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EVALUATING THE MULTIVARIATE RELATIONSHIP BETWEEN BREASTFEEDING, EARLY CHILDHOOD OBESITY, ASTHMA, AND MENTAL ILLNESS IN DALLAS, TX

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APPROVED:

KATELYN JETELINA, MPH PHD

FOLEFAC ATEM, MS PHD

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SITARA WEERAKOON
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Sitara Weerakoon, BA, MPH
The University of Texas
School of Public Health, 2019

Thesis Chair: Katelyn Jetelina, MPH, PhD

The aim of this study was to examine the associations between breastfeeding, asthma and mental illness in North Texas children aged two to five years, and to explore whether these associations are explained by the presence of obesity. The study population comprised of 1,174 children whose caregivers responded to a 2015 survey administered by Children's Health and the Health & Wellness Alliance for Children. Information on breastfeeding, BMI, asthma, and mental illness were self-reported by primary caregivers. Of the 1,174 children, 61% were breastfed, 13% had asthma, and 17% had a mental illness. The odds of having asthma were 2.28 times higher among children who were obese compared to non-obese children (95% CI: 1.37-3.79; p-value= 0.001). There were no statistically significant relationships between breastfeeding, obesity, or mental health illness. Children living in a household where the caregivers had more than a college education (OR: 2.07, p-value= 0.007) or a household income of $50,000 to $100,000 (OR: 1.80, p-value= 0.006) were more likely to have been breastfed. Obesity was not found to be a statistically significant mediator in the relationship between breastfeeding, asthma, and mental illness. This study hopes to inform future studies about the complex relationship among breastfeeding, early childhood obesity, asthma, and mental illness.

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BACKGROUND

Literature Review

Burden of Early Childhood Obesity

Reducing early childhood obesity has consistently been a key priority in improving child and adolescent health across the state of Texas and the United States (Department of Health and Human Services, 2013; Febrraro, 2015). In 2015, the Centers for Disease Control and Prevention (CDC) reported that over twenty percent of children aged two to five years, which the CDC defines as 'early childhood,' were overweight or obese. For children aged two to nineteen, the prevalence of obesity was 18.5 percent, which is almost a five-point increase from 13.9 percent in 2000 and almost a 13-point increase from 5.5 percent in 1980 (StateofObesity.org, 2019). Rates of childhood obesity have climbed significantly since the 1970s and continue to climb as more recent surveys are conducted (CDC, 2018).

Childhood Obesity Disparities

Obesity has detrimental effects to health as a patient increases in age, causing complications with blood pressure, cholesterol, as well as increasing the risk of heart diseases and cancers (CDC, 2018). The CDC also reports that obesity is more prevalent in people of low socioeconomic status and people of Hispanic background. Additionally, a higher maternal education level is associated with lower BMI trajectories, according to a 2016 longitudinal cohort study of children in early childhood, indicating that obesity may be more prevalent in children born to mothers with a lower education level (Guerrero, et al.)

Negative Health Outcomes

Childhood obesity, and specifically early childhood obesity, is known to cause an array of negative health outcomes, specifically breathing problems such as asthma and psychological

problems such as depression and anxiety (Esposito, et al., 2014, pg. 1899). The Esposito childhood obesity case-control study found statistically significant differences in depression and anxiety between the obese group and the control group, with the obese group experiencing more severe depression and anxiety than the control group (CDI total score: 16.82±7.73 vs 8.2±2.9, $P<0.00$; SAFA-A total scale score: 58.71±11.84 vs 27.75±11.5, $P<0.001$). A 2008 analysis of the 2006 Behavioral Risk Factor Surveillance System (BRFSS) findings found that "people who…were obese were significantly more likely than persons who did not have [obesity] to have current depressive symptoms or a lifetime diagnosis of depression or anxiety" (Strine, et al., p.1386). The relationship between obesity and asthma is another highly studied relationship among children. A longitudinal children's health cohort study was conducted in California in 2003 and found that risk of developing asthma was higher among children who were obese (RR = 1.60, 95% CI: [1.08, 2.36]; [Gilliland, et al., p.409]).

