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Urban residential tree canopy and perceived stress among pregnant women

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ABSTRACT

Objective: To examine the association of urban residential tree canopy cover with perceived stress in a cohort of pregnant women in Philadelphia, PA, and explore whether this association differed among participants with a history of anxiety and depression.

Study design: We performed a secondary analysis of 1294 participants of the Motherhood & Microbiome (M&M) pregnancy cohort who lived in Philadelphia, with first visit perceived stress (Cohen's Perceived Stress Scale, PSS-14), and key covariate data. Tree canopy cover was calculated as percent cover within 100 and 500 m radii buffers around participants' homes. We performed multilevel mixed effects linear regression models, with perceived stress as the dependent variable. The main independent variable was tree canopy coverage. Individual-level covariates included season of last menstrual period, history of depression or anxiety, race/ethnicity, insurance, parity, and age. Census tract neighborhood deprivation index was used to account for area-level socioeconomic confounding variables. We also examined whether a history of anxiety or depression, modified the association between tree canopy coverage and perceived stress.

Results: Most participants were non-Hispanic Black (70.6%, n = 913), on Medicaid or uninsured (60.4%, n = 781), and 15.8% (n = 204) of participants had a prior history of depression or anxiety. We did not detect associations between tree canopy coverage and perceived stress overall. However, we detected effect modification; among participants with a history of depression or anxiety, each standard deviation increase in tree canopy cover was associated with lower PSS-14 in 100 m buffers (β −1.0, 95% CI -1.8, −0.2), but not among participants with no histories of depression or anxiety (β 0.2, 95% CI -0.3, 0.7) (interaction P = 0.007). Results were similar in directionality but not statistically significant within 500 m buffers.

Conclusion: Residential tree canopy coverage was associated with reduced perceived stress among urban-dwelling pregnant women with history of anxiety or depression. Future studies of the effects of greenness and other stress-reducing efforts should consider underlying mental health conditions as effect modifiers.

1. Introduction

Pregnancy is a major life event, marked by varying levels of stress. Psychological stress during pregnancy has been associated with poor maternal outcomes in the perinatal period such as anxiety (Pluess et al., 2010) and postpartum depression (Beck, 2001) which can lead to suicide (Faisal-Cury and Rossi Menezes, 2007), a leading cause of post-partum maternal mortality (Mangla et al., 2019; Metz et al., 2016; Howard et al., 2014). When screened, between 6.5% and 13% of pregnant patients screen positive for depression – a prevalence that is similar to non-pregnant patients (Faisal-Cury and Rossi Menezes, 2007; Howard et al., 2014). Pregnancy-related depression is more likely to present earlier (even antenatally) among women with a prior history of depression than women without a history of depression (Rallis et al., 2014; Stowe et al., 2005). The confluence of prenatal stress, anxiety and depression can lead to adverse birth outcomes such as low birthweight

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and preterm birth (Rondó et al., 2003; Staneva et al., 2015).

Given the relationship between stress and pregnancy outcomes, strategies to reduce stress are paramount for maternal health. Nature, including tree canopy, may be one such strategy. While other mechanisms have been proposed to explain benefits of greenspace, a social cohesion framework proposes that proposes that urban greenspaces increase positive social interactions, providing shaded areas for relaxing environments, may improve mental health (Peters et al., 2010; Braat and de Groot, 2012; Jennings and Bamkole, 2019). Growing evidence suggests that living near and spending time in nature improves self-reported and biologically measured stress (Shanahan et al., 2015; Martin et al., 2020; Kondo et al., 2018; Branas et al., 2011; Dzhambov et al., 2020). A recent U.S.-based study showed that women living in neighborhoods with more natural features had greater self-reported general health (Tsai et al., 2020). In terms of pregnancy, several studies have found associations between exposure to greenness and a better pregnancy outcomes, higher birthweight, and lower risk of preterm birth (Agay-Shay et al., 2014; Akaraci et al., 2020; Dadvand et al., 2012). Additionally, a handful of studies have evaluated the relationship between greenness and maternal mental health and found that maternal exposure to greenness was associated with decreased mental disorders including antenatal depression and antenatal stress (Zhan et al., 2020; McEachan et al., 2016). However, none of these studies took place in the United States, and few Black women were included. This is particularly important because there are large inequities in greenspace by race in the United States and in maternal stress and mental health outcomes. (Casey et al., 2017)' (Orr et al., 2006).' (Grobman et al., 2018)

