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Association of Food Deserts and COVID-19 Severity in Pregnancy as Reflected by Need for Hospitalization

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Abstract

Background Socioeconomic disparities play an important role in disease epidemiology and outcomes in pregnancy.
Objective The objective was to evaluate whether pregnant women with COVID-19 living in a food desert, are at increased risk of more severe disease reflected by symptoms at presentation and need for hospitalization.
Methods In this retrospective observational study, the electronic medical records of all pregnant patients with documented SARS-CoV-2 infection were reviewed. Food deserts were defined by the USDA and the patient's residence was mapped on the *Food Access Research Atlas* to determine whether each patient lived within a food desert. Comparisons between those with documented symptomatic COVID-19 required hospitalization to those with documented COVID-19 without need for hospitalization were made using univariate analysis and multivariable logistic regression analysis.
Results The cohort consisted of 129 pregnant patients with COVID-19, with 59.7% (n = 77) asymptomatic and 33.3% (n = 43) requiring admission due to disease severity. The majority were Hispanic (70.5%), and obese (median BMI 31.91 kg/m^2), with 33.3% living in a food desert. Patients with disease severity necessitating admission were significantly more likely to reside in a food desert (46.5% vs. 27.9%, *P* 0.037, OR 2.246, 95% CI 1.048–4.814). No other significant differences were identified on univariate. Multivariable binary logistic regression modeling confirmed food desert residence to be the only independent predictor of more severe COVID-19.
Conclusion for Practice There is a strong association between living in a food desert and the development of symptomatic COVID-19 requiring hospitalization in pregnancy.

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Significance

What is already known on this subject? Food deserts reflect socioeconomic disparities that affect the health of pregnant women. Those that reside in a food desert have an overall increase in pregnancy morbidity. In addition, current understanding has demonstrated that pregnant women are at increased risk of severe COVID-19 infection.

What this study adds? In pregnancy, COVID-19 disproportionally affects those who reside in a food desert locale with more severe infection, reflecting the existence of health disparities in an urban community.

Keywords COVID-19 · SARS-CoV-2 · Coronavirus · Pregnancy · Food desert · Health inequality

Objectives

Socioeconomic disparities play an important role in disease epidemiology and outcome. Inequalities in nutrition environments exist in the United States affecting the daily lives and medical conditions amongst people of different socioeconomic status (SES) (American College of Obstetricians and Gynecologist, 2015; American College of Obstetricians and Gynecologist, 2018). Those living in low income and minority areas tend to have poor access to healthy and affordable food. These areas, termed food deserts, are characterized by areas of poor access to affordable healthy foods often inhabited by racial and ethnic minorities (Beulac et al., 2009; Block & Kouba, 2006; Bower et al., 2014; Hager et al., 2017; Larson et al., 2009; Walker et al., 2010). Food deserts may also be described as lacking in large chain supermarkets which offer high quality fresh produce at fair prices. Studies have demonstrated that access to healthy and affordable food contributes to diet and diet-related health outcomes. For example, population research in the US demonstrates that those with improved fruit and vegetable consumption have lower prevalence of obesity (Beulac et al., 2009). In non-pregnant populations, residing in a food desert has been independently associated with elevated risk of cardiovascular disease (Kelli et al., 2005; Suarez et al., 2015). In pregnancy, a recent study by Tipton et al. (2020) demonstrated an overall increase in pregnancy morbidity in women residing in food deserts. Food deserts reflect socioeconomic disparities that affect the health of pregnant women.

The first case of coronavirus disease 2019 (COVID-19) caused by the novel severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) infection was reported in December of 2019 in Wuhan Hubei province of China. Since it first emerged it has quickly spread across the world. Throughout this past year scientists, researchers, and medical professionals continue to learn about the epidemiology, disease course, and treatment of coronavirus disease 2019 (COVID-19). Clinical and epidemiologic characteristics for Covid-19 patients have been reported and certain demographics such as age and gender have been identified to be associated with more severe disease. Comorbidities such as diabetes mellitus, hypertension, cardiovascular disease, obesity, and smoking have also been identified to be conditions associated with more severe illness and mortality. When analyzing the general population in large data sets in the United States and United Kington, Black, Hispanic and South Asians have been identified as comprising a disproportionally high number of SARS-CoV-2 infections and deaths believed to be due to underlying disparities in social determinants of health (Williamson et al., 2020).

