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Neighborhood disorder predicts lower serum vitamin D levels in pregnant African American women: A pilot study

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ABSTRACT

Pregnant African American women are more likely to live in neighborhoods with more disorder (e.g., vacant housing, littler, crime) and to have vitamin D deficiency due to their darker skin pigmentation and poor production of vitamin D [25(OH)D] from ultraviolet rays. However, no study has examined the potential link between neighborhood disorder and 25(OH)D status in African American pregnant women. Forty-one pregnant African American women completed validated questionnaires about perceived neighborhood disorder (6 items; 3-point scale; range 6–18) and with concurrent serum levels of 25-hydroxyvitamin D [25(OH)D] assessed during pregnancy at 18–24 weeks gestation. Higher levels of perceived neighborhood disorder were associated with lower levels of serum 25(OH)D. Pregnant African American women who report higher disorder in their neighborhood may spend less time outside. Health care providers should include assessment of perceived neighborhood disorder. Future research needs to evaluate the relationships among neighborhood disorder and 25(OH)D levels among pregnant African American women.

1. Introduction

Neighborhood disorder, defined as "visible cues indicating a lack of order and social control" [1] in the community, has been linked to poorer health outcomes (e.g., cardiovascular disease, diabetes, obesity, and adverse birth outcomes [e.g., preterm birth (<37 completed weeks gestation), low birthweight infants (<2,500 g)] [2–4,30]. Pregnant African American women are more likely to live in neighborhoods with more disorder (e.g., vacant housing, litter, crime) compared with pregnant non-Hispanic White women [5,6]. Neighborhood disorder is often an indicator of poverty and a more descriptive measure of the social problems that come with poverty [1]. Vitamin D deficiency (VDD) may be one potential pathway by which neighborhood disorder increases risk for adverse health outcomes. Individuals living in neighborhoods with higher levels of disorder may be less likely to spend time outdoors in their neighborhoods; and thus, have less exposure to sunlight which may increase risk for VDD.

Serum 25(OH)D is the measure used clinically to assess vitamin D status. Serum 25(OH)D levels are based on a combined product of dietary intake and synthesis from skin exposure to sunlight. Pregnant women who take prenatal vitamins are still at risk of VDD [7], because typically prenatal vitamins only contain typically 400–800 IUs. Moreover, levels of 25(OH)D as high as 40 ng/ml may be required for a healthy pregnancy [8,31]. There is also evidence that pregnant women who are severely deficient <10 ng/ml need as high as 4000 IUs daily for repletion of their vitamin D level [9]).

There are racial disparities in VDD for pregnant African American women. Pregnant African American women have higher rates of VDD

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compared with pregnant non-Hispanic White women (81.6 % vs. 40.5 %, respectively) [10]. Similarly, Bodnar et al., reported that pregnant African American women have higher rates of both VDD (29.2 % vs. 5% respectively) and vitamin D insufficiency (54.1 % and 42.1 %, respectively) compared with pregnant White women [7]. According to the United States National Health and Nutrition Examination Surveys (NHANES) data (n = 925), 95 % of pregnant Black women had vitamin D less than 30 ng/ml compared with 54 % for pregnant White women [11]. Vitamin D metabolism in pregnancy is unique in that pregnant women need to account for additional 25(OH)D needs of the fetus [31]. Therefore, African American women are already at increased risk for VDD and pregnancy may put them at greater risk.

Housing conditions can influence sunlight exposure and ultimately serum/plasma levels of 25(OH)D. In a sample of Saudi Arabian women, plasma levels of 25(OH)D were significantly lower in subjects living in apartments than in those living in villas or rural areas [12]. In a study of Pakistani adults (70 % women), participants with the highest serum levels of 25(OH)D lived in single homes and housing styles that provided proper ventilation and sunlight exposure [13]. In a representative sample of the NHANES, people who lived in attached family houses or apartments had higher risk of 25(OH)D < 30 ng/mL compared to those who lived in detached family houses [14]. No studies have assessed the association between neighborhood disorder and serum/plasma levels of 25(OH)D in pregnant women. Therefore, the purpose of this pilot study was to examine the association between perceived neighborhood disorder and serum levels of 25(OH)D in a sample of pregnant African American women. We hypothesized that women who perceive more disorder in their neighborhood were more likely to have lower serum levels of 25(OH)D.