Due to the history of state-sanctioned residential racial segregation and government disinvestment from Black neighborhoods, there are disparities in the distribution of greenness such as tree canopy and parks based on neighborhood racial and economic composition across U.S. cities. A study of tree canopy cover in large US cities showed a decrease in tree canopy cover in census tract with greater proportions of people of color, and an increase in tree canopy cover in census tracts with greater proportions of White residents (Casey et al., 2017). In a separate study, Philadelphia, the poorest large city in the U.S., and with the greatest proportion of Black residents, low median household income was associated with lower tree canopy cover (Wen et al., 2013). Among Black women, neighborhood factors such as safety, walkability and social disorder (all of which may be affected by greenness), are associated with both prenatal stress and depressive symptoms (Giurgescu et al., 2015; Sealy-Jefferson et al., 2016a; Shannon et al., 2020), and Black women report greater rates of prenatal stress, as well as perinatal depression compared to White women (Orr et al., 2006; Grobman et al., 2018). Furthermore, compared to Black women without perinatal depression, Black women with perinatal depression are at greater risk of adverse pregnancy outcomes (Field et al., 2009).

Understanding whether greenspace reduces stress in pregnancy is relevant for policymakers and urban planners seeking to identify effective structural interventions to promote health, as well as for healthcare providers and organizations seeking to tailor recommendations for non-pharmaceutical interventions towards improving maternal mental health. In this study, we sought to quantify associations between tree canopy cover and stress during pregnancy in a U.S.-based, urban, pregnancy cohort. We also sought to determine if the relationship between tree canopy cover and stress during pregnancy was different for individuals with a history of anxiety or depression.

2. Methods

2.1. Study cohort

We performed a secondary, post-hoc analysis of a prospective cohort of the 1294 eligible participants in the *Motherhood &Microbiome* cohort study recruited during the course of prenatal care in a tertiary hospital in Philadelphia, PA from December 2013 through December 2016 (Elovitz et al., 2019; Gerson et al., 2020). The primary focus of the original study was to investigate risk factors for preterm birth, specifically the vaginal microbiome. Participants (n = 1943) with singleton gestations were recruited between 16 0/7 and 20 6/7 weeks and provided written-informed consent. Inclusion criteria for these analyses were the following: a home address within Philadelphia, perceived stress data at the first study visit 1 (n = 1294) (Fig. 1). The University of Pennsylvania institutional review board approved this study. We followed the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) reporting guideline (Von Elm et al., 2007).

2.2. Exposure assessment

Our exposure of interest was residential tree canopy coverage, which we obtained from the Philadelphia's Parks and Recreation open access database on tree canopy. Tree canopy data is a collection of tree canopy outlines generated by Intergraph Government Solutions (IGS) for trees greater than 6′ diameter (ree Canopy Outlines, 2015) from 2015 LiDAR data capture (ree Canopy Outlines, 2015). While the exposure was independently assessed over halfway through our study period, evidence shows neighborhood characteristics such as tree canopy cover change relatively slowly (Casey et al., 2017), and the Philadelphia Tree Canopy assessment shows minimal changes in the areas most inhabited by our sample population between 2008 and 2018 (O'Neil-Dunne, 2019). For each participant's home address, we used ArcGis Pro 10.0 (Esri, Redlands, California) to create buffers at 100 m and 500 m radii, which approximate one and four city blocks, respectively. Buffer radii were selected based upon prior studies reporting health benefits associated with greenness and assumptions about the neighborhood environment where people may spend time sitting, relaxing, walking, and interacting with neighbors (Astell-Burt and Feng, 2020; Zhang and Tan, 2019). Buffers were then spatially joined to the tree canopy dataset. We calculated the amount of tree canopy area within each buffer as a percentage of total land area. For the analyses, tree canopy cover was used as a continuous variable.