Multiple studies have demonstrated that when adjusted for sociodemographic and socio economic factors ethnicity has not been linked to adverse outcome compared to white counterparts suggesting other factors (Kabarriti et al., 2020; Muñoz-Price et al., 2020; Price-Haywood et al., 2020; Williamson et al., 2020). In addition, findings in a cross-sectional study of 2595 patients by Muñoz-Price et al. (2020) identified both race and poverty were associated with higher hospitalization rate but only poverty was associated with admission to the intensive care unit. These studies highlight that socioeconomic factors may play a larger role over race or ethnicity.

Pregnancy has been identified to be a risk factor for worsening COVID-19 clinical outcome, with pregnant patients more likely than those non-pregnant to be admitted to the ICU Zambrano et al., 2020). Most recently Lokken et al. looked at 240 pregnant patients and found a 70% higher infection rate compared to age matched non-pregnant adults in Washington State (Lokken et al., 2021). In addition, pregnant patients from all racial and ethnic minority groups were overrepresented (Lokken et al., 2021). Other risk factors for severe illness that have been reported are similar to non-pregnant individuals and include mean age, higher body mass index, and preexisting medical comorbidities (Lokken et al., 2020). Pregnant women are at increased risk of severe COVID-19 infection, and socioeconomic disparities may further be related to COVID-19 disease presentation in pregnancy.

Given the interplay of food deserts to health comorbidities and unprecedented urgency to understand who is most at risk, we seek to use residence in a food desert we defined by U.S. Department of Agriculture (USDA) as a surrogate marker of socioeconomic disparities to evaluate their association with pregnancy and COVID-19 disease severity.

Methods

The aim of this study was to explore the association between the local food environment and severity of COVID-19 in women cared for in a 3-hospital urban healthcare system. A retrospective study was designed and approved by the Loyola University Medical Center Institutional Review Board (LU #210365), with need for informed consent waived. Our hypothesis was that those residing in a food desert would have 50% proportionately higher risk of having symptomatic COVID-19 infection. To determine the sample size necessary to evaluate this hypothesis, multiple assumptions had to be made, which were particularly challenging given this new disease pandemic with little background information for guidance. Based on projected delivery volume of 3500 for the year in our 3-hospital system and utilizing prior evidence of a cross-section of that delivery population of 20% residing in a food desert, we estimated that 700 of those delivering would reside in a food desert locale (Tipton et al., 2020). From internal tracking, the racial and ethnic breakdowns for the 3-hospital population for the year prior showed a range of 30–37% of Hispanic ethnicity, and 23–40% of Black race. We estimated SARS-CoV-2 infection rates in our pregnant patients would mirror the non-pregnant population. Sample size estimate per group (symptomatic versus asymptomatic) were determined to detect a 50% difference for those residing in a food desert having symptomatic COVID-19, with Power of 0.8 and alpha of 0.05. Based on our estimates a nine-month period of tracking from April 1, 2020–December 31, 2020 was determined sufficient to provide the study population volume.

All medical records for pregnant women who tested positive for SARS-CoV-2 on reverse transcription quantitative polymerase chain reaction assay at our academic urban 3-hospital system were reviewed from the first documented case on April 1, 2020 through December 31, 2020. Each site identified patients with positive test results during any trimester of pregnancy and abstracted demographic and clinical data from electronic medical records. Pregnant women were tested as part of routine universal screening upon presentation to labor and delivery, symptomatic outpatient testing, or known exposure.

Exposure and symptom presentation at time of testing were recorded. Commonly reported symptoms included fever, cough, congestion, myalgia, anosmia, loss of taste, and shortness of breath. Pregnancy outcome data collected included maternal ICU admission, need for mechanical ventilation, and maternal death. Patient's underlying comorbidities and medical history were also obtained from electronic medical records. In addition, outcomes for infant were obtained included gestational age at delivery, birth weight, Apgar scores, cord gas values, and NICU admission if required.

To determine if a patient resided in a food desert, we used the Food Access Research Atlas (FARA) published by the Economic Research Service of the U.S. Department of Agriculture, a web based mapping tool that allows users to investigate access to food stores at the census tract level. In the map, low income (LI) and low access (LA) status census tracts are separated and overlapped. By definition low income is determined by either median family income (below 80%) of either state median or metropolitan area income) or poverty rate (< 20%) (Rohn et al., 2017). Low access tracts are measured in four ways, three of which are based on proximity by different thresholds measured in miles to nearest store and lastly based on number of households without vehicles (Rohn et al., 2017). Each patient was mapped using the interactive map and considered to be in a food desert if they met criteria for both LI and LA.