Breastfeeding as a Protective Factor

According to a 2014 study, protective factors for obesity, asthma, and mental illness include breastfeeding in the first few months of life (Verstraete, Heyman, & Wojcicki, p. 483). Breastmilk can prevent onset of obesity for several reasons, including that "breast milk has a lower protein content than infant formula" which can lower insulin levels and reduce the risk of obesity (Olson, 2016, p. 25). A 2013 cross-sectional study that used longitudinal data explored how breast milk feeding patterns mediated the relationship between social class and obesity and found that "targeting socioeconomically disadvantaged mothers for breastfeeding support and for infant-led feeding strategies may reduce the negative association between SES and child obesity" (Gibbs and Forste, p.135). Additionally, a 2011 cohort study examined breastfeeding and child behavior and found that breastfeeding protects against risk of behavioral problems (Heikkila, Sacker, Kelly,

Renfrew, & Quigley, p.641). Using a Strengths and Difficulties Questionnaire (SDQ) score to measure behavioral problems, the cohort study reported that children who were breastfed for four months or longer had lower odds of an abnormal score with statistical significance. Some studies have found that breastfeeding may prevent onset of asthma in children and adults, however others have found that it may increase risk (Brew, et al., 2012; Sears, et al., 2002). This study uses the findings from a study published in the European Respiratory Journal which specifically looked at 5,000 children aged one to four to infer that breastfeeding is a protective factor against asthma (Sonnenschein-van der Voort, et al., 2012). Sonnenschein-van der Voort, et al. report that, compared to children who were breastfed for 6 months, children who were never breastfed were more likely to display asthmatic symptoms during their first four years of life with statistical significance (OR: 1.44 and 1.26 for wheezing and shortness of breath, respectively).

Gap in Literature

As shown, several studies have explored breastfeeding, asthma, mental illness, and obesity. Obesity is the subject of numerous studies that look at external mediators in risk of developing obesity, but few have explored obesity as a mediator itself on other relationships. This study aims to explore statistical relationships between breastfeeding, obesity, and obesity-related outcomes, like asthma and mental illness, among a diverse pediatric population in North Texas.

Public Health Significance

The results of this study will open up discussion about how early childhood obesity could be explaining the relationship between breastfeeding and asthma and mental illness, as there is no previous literature that explores this relationship. Additionally, early childhood obesity is a more recent phenomenon and therefore all aspects should be studied in extent.

Study Aims & Hypotheses

The overall goal of this study is to evaluate the impact of breastfeeding on asthma and mental illness, and the extent in which this is relationship is explained by obesity, among children aged two to five years in North Texas. The study will describe early childhood obesity and obesity-related illness in North Texas, evaluate the direct and indirect relationships between breastfeeding and asthma and breastfeeding and mental illness, and evaluate any relationships found between obesity, asthma, and mental illness. Figure 1 shows this hypothesized relationship. Briefly, breastfeeding has been found to prevent asthma and mental illness (creating negative associations), once obesity is included in the equation, the relationship will shift and become positive. Our specific aims and hypotheses are as follows:

Specific Aim 1: To evaluate the direct effect between breastfeeding and asthma and breastfeeding and mental illness.

Hypothesis 1A: There will be a statistically significant positive association between breastfeeding and asthma/mental illness.

Specific Aim 2: To assess the indirect effect of obesity on the relationship between breastfeeding and asthma/mental illness.

Hypothesis 2A: There will be a statistically significant negative association between breastfeeding and obesity and a statistically significant positive effect between obesity and asthma/mental illness.

Specific Aim 3: Measure the potentially confounding effect of age, sex, race, income, and caregiver education on breastfeeding.

Hypothesis 3C: Hispanics and non-Hispanic Blacks will have lower odds of breastfeeding compared to non-Hispanic Whites.

Hypothesis 3D: Higher income will have higher odds of breastfeeding compared to low income.

Hypothesis 3E: Caregiver having attended more than high school will have higher odds of breastfeeding compared to high school or less.

Specific Aim 4: Describe the geospatial prevalence of breastfeeding, obesity, asthma, and mental illness in North Texas.

Hypothesis 4A: Where there are noticeably higher obesity rates, there will be lower breastfeeding rates and higher asthma/mental illness rates. Where there are noticeable lower obesity rates, there will be higher breastfeeding rates, and lower asthma/mental illness rates.

METHODS

Study Population

The data used in this study was collected from the 2015 Children's Health Assessment and Planning Survey, administered by Children's Health and the Health & Wellness Alliance for Children. Dallas, Ellis, Collin, Rockwall, and Kaufman counties were chosen from the greater Dallas, Texas area to participate in the study. From these five counties, 5,791 households received and completed the survey out of the 26,570 households that were initially randomly selected, which equated to a 27% response rate. Inclusion criteria included primary caregivers of children ages 0–17, however this specific study excluded all children less than 2 years of age and older than 5 years of age, according to the definition of early childhood by the CDC. Parents completed the survey for their child; therefore, information was collected about both the parent

and the child. If a family had more than one child, parents were asked to complete the survey for the child whose birthday is closest to the day the survey was filled.

