

1 **Feeding the disparities: the geography and trends of**
2 **breastfeeding in the United States**

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15 **Short title:** Breastfeeding trends in the United States.

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17

18 **Abstract**

19 There is scientific consensus on the importance of breastfeeding for the present and future health
20 of newborns, in high- and low-income settings alike. In the United States, improving breast milk
21 access is a public health priority but analysis of secular trends are largely lacking. Here, we used
22 data from the National Immunization Survey of the CDC, collected between 2003 and 2016, to
23 illustrate the temporal trends and the spatial heterogeneity in breastfeeding. We also considered
24 the effect sizes of two key determinants of breastfeeding rates. We show that, while access to
25 breast milk both at birth and at 6 months old has steadily increased over the past decade, large
26 spatial disparities still remain at the state level. We also find that, since 2009, the proportion of
27 households below the poverty level has become the strongest predictor of breastfeeding rates.
28 We argue that, because variations in breastfeeding rates are associated with socio-economic
29 factors, public health policies advocating for breastfeeding are still needed in particular in
30 underserved communities. This is key to reducing longer term health disparities in the U.S., and
31 more generally in high-income countries.

32

33 **Keywords:** breast milk, infant health, infant nutrition, lactation

34

35 **Introduction**

36 Maternal breast milk represents the best source of nutrition for newborns, boosting the
37 development of brain function, and providing short and long-term benefits to individual health
38 (UNICEF & WHO, 2018). In addition, breastfeeding leads to the transfer of an array of immune
39 compounds (IgA and to a lesser extent IgG) from mother to infant allowing specific protection
40 against respiratory and enteric pathogens during a time when the risk of severe outcomes is
41 highest (Victora et al., 2016), and shaping the establishment of the infant's gut microbiota
42 (Pannaraj et al., 2017). The important role of breastmilk in early life health is illustrated by the
43 half-fold infectious disease mortality among breastfed infants (compared to non-breastfed) in
44 low and middle income countries (Victora et al., 2016), and by the 53% reduction in monthly
45 diarrheal hospital admissions due to exclusive breastfeeding in a high income country (Quigley,
46 Kelly, & Sacker, 2007). Because of the nutritional, immunological, and developmental benefits,
47 hundreds of thousands of annual deaths in children under five years of age are expected to be
48 prevented by global improvements in access to breastfeeding (UNICEF & WHO, 2018; Victora
49 et al., 2016), and high income countries would also receive potentially large economic benefits
50 (Rollins et al., 2016). The scientific consensus around the importance of breastfeeding has led
51 the World Health Organization (WHO) to set a target of 50% of infants under 6 months old
52 being exclusively breastfed. However, this target remains elusive, and concerns with access to
53 breastfeeding has prompted the World Health Assembly, during its 2018 meeting, to issue a
54 resolution in support of the practice (Seventy-first World Health Assembly, 2018). The
55 resolution emphasized the need for further efforts in supporting continued breastfeeding, in
56 particular in high-income countries.

57 In the United States, the Healthy People 2020 program highlights breastfeeding as a public
58 health priority and sets targets of breastfeeding initiation among 81.9% of births and of
59 continuation of breastfeeding until six months of age in 60.6% of infants by year 2020.
60 Suboptimal breastfeeding in the United States is responsible for additional maternal and infant
61 deaths, and carries economic costs in the order of the billions of dollars (Bartick et al., 2017).
62 Achieving the Healthy People 2020 goals will require ensuring socio-demographic equity in
63 breastfeeding rates. A previous study showed that black infants were generally less likely to be
64 breastfed, and that the magnitude of this difference varied extensively depending on the state
65 (Anstey, Chen, Elam-Evans, & Perrine, 2017). However, comprehensive analyses of recent
66 secular trends and spatial heterogeneity in breastfeeding rates in the United States are still
67 lacking.

68

69 **Methods**

70 Annual data on breastfeeding is available from the Center for Diseases Control and Prevention
71 (CDC) for the 2003-2016 period, as part of successive rounds of the National Immunization
72 Survey (NIS). The NIS represents a unique long-term source of comparable data at the state level
73 and has so far been largely underused for analyses of spatial and temporal breastfeeding trends.
74 Data is directly available on the rates of initiation (“breastfeeding initiation”). Data on the rates
75 of breastfeeding at 6 months old (“breastfeeding continuation”) are derived from information
76 collected on the duration of breastfeeding.

