Neighborhood deprivation and severe maternal morbidity in a medicaid-Insured population in Georgia

Christian Freeman, Kaitlyn K. Stanhope, Hannah Wichmann, Denise J. Jamieson and Sheree L. Boulet

Gynecology and Obstetrics, Emory University School of Medicine, Atlanta, GA, USA

ABSTRACT

Background: Despite growing acceptance of the role of context in shaping perinatal risk, data on how neighborhood factors may identify high-risk obstetric patients is limited. In this study, we evaluated the effect of neighborhood deprivation and neighborhood racial composition on severe maternal morbidity (SMM) among persons delivered in a large public health system in Atlanta, Georgia.

Methods: We conducted a population cohort study using electronic medical record data on all deliveries at Grady Memorial Hospital during 2011–2020. Using residential zip codes, we calculated neighborhood deprivation index based on data from the US Census. We used log-binomial regression with generalized estimating equations to estimate crude and adjusted relative risks (aRR) and 95% confidence intervals (CI) for the association between tertile of neighborhood deprivation and SMM, adjusting for demographic, clinical, and neighborhood-level (racial composition, food desert, and transit access) covariates.

Results: Among 25,257 deliveries, 6.2% (1566) experienced SMM. Approximately 24.0%, 32.0%, and 44.0% of women lived in the lowest, middle, and highest tertile of neighborhood deprivation, respectively and 64.9% lived in a neighborhood with majority non-Hispanic Black residents. After adjustment, there was no association between neighborhood deprivation and SMM (aRR: 1.0 (0.8, 1.1)) or residence in a majority Black neighborhood and SMM (aRR:1.0 (0.9, 1.2)).

Conclusion: In this safety-net hospital, residence in a high deprivation or majority Black neighborhood did not predict SMM at or following delivery. Individual-level social determinants may better explain variation in risk, particularly in high-burden populations.

Introduction

The US has the highest pregnancy-related mortality ratio among developed countries, rising from 7 to 17 pregnancy-related deaths per 100,000 live births over the past three decades [1]. In the United States, non-Hispanic Black women are three times as likely to experience a maternal death as non-Hispanic White women [2]. Maternal health lies on a spectrum, ranging from a completely healthy mother to one who has experienced morbidity or mortality [3]. The American College of Obstetricians and Gynecologists (ACOG) classifies severe maternal morbidity (SMM) as any unexpected outcome of labor and delivery that results in a significant short- or long-term consequence to a woman’s health [4]. Like maternal deaths, the overall rate of SMM in the US increased by nearly 200% between 1993 and 2014 [5]. There are persistent racial disparities in both maternal death and SMM; non-Hispanic Black or American Indian/Alaska Native women are 30% more likely to experience SMM during or following delivery compared to non-Hispanic White women [6]. This excess risk is not fully explained by comorbidities or health care factors [6], suggesting social factors, including systemic racism, may play a role in increasing maternal risk.

Beyond individual-level risk factors, the environments in which women live may increase maternal risk [7]. For example, neighborhoods may facilitate access to health-promoting resources, such as green space, healthy foods, and safe transit to clinics. Alternately, neighborhoods may act as barriers to optimal health by increasing stress or encouraging
unhealthy behaviors (e.g. consumption of unhealthy foods or smoking) [7]. Evidence from Canada and Australia showed that individuals from lower socioeconomic status neighborhoods (as measured through indices) have a higher risk of SMM compared to individuals from high socioeconomic status neighborhoods [8,9]. Similarly, Janevic et al. showed that neighborhoods at extremes of racial and economic polarization in New York City had the highest rates of SMM [10]. Neighborhood characteristics are a result of contemporary and historic policies and processes, and individuals have been sorted into these neighborhoods through processes of racial and economic polarization. Thus, observed differences in outcomes across neighborhoods may reflect a combination of present-day access to resources or the long-term results of historic segregation [11]. Regardless of the mechanism, neighborhood characteristics may serve to indicate higher obstetric risk, allowing for tailoring of interventions or clinical practice.

Due to the growing recognition of the importance of social context for health, providers and health systems have begun to measure social determinants of health in order to provide context-informed care [12–14]. While many screening tools to date rely on self-reported data, these can be burdensome and affected by missing data, particularly for individuals with low-literacy [15].