Measures

Main Exposure: *Child ever breastfed* was coded as a binary variable with 'yes' ever breastfed, and 'no' never breastfed.

Main Outcome: *Childhood asthma* was coded as a binary variable with 'yes' ever diagnosed with asthma, and 'no' never diagnosed with asthma. *Child mental illness* was coded based on a multi-tiered approach; responding yes to "has the child ever needed mental healthcare?", "has the child ever attempted suicide?", "has the child ever been suspended from daycare, school, or a program of activities due to "reported" behavioral problems?", or "has the child ever had behavior problems at school?" was considered an indicator of a mental health issue according to the CDC, which reports that depression and anxiety in children can lead to behavioral problems manifesting at school and in a home setting and can be identified through disruptive behaviors and other behavioral problems (CDC, 2018). If a primary caregiver responded yes to any of the four questions, their child was considered to have a mental illness.

Mediator: *Childhood obesity* was determined using the calculated BMI from caregiver-reported height and weight of the child. Each category of BMI was generated using recommended percentiles based on a CDC age- and sex-specific BMI growth chart); [1]= <5th percentile for weight; [2]= 5th-85th percentile for weight; [3]= 85th-95th percentile for weight; [4]= >95th percentile for weight. Childhood obesity is defined as at or above the 95th percentile for weight (CDC, 2019). If the caregiver did not report the age, sex, height, and/or weight of the child, this

caused missingness in the variable. As a continuous variable, BMI was 29.5 percent missing, and as a categorical and, subsequently, binary variable, BMI was 48.5 percent missing.

Confounders: *Child age* was considered a categorical variable with four subcategories: [1]= 2 years; [2]= 3 years; [3]= 4 years; [4]= 5 years, *sex* was kept as a binary variable, *race* remained as categorical variable containing non-Hispanic White, non-Hispanic Black, Hispanic, and Other. 'Other' was not further specified by the survey. *Caregiver education* was recoded to reflect three levels: [1]= high school, [2]= college, and [3]= more than college. 'High school' includes any education up to a GED or a high school diploma, 'college' includes some college to a four-year degree, and 'more than college' includes any degree beyond a bachelors. *Household income* was used as the primary indicator of socioeconomic status. The subcategories of household income include less than $25,000, $25,000 to $50,000, $50,000 to $100,000, and greater than $100,000. These values were determined for a four-person household by the US Department of Health and Human Services; however, family size was not considered in the creation of this variable since it was not addressed in the survey (ASPH, 2015).

Statistical Analyses

Following the cleaning of the dataset, basic descriptive analyses were run on each variable to determine frequency and spread. Chi-square and t-tests were used to evaluate bivariate associations between the exposure (i.e., breastfed) and the outcomes (i.e., obesity, asthma, and mental illness). At this stage, BMI was kept as a continuous variable to prevent loss of data due to missingness. Following univariate and bivariate analyses, generalized structural equation modeling (GSEM) was used to analyze the relationship between mental health, breastfeeding, asthma, and obesity. Structural equation modeling is used to study latent and observed variables using multiple

simultaneous regressions, and further, GSEM allows for the response variables to have distributions other than the normal distribution. For this study, it was used to examine obesity as a mediating variable. At this stage, BMI was converted to a binary variable to specifically examine obesity. Confounding variables for this analysis included sex, age, caregiver education, income, and race/ethnicity, and were controlled for by inclusion in the SEM. Though sex and age were each found to have insignificant associations with breastfeeding and the mental health outcome, they were included in the both models as recommended by past literature. All hypotheses were tested at a confidence level of 95 percent, $\alpha = 0.05$, using Stata 14.0 statistical software (College Station, TX, 2014).

GIS Mapping

Point prevalences (i.e. percentages) of breastfeeding, obesity, asthma, and mental illness by zip code were generated using Stata. Percentages, along with the corresponding zip codes, were mapped using ESRI ArcMap geospatial processing software. Obesity hotspots were identified using graduated symbols.