2. Materials and methods

2.1. Design and sample

This pilot study used a cross-sectional design. A sample of 54 women were enrolled in the study if they were African American, at least 18 years of age, and were in the second trimester of pregnancy. Three women who were consented to participate in the study did not follow-up for data collection. Nine women did not have blood drawn or had samples that were not processed within three hours of venipuncture and one woman had missing data on maternal characteristics. Thus, the final sample consisted of 41 pregnant African American women.

2.2. Procedures

The study was approved by the Institutional Review Board (IRB) at the participating site. Data were collected from the prenatal clinic at a medical center in Chicago. We received IRB approval to access prenatal records in order to screen for eligibility. The research staff invited eligible African American women to participate in the study. Participants completed an informed consent process prior to data collection. Women completed questionnaires and had blood drawn between 18–24 weeks gestation (August 2011 to April 2013) by a trained registered nurse at the clinical research site. The blood samples were centrifuged, aliquoted and stored at -80 °C until analysis. Women were reimbursed $25 for their participation.

2.3. Variables and instruments

2.3.1. Sample characteristics

Socio-demographic characteristics (e.g., maternal age, level of education, marital status) were collected from self-report. Gestational age at data collection, and medical and obstetrical history were obtained from medical records. Body Mass Index (BMI) was collected from medical records based on each participant's self-reported pre-pregnancy weight and height (kg/m^2).

2.3.2. Perceived neighborhood disorder

Perceived neighborhood disorder was measured using 6 items (open drug use/dealing, gangs, prostitution, homeless people, people loitering or hanging around, public drinking) rated on a 3-point scale (*not a problem* to *a big problem*) [15,16]. The possible range of scores is 6–18, with higher scores representing a greater degree of perceived neighborhood disorder. Construct validity has been shown in urban African American women [16]. Internal consistency reliability for the current sample had a Cronbach α = 0.88.

2.3.3. Dietary and supplemental Vitamin D

Participants completed the Block Brief 2000 food frequency questionnaire (FFQ) [17] (NutritionQuest, Berkeley, CA). The FFQ is designed to provide estimates of typical dietary intake and includes 70 food items. Participants were asked to estimate their usual food and supplement intake over the past month. Pictures were provided for participants to estimate portion sizes of typical meals. The food list was created from the NHANES III dietary recall data. Dietary vitamin D and calcium levels were determined from their dietary recall of foods based on their FFQ. The nutrient database was based on the United States Department of Agriculture (USDA) Nutrient Database for Standard Reference.

2.3.4. Serum 25(OH)D

Venous blood was processed and serum stored at −80 °C until analysis. Serum 25(OH)D was assessed via liquid chromatography – mass spectrometry at Quest Diagnostics (Wood Dale, IL). The detection limit is 4 ng/mL; the intra-assay coefficient of variation (CV) is 9% and the inter-assay coefficient of variation is 12 %.

2.4. Data management and analysis

Data were entered, cleaned, and prepared for analysis on an ongoing basis using SPSS 22 (SPSS Inc., Chicago, IL) and Stata 12 (StataCorp., College Station, Texas). Initial data preparation included identifying invalid cases, values outside of the expected range, checking study variables for normality (outliers, skewness, and kurtosis). Additionally, all variables included in the current study met assumptions of regression analysis. Descriptive statistics (means, standard deviations, frequencies) were used to describe the sample and major variables of the study [perceived neighborhood disorder, serum 25(OH)D]. Pearson *r* correlation coefficients were calculated to examine the relationships among variables. Multiple linear regression analysis was used to determine predictors of serum 25(OH)D levels. We created a sunlight exposure variable based on season of blood draw to use as a predictor of serum 25(OH)D levels. The sunlight exposure variable was coded as 1 = *high sunlight exposure* for blood sample collection between April and October and 0 = *low sunlight exposure* for blood sample collection between November and March. We controlled for dietary and supplemental vitamin D intake, pre-pregnancy BMI, season of blood draw, maternal age and gestational age in the analyses.

