61·5)	551 (57·7)	2,167 (62·6)
Self-pay	116,943 (87·3)	185 (63·1)	44 (52·4)	141 (67·5)
Other	108,978 (87·8)	194 (76·4)	38 (76·0)	156 (76·5)
P value	<0·001	<0·001	0·002	<0·001
Maternal Diabetes				
Yes	196,220 (83·0)	303 (68·1)	67 (63·8)	236 (69·4)
No	2,502,343 (83·6)	4,293 (65·9)	1,007 (62·5)	3,286 (67·1)
P value	<0·001	0·355	0·783	0·378
Maternal Hypertension				
Yes	230,563 (79·7)	583 (67)	151 (65·7)	432 (67·5)
No	2,468,000 (84)	4,013 (65·9)	923 (62·1)	3,090 (67·2)
P value	<0·001	0·536	0·296	0·881
Infant Characteristics				
NICU[c]				
Yes	216,549 (74·9)	1,887 (64·2)	738 (61·4)	1,149 (66·1)
No	2,481,988 (84·4)	2,709 (67·5)	337 (65·4)	2,372 (67·8)
P value	<0·001	0·004	0·113	0·212
Gestational Age (weeks)				
<34	74,500 (72·3)	1,365 (64·4)	638 (63·2)	727 (65·4)
34–36	209,994 (77·1)	540 (60·5)	88 (56·1)	452 (61·5)
37–38	682,959 (82·4)	985 (67·1)	133 (63·9)	852 (67·6)
39–40	1,355,501 (85·5)	1,294 (69·0)	156 (63·7)	1,138 (69·8)
≥41	376,675 (85·7)	418(69·0)	61 (61·6)	357 (70·4)
P value	<0·001	<0·001	0·963	<0·001
Birth Order				
1	1,063,965 (87·3)	1,622 (72·4)	457 (68·4)	1,165 (74·1)
2	868,792 (84·1)	1,326 (66·8)	279 (61·2)	1,047 (68·4)
>=3	761,572 (78·5)	1,641 (60·5)	336 (56·9)	1,305 (61·5)

	Total live births Breastfed n (% breastfed of total)	Infant deaths 7–364 days Breastfed n (% breastfed oftotal)	Late-neonatal deaths 7–27 days Breastfed n (% breastfed of total)	Post-neonatal death 28–364 days Breastfed n (% breastfed of total)
P value	<0·001	<0·001	<0·001	<0·001
Birth Weight (grams)				
500–1499	26,875 (71 ·6)	1,181 (65·2)	591 (63·2)	590 (67·4)
1500–2499	166,916(74·7)	673 (60·0)	139 (58·9)	534 (60·3)
2500–3999	2,286,098 (84·1)	2,586 (67·9)	328 (63·1)	2,258 (68·6)
≥4000	219,573 (87·4)	161 (72·9)	18 (62·1)	143 (74·5)
P value	<0·001	0·001	0·845	0·008
Sex				
Male	1,379,554 (83·5)	2,624 (66·9)	624 (63·8)	2,000 (67·9)
Female	1,320,780 (83·7)	1,979 (65·0)	452 (60·8)	1,527 (66·4)
P value	<0·001	0·108	0·195	0·259

[a] WIC=Special Supplemental Nutrition Program for Women, Infants, and Children

[b] BMI= Body Mass Index

[c] NICU=Neonatal Intensive Care Unit

[d] Results not available because of less than 10 observations in display

Table 3:

Logistic regression analyses for the association of ever breastfeeding with post-perinatal infant deaths among 2017 birth cohort, United States