Incorporating information on neighborhood social determinants of health using patient zip codes is a low-burden alternative or addition to collecting individually-reported data that can inform clinical care or neighborhood-based interventions [16]. However, only limited evidence guides the implementation of contextual information into clinical care and, to our knowledge, none specific to the obstetric setting [15]. Identification of neighborhood-level risk factors may serve many purposes including identifying individuals at higher risk of poor clinical outcomes who may benefit from more tailored care and detecting communities that may benefit from outreach [14,16]. Specific to this analysis, limited data exist on whether social context can serve as an effective risk marker within high-burden health systems, identifying patients who might benefit from more intensive clinical management or monitoring.

The goal of this analysis was to understand whether neighborhood factors (neighborhood deprivation and neighborhood racial composition) serve as a marker of higher obstetric risk (SMM) in a safety net hospital system in Atlanta, Georgia.

Materials and methods

Study setting

Grady Memorial Hospital is a large, safety-net hospital in Atlanta, GA with a mandate to serve the populations of DeKalb and Fulton counties, two urban majority-Black counties. Approximately 2200 individuals deliver at Grady each year, with the majority from DeKalb and Fulton counties and others from the surrounding counties of the Metro Atlanta area [17]. Residents of DeKalb and Fulton county are eligible for sliding scale care, if uninsured, and Grady offers a number of wrap-around services (non-medical support or referral services to improve whole person care; e.g. onsite WIC enrollment and a zip code-based social service referral system) for pregnant and postpartum persons. Nevertheless, the incidence of morbidity and mortality at Grady remains high. The rate of SMM at Grady was 795 per 10,000 deliveries during 2016–2018, representing an over five-fold difference compared to a national rate of 147 per 10,000 [18]. The use of deidentified data from GOGO for projects related to maternal health has been approved by the Emory Institutional Review Board (IRB00103211).

Patient level data

The data for this study were derived from the Grady Obstetric & Gynecologic Outcomes (GOGO) database, a longitudinal database of all deliveries (live and still-born) >20 weeks’ gestation at Grady Memorial Hospital. The database is created using automated, monthly electronic medical record (EMR) abstraction. In this analysis, we included all deliveries between January 1, 2011 and March 31, 2020. We identified SMM using the CDC SMM indicators, which are based on the International Classification of Disease (ICD), 9th and 10th revision, recorded at delivery or up to 42 days postpartum [19]. For our primary analysis, we included all SMM indictors. We also conducted a sensitivity analysis excluding cases for which blood transfusion was the only indicator as these may include false positives (individuals who received a transfusion under the threshold of 4 pints to meet SMM criteria). We considered individual-level confounders that may differ across neighborhoods and influence the risk of SMM. We used GOGO to obtain information on maternal age, race/ethnicity, insurance type, parity, mode of delivery, chronic conditions, pregnancy complications, and residential zip code at delivery.
Neighborhood-level data

We used maternal residential zip code to represent patients’ neighborhood context, linking patients to neighborhood data using the zip code on record at the delivery in the EMR. Using a validated crosswalk, we matched zip codes to census tracts [20]. We considered two potential indicators of higher risk: neighborhood racial composition, serving as a marker for historic and contemporary segregation, and neighborhood deprivation, serving as a marker for neighborhood resource availability. Both of these markers are available through publicly available data.

We used data from the American Community Survey 5-year estimates to calculate the neighborhood deprivation index (NDI) [21–23]. The NDI represents the socio-contextual environment in which patients reside: percent of males in management and professional occupations, percentage of crowded housing, percentage of households in poverty, percentage of households with dependents with a female-head, percentage of households receiving public assistance, percentage of households earning <$30,000 per year, percentage of those earning less than a high school diploma, and percent unemployed [21]. As have prior authors, we categorized the NDI for bivariate and multivariable analyses [21]. To facilitate comparison between our patient population and other populations, we used the distribution of the NDI across all census tracts in the state of Georgia to categorize census tracts into three categories (tertiles) representing the lowest, medium, and highest deprivation across Georgia.

We defined neighborhood racial composition as the percent of neighborhood residents who identify as non-Hispanic Black, using American Community Survey 5-year estimates. We dichotomized this variable at 50% to identify majority-black neighborhoods.

We selected additional neighborhood-level covariates a priori based on their theoretical influence on neighborhood deprivation, healthcare access, and the development of comorbid conditions. We controlled for binary residence in a food desert, defined by the United States Department of Agriculture as a census tract where a significant number (at least 500 people) or share (at least 33 percent) of the population is greater than 1/2 mile from the nearest supermarket, supercenter, or large grocery store for an urban area or greater than 10 miles for a rural area [24]. We created a continuous transit access variable by summing all transportation routes (bus or train) that intersected with patients’ zip codes, using data from the Atlanta Regional Commission [25].