77 We analyzed trends of breastfeeding using Mann-Kendall tests, and tested the effect of the
78 proportion of black people and of households below the poverty level using multiple linear
79 regressions. All statistical analyses were run in R 3.5.0.

80

81 **Results**

82 Breastfeeding initiation in the United States follows a significant positive trend over the past 14
83 years (Mann-Kendall test; $p < 0.001$) to reach a maximum of 84.4% in 2016 (Figure 1). Similar
84 significant positive trends are found in all but four states (Arizona, Georgia, Montana, and Utah;
85 no significant trend in these states) indicating that the upwards trend is robust across the country.

86 Breastfeeding rates at 6 months are highly correlated with rates of initiation ($R^2 = 0.75$; $p <$
87 0.001 ; Figure S1) and follow a significant positive trend at the national scale (Mann-Kendall test;
88 $p < 0.001$), reaching 58.6% in 2016. This upward trend in continuation of breastfeeding to 6
89 months is also found in all but five states (Alabama, Kentucky, New Hampshire, New Mexico,
90 and Oregon). We note that there is no overlap between these states where increase in
91 continuation rates was not significant and the states where the increase in initiation rates was not
92 significant.

93 Despite the overall national increase, substantial spatial variation in breastfeeding rates persists
94 in 2016 (Figure 2), varying between 65.3% in Mississippi at the lowest and 93.4% at the highest
95 in Oregon. In addition, twenty states had a breastfeeding rate below the national average. Among
96 these, the six states (Alabama, Arkansas, Kentucky, Louisiana, Mississippi, and West Virginia)
97 with the lowest relative ratios of breastfeeding belonged to the U.S. Census South region. New
98 policies aimed at increasing access to breast milk may thus be most effective in this region. We
99 also found similar spatial variation in the rates of breastfeeding at 6 months (Figure S2).

100 In 2016, we found that low levels of breastfeeding were associated with two socio-economic
101 predictors: larger proportions of households below the poverty level (multiple linear regression:

102 $p < 0.001$), and larger proportions of black infants (multiple linear regression: $p = 0.02$) in a
103 state. As an illustration, we separated states with an above-average rate of breastfeeding (mean =
104 88.2%) from states below the national average (mean = 79.9%). Similar to Anstey et al. (2017),
105 we found a 4.1 percentage points increase in the average proportion of black infants in states
106 with low breastfeeding compared to states with high breastfeeding. Further, we found an even
107 stronger difference in the proportion of households below the poverty line: 25.4% of families
108 were below the poverty line in states with low breastfeeding, compared to 18.1% in states with
109 high breastfeeding. While it is difficult to fully disentangle the racial and socio-economic
110 contexts, we nevertheless found that their respective influences varied throughout the period
111 covered by the NIS data (Figure 3). The association with income first appeared significant in
112 2009 while the proportion of black infants appeared to become less predictive after that date. The
113 association between income and breastfeeding rates at 6 months followed the same pattern
114 (Figure S3). However, breastfeeding at 6 months appeared less often to be significantly
115 associated with the proportion of black people in a state, in particular in the recent years covered
116 in the NIS dataset.

117

118 **Discussion**

119 Overall, the positive trend in breastfeeding initiation in the United States is in line with the
120 targets set by public health policies. However, breastfeeding rates at six months old remain
121 below the target set by the Healthy People 2020 program (58.6% in 2016 versus the target of
122 60.6%), but this target remains achievable by the end of the program. Looking past national
123 averages also reveals deep disparities among states, highlighting the need for state-level policies
124 to remain conducive to breastfeeding and support all aspects of maternal and infant health.

125 Importantly, the extent of variation in breastfeeding initiation between states has remained
126 relatively stable throughout the period of 2003-2016 (Figure 1, shaded area), suggesting that a
127 “one size fits all” approach for all states will not be sufficient to move the national average.
128 Ensuring that disparities are reduced will be essential in minimizing the mortality and economic
129 burdens of inadequate breastfeeding practices in the United States (Bartick et al., 2017).

130 We also found that the effect of the proportion of households below the poverty line on both
131 rates breastfeeding initiation and continuation has increased rapidly since 2009, suggesting a
132 possible link to the economic recession of 2008-2009. Economic disparities and the
133 amplification of socio-economic inequalities during economic crises may thus currently be
134 important drivers of spatial variation in breastfeeding, although further research addressing the
135 interplay of racial and economic inequalities will be necessary. This could help identify factors
136 explaining why racial disparities appear less predictive of maintaining breastfeeding up six
137 months.

