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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Abstract

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

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

Introduction

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

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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.

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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 ($R2 = 0.75$; $p <$

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:

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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.

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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.

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Acknowledgements:

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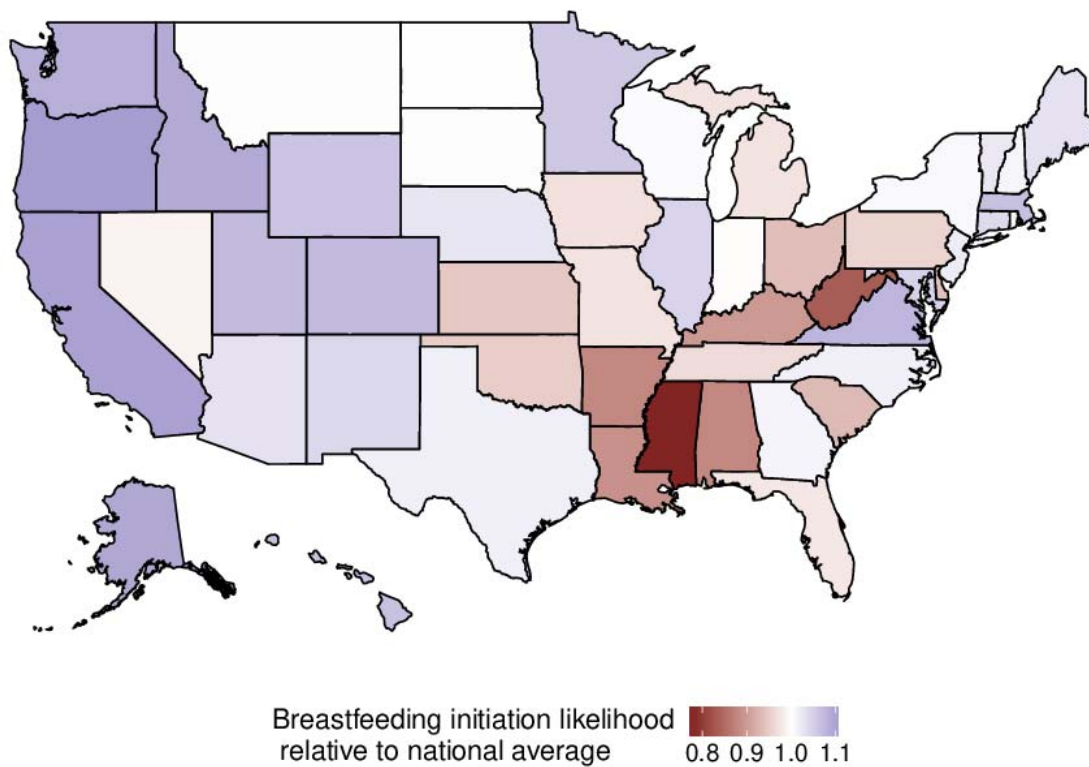197   *J Pediatr*. doi:10.1016/j.jpeds.2018.08.020

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199 **Figures**

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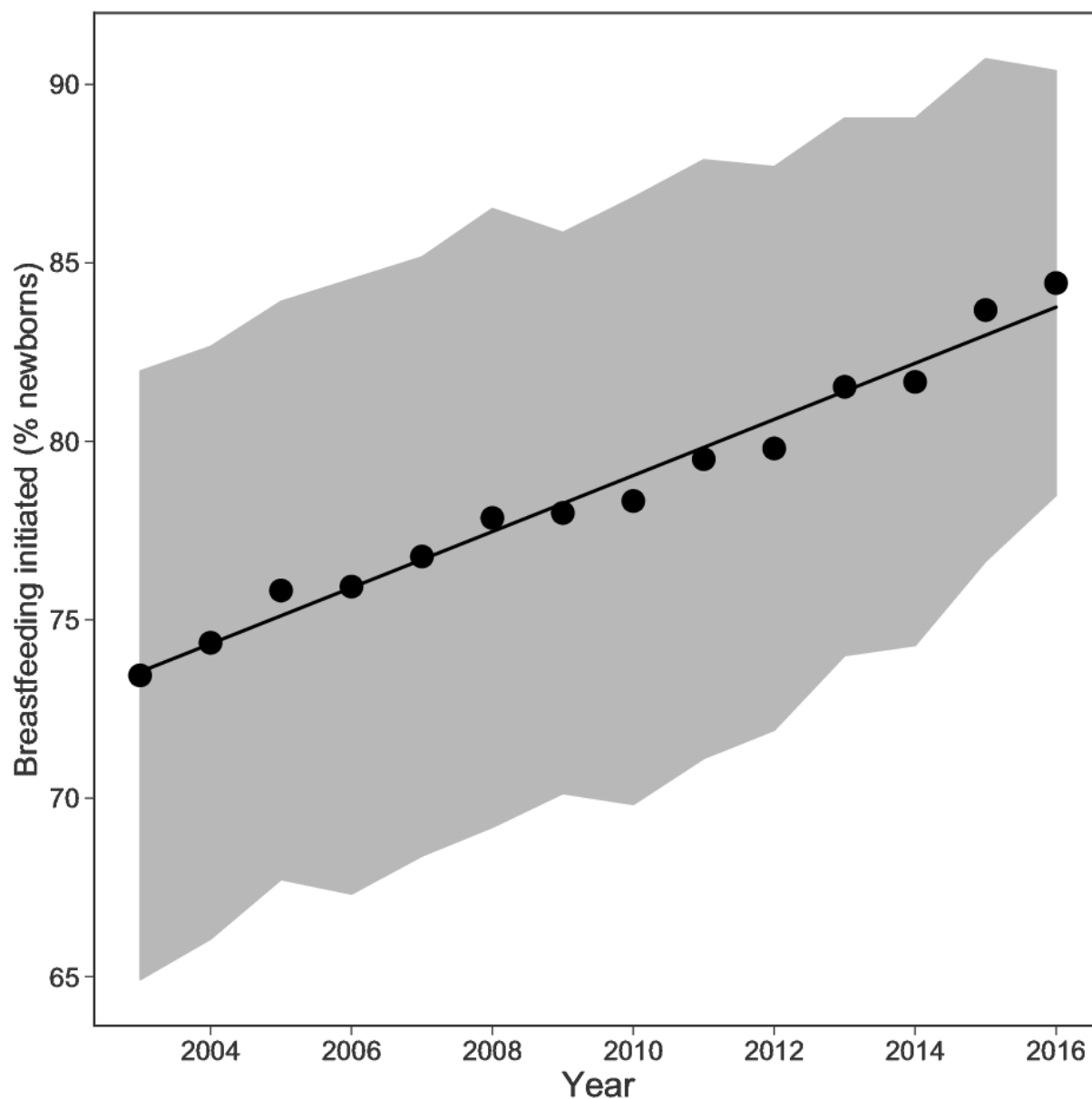
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202 **Figure 1**: Breastfeeding rates in the United States between 2003 and 2016, estimated from the