We conducted a complete case analysis, excluding observations missing data on covariates (race, parity). We used multivariable log-binomial regression to estimate the relative risks and 95% confidence intervals (CI) of SMM for the upper tertiles of neighborhood deprivation relative to the lowest tertile of deprivation. We used generalized estimating equations to account for potential clustering at the neighborhood (zip code) or individual level (as some patients had multiple deliveries in the dataset). We fit sequential models adjusting for individual-level covariates (maternal race/ethnicity (classified as non-Hispanic White, non-Hispanic Black, Hispanic, or non-Hispanic other (inclusive of individuals identifying as Asian, American Indian/Alaska Native, and multiracial), age (quadratic), parity (primiparous v. multiparous), and insurance type (public, private, or uninsured), class III obesity, multiple gestation, and chronic hypertension) and neighborhood level confounders (neighborhood percent Black population (binary – less than 50% or greater than or equal to 50% non-Hispanic Black residents), food access (binary; resident in a food desert or not), and transportation access (continuous)). As sensitivity analyses, we fit a model including a multiplicative interaction term between deprivation and percent-Black to examine the joint effect of these characteristics and a model stratified by individual race (Black v. non-Black).

Results

There were 25,257 deliveries between January 1, 2011 and March 31, 2020. After excluding observations missing data on race (n = 86) or parity (n = 595), we were left with a final sample of 25,257 deliveries to 19,939 individuals residing in 365 zip codes.

Approximately 24.0%, 32.0%, and 44.0% of patients lived in the lowest, middle, and highest tertile of neighborhood deprivation, respectively (Table 1). Overall, 6.2% (1566) of patients experienced SMM at or following delivery. SMM risk was similar across tertiles of deprivation (5.9%, 6.3%, and 6.3% in the lowest, medium, and highest tertiles, respectively). The composition of patients varied by residence in low, medium, and high deprivation neighborhoods. A larger proportion of patients from neighborhoods in the highest deprivation tertile were non-Hispanic Black (78.9% compared to 41.0% in the lowest tertile), and were teenagers (12.7% v. 6.8%) compared to patients from the lowest deprivation tertile. Patients residing in the highest deprivation tertile had slightly higher rates of all hypertensive disorders, morbid obesity, and
cesarean section compared to patients in the medium and lowest tertile.

There was no association between neighborhood deprivation and SMM in the crude model (Table 2; RR: 1.1 (0.9, 1.3)) or following adjustment for individual and neighborhood covariates (aRR: 1.0 (0.8, 1.1)). Residents in a majority black neighborhood demonstrated a slightly higher risk of SMM in the crude model (RR: 1.2 (1.1, 1.3)). However, after adjusting for individual and neighborhood covariates, this association was attenuated to null (Model 2, aRR 1.0 (0.9, 1.2)). There was no evidence of multiplicative interaction between neighborhood deprivation and percent of black residents; nor did estimates differ meaningfully in models stratified by individual race (Supplemental Tables 1 and 2).

### Table 1. Individual and neighborhood characteristics of 25,257 deliveries to 19,939 individuals at Grady Memorial Hospital, 2016–2018, stratified by Neighborhood Deprivation Index tertile.