RESULTS

Table 1 shows the demographics of the study population. Age was evenly distributed with 25-30 percent represented at each age of early childhood. The study population was 52 percent male and 48 percent female. Non-Hispanic Whites represented 41% of the study population while Hispanics were the second most common, representing 33%. More than 50%of caregivers attended college for more than one year and/or completed college. Sixty one percent of children were breastfed at some point in their life and the mean BMI for all children ages two to five years was 19.39 (SD: 7.23).

Table 2 displays the bivariate results between breastfeeding and obesity, mental illness, and asthma. The odds of obesity, mental illness, and asthma were all significantly higher among children that were breastfed compared to children not breastfed.

Figures 2 and 3 shows the results of the SEM analyses. Obesity and breastfeeding were found to have insignificant associations with mental health after adjusting for confounding variables; the relationship between breastfeeding and obesity in the mental health model was also insignificant. Compared to less than high school, more than college was found to be negatively associated with breastfeeding in the mental health model and in the asthma model. In the asthma model, obesity was found to be positively associated with having asthma after adjustment (OR: 2.28; p-value: 0.001); however, again, the relationship between breastfeeding and obesity was found to be insignificant.

Figures 4 and 5 display the distribution of breastfeeding, obesity, mental illness, and asthma across the greater Dallas area. Obesity was highly prevalent in all areas of the greater Dallas metroplex while asthma and mental illness are evenly distributed throughout rural, suburban, and urban areas. More than 50 percent of the surveyed population breastfed their children, however the average percent breastfed among all zip codes was 60.5%, which is less than the national average of 81% (CDC, 2016).

DISCUSSION

This study is the first to analyze obesity as a mediator in the relationship between breastfeeding and asthma and mental health. Contrary to our hypotheses, this study found no relationship between breastfeeding and obesity in relation to mental health illness and asthma. This is also contrary to previous literature (Verstraete, Heyman, & Wojcicki, 2014). The discordant

findings are likely due to the small sample size, amount of missing data, and misclassification of the outcomes, specifically mental illness due to the method in which the mental illness variable was formed. For example, the true number of diagnoses could have been larger which might have produced a more significant result. Additionally, the substantial amount of missing data in the BMI variable (48.5% missing) and small number of children experiencing mental illness (n=185) could have contributed to discordant results. More than a college degree and a household income of $50,000 to $100,000 were identified as the strongest confounders, both of which are understood as protective factors against obesity and positively associated with breastfeeding (Jing Yan, Lin Liu, Yun Zhu, Guowei Huang, & Peizhong Peter Wang, 2014, p.5). The association between asthma and obesity concurs with previous literature (Sonnenschein-van der Voort, et al., 2012). Though breastfeeding was found to be negatively associated with asthma, and therefore a protective factor, the resulting p-value is greater than $\alpha = 0.05$ concluding that the relationship is not statistically significant.

The most informative results of this study are the zip codes with high frequencies of mental illness, asthma, and obesity, and below average frequencies of breastfeeding. This study found that obesity was highly prevalent in all areas of the greater Dallas metroplex while asthma and mental illness are evenly distributed throughout rural, suburban, and urban areas. The average percent breastfed for all zip codes was 60.5%; most zip codes did not achieve higher than the national average of 81%. This information is important because it can inform targeted primary, secondary, and tertiary prevention efforts. For example, health promotion efforts could be focused in central Dallas and rural Dallas; specifically, 75158, 75154, 75143, 75137, 76064, 76651, 75116, 75069, 75241, 75204, 75206, 75093, 75232, and 75253, or fourteen out of the one hundred and twenty seven zip codes, showed low prevalence of breastfeeding, high prevalence of obesity, and high

prevalence of asthma and mental illness. Health promotion efforts in these areas should focus on reducing BMIs in early childhood through breastfeeding and healthy eating promotion programs. Interventions and programs like the international Baby Friendly Hospital Initiative, the Texas Ten Step Program, and, more locally, the Community Baby Café in Dallas have been shown to be highly effective in past studies among children (World Health Organization, 2018; Texas Department of State Health Services, 2019; City of Dallas, 2019). Similarly, mental illness should be approached in a preventative manner through educational awareness classes and proactive screening initiatives. Because the majority of disparities found in the study are in rural areas, innovative approaches to mental health screening may need to be leveraged. For example, finding ways to increase access to urban resources whether through transportation or through phone help lines is crucial. The Rural Health Information Hub highlights that accessibility, availability, and acceptability are the key challenges by rural communities today (RHIhub, 2018). In regard to asthma, a built environment analysis could also be conducted in these zip codes to determine what asthma triggers exist and where they are most severe.