138 It is also likely that the spatial heterogeneity we observe at the state-level would be even more
139 pronounced at smaller spatial scales such as counties or zipcodes, potentially even within states
140 with relatively high average levels of breastfeeding. Neighborhood-level socio-economic
141 predictors can indeed be important determinants of children health outcomes (e.g. Yaeger,
142 Moore, Melly, & Lovasi, 2018), and similar effects may be expected for breastfeeding. Future
143 studies are needed, especially harnessing the ever improving power of spatial statistical modeling
144 (Lee et al., 2018), and will help determine the relevant spatial scale for the design and
145 implementation of targeted public health actions thus remains an urgent need.

146 As clearly outlined in a the recent World Health Assembly resolution (Seventy-first World
147 Health Assembly, 2018), improving access to breast milk is, and should remain, a public health

148 priority in both developing and developed countries. Concerns that women unable to breastfeed
149 could be stigmatized, cited by the United States as reasons to oppose the resolution (Jacobs,
150 2018), should not stop these efforts. In the United States, and in other high income countries,
151 future public health efforts must focus on reducing spatial disparities in breastfeeding and
152 underlying healthcare factors where low economic status and limited access to care can further
153 hinder positive maternal and infant health behaviors (Anstey et al., 2017). We also advocate that
154 future epidemiological studies should focus on determining whether clusters of low
155 breastfeeding rates spatially covary with low maternal or infant immunization rates creating
156 pockets of double jeopardy for vaccine-preventable childhood diseases such as measles, pertussis
157 and rotavirus. Understanding such population-level epidemiological consequences could be an
158 important motivation to increase breastfeeding uptake in high-income countries.