| Neighborhood Deprivation | Low neighborhood deprivation* | Medium neighborhood deprivation | High neighborhood deprivation |
|--------------------------|-------------------------------|---------------------------------|------------------------------|
|                          | % (n)                         | % (n)                           | % (n)                        |
| Deliveries               | 24 (6,068)                    | 32 (8,078)                      | 44 (11,111)                  |
| Severe maternal morbidity| 5.9 (359)                     | 6.3 (511)                       | 6.3 (696)                    |
| SMM excluding cases with transfusion as only indicator | 2.9 (173) | 2.8 (226) | 2.7 (303) |
| Patient race             |                               |                                 |                              |
| Non-Hispanic white       | 4.2 (254)                     | 2.2 (178)                       | 1.7 (187)                    |
| Non-Hispanic black       | 41 (2488)                     | 75.4 (6087)                     | 78.9 (8762)                  |
| Asian                    | 4.3 (261)                     | 1.3 (105)                       | 1.7 (187)                    |
| American Indian/Alaska native | 0.3 (18) | 0.2 (16) | 0.2 (27) |
| Hawaiian/Pacific Islander | 0.4 (21)          | 0.1 (10)                   | 0.1 (14)                     |
| Hispanic                 | 45.5 (2759)                   | 19.4 (1567)                     | 15 (1663)                    |
| Multiple races/other     | 4.4 (267)                     | 1.4 (115)                       | 2.4 (271)                    |
| Insurance                |                               |                                 |                              |
| Private                  | 5.7 (348)                     | 5 (401)                         | 4.6 (507)                    |
| Public                   | 84.1 (5102)                   | 89.1 (7199)                     | 91.6 (10174)                 |
| Uninsured                | 10.2 (618)                    | 5.9 (478)                       | 3.9 (430)                    |
| Age                      |                               |                                 |                              |
| <20                      | 6.8 (414)                     | 12.7 (1027)                     | 12.7 (1410)                  |
| 20–34                    | 73.3 (4445)                   | 74.2 (5996)                     | 75.8 (8417)                  |
| ≥35                      | 19.9 (1209)                   | 13.1 (1055)                     | 11.6 (1284)                  |
| Primiparous              | 30.6 (1856)                   | 33.2 (2681)                     | 32.2 (3574)                  |
| Cesarean                 | 26.9 (1629)                   | 28.5 (2302)                     | 29.3 (3253)                  |
| Gestational hypertension | 9.9 (602)                     | 12.5 (1007)                     | 12.8 (1422)                  |
| Chronic hypertension     | 6 (361)                       | 9.3 (747)                       | 11 (1221)                    |
| Preeclampsia without severe features | 3.9 (237) | 4.5 (366) | 4 (448) |
| Preeclampsia with severe features | 4.2 (256) | 4.8 (389) | 4.5 (502) |
| Class III obesity        | 5.4 (327)                     | 8.3 (668)                       | 9.3 (1028)                   |
| Neighborhood characteristics |                                 |                                 |                              |
| Majority (>50%) black residents | 19.3 (1182) | 74.7 (6136) | 83.6 (9091) |
| Food desert              | 2.3 (141)                     | 26.9 (2175)                     | 14.2 (1573)                  |
| Transit access           |                               |                                 |                              |
| Low                      | 50.7 (3074)                   | 25.2 (2039)                     | 19.4 (2154)                  |
| Medium                   | 46.1 (2799)                   | 22 (1773)                       | 40.3 (4482)                  |
| High                     | 3.2 (195)                     | 52.8 (4266)                     | 40.3 (4475)                  |

*Defined using the Neighborhood Deprivation Index created using 5-year estimates from the American Communities Survey [19,21].

### Table 2. Unadjusted and Adjusted Associations between neighborhood deprivation and racial composition and severe maternal morbidity, 25,257 deliveries to 19,939 individuals at Grady Memorial Hospital, 2011–2020.

|                          | Model 0a | Model 1b | Model 2c | Model 3d |
|--------------------------|----------|----------|----------|----------|
| Highest deprivation tertile | 1.1 (0.9, 1.3) | 1.0 (0.8, 1.1) | 0.9 (0.8, 1.1) | 1.0 (0.8, 1.1) |
| Medium deprivation tertile | 1.1 (0.9, 1.2) | 1.0 (0.8, 1.1) | 1.0 (0.9, 1.1) | 1.0 (0.8, 1.1) |
| Lowest deprivation tertile (ref) | 1.0 | 1.0 | 1.0 | 1.0 |
| Majority black           | 1.2 (1, 1.3) | 1.0 (0.9, 1.1) | 1.0 (0.9, 1.2) | 1.0 (0.9, 1.2) |

Abbreviations: aRR: adjusted risk ratio, CI: confidence interval, ref: referent.
aUnadjusted.
bAdjusted for individual race, parity, age, insurance.
cAdjusted for individual race, parity, age, insurance, chronic hypertension, multiple gestation, Class III obesity.
dAdjusted for individual race, parity, age, insurance, food desert, transit density, neighborhood racial composition, deprivation.
Discussion and conclusion

In this study, we examined the relationship between neighborhood deprivation and the risk of SMM in patients delivered at Grady Memorial Hospital in Atlanta, GA. We found that neighborhood deprivation was not associated with an increased risk of SMM in this population. Our results were unexpected, given the outcomes of prior studies assessing the effect of neighborhood deprivation on health outcomes [10,11]. However, these null findings are consistent with some prior work showing weak or null associations between neighborhood factors and pregnancy outcomes among Black women [26,27]. We postulate that our findings may be due to the relative homogeneity of our population, wherein half of the patients report one or more individual social risks during pregnancy, such that differences in neighborhood-level social determinants are not useful markers of risk.