The demographics and outcomes were analyzed for the dichotomous severity of disease based on whether the patient had symptoms consistent with COVID-19 requiring admission, which we selected as a surrogate measure reflecting disease severity. We used the severity scale as defined by the Society of Maternal Fetal Medicine in our categorization of patients (Society of Maternal Fetal Medicine, 2021). Patients were designated asymptomatic if they tested positive for SARS-CoV-2 with no symptoms. Those symptomatic were designated as mild, moderate, severe or critical disease by definition. The 9 symptomatic but mild cases were included in the non-hospitalized group.

All data were entered in a secure de-identified database and analyzed via SPSS version 25. Independent samples t-tests and Mann–Whitney U tests compared normally and non-normally distributed continuous variables, respectively, among subjects who required hospitalization for COVID-19 infection (moderate, severe, critical) versus those who did not (mild or symptomatic). Chi-square and Fisher's Exact tests were used to compare categorical variables between these groups. Data are presented as mean ± standard deviation, median with range, or percent as appropriate. A p value less than 0.05 was considered statistically significant, and unadjusted odd ratios (OR) and 95% confidence intervals (CI) were calculated. The bivariate comparisons were followed by parametric and nonparametric bivariate Pearson correlation analysis as appropriate, and then subsequently a multivariable binary logistic regression analysis was conducted to estimate the adjusted effects of select variables on the outcomes. The regression model included the food desert variable which demonstrated significant effects in bivariate analysis, as well as variables considered by the research team to be the most conceptually important based on reports of potential associations by others in the literature (Kabarriti et al., 2020; Lokken et al., 2020, 2021; Muñoz-Price et al., 2020; Price-Haywood et al., 2020; Zambrano et al., 2020).

Results

A total of 129 pregnant patients who tested positive for SARS-CoV-2 were identified, with 59.7% (n = 77) asymptomatic and 33.3% (n = 43) requiring admission due to disease severity. Table 1 illustrates the breakdown of the cohort

Table 1 Total COVID-19 study population

	Frequency	Percent (%)
Symptomatic	52	40.3
Mild	9	7
Moderate	18	14
Severe	18	14
Critical	7	5.4
Asymptomatic	77	59.7
Hospitalized	43	33.3
Not Hospitalized	86	66.7

Hospitalized—moderate/severe/critical, Non-hospitalized—mild or asymptomatic

based on disease severity scale (Society of Maternal Fetal Medicine, 2021). Of those admitted, 58% (25/43) had severe or critical disease.

The demographics and underlying comorbidities are presented in Table 2. The majority of women were among racial and ethnic minority groups, including 70.5% Hispanic ethnicity and 10.10% Black race, and obese (median BMI 31.91 kg/m^2), with 33.3% living in a food desert. For the 82.7% (43/52) of those symptomatic requiring admission, the overwhelmingly indication was the need for oxygen supplementation to maintain a pulse oximetry value of 95% or above in 58.1% (25/43). On presentation for those requiring admission otherwise, symptoms were in order of frequency cough (19.4%), loss of taste (12.4%), headache (10.9%), and dyspnea (10.1%). Only 8.5% were febrile. For those hospitalized, the course included ICU admission for 7/43(16.3%) intubation in 3/43 (7.0%), need for extracorporeal membrane oxygenation in 1/43(2.3%), with 2 maternal deaths (4.7%).

Bivariate analysis between groups defined as those requiring hospitalization versus those who did not as outlined above are illustrated in Table 2. For the continuous variables, there was no difference in mean maternal age, median EGA at delivery or median BMI. For the nominal categorical values food desert residence differences between groups were significant (27.9% vs. 46.5%, OR 2.246, 95% CI 1.048–4.814). We did identify a significant difference between groups with regard to exposure history but suspect this in part reflects recall bias on the part of those with more severe disease (21.4% vs. 78.6%, OR 9.5, CI 2.49–36.33).