Limitations

Results should be considered in light of several limitations. First, due to the cross-sectional nature of this study, causality cannot be determined nor inferred when examining the complex relationship between breastfeeding, obesity, asthma, and mental illness. Though risk is implied by the direction of the effects in both models, it is not present and was not hypothesized. Second, there is a lack of information on duration or exclusivity of breastfeeding. Previous research has found that three to six months of exclusive breastfeeding led to healthier outcomes, a conclusion that is supported in countless of other studies on duration of exclusive breastfeeding. The

distinction between exclusive (only breastmilk) and non-exclusive (breastmilk with other foods/drinks) is also an important one since both have different effects on the health of a child (Diallo, Bell, Moutquin, & Garant, 2010). This distinction was not made in the survey. Third, because the survey was filled out by parents on behalf of their children, there is the possibility of misclassification. Specifically, the underreporting of unfavorable or undesirable information which biases the study to produce false odds ratios. For example, many caregivers chose not to respond to the questions about mental health. Either this means the questions were not relevant to the child and can be understood as "no mental health illness present in child," or the caregiver did not feel comfortable answering and did not want to admit a problem might exist, which could be understood as "mental health illness present in child." Either result would change the results of the study considerably. Further, the complexity and sensitivity of height and weight in early childhood called for a hyper-specific BMI variable that contained information about the sex and age of each child. Creating this variable dropped a significant amount of partially missing data and reduced the sample size considerably. It is also important to keep in mind that removing the observations younger than two years and older than five years resulted in some zip codes having just two or three respondents which means that an average asthma prevalence of 50% might mean one respondent out of two was diagnosed with asthma. Finally, the demographics of this study population are not generalizable to the US population due to the sampling methods, which means the results cannot be extrapolated to represent all Americans.

Strengths & Future Direction

This study just begins to close the gap in research on obesity as a mediator given that the results were statistically insignificant. The mapping aspect of this study provided a wealth of

information on the prevalence and distribution of these diseases. The next step for this study is to conduct analytical geospatial tests beyond descriptive mapping to determine if there is a statistically significant geographical aspect to the relationship between breastfeeding, obesity, asthma, and mental illness. It would also be informative to expand the sample to include all children up to 18 years of age, or to include more Texas and/or national counties. This would provide more knowledge into the newer realm of obesity as a mediating variable and would increase the sample size and power of the study. Additionally, given the relatively recent increase in early childhood obesity prevalence, further longitudinal research should be conducted as to the causes of and pathways to development of early childhood obesity.

FIGURES AND TABLES

Table 1. Descriptive statistics (n=1,174)	
Demographics	**N (%)**
Child Age (years)	
2	272 (23)
3	272 (23)
4	283 (24)
5	347 (30)
Child Sex	
Boy	605 (52)
Girl	568 (48)
Child Race	
NH White	478 (41)
NH Black	210 (18)
Hispanic	392 (33)
Other	94 (8)
Household income	
<$25,000	294 (29)
$25,000-$50,000	197 (19)
$50,000-$100,000	263 (26)
>$100,000	271 (26)
Caregiver education	
High school	323 (28)
College	629 (54)
More than college	217 (18)
Outcomes	
Asthma diagnosis	150 (13)
Mental illness present	185 (17)
Exposure	
Breastfed	694 (61)
BMI (mean (SD))	19.39 (7.23)

Table 2. Chi-square and t-test results for bivariate associations between breastfeeding, BMI, mental illness, and asthma diagnosis.

	Mental Health	Asthma	BMI
Breastfeeding	$\chi^2=8.5$; (pr=0.004)	$\chi^2=5.8$; (pr=0.016)	t=87.4; (pr=0.000)
BMI	t=86.7; (pr=0.000)	t=90.7; (pr=0.000)	--