	Live birth Number	Overall Infant Death (7–364 days)			Late-neonatal deaths (7–27 days)			Post-neonatal deaths (28–364 days)		
		n	COR[a] (95% CI, p value)	AOR[b] (95% CI, p value)	n	COR[a] (95% CI, p value)	AOR[b] (95% CI, p value)	n	COR[a] (95% CI, p value)	AOR[b] (95% CI, p value)
Total	3,230,500	6,969	038	0·74	1,722	0·33	0·60	5,247	0·40	0·81
			(0·36–0·40, <·001)	(0·70–0·79, <·001)		(0·30–0·36, <·001)	(0·54–0·67, <·001)		(0·38–0·43, <·001)	(0·76–0·87, <·001)
Race										
Hispanic	663,545	1,067	039	0·64	268	0·26	0·47	799	0·45	0·73
			(0·34–0·45, <·001)	(0·55–0·74, <·001)		(0·20–0·33, <·001)	(0·36–0·62, <·001)		(0·39–0·53, <·001)	(0·61–0·88, 0·001)
Non-Hispanic white	1,769,279	3,252	0·36	0·75	824	0·33	0·61	2,428	0·38	0·81
			(0·34–0·39, <·001)	(0·69–0·81, <·001)		(0·29–0·38, <·001)	(0·52–0·72, <·001)		(0·35–0·41, <·001)	(0·73–0·89, <·001)
Non-Hispanic black	506,440	2,022	0·56	0·83	463	0·51	0·71	1,559	0·58	0·87
			(0·52–0·62, <·001)	(0·75–0·91, <·001)		(0·42–0·61, <·001)	(0·58–0·87, 0·001)		(0·53–0·64, <·001)	(0·78–0·98, 0·018)
Non-Hispanic Asian	171,023	187	0·25	0·51	64	0·17	0·33	123	0·32	0·65
			(0·18–0·35, <·001)	(0·36–0·72, <·001)		(0·10–0·28, <·001)	(0·20–0·55, <·001)		(0·21–0·49, <·001)	(0·42–1·03, 0·064)
Non-Hispanic Hawaiian/Pacific Islander	7,430	20	0·60	0·77	4	N/A[c]	N/A[c]	16	0·59	0·50
			(0·23–1·58, 0·300)	(0·32–1·87, 0·569)					(0·20–1·73, 0·336)	(0·21–1 ·21, 0·125)
Non-Hispanic American Indian/ Alaska Native	27,757	129	0·52	0·90	22	0·39	0·77	107	0·56	0·93
			(0·37–0·75, <·001)	(0·61–1·32, 0·589)		(0·17–0·88, 0·023)	(0·36–1·66, 0·506)		(0·38–0·83, 0·004)	(0·61–1·42, 0·751)
2 or more races	67,490	251	0·54	0·90	60	0·51	1·03	191	0·55	0·86
			(0·41–0·71, <·001)	(0·66–1·22, 0·500)		(0·29–0·89, 0·018)	(0·56–1·90, 0·917)		(0·40–0·75, <·001)	(0·61–1·21, 0·389)
Gestational Age (weeks)										
<34	103042	2120	0·69	0·79	1009	0·66	0·71	1111	0·72	0·88
			(0·63–0·75, <·001)	(0·71–0·87, <·001)		(0·58–0·75,<·001)	(0·61–0·82, <·001)		(0·63–0·81, <·001)	(0·77–1·01, 0·078)
34–36	272,468	892	0·45	0·76	157	0·38	0·57	735	0·47	0·80
			(0·40–0·52, <·001)	(0·65–0·88, <·001)		(0·28–0·52, <·001)	(0·40–0·81, 0·002)		(0·41–0·55, <·001)	(0·68–0·95, 0·010)
37–38	828,963	1,469	0·43	0·80	208	0·38	0·61	1,261	0·44	0·84
			(0·39–0·48, <·001)	(0·71–0·91, <·001)		(0·28–0·50, <·001)	(0·45–0·83, 0·002)		(0·39–0·50, <·001)	(0·73–0·96, 0·009)
39–40	1,584,870	1,875	0·38	0·77	245	0·30	0·54	1,630	0·39	0·81