3. Results

3.1. Sample characteristics

Women had a mean age of 28 years and a mean gestational age at data collection of 21 weeks. The majority of women were unemployed (68 %), did not live with the father of the baby (59 %), and reported a household income of less than $10,000 (59 %). Ten women had a history of chronic hypertension and five women had diabetes mellitus. Women had a mean neighborhood disorder scale score of 10 ± 3.3 and a mean serum 25(OH)D of 22.3 ± 7. Thirty-five women (83.3 %) had either VDD (45.2 %) or vitamin D insufficiency (38.1 %) (see Table 1).

Correlation analysis were used to investigate bivariate relationships between study variables. Women who reported higher levels of

Table 1
Descriptive statistics for maternal characteristics (N = 41).

Variable		
	Mean (Standard Deviation)	*Range*
Age	27.79 (6.46)	18–42
Gestational age (weeks)	21.11 (1.52)	18–24
Pre-pregnancy Body Mass Index (kg/m^2)	30.66 (10.75)	17–56
Serum 25(OH)D(ng/ml)	22.2 (7.0)	9–42
Neighborhood disorder score	10.0 (3.2)	6–18
Dietary vitamin D (IUs)	238(192)	15–957
Vitamin D supplementation (IUs)	92(159)	0–600
	Number (Frequency)	
Multigravida	36 (85.7 %)	
Season of blood draw		
Nov to March	13 (32 %)	
April to Oct	28(68 %)	
Education		
Technical/ vocational	18 (43.9 %)	
Some college or higher	23 (56.1 %)	
Unemployed	28 (68.3 %)	
Household income		
Less than \$10,000	24 (58.5 %)	
\$10,001–30,000	15 (36.6 %)	
More than \$30,001	2 (4.9 %)	
Chronic hypertension	10 (24.4 %)	
Diabetes mellitus	5 (12.5 %)	

Table 2
Bivariate relationships among all variables.

Variables	(1)	(2)	(3)	(4)	(5)	(6)
(1) Maternal Age	–					
(2) Gestational age	.12	–				
(3) Pre-pregnancy BMI	.26	.28	–			
(4) Season of blood draw	−.04	−.31*	−.07	–		
(5) Neighborhood disorder	.16	.03	.20	.18	–	
(6) Serum 25(OH)D (ng/ml)	.20	−.09	−.14	.14	−.31*	–
(7) Dietary vitamin D (IU)	−.13	−.10	−.02	.00	−.18	.06

Note. Season coded as 1 = Summer, 0 = Winter.
BMI: Body Mass Index.
* $p < .05$.

neighborhood disorder had lower levels of serum 25(OH)D levels. Serum 25(OH)D levels were not related to maternal age, gestational age at data collection, pre-pregnancy BMI, season of blood draw, or dietary or supplemental vitamin D intake (see Table 2). Serum 25(OH)D was also not correlated with chronic hypertension or diabetes mellitus (data not shown).

A hierarchical regression analysis was conducted to predict serum 25(OH)D levels with maternal factors (age, gestational age, pre-pregnancy BMI, season of the year, and dietary vitamin D intake) and perceived social disorder. Even though these maternal factors were not related to serum 25(OH)D levels in our study, we included them in the analysis based on prior studies that suggest these associations. Maternal factors were entered in Step 1 of the regression and perceived social disorder was entered as an additional predictor in Step 2. Results indicated that maternal factors did not significantly relate to serum 25(OH)D level in Step 1, $F(5, 35) = .68$, $p = .64$, $R^2 = .07$. However, Step 2 of the analysis was statistically significant, $F(6,34) = 2.48$, $p = .04$, $R^2 = .30$. Inspection of individual regression coefficients indicated that only perceived social disorder was a significant predictor of serum 25(OH)D levels, $\beta = -.49$, $p = .003$. Based on the unstandardized regression coefficient, a 1 unit increase on neighborhood disorder yielded a reduction of 1 ng/ml in serum 25(OH)D levels. Thus, women who reported higher level of perceived social disorder had lower serum 25(OH)D levels after controlling for maternal factors (see Table 3).