Table 2 Maternal characteristics and pregnancy outcome for women requiring admission for CoVID-19 infection

	CoVID-19 infection			
	Total (N = 129)	No admission 66.7% (n = 86)	Admission 33.3% (n = 43)	*P* (OR, 95%CI)
Age (y) Mean ± SD	28.62 ± 5.69	28.49 ± 5.43	28.53 ± 5.66	0.785 (1.066, – 2.40–1.818)
BMI (kg/m^2) median (range)	31.91 (18.14–59.09)	31.25 (18.14–59.09)	31.98 (20.09–50.00)	0.447 (1.444, – 3.930–1.830)
GA at delivery median (range)	39.00 (26.00–41.00)	39.00 (26.00–40.71)	39.14 (32.57–41.00)	0.678 (1.23, – 1.960–2.990)
Primigravid	23.4% (30)	20.9% (18)	28.6% (12)	0.340 (1.511, 0.648–3.526)
BMI ≥ 30 kg/m2	61.20% (79)	64.6% (53)	66.7% (26)	0.826 (1.094, 0.489–2.448)
Hispanic ethnicity	70.50% (91)	74.1% (63)	68.3% (28)	0.495 (0.752, 0.332–1.703)
Reside in food desert	33.30% (43)	27.9% (24)	46.5% (20)	0.037 (2.246, 1.048–4.814)
Asthma	5.5% (7)	4.7% (4)	7.1% (3)	0.563 (1.577, 0.336–7.391)
Diabetes (Any)	13.2% (17)	12.8% (11)	14.0% (6)	0.854 (1.106, 0.379–3.223)
Composite HTN	6.3% (8)	5.8% (5)	7.1% (3)	0.771 (1.246, 0.283–5.482)
Tobacco	3.9% (5)	2.3% (2)	7.1% (3)	0.209 (3.231, 0.519–20.121)

N number total Covid population, *n* number admitted or not admitted due to Covid, *P p*-value, *OR* odds ratio, *CI* 95% confidence interval, *y* years, *BMI* body mass index, *kg* kilograms, *m^2* meters squared, *GA* gestational age, *PDM* pregestational diabetes, *GDM* gestational diabetes, *Any Diabetes* GDM or PDM, *Composite HTN* includes all pregnancy HTN and chronic hypertension

Data are mean ± standard deviation, median with range, or percent (n), unless otherwise specified

P < 0.05 significant, t-test or X^2, Fisher Exact test, Mantel-Haensel Common OR (95% CI) as appropriate. For BMI and GA at delivery Mann–Whitney U nonparametric test used with median and range as Shapiro–Wilk test of Normality showed not normally distributed

Correlation analysis identified a relationship only with residence in a food desert ($p = 0.018$).

Binary logistic regression analysis demonstrated patients residing in food deserts were 2.5 times more likely to experience symptomatic infection regarding hospitalization (OR 2.496, 95% CI 1.087–5.732). No other covariates were significantly associated with symptomatic Sars-CoV-2 infection significant enough to necessitate hospitalization (Table 3). Goodness-of-fit testing showed strong evidence the model fit the data well, confirming food desert residence to be the only independent predictor of more severe COVID-19 in our cohort.

Conclusions of Practice

In this retrospective observational study in a 3-hospital system, there was an independent association between more severe COVID-19, reflected by need for hospitalization, and living in a food desert as defined by the US Department of Agriculture. This research demonstrates evidence that pregnant women diagnosed with COVID-19 who live in areas considered food desert are at risk for more severe symptomatic presentation and subsequent hospitalization. Both uni-variable and multivariable binary logistic regression had consistent results. While obesity, Hispanic ethnicity, asthma, hypertension in pregnancy, and smoking are established risk factors for severe COVID-19 in pregnancy, they were not found to be statistically significant in our severe COVID-19 population when compared to those with who were asymptomatic or had mild disease amenable to outpatient supportive care (Lokken et al., 2020). We do recognize and acknowledge this may in part be a reflection of the small cohort volumes in our study. However, residing in a food desert increased by more than twofold the odds of more severe symptoms of COVID-19.

Table 3 Logistic regression analysis of risk factors for admission for COVID-19 in pregnancy

	Multivariable binary logistic regression analysis		
	OR	95% CI	*P*
Primigravid	1.672	0.658–4.251	0.280
BMI ≥ 30 (kg/m^2)	0.962	0.398–2.328	0.932
Hispanic	0.633	0.245–1.633	0.344
Food desert	2.496	1.087–5.732	0.031
Diabetes	1.465	0.468–4.589	0.512
Tobacco	4.280	0.621–29.489	0.140
Asthma	1.236	0.221–6.901	0.809

P *p*-value, *OR* odds ratio, *CI* confidence interval, *P* *p*-value, *BMI* body mass index, *kg* kilograms, *m^2* meters squared, *Diabetes* gestational and pre-gestational diabetes

Outside of pregnancy, more extensive studies on local food environments and effects on health have been conducted in the general population. Although not formally considered a medical risk factor, living in a food desert with poor access to supermarkets has been associated with adverse health outcomes (Beulac et al., 2009; Kelli et al., 2005; Suarez et al., 2015). Higher mean systolic blood pressure, greater BMI have been linked to residence within a food desert (Moreland et al., 2006).

