Association of neighborhood social determinants of health and hypertensive disorders of pregnancy

OBJECTIVE: Hypertensive disorders of pregnancy (HDP) are a major cause of maternal mortality, accounting for 20% of maternal deaths in the U.S. HDP affects 1 in 7 pregnant individuals in the U.S. annually, and the rate has doubled over the past decade.[1] HDP are associated with adverse pregnancy and long-term health outcomes for both the pregnant individual and exposed child.

Individual-level adverse social determinants of health (SDOH) are associated with an increased risk of HDP.[2,3] Whether neighborhood-level adverse SDOH is associated with HDP remains to be examined. Identification of such associations could result in structural initiatives to reduce this risk.

We examined the associations between three neighborhood measures of adverse SDOH (socioeconomic disadvantage, living in a food desert, and less walkability) and HDP.

STUDY DESIGN: This is a secondary analysis of data from the prospective Nulliparous Pregnancy Outcomes Study: Monitoring Mothers-To-Be (NuMoM2b) conducted between 2010 and 2013. NuMoM2b was a multi-center prospective cohort study that enrolled 10,038 nulliparous individuals with singleton pregnancies (NCT01322529). Inclusion criteria included no prior history of delivery at 20 weeks gestation or later, viable singleton gestation between 6 and 13 weeks 6 days gestation, and no major genetic or structural anomalies. Over the course of four visits, data were collected through interviews, questionnaires, physical examination, ultrasound assessment, and biological markers. First-trimester residential addresses were geocoded in ArcGIS at the census-tract level and linked to three community-level measures: (1) socioeconomic disadvantage by the 2015 Area Deprivation Index (ADI); (2) food insecurity by the USDA *Food Access Research Atlas*; and (3) less walkability by the Environmental Protection Agency (EPA) *National Walkability Index*.

The ADI combines metrics of income, education, employment, and housing quality into a composite.[4] The ADI was analyzed in tertiles from least (tertile 1, T1, reference) to most disadvantage (T3). Living in a food desert (yes/no) was measured by both low income and low access to supermarkets. Neighborhood walkability (yes/no), incorporating proximity to transit stops, intersection density, employment mix, and employment and household mix, was categorized as less (score <15.26) vs more walkable (score 15.26−20.0) per EPA recommendations.

The outcome was HDP, defined as antepartum gestational hypertension and any preeclampsia, inclusive of superimposed preeclampsia, HELLP (hemolysis, elevated liver enzymes, low platelets) syndrome, and eclampsia, determined according to the American College of Obstetrics and Gynecology criteria.

Poisson regression with robust error variance was used to estimate the adjusted relative risk (aRR) of HDP as a function of socioeconomic disadvantage, living in a food desert, and less walkability (modeled separately). Confounding was assessed based a directed acyclic graph (Appendix Figure 1); models were adjusted for age, insurance status, educational attainment, household income, and diagnosis of pregestational diabetes. We did not adjust for covariates deemed to be on the causal pathway between the exposure and the outcome.

RESULTS: Of 10,038 enrolled individuals, 450 (4.4%) were excluded due to missing geocoded addresses and 526 (5.5%) due to missing HDP outcomes, resulting in a final sample of 9062 individuals (Appendix Figure 2). Clinical co-morbidities and adverse individual-level SDOH were more common among those excluded ($P<0.05$) (Appendix Table 1).

The median ADI score of the analytic sample population was 39.0 (IQR 18.0, 71.0), 24.5% lived in a food desert, and 66.3% lived in a less walkable neighborhood. Those living in neighborhoods in the top tertile of ADI (ie, highest disadvantage), living in a food desert, and living in a less walkable area were more likely to be younger, live with clinical co-morbidities, report smoking, and experience individual-level adverse SDOH ($P<0.01$) (Appendix Tables 2 and 3).

Individuals living in a neighborhood with higher socioeconomic disadvantage were at increased risk of developing HDP (T2 vs T1: 14.0% vs 11.0%, aRR 1.26; 95% CI: 1.10, 1.44; and T3 vs T1: 14.0% vs 11.0%, 1.19; 95% CI: 1.02, 1.38), as were those living in a food desert (14.6% vs 12.5%, aRR=1.14, 95% CI: 1.01, 1.29), or living in a less walkable neighborhood (13.8% vs 11.3%, aRR=1.21, 95% CI: 1.07, 1.36) (Table).