2.3. Outcome

Participants completed Cohen's Perceived Stress Scale (PSS-14) during the first clinical visit of the study, which occurred between 16 and 20 weeks of gestation. PSS-14 is a validated self-report rating scale measuring the degree to which situations in one's life are considered stressful, measuring both perceptions of stressors and how often people feel they are able to handle the stressors they perceive (Cohen et al., 1983; Cohen and Williamson, 1988). We treated this dependent variable as continuous in our analysis. We chose to focus this analysis on the first visit (16–20 weeks of gestation) because the most women had stress data from that visit and because the scores had moderate-to-strong

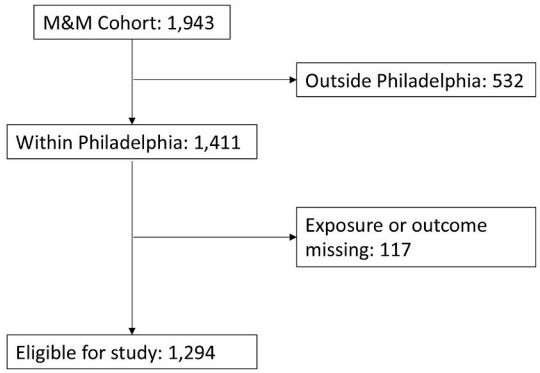

Fig. 1. Flow chart of *Motherhood & Microbiome* (M&M) study participants and participants included in the present analysis (PSS-14: Perceived Stress Score).

correlations at the three time points (r = 0.64–0.74, p < 0.0001).

2.4. Covariates

Individual-level covariates included history of anxiety or depression (ascertained via electronic health record review during the primary study), self-identified race/ethnicity, health insurance status, age at delivery, parity, and level of education. To account for neighborhood-level socioeconomic status, we used neighborhood deprivation data from the Nationwide Community Deprivation Index (Brokamp et al., 2019). The index ranges from 0 to 1 (national average is 0.4) with lower numbers reflecting lower deprivation. Variables included in the index are poverty rate, median household income, education, rates of health insurance coverage, the fraction of households receiving public assistance, and fraction of vacant homes. Appendix Fig. 1 shows the relationship between neighborhood deprivation and residential tree canopy cover.

We also accounted for seasonality, since some health benefits of trees such as shade and decreased temperature are only present during leaf-growing time periods. We defined leaf-growing season as March 21st to September 21st given that deciduous trees begin to lose their leaves in the fall, then regrow them in the spring. We then determined if each participant's last menstrual period (LMP) took place in or out of leaf-growing season. We categorized seasonality based on LMP, assuming that the benefits of greenness specific to the pregnancy of interest would be conferred during the first trimester since the first study visit took place early in the second trimester (16–20 weeks of gestation).

2.5. Statistical analysis

We first performed descriptive analyses. We then used multilevel mixed linear regressions accounting for clustering of participants within census tracts to examine the association between tree canopy cover per standard deviation and PSS-14 scores. The primary model assessed associations between one standard deviation increase in greenness and PSS-14 in each buffer, adjusting for our described covariates. Because the stress recovery and attention restoration theories suggest that the benefits of nature exposure depend on individuals' mental health status (Kaplan, 1995), we also performed secondary analyses examining effect modification of a history of anxiety or depression on the association between greenness and PSS-14 scores. Effect estimates in the model that included the interaction terms were generated using the margins command in STATA (Marginal analysis | Stata, 2021). We conducted an additional analysis comparing participants with greater than 30% residential tree canopy cover to those with less than 30% residential tree canopy cover, given that the city of Philadelphia has a goal of reaching greater than 30% tree canopy cover city-wide by the year 2025, and recent evidence showing that reaching this goal would have a positive effect on reducing premature deaths especially in low-income neighborhoods (Kondo et al., 2020). In this analysis, we dichotomized PSS-14 scores as high vs low, with a cutoff score of 30, with a score greater than 30 considered a high PSS-14 score as we have done before (Burris et al., 2020). Statistical analyses were performed using STATA (Version 16, StataCorp, College Station, Texas). Statistical tests were 2-tailed, and P < 0.05 was considered statistically significant.