Figure 1. Hypothesized SEM

Figure 2. SEM Results for Asthma. * = NS; ** = p-value <0.05

Figure 3. SEM Results for Mental Illness. * = NS; ** = p-value <0.05
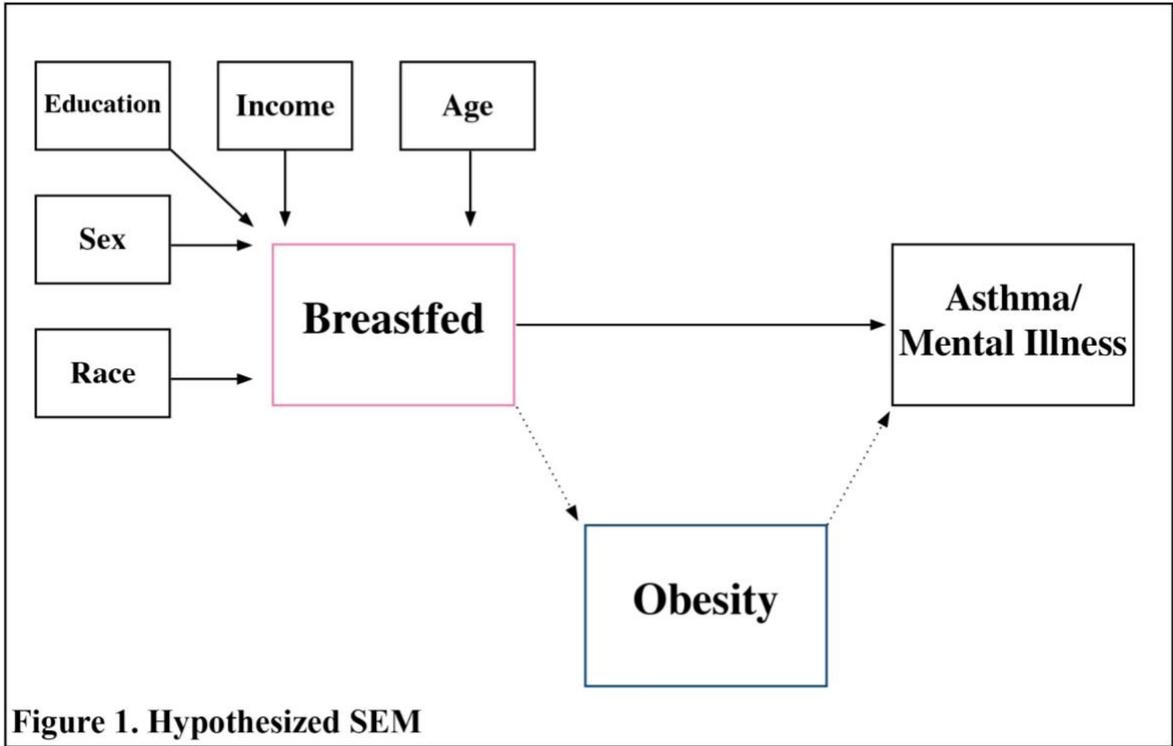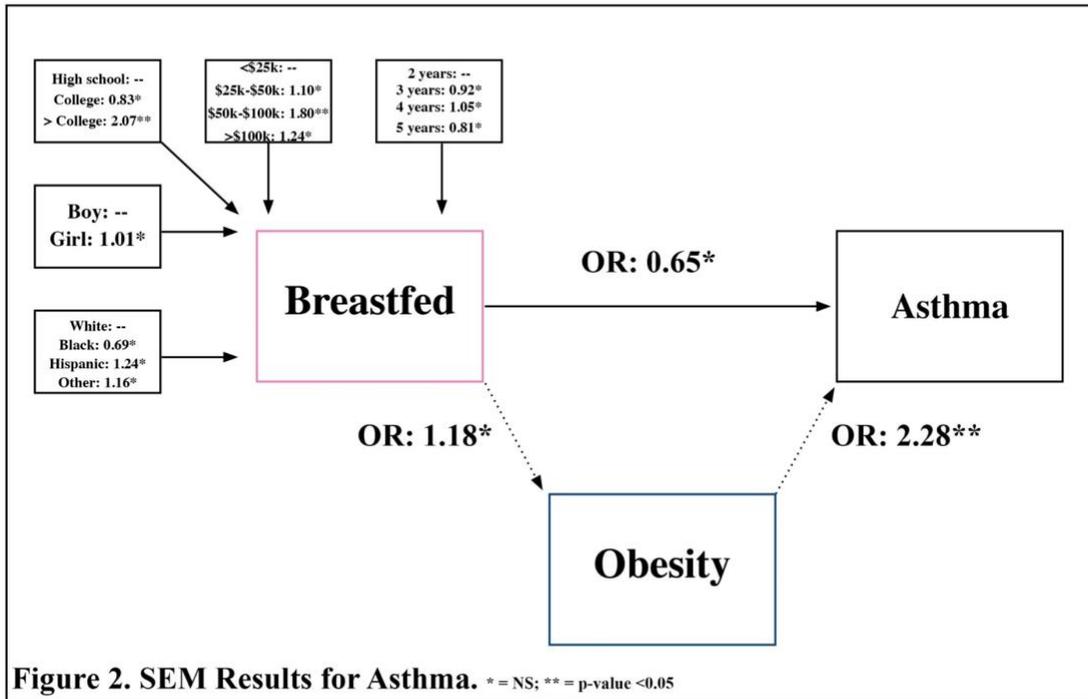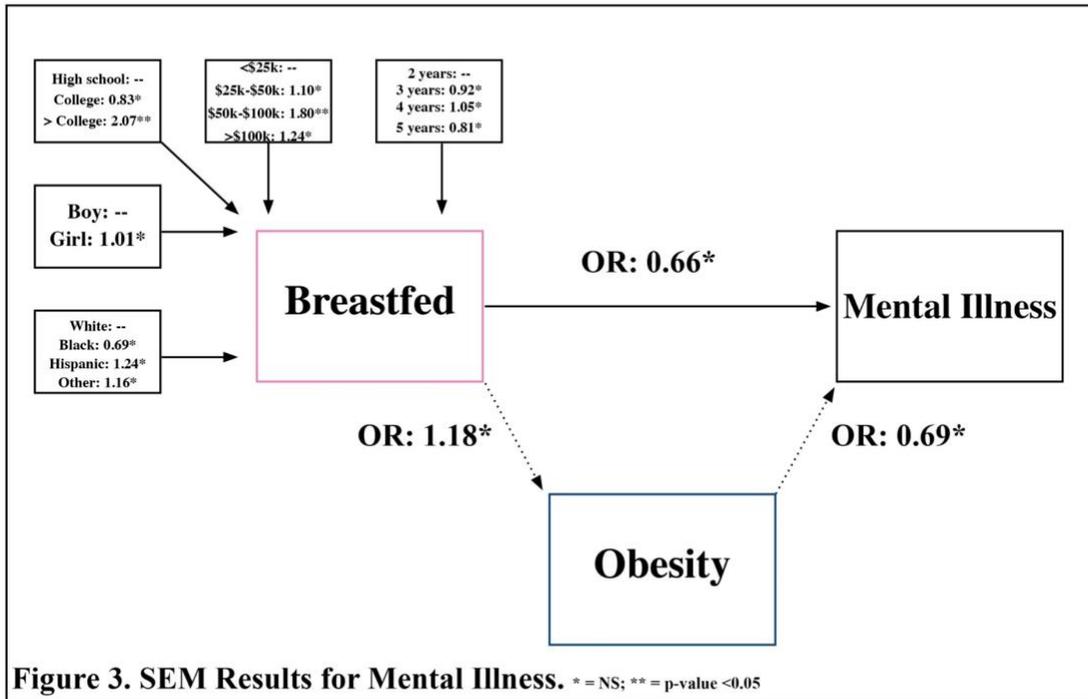
Figure 4. Breastfeeding, Obesity, and Asthma prevalence in the greater Dallas, TX area