Table 3
Hierarchical regression predicting vitamin D status.

	R^2	b	SE	β	p
Step 1	.07				
Season of the year		1.62	2.36	.12	.50
Pre-pregnancy BMI		−.12	.11	−.20	.27
Gestational age		.05	.76	.01	.95
Maternal Age		.24	.17	.24	.17
Dietary vitamin D		.00	.01	.11	.52
Step 2	.30*				
Season of the year		2.91	2.13	.21	.18
Pre-pregnancy BMI		−.07	.10	−.11	.49
Gestational age		.13	.68	.03	.85
Maternal Age		.28	.15	.27	.08
Dietary vitamin D		.001	.01	.03	.86
Neighborhood disorder		−.10	.31	−.49	.003**

[a]Note. BMI = Body Mass Index; b = unstandardized regression coefficients; SE = standard error of the unstandardized regression coefficients; β = standardized regression coefficients.
* $p < .05$.
** $p < .01$.

4. Discussion

This study examined the relationship between perceived neighborhood disorder and serum 25(OH)D levels among pregnant African American women. Higher levels of perceived neighborhood disorder predicted lower levels of serum 25(OH)D in the second trimester of pregnancy among African American women. Conversely, dietary and supplemental vitamin D did not predict serum 25(OH)D levels. This was not entirely surprising since there is evidence that the vitamin D supplement in prenatal vitamins of 400–800 IUs does not provide enough supplementation to make a significant change in vitamin D levels and typically diet alone does not contribute significantly to serum 25(OH)D levels [9,18–21]. Pregnant women who perceive disorder in their neighborhood may avoid spending time outside in their neighborhoods and, therefore, have limited sunlight exposure resulting in lower serum 25(OH)D levels. A vicious circle could be created by which women with lower levels of serum 25(OH)D could potentially result in unhealthy behaviors such as lower levels of physical activity, however it is unclear whether it is the perceived neighborhood disorder or it is pregnancy itself that causes women to have less physical activity and therefore lower levels of serum 25(OH)D. Due to the cross sectional nature of the current study, it was not possible to examine causation. Indeed, there has been evidence that lower serum 25(OH)D levels are associated with less physical activity. Those individuals who were insufficiently active were 1.32 times more likely to be vitamin D deficient (levels < 20 ng/mL) than those who were sufficiently active [22]. The associations were not stronger for self-reported outdoor activities compared to indoor activities, indicating that other effects independent of sunlight exposure may play a role [22].

Higher levels of neighborhood disorder and lower serum levels of 25(OH)D have been related to higher levels of depressive symptoms among pregnant African American women. For example, pregnant African American women who reported higher levels of neighborhood disorder (e.g., prostitution, gangs, drug dealing) also reported higher levels of depressive symptoms [4]. Similarly, pregnant women (77 % of sample was African American) living in neighborhoods with more disorder (e.g., property damage, higher vacancy rates) had higher levels of depressive symptoms [23]. Furthermore, African American women who had lower serum levels of 25(OH)D in the first trimester had higher levels of depressive symptoms in the second trimester of pregnancy [24]. For every 1-unit increase in log 25(OH)D [corresponding to 2.72 ng/mL increase in 25(OH)D], the odds of women having an elevated depression score (Center for Epidemiological Studies-Depression score ≥ 16) decreased by 46 % [24]. Depressive symptoms may be the pathway by which perceived neighborhood disorder relates to lower serum 25(OH)D levels. Therefore, future research needs to examine depressive symptoms as potential mediators of the association between perceived neighborhood disorder and vitamin D levels in a larger sample of African American women.