3. Results

The majority of participants were non-Hispanic Black (n = 913, 70.6%), and 18.8% (n = 243) were non-Hispanic White. The majority of participants were either on Medicaid or uninsured (n = 781, 60.3%). One in six participants had a prior history of depression, anxiety or both (n = 204, 15.8%) (Table 1). Mean (SD) PSS-14 scores were higher among participants with a history of anxiety or depression (26.3 [7.9]) than participants without a history of anxiety or depression (22.6 [7.7]) (P < 0.001). Additionally, PSS-14 mean scores were greater among non-Hispanic Black (24.4 [7.9]) and Hispanic participants (23.8 [7.8]) compared to non-Hispanic White participants (19.1 [6.7]), P < 0.001. Table 1 describes tree canopy cover range for 100 m and 500 m buffers.

Table 1
Baseline characteristics of participants included (n = 1294).

Perceived Stress Score, mean (SD)	23.2 (7.9)
History of depression or anxiety	204 (15.8%)
Race/Ethnicity	
White	243 (18.8%)
Black	913 (70.6%)
Hispanic	61 (4.7%)
Other	77 (6.0%)
Insurance	
Commercial	513 (39.6%)
Medicaid/Uninsured	781 (60.4%)
Parity	
Multiparous	719 (55.6%)
Nulliparous	575 (44.4%)
Age at Delivery, mean (SD)	27.8 (5.9)
Neighborhood Deprivation Index	0.51 (0.13)
% Tree Canopy Cover, mean (SD)	
100 m buffer	16.6% (9.2%)
500 m buffer	17.1% (7.5%)
Education	
Less Than High School	124 (9.6%)
High School/Some College	683 (52.8%)
Graduated college	207 (16.0%)
Graduate/Professional School	196 (15.2%)
Unknown	84 (6.5%)

Data presented as n (column %) unless otherwise specified.

In the primary analysis, multilevel mixed linear regression models did not reveal significant associations between each standard deviation increase in tree canopy coverage and PSS-14 scores for the entire cohort. After adjusting for key covariates previously shown to be associated with maternal stress including race-ethnicity, age, parity, history of anxiety or depression, education, insurance status, and neighborhood deprivation (Table 2), for each standard deviation increase in tree canopy cover within 100 m buffers (SD 9.2%), PSS-14 scores were unchanged (β −0.02, 95% CI: 0.43, 0.39). Within 500 m buffers (SD 7.5%), the association was similarly null (β 0.3, 95% CI: 0.1, 0.6).

Appendix table 1 describes baseline characteristics by history of depression or anxiety. We conducted subsequent analyses with an interaction term between tree canopy cover and history of anxiety or

Table 2
Adjusted associations between Tree Canopy Cover and Perceived Stress (n = 1294).

	Buffer size	
	100 m buffer	500 m buffer
Independent Variables	β (95% CI)	β (95% CI)
Tree Canopy Cover per SD	−0.02 (−0.4, 0.4)	3.4 (−1.4, 8.3)
History of Depression or Anxiety	3.8 (2.7, 4.8)	3.4 (2.3, 4.4)
Race/ethnicity		
Non-Hispanic White	Ref	ref
Non-Hispanic Black	3.4 (2.1, 4.6)	3.3 (2.0, 4.6)
Hispanic	3.4 (1.2, 5.6)	3.4 (1.3, 5.6)
Other	2.8 (1.0, 4.5)	2.7 (1.0, 4.5)
Parity		
Multiparous	Ref	ref
Nulliparous	−0.6 (−1.6,0.3)	−0.6 (−1.6, 0.3)
Insurance Status		
Commercial insurance	Ref	ref
Medicaid/Uninsured	1.2 (0.2, 2.3)	1.2 (0.2, 2.3)
Age at Delivery	−0.2 (−0.3, −0.1)	−0.2 (−0.3, −0.1)
Seasonality		
Not leafgrowing	ref	ref
Leafgrowing	−0.1 (−1.1, 0.8)	−0.1 (−1.1, 0.8)
Neighborhood deprivation index	2.5 (0.2, 35.1)	2.9 (0.4, 21.3)