159

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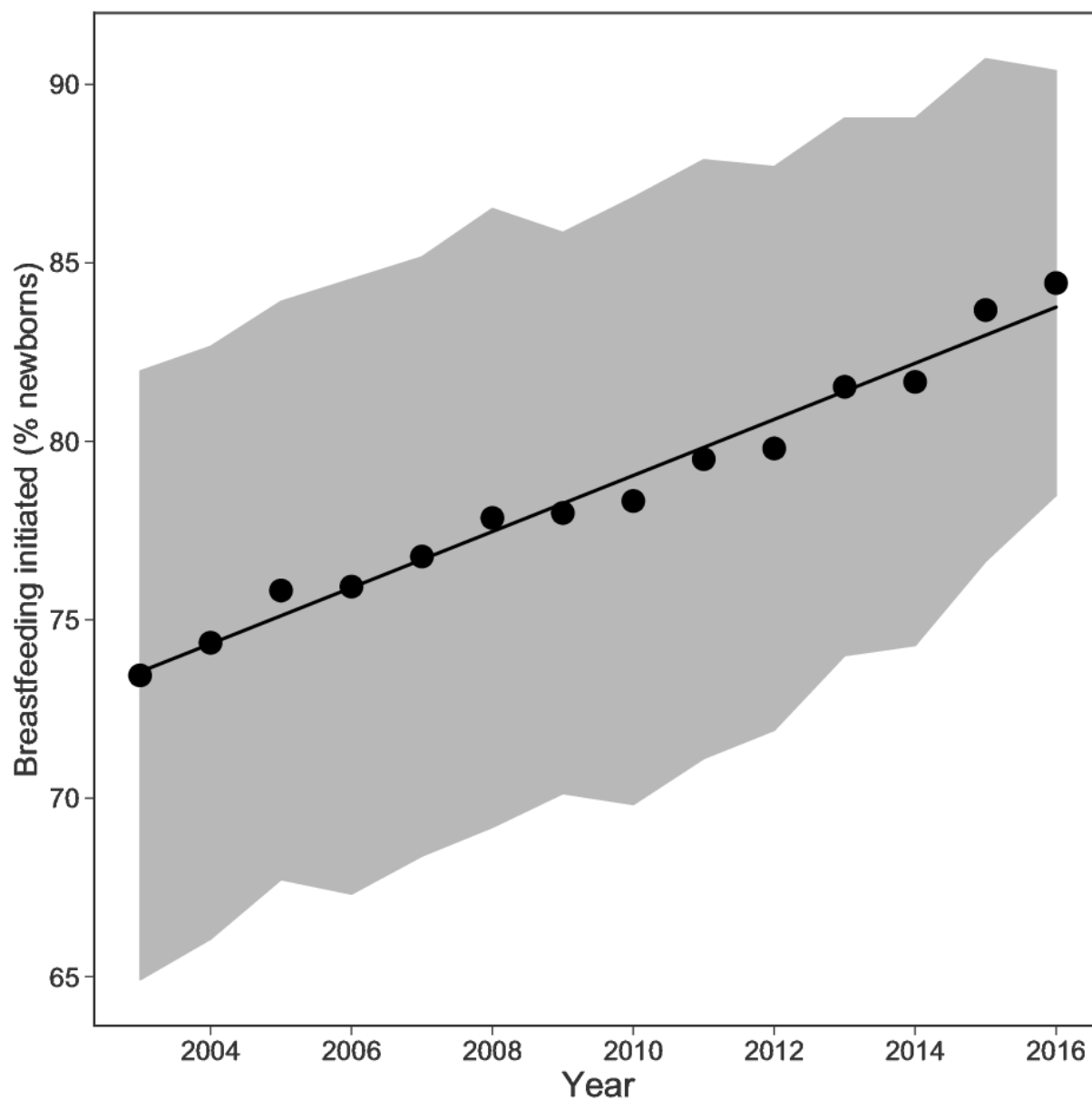
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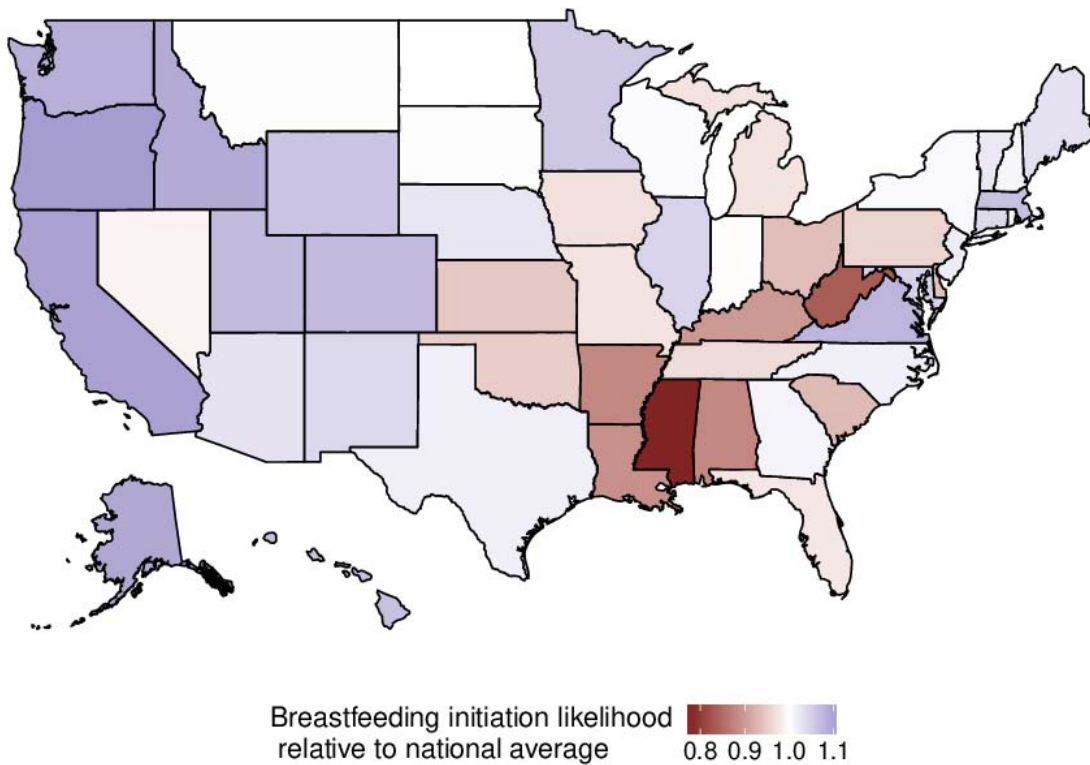
199 Figures