These data highlight the challenges of using neighborhood social determinants of health for risk stratification within an individual health system. The patient population of such health systems represents a selected population, rather than the overall population of an area. In the case of Grady Hospital, the obstetric patient population represents a higher risk subgroup compared to the overall Atlanta or Georgia population. In this context, adding information on neighborhood social determinants does not provide enough additional information for risk stratification. However, screening for individual-level social risks may allow for referrals, which could be customized based on neighborhood resource availability. In addition, screening for individual or neighborhood risks may allow clinicians to connect with their patients and provide context-informed care.

These results should be interpreted in light of several limitations. The list of neighborhood covariates (transit-access, food environment, neighborhood deprivation, neighborhood racial composition) is not comprehensive and represents a selected group of publicly-available neighborhood data. Additional measures of neighborhood context representing positive resources (e.g. availability of churches or other social organizations) or challenges (e.g. gentrification) may be useful for context-informed care in the setting of a single institution. Second, this study is not intended to reflect a causal question. While neighborhood environment may be part of the complex etiology of SMM, the data from a single institution wherein patients are selected into the study population is likely to be biased in answering that question. In fact, increased deprivation may increase SMM in the total population but could not be observed in our study population due to selection bias. Additionally, zip code and census tract may not be the optimal level at which to capture indicators of neighborhood risk. While US-based research often relies on zip code and tract due to data availability, deprivation may vary within neighborhoods. Reassuringly, prior research on neighborhood incivility and maternal morbidity across census tracts, block groups, and smaller units showed consistent relationships across different neighborhood constructs [27]. Finally, the identification of SMM cases using ICD-9 and ICD-10 codes may result in misclassification, as suggested by one validation study of ICD-9 codes [28,29].

Ongoing efforts to measure social determinants of health in the clinical setting are critical to improving care and addressing health disparities, particularly in obstetric care for communities facing structural challenges. However, the intended use of social determinants of health data should guide the measurement strategy. In our obstetric population, neighborhood deprivation or racial composition were not associated with higher SMM risk, despite compelling theoretical evidence and results from other studies suggesting positive associations [7–9,11]. Neighborhood characteristics may not serve as effective risk-stratification markers in high-burden populations due to the relative homogeneity of the population. In high-burden settings, individual-level social risk screening, tailored to the needs of the population, may be necessary to effectively identify high-risk individuals based on their social risks and to refer patients to services.

Disclosure statement

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References

[1] Division of Reproductive Health. Pregnancy Mortality Surveillance System | Maternal and Infant Health | CDC. National Center for Chronic Disease Prevention; 2018. [cited 2018 Aug 31]. Available from: https://www.cdc.gov/reproductivehealth/maternalinfan-thealth/pregnancy-mortality-surveillance-system.htm.

[2] Petersen EE, Davis NL, Goodman D, et al. Racial/ethnic disparities in pregnancy-related deaths — United States, 2007–2016. MMWR Morb Mortal Wkly Rep. 2019;68(35):762–765.
[3] Geller SE, Rosenberg D, Cox SM, et al. Defining a conceptual framework for near-miss maternal morbidity. J Am Med Womens Assoc. (1972). 2002;57(3):135–139.

[4] Kilpatrick SK, Ecker JL. Obstetric Care Consensus No. 5: Severe maternal morbidity: screening and review. Am J Obstet Gynecol. 2016;215(3):B17–B22.

[5] Severe Maternal Morbidity in the United States | Pregnancy | Reproductive Health | CDC. 2021. [cited 2021 Sep 29]. Available from: https://www.cdc.gov/reproductivehealth/maternalinfanthealth/severematernalmorbidity.html.

[6] Leonard SA, Main EK, Scott KA, et al. Racial and ethnic disparities in severe maternal morbidity prevalence and trends. Ann Epidemiol. 2019;33:30–36.

[7] Kramer MR, Strahan AE, Preslar J, et al. Changing the conversation: applying a health equity framework to maternal mortality reviews. Am J Obstet Gynecol. 2019;221(6):609.e1–609.e9.

[8] Lindquist A, Noor N, Sullivan E, et al. The impact of socioeconomic position on severe maternal morbidity outcomes among women in Australia: a national case–control study. BJOG. 2015;122(12):1601–1609.