TCC = Tree canopy cover, A/D = anxiety or depression presented as n (column %) unless otherwise specified.

depression. In this model, in 100 m buffers, the adjusted average marginal effect of tree canopy cover per increase in standard deviation on PSS score was 0.2 (95% CI -0.3, 0.7) among participants with no history of anxiety or depression, compared to −1.0 (95% CI -1.8, −0.2) among participants with a history of depression or anxiety (interaction P = 0.007) (Fig. 2). Within 500 m buffers, the results were similar in directionality but not statistically significant. Among participants with no history of anxiety or depression, the adjusted average marginal effect of tree canopy cover per increase in standard deviation on PSS score was 0.5 (95% CI 0.0, 0.9), compared to −0.5 (95% CI -1.4, 0.4) among participants with a history of anxiety or depression (interaction P = 0.05). In addition, we performed these analyses controlling for education, and the results were similar (appendix Tables 2 and 3).

In a secondary analysis using tree canopy cover as a categorical variable and participants with greater than 30% tree canopy cover as the reference group, results are similar. Among participants with a history of anxiety or depression, participants with greater than 30% tree canopy cover had lower odds of having a high perceived stress score (aOR 0.17, 95% CI 0.03–0.81) than those with less than 10% tree canopy cover, a difference not observed among participants without a history of anxiety or depression.

4. Discussion

This study has two main findings. We did not detect a relationship between tree canopy coverage and stress across the whole cohort. However, among pregnant women with a history of depression or anxiety, urban residential greenness was associated with lower perceived stress. To the best of our knowledge, this is the first U.S.-based study to examine the association between urban residential greenness and perinatal stress and mental health.

Our findings add to the body of evidence on the association between greenness and mental well-being in the general population, and especially among pregnant women with a history of mental illness. A recent experimental trial of urban-dwelling adults in Philadelphia showed that adding newly greened spaces including trees lead to decreased feelings of depression and worthlessness for residents living nearby (South et al., 2018). Similarly, a recent study found that during the COVID-19 pandemic, perceived access to public green space and reported access to a private green space were associated with better wellbeing and self-rated health (Poortinga et al., 2021). With respect to pregnancy, a 2016 United Kingdom-based study showed that pregnant women with greater greenness within 100 m buffers were less likely to report depressive symptoms, especially among women with lower education and those who were active (McEachan et al., 2016). This study differed from ours in that we measured stress as an outcome and use mental health history as an effect modifier, while they measured depressive symptoms. An Australia-based study did not find any associations between greenness and depressive symptoms in pregnancy; however, they did not differentiate patients based on prior history of depression. The also did not include perceived stress as an outcome, and limited mental health-related covariates to substance use during pregnancy, and pre-pregnancy general health status (Nichani et al., 2017). In a large study also done in Australia, greater residential tree canopy, but not other measures of greenness, was associated with better mental health outcomes (Astell-Burt and Feng, 2019).

Fig. 2. Average marginal effects of tree canopy cover (per standard deviation) on perceived stress among participants with and without history of anxiety or depression, with 95% CI (interaction term P = 0.007), 100 m buffer.

The lack of an association between tree canopy cover and perceived stress in our overall cohort may be due to some heterogeneity among participants in terms of key measured and unmeasured characteristics that may mediate the effect of tree canopy cover exposure, such as mental health history, level of activity and engagement with the outdoors, and socioeconomic status. For instance, there were stark racial disparities in PSS scores, in alignment with prior evidence that Black women experience greater stress during pregnancy, attributable to both current neighborhood quality and lifetime cumulative stressors (Giurgescu et al., 2015; Rosenthal and Lobel, 2011). It is also possible that tree canopy cover may not be associated with decreased perceived stress overall, but only under specific circumstances.

The association between tree canopy and decreased perceived stress during pregnancy specifically among women with a history of anxiety or depression is a novel finding. While participants with a history of depression or anxiety had overall greater PSS scores, it is possible that the protective effects of tree canopy are most beneficial to those already at risk of greater perceived stress. This would be supported by the stress recovery and attention restoration theories, which both suggest that the benefits of nature exposure depend on the recipient's mental health status, based on cognitive fatigue and or chronic stress (Kaplan, 1995; Ulrich et al., 1991). While we did not ascertain contact with nature, another explanation for our findings is that it is possible that people with a history of depression or anxiety, who have higher residential tree canopy, spent more time outdoors and had a higher "dose" of greenness exposure. Furthermore, growing awareness of nature's mental health benefits may drive people with histories of mood disorders or anxiety to seek contact with nature more.