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.

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Figure 2: Map of breastfeeding initiation likelihood relative to the national mean (μ) for the year

of 2016. A value of 1 indicates a breastfeeding rate matching μ and a value < 1 represents low

breastfeeding rates relative to μ.

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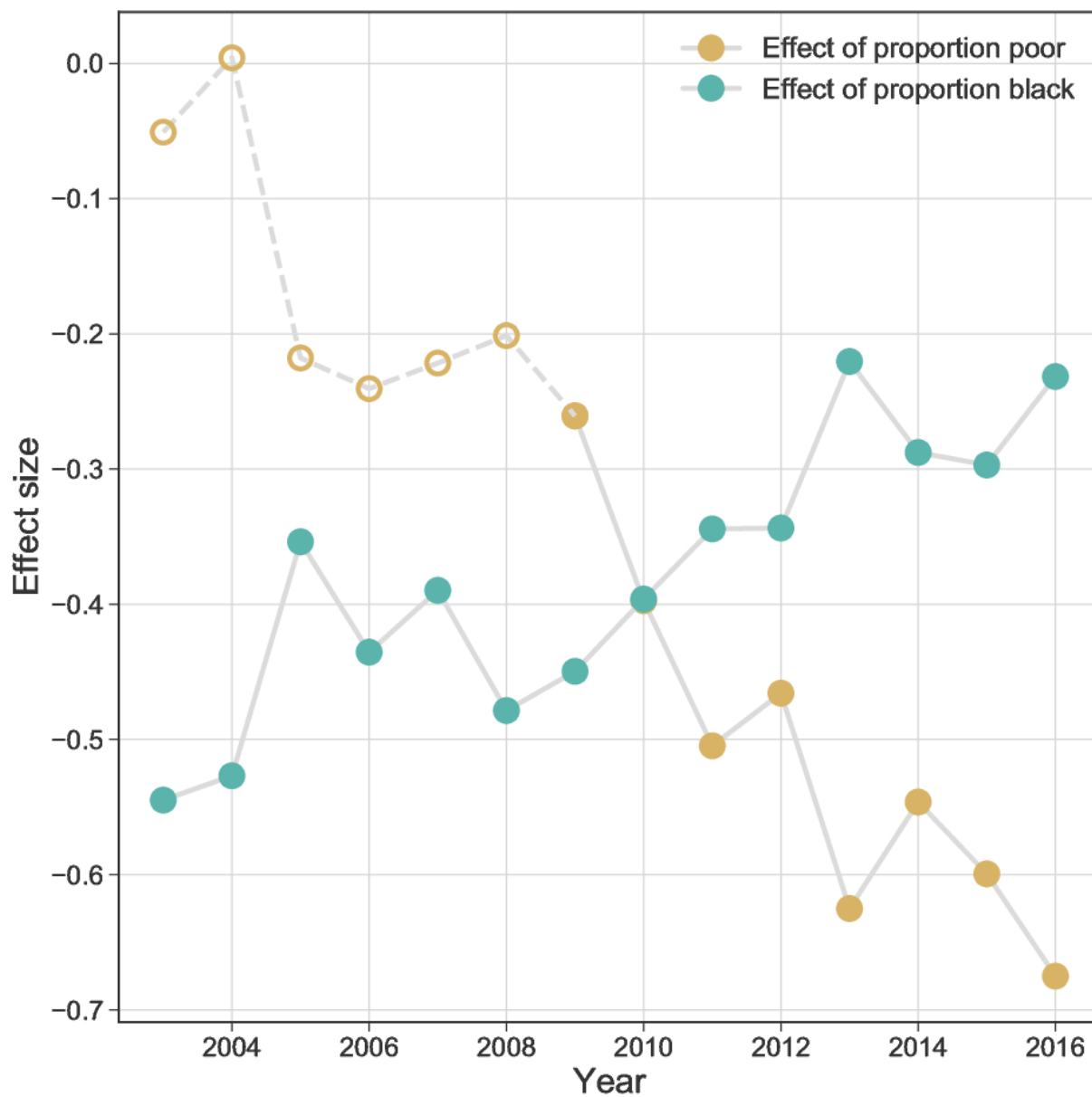
Figure 3: Estimates of the association of poverty (yellow) and being black (green) with the rates of breastfeeding initiation during 2003-2016. The open circles indicate non-significant estimates and closed circles indicate significant ($p < 0.05$) estimates.