[9] Snelgrove JW, Lam M, Watson T, et al. Neighbourhood material deprivation and severe maternal morbidity: a population-based cohort study in Ontario, Canada. BMJ Open. 2021;11(10):e046174.

[10] Janevic T, Zeitlin J, Egorova N, et al. Neighborhood racial and economic polarization, hospital of delivery, and severe maternal morbidity: an examination of whether racial and economic neighborhood polarization is associated with severe maternal morbidity rates and whether the delivery hospital partially explains the association. Health Aff. 2020;39(5):768–776.

[11] Crear-Perry J, Correa-de-Araujo R, Lewis Johnson T, et al. Social and structural determinants of health inequities in maternal health. J Womens Health. 2021;30(2):230–235.

[12] State of California. Medi-Cal NewsFlash: screening for adverse childhood experiences is a medi-cal covered benefit. Medi-Cal Providers; 2020. [cited 2021 Dec 14]. Available from https://files.medi-cal.ca.gov/pubsdoco/newsroom/newsroom_30091_02.aspx.

[13] Gold R, Cottrell E, Bunce A, et al. Developing electronic health record (EHR) strategies related to health center patients’ social determinants of health. J Am Board Fam Med. 2017;30(4):428–447.

[14] Davidson KW, McGinn T. Screening for social determinants of health: the known and unknown. JAMA. 2019;322(11):1037–1038.

[15] Andermann A. Screening for social determinants of health in clinical care: moving from the margins to the mainstream. Public Health Rev. 2018;39:19.

[16] Gottlieb LM, Francis DE, Beck AF. Uses and misuses of patient- and neighborhood-level social determinants of health data. Perm J. 2018;22:13.

[17] Jamieson DJ, Haddad LB. What obstetrician–gynecologists should know about population health. Obstet Gynecol. 2018;13(10):1145–1152.

[18] Boulet SL, Platner M, Joseph NT, et al. Hypertensive disorders of pregnancy, cesarean delivery, and severe maternal morbidity in an urban safety-net population. Am J Epidemiol. 2020;189(12):1502–1511.

[19] Centers for Disease Control and Prevention. Severe Morbidity Indicators and Corresponding ICD-9-CM/ICD-10-CC/PCS Codes during Delivery Hospitalizations. 2019. [cited 2021 Mar 3]. Available from: https://www.cdc.gov/reproductivehealth/maternalinfanthealth/smm/severe-morbidity-icd.htm.

[20] HUD USPS ZIP Code Crosswalk Files | HUD USER. [cited 2021 Sep 30]. Available from: https://huduser.gov/portal/datasets/usps_crosswalk.html#faq.

[21] Messer LC, Laraia BA, Kaufman JS, et al. The development of a standardized neighborhood deprivation index. J Urban Health. 2006;83(6):1041–1062.

[22] U.S. Census Bureau. American Community Survey, 5-year estimates 2010–2014. U.S.

[23] U.S. Census Bureau. American FactFinder – Search. [cited 2019 Jul 14]. Available from: https://factfinder.census.gov/faces/nav/jsf/pages/searchresults.xhtml?refresh=t.

[24] USDA ERS – Food Environment Atlas. [cited 2021 Sep 30]. Available from: https://www.ers.usda.gov/data-products/food-environment-atlas/.

[25] Georgia Association of Regional Commissions. Transit Stops; 2019. ed. [updated 2021 July 22; cited 2020 Aug 10]. Available from: https://opendata.atlantaregional.com/datasets/transit-stops-2019/explore.

[26] Vinikoor-Imler LC, Messer LC, Evenson KR, et al. Neighborhood conditions are associated with maternal health behaviors and pregnancy outcomes. Soc Sci Med. 2011;73(9):1302–1311.

[27] Messer LC, Vinikoor-Imler LC, Laraia BA. Conceptualizing neighborhood space: consistency and variation of associations for neighborhood factors and pregnancy health across multiple neighborhood units. Health Place. 2012;18(4):805–813.

[28] Main EK, Abreo A, McNulty J, et al. Measuring severe maternal morbidity: validation of potential measures. Am J Obstet Gynecol. 2016;214(5):643.e1–643.e10.

[29] Metcalfe A, Sheikh M, Hetherington E. Impact of the ICD-9-CM to ICD-10-CM transition on the incidence of severe maternal morbidity among delivery hospitalizations in the United States. Am J Obstet Gynecol. 2021;225(4):422.e1–422.e11.