Our findings are also relevant in the context of racial health disparities in maternal morbidity and pregnancy outcomes (a burden borne disproportionately by Black and Indigenous women), as perceived neighborhood disorder during childhood and around the time of the pregnancy are both associated with adverse pregnancy outcomes among Black women (Sealy-Jefferson et al., 2016b, 2019). Our findings also have policy implications, in that they add to evidence regarding tree canopy and a potential against all-cause mortality. For instance, relevant to our patient population, a recent study showed that if the city of Philadelphia reached its target of at least 30% tree canopy cover across the city by 2025, 403 premature deaths could be prevented annually, disproportionately so among people from low socioeconomic neighborhoods (Kondo et al., 2020). In addition, a recent study showed that people who live in urban areas with more green space have lower risk of death (Bauwelinck et al., 2021). Given the history of redlining and its impact on today's patterns of tree canopy distribution across U.S. cities, we add to mounting evidence that targeted greening initiatives may help counter some of the health consequences of residential segregation (Nardone et al., 2021).

It is notable that the association was only statistically significant in the 100 m buffer and not 500 m buffer. This may be because a smaller buffer size captures the immediately visible environment surrounding individuals' homes more specifically. Studies have found associations between neighborhood street view as a measure of visible greenness and physical disorder, and health outcomes, including pregnancy outcomes

such as preterm birth and hypertensive disorders of pregnancy (Mayne et al., 2019; Larkin and Hystad, 2019).

5. Strengths and limitations

Strengths of our study include a large sample of non-Hispanic Black women who are particularly at-risk for greater perceived stress (Grobman et al., 2016). However, this study is based out of a single-center, tertiary care center in an urban setting; therefore, our findings may not be generalizable. Tree canopy cover is a static measure that does not necessarily reflect participants' engagement and activity related to green spaces such as frequency or time spent outdoors, and there may be unmeasured confounders we were not able to adjust for. However, our findings were robust to adjustment for neighborhood deprivation. Mental health history was ascertained via electronic health record review; however, we did not collect more specific information such as whether the diagnoses of anxiety and depression were active, or whether the participants had received any form of treatment. Our study is observational, therefore the associations identified cannot be determined to be causal.

6. Conclusion

In this cohort of pregnant women in a single urban, tertiary healthcare system, residential tree canopy cover was associated with lower perceived stress for women with a history of depression or anxiety. Our findings have many clinical implications in terms of antenatal stress as it relates to perinatal health. For women with a history of anxiety or depression, residential tree canopy cover may be an environmental buffer against antenatal stress and worsening mental health, warranting future experimental studies to identify the potential causal effect of greenness on reducing perinatal stress. Additionally, future studies on the effect of greenness on stress and mental health should take into consideration subjects' mental health histories.

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Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendices

Appendix Table 1
Baseline characteristics of participants included in the analysis by history of depression or anxiety.

	No History of Depression or Anxiety (n = 1090)	History of Depression or Anxiety (n = 204)
Perceived Stress Score, mean (SD)	22.6 (7.7)	26.3 (7.9)
Race/Ethnicity		
White	200 (19.4%)	43 (21.1%)
Black	769 (70.6%)	144 (70.6%)
Hispanic	47 (4.3%)	14 (6.9%)
Other	74 (6.8%)	3 (1.5%)
Insurance		
Commercial	453 (41.6%)	60 (29.4%)
Medicaid/Uninsured	637 (58.4%)	144 (70.6%)
Parity		
Multiparous	588 (53.9%)	131 (64.2%)
Nulliparous	502 (46.1%)	73 (35.8%)
Age at Delivery, mean (SD)	27.6 (5.8)	28.8 (6.3)
Neighborhood Deprivation Index	0.51 (0.13)	0.53 (0.13)
% Tree Canopy Cover, mean (SD)		
100 m buffer	16.4% (9.0%)	17.3% (10.2%)
500 m buffer	17.0% (7.3%)	17.7% (8.4%)
Education		
Less Than High School	86 (7.9%)	38 (18.6%)
High School/Some College	582 (53.4%)	101 (49.5%)
Graduated college	178 (16.3%)	29 (14.2%)
Graduate/Professional School	173 (15.9%)	23 (11.3%)
Unknown	71 (6.5%)	13 (6.5%)

Appendix Table 2
Adjusted associations between Tree Canopy Cover and Perceived Stress (n = 1294).