Legend

% Ever breastfed
<80%
>80%

% BMI >95th percentile
<30%
30%-65%
>65%

% Asthma prevalence
<15%
15%-30%
30%-50%
>50%

0 0.075 0.15   0.3   Decimal Degrees
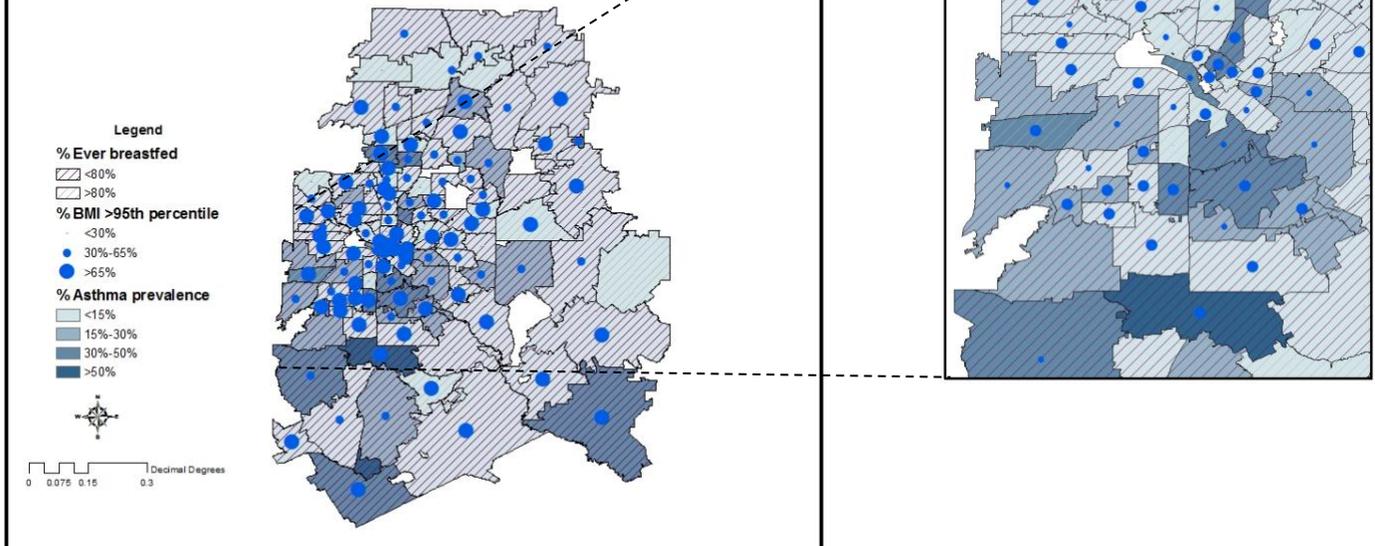
Figure 5. Breastfeeding, Obesity, and Mental Illness prevalence in the greater Dallas, TX area

Legend

% Ever breastfed
<80%
>80%

% BMI >95th percentile
· <30%
• 30%-65%
● >65%

% Mental Illness prevalence
<15%
15%-30%
30%-50%
>50%

0 0.075 0.15   0.3   Decimal Degrees
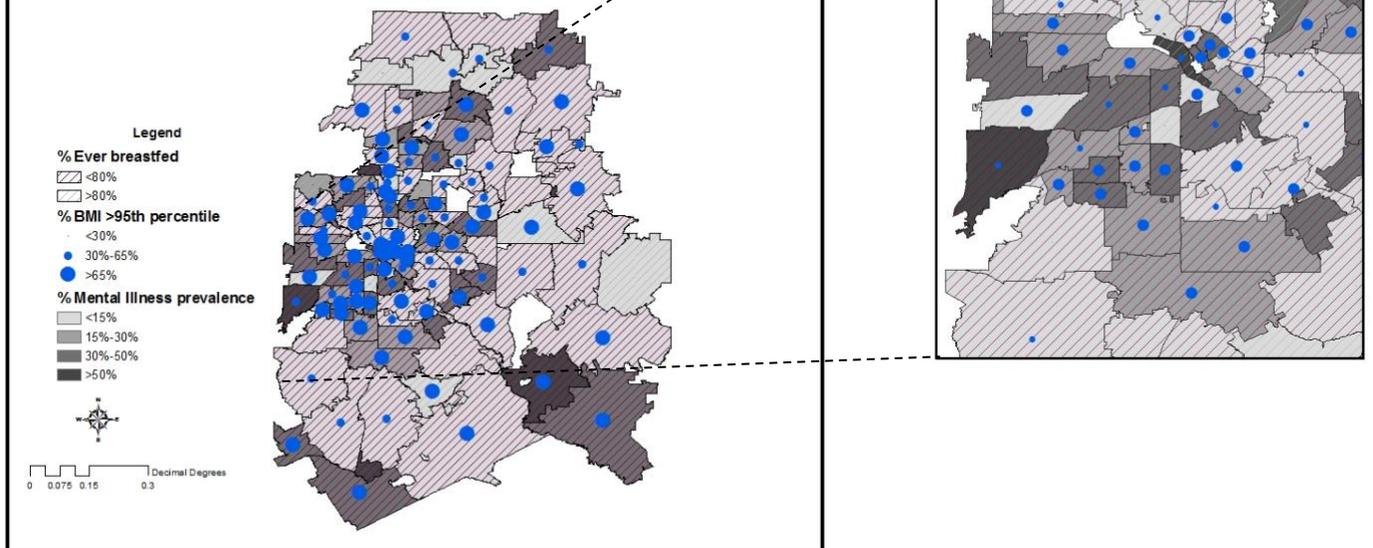
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