CONCLUSION: Nulliparous pregnant individuals living in neighborhoods with higher socioeconomic disadvantage, that are food deserts, or have less walkability, were more likely to develop HDP.

Prior data have demonstrated associations between community-level adverse SDOH and adverse pregnancy outcomes, including preterm birth, gestational diabetes, and abnormal fetal growth.[5] In addition, individual-level SDOH has been associated with HDP. The current study suggests that multiple community-level measures are consistently associated with an increased risk of HDP as well.

TABLE
Association of neighborhood-level socioeconomic disadvantage, food insecurity, and less walkability in early pregnancy and HDP

	n	Frequency of HDP (row percentage)		Adjusted risk ratio[a,b], aRR (95% CI)
		No, *n* (%)	Yes, *n* (%)	
Area Deprivation Index		2752 (89.0)	339 (11.0)	
Tertile 1 (least deprived)	3091	2514 (85.9)	413 (14.1)	1.00
Tertile 2	2927	2619 (86.0)	425 (14.0)	1.26 (1.10, 1.44)
Tertile 3 (most deprived)	3044			1.19 (1.02, 1.38)
Food insecurity		5989 (87.5)	853 (12.5)	
No	6842	1896 (85.4)	324 (14.6)	1.00
Yes	2220			1.14 (1.01, 1.29)
Less walkability				
No	3051	2706 (88.7)	345 (11.3)	1.00
Yes	6011	5179 (86.2)	832 (13.8)	1.21 (1.07, 1.36)

[a] Modified Poisson regression with robust error variance was used with imputation for missing covariates; [b] Model adjusted for age, insurance, educational attainment, household income, and pregestational diabetes.

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Neighborhood-level socioeconomic disadvantage may increase HDP risk through chronic stress and, consequently, inflammation. Less walkability may result in less physical activity and higher gestational weight gain.

A limitation of this study includes the assessment of residence at a single time point in early pregnancy, which may have resulted in exposure misclassification. Although individuals with high ADI are more likely to relocate, a current address is an accurate indicator of neighborhood deprivation through a 3-year timeframe.[6] The data are a decade old; however, it is unlikely that the underlying association between SDOH and adverse pregnancy outcomes has changed. A strength is the assessment of multiple neighborhood-level measures of SDOH that are easily available on online portals and can be integrated into the electronic health record. Further analytic models are needed to elucidate the relationship or intersection of individual and neighborhood-level social factors, such as multilevel regression analyses.[7]

This study underscores the importance of investigating community-level structural interventions as a strategy to reduce HDP.

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REFERENCES

1. Cameron NA, Everitt I, Seegmiller LE, Yee LM, Grobman WA, Khan SS. Trends in the incidence of new-onset hypertensive disorders of pregnancy among rural and urban areas in the United States, 2007 to 2019. J Am Heart Assoc 2022;11(2):e023791. https://doi.org/10.1161/JAHA.121.023791.

2. Conklin MB, Wells BM, Doe EM, et al. Understanding health disparities in preeclampsia: a literature review. Am J Perinatol 2024;41:e1291–300. https://doi.org/10.1055/a-2008-7167.

3. Umesawa M, Kobashi G. Epidemiology of hypertensive disorders in pregnancy: prevalence, risk factors, predictors and prognosis. Hypertens Res 2017;40(3):213–20. https://doi.org/10.1038/hr.2016.126.

4. Kind AJH, Buckingham WR. Making neighborhood-disadvantage metrics accessible—the neighborhood atlas. N Engl J Med 2018;378(26):2456–8. https://doi.org/10.1056/NEJMp1802313.

5. Field C, Lynch CD, Fareed N, et al. Association of community walkability and glycemic control among pregnant individuals with pregestational diabetes mellitus. Am J Obstet Gynecol MFM 2023;5(5):100898. https://doi.org/10.1016/j.ajogmf.2023.100898.

6. Knighton AJ. Is a patient's current address of record a reasonable measure of neighborhood deprivation exposure? A case for the use of point in time measures of residence in clinical care. Health Equity 2018;2(1):62–9. https://doi.org/10.1089/heq.2017.0005.

7. Merlo J, Chaix B, Yang M, Lynch J, Råstam L. A brief conceptual tutorial on multilevel analysis in social epidemiology: interpreting neighbourhood differences and the effect of neighbourhood characteristics on individual health. J Epidemiol Community Health (1978) 2005;59(12):1022–8. https://doi.org/10.1136/jech.2004.028035.