	Buffer size	
	100 m buffer	500 m buffer
Independent Variables	β (95% CI)	β (95% CI)
Tree Canopy Cover per SD	0.1 (−0.4, 0.5)	0.1 (−0.4, 0.5)
History of Depression or Anxiety	3.5 (2.5, 4.6)	3.5 (2.4, 4.5)
Race/ethnicity		
Non-Hispanic White	ref	ref
Non-Hispanic Black	2.6 (1.3, 3.9)	2.5 (1.2, 3.8)
Hispanic	2.9 (0.8, 5.0)	3.0 (0.8, 5.1)

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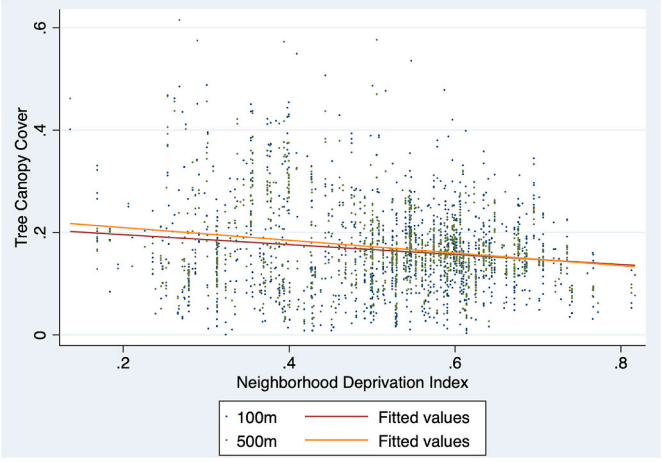
Appendix Table 2 (*continued*)

	Buffer size	
	100 m buffer	500 m buffer
Other	2.5 (0.7, 4.3)	2.5 (0.7, 4.3)
Parity		
Multiparous	ref	ref
Nulliparous	−0.4 (−1.3, 0.6)	−0.4 (−1.3, 0.6)
Insurance Status		
Commercial insurance	ref	ref
Medicaid/Uninsured	0.5 (−0.6,1.7)	0.5 (−0.6,1.7)
Age at Delivery	−0.1 (−0.2, −0.04)	−0.1 (−0.2, −0.03)
Seasonality		
Not leafgrowing	ref	ref
Leafgrowing	−0.2 (−1.1, 0.8)	−0.2 (−1.1, 0.7)
Education		
Less Than High School	ref	ref
High School/Some College	−1.6 (−3.2, −0.01)	−1.6 (−3.3, −0.04)
Graduated college	−3.6 (−5.7, −1.5)	−3.7 (−5.9, −1.6)
Graduate/Professional School	−3.5 (−5.9, −1.0)	−3.6 (−6, −1.2)
Unknown	−0.5 (−2.7, 1.7)	−0.6 (−2.8, 1.7)
Neighborhood deprivation index	2.6 (0.3, 23.7)	2.4 (0.2, 25.1)

Appendix Table 3
Adjusted average marginal effect of between tree canopy cover per standard deviation on PSS-14 score (adjusted for age, parity, insurance status, education, seasonality and neighborhood deprivation).

	Buffer size	
	100 m buffer	500 m buffer
History of anxiety or depression		
No (n = 1090)	0.3 (−0.1, 0.8)	0.1 (0.1, 1.0)
Yes (n = 204)	−1.0 (−1.9,-0.1)	−0.5 (−1.3, 0.2)



Appendix Fig. 1. Tree canopy cover distribution by neighborhood deprivation index.

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