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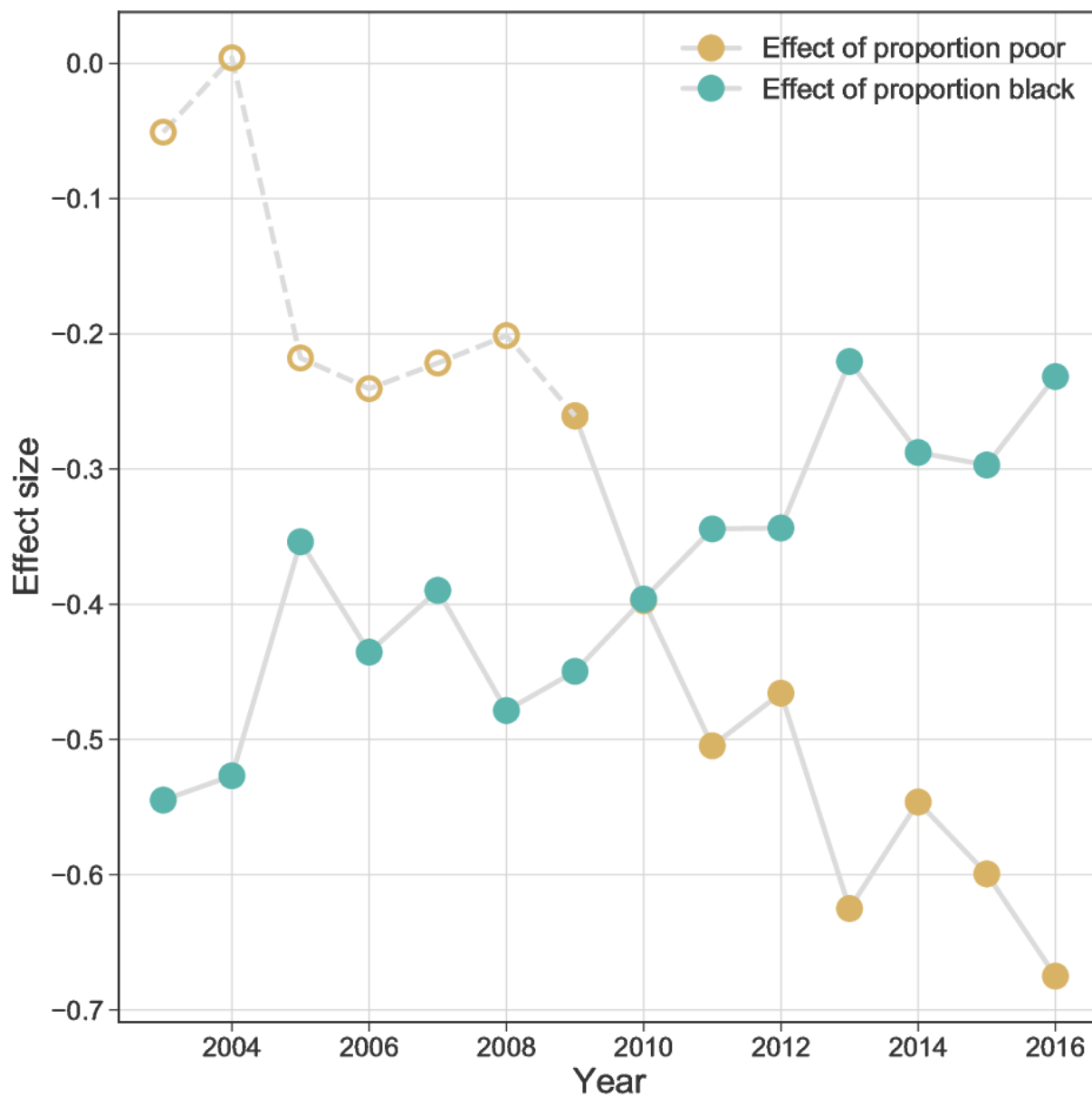
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202 **Figure 1:** Breastfeeding rates in the United States between 2003 and 2016, estimated from the
203 National Immunization Survey. The significant trend line is estimated from a linear model and
204 the shaded area corresponds to one standard deviation around the mean.



206 **Figure 2:** Map of breastfeeding initiation likelihood relative to the national mean (μ) for the year
207 of 2016. A value of 1 indicates a breastfeeding rate matching μ and a value < 1 represents low
208 breastfeeding rates relative to μ .

209



210

211 **Figure 3:** Estimates of the association of poverty (yellow) and being black (green) with the rates
212 of breastfeeding initiation during 2003-2016. The open circles indicate non-significant estimates
213 and closed circles indicate significant ($p < 0.05$) estimates.

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