	Live birth Number	Overall Infant Death (7–364 days)			Late-neonatal deaths (7–27 days)			Post-neonatal deaths (28–364 days)		
		n	COR[a] (95% CI, p value)	AOR[b] (95% CI, p value)	n	COR[a] (95% CI, p value)	AOR[b] (95% CI, p value)	n	COR[a] (95% CI, p value)	AOR[b] (95% CI, p value)
			(0·34–0·41, <·001)	(0·69–0·86, <·001)		(0·23–0·38,<·001)	(0·41–0·72, <·001)		(0·35–0·43, <·001)	(0·72–0·91, 0·001)
≥40	439,725	606	0·37	0·75	99	0·27	0·48	507	0·40	0·82
			(0·31–0·44, <·001)	(0·62–0·91, 0·003)		(0·18–0·40, <·001)	(0·32–0·74, 0·001)		(0·33–0·48, <·001)	(0·67–1·01, 0·065)
Birth Weight (grams)										
500–1499	37,518	1,811	0·73	0·79	935	0·67	0·69	876	0·80	0·92
			(0·66–0·81, <·001)	(0·71–0·88, <·001)		(0·59–0·77, <·001)	(0·60–0·80, <·001)		(0·70–0·93, 0·003)	(0·78–1·07, 0·283)
1500–2499	223,364	1,121	0·51	0·80	236	0·48	0·68	885	0·51	0·84
			(0·45–0·57, <·001)	(0·7–0·92, 0·002)		(0·37–0·63, <·001)	(0·51–0·90, 0·008)		(0·45–0·59, <·001)	(0·72–0·98, 0·025)
2500–3999	2,717,184	3,810	0·40	0·76	520	0·32	0·55	3,290	0·41	0·80
			(0·37–0·43, <·001)	(0·71–0·82, <·001)		(0·27–0·38, <·001)	(0·45–0·67, <·001)		(0·38–0·44, <·001)	(0·74–0·87, <·001)
≥4000	251,317	221	0·39	0·77	29	0·23	0·32	192	0·42	0·87
			(0·29–0·52, <·001)	(0·56–1·06, 0·108)		(0·11–0·49, <·001)	(0·16–0·63, 0·001)		(0·30–0·58, <·001)	(0·62–1·23, 0·431)

[a] Crude odds ratio.

[b] Adjusted odds ratio (AOR) with 95% confidence interval (CI) were obtained by controlling for maternal race (except for race subgroup analysis), maternal age, maternal education, WIC participation, marital status, prenatal care, smoking during pregnancy, maternal prepregnancy BMI, type of delivery, birth plurality, insurance, maternal diabetes, maternal hypertension, birth order, sex, and birth weight (except for birth weight subgroup analysis).

[c] Results not available because of small numbers and questionable validity of the model fit.

Table 4:

Logistic regression analyses for the associations of ever breastfeeding with each cause of post-perinatal infant death among 2017 birth cohort, United States

Cause of Death	Live births (N)	Infant deaths (N)	Crude Odds Ratio Ever/Never breastfeeding (95% CI, p-value)	Adjusted Odds Ratio[a] Ever/Never Breastfeeding (95% CI, p-value)
Total population				
Infection	3,027,904	802	0·44(0·38–0·51, <·001)	0·81(0·69–0·94, 0·007)
Sudden Unexpected Infant Death	3,029,916	2,814	0·38(0·35–0·41, <·001)	0·85(0·78–0·92, <·001)
Sudden Infant Death Syndrome (R95)	3,028,145	1,043	0·40(0·35–0·46, <·001)	0·89(0·78–1·03, 0·11)
Accidental Suffocation and Strangulation in Bed (W75)	3,027,863	761	0·39(0·33–0·45, <·001)	0·90(0·77–1·05, 0·191)
Unknown (R99)	3,028,112	1,010	0·34(0·30–0·39, <·001)	0·76(0·67–0·87, <·001)
Necrotizing Enterocolitis	3,027,308	206	0·43(0·32–0·57, <·001)	0·67(0·49–0·90, 0·009)
Injuries	3,027,555	453	0·44(0·36–0·54, <·001)	0·88(0·71–1·08, 0·223)
Other	3,029,109	2,007	0·37(0·34–0·41, <·001)	0·62(0·56–0·69, <·001)

[a] All models were adjusted for maternal race, maternal age, maternal education, WIC participation, marital status, prenatal care, smoking during pregnancy, maternal prepregnancy BMI, type of delivery, birth plurality, insurance, maternal diabetes, maternal hypertension, birth order, sex, and birth weight (except for the modeling on Necrotizing Enterocolitis).