Systemic inflammation may also explain the association of perceived neighborhood disorder with VDD. Higher levels of neighborhood disorder based on census and administrative data were associated with higher C-Reactive Protein(CRP) levels and lower serum 25(OH)D levels based on NHANES data in a population of male and females, although 70 % of the sample was composed of non-Hispanic white men and women [25]. VDD has also been associated with greater systemic inflammation among pregnant African American women [26,27].

In our sample of pregnant African American women from Chicago, we found that 83 % of women had either VDD or vitamin D insufficiency. Similarly, 81.6 % of pregnant African American women living in Detroit had vitamin D deficiency [10]. African American women and women who live in the northern latitudes where sunlight exposure is limited during the winter months are at higher risk of VDD [20]. However, the sunlight exposure did not predict serum 25(OH)D levels in our sample which is notable because evidence shows that in summer months 25(OH)D levels are typically higher than in winter months, but this was not the case with our cohort. However, we did not utilize an instrument measuring actual sun exposure, but used season of blood draw as a proxy, which is a limitation of the study. The results suggest that women in this study had inadequate sunlight exposure regardless of the season of the year, potentially due to increased perceived neighborhood disorder and consequently not participating in outdoor activities during the summer months in addition to race because darker skin pigmentation can prevent adequate vitamin D metabolism [28].

Health care providers need to inquire about women's perceptions of their neighborhood because there is evidence to show that neighborhood disorder can have a detrimental impact on health. Clinicians should discuss with women who report negative perceptions of their neighborhoods about safe places where women can walk outside such as schools or community centers courtyards which can also have an impact on mental health. Pregnant women should be encouraged to take vitamin D supplementation and consume foods that are high in vitamin D such as salmon, vitamin D fortified cow and soymilk, eggs and fortified ready-to-eat cereals [29].

This study has several limitations. Pregnant African American women were recruited from a medical center in Chicago and, therefore, the results cannot be generalized to pregnant women from other racial groups or settings. The sample size was small and we were not able to examine the effect of perceived neighborhood disorder on serum vitamin D levels across pregnancy. Research studies with larger sample sizes, multiple measures of serum vitamin D during pregnancy, and measures of sunlight exposure are needed. In addition, possible associations among perceived neighborhood disorder, depressive symptoms, systemic inflammatory status and vitamin D levels should be evaluated.

5. Conclusion

Pregnant African American women in our study who reported higher levels of neighborhood disorder had lower levels of serum 25(OH)D. It is possible that women with negative neighborhood perceptions have more concerns about walking outside and, therefore, have less sunlight exposure. VDD has been associated with increased systemic inflammation, which could be a biological mechanism linking neighborhood disorder to worsened health and birth outcomes (e.g., preterm birth). Clinicians should be aware of the relationship between neighborhood perceptions and VDD. Future research needs to be done to evaluate the association of perceived neighborhood disorder with serum 25(OH)D status in larger cohorts of pregnant women, along with exploring depressive symptoms and systemic inflammation as potential pathways connecting neighborhood disorder to maternal health and ultimately infant health.

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CRediT authorship contribution statement

J. Woo: Writing - original draft, Visualization, Conceptualization. **M.D. Koenig:** Investigation, Data curation, Funding acquisition, Project administration, Writing - review & editing. **C.G. Engeland:** Data curation, Formal analysis, Writing - review & editing. **M.A. Kominiarek:** Conceptualization, Writing - review & editing. **R. White-Traut:** Funding acquisition, Writing - review & editing. **P. Yeatts:** Formal analysis, Data curation. **C. Giurgescu:** Writing - original draft, Visualization, Funding acquisition, Conceptualization, Project administration.

Declaration of Competing Interest

There is no conflict of interest.

Appendix A. Supplementary data

Supplementary material related to this article can be found, in the online version, at doi:https://doi.org/10.1016/j.jsbmb.2020.105648.

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