In a September 2020, cross sectional study of COVID-19 in the general population identified poverty as an independent factor associated with increased likelihood with a threefold increase in intensive care unit admission (Muñoz-Price et al., 2020). As poverty and living in a food desert are both determinants of SES our pregnant patient cohort findings are consistent when compared to this large non-pregnant cohort. Patient SES representation through mapping varied slightly between this study and ours. For our study, we used specific address applied to the FARA map with food deserts determined by LI and LA status census tracts while Munoz Price et al. used 9-digit residence zip code classified based on scores from Area deprivation index abstract from neighborhood atlas with threshold based on state specific US census tract indicators (Muñoz-Price et al., 2020).

This study also expands on previous pregnancy specific work by Tipton et al. (2020) demonstrating an independent association of overall pregnancy morbidity and living in food desert. In their cohort women who lived in a food desert were more likely to be diagnosed with preterm labor and preeclampsia (Tipton et al., 2020). Our collective studies demonstrate that residence in a food desert during pregnancy adds significant morbidity that extends to the current COVID-19 pandemic.

Much of the focus in maternal research during the pandemic has been on identifying demographic characteristics and risk factors that contribute to severe infection. However, many of those are non-modifiable risk factors that only help in guiding counseling. Identification and subsequent eradication of food deserts should perhaps be a priority to those who advocate for maternal health. The findings of this study are consistent with the overall health care inequalities currently present. The study identifies a modifiable risk factor with potential for improvement. Although beyond the scope of this paper we postulate modifiable risk factors such as diet, exercise, level of health literacy, other environmental factors contribute to severity and subsequent hospitalization. As this is a small study within a local community, larger population-based studies need to be conducted to improve our understanding of the impact of food deserts on COVID-19 in pregnancy, and perhaps even outside of pregnancy.

As we did not evaluate the entire obstetric population during the study period, it is beyond our scope to make definitive conclusions about the ethnic discordance we identified between our COVID-19 cases as compared to the ethnic breakdown in our 3 hospital system during the year prior, although it does raise concern and is consistent with Lokken et al. (2021) recent publication that racial and ethnic minority groups particularly Hispanic pregnant patients are disproportionally affected by COVID-19 (Lokken et al., 2020). In studying SARS-CoV-2 infection within our community we found an overwhelming large majority of patients were Hispanic who reside within a food desert community.

To expand on our study, further stratification for determinants of SES can be performed. Instead of LI and LA tracts used in our study, variables such as mean household income, poverty status, insurance type, and education status can be assessed. Information such as mean household income can be used to represent lower income and can be further stratified in analysis. Education status and health literacy can also be examined. These social determinants can be analyzed individually to help identify other modifiable risk factors.

There are several strengths of this study. The study was initiated at the onset of current COVID-19 pandemic with no exclusion factors. All pregnant women in all trimesters were included since the beginning of the pandemic. A validated FARA mapping tool published by the Economic Research Service of the U.S. Department of Agriculture was used for this study (Rohn et al., 2017). This same tool is utilized by government at the local, state, and federal level as well as public health officials and researchers in understanding food access in different communities.

We recognize several limitations exist in our study related to the design and use of the FARA atlas. Although the FARA atlas is a valuable tool the accuracy and representativeness of the data within the atlas should be critically evaluated. The atlas relies on various data sources including the U.S. Census bureau and the U.S. Department of agriculture, which may have inherent limitations. At the time of the study, we used the most up to date census tract available combining both income and access tracts. However, we also recognize that the available data is not published annually and per Rhone et al. the data reflects 2014–2015 supermarket listings which may not accurately reflect the environment our patients resided within from April-December 2020 (Rohn et al., 2017).

Additionally, the atlas uses aggregate data at the census tract level and may potentially overlook within-tract variation and may not capture the true complexity of food access within the specific areas and neighborhoods. The inability of the FARA to provide information at an ecological level makes it challenging to fully understand the mechanism underlying the observed association and may limit the generalizability of the findings to pregnant individuals. Although the FARA provides valuable information on food access it may not capture all relevant confound factors such as socioeconomic status, race/ethnicity, individual health behaviors, and healthcare access which influence food access and COVID-19 severity in pregnancy. One may also consider the potential limitation of temporal ambiguity and reverse causality given FARA provides static information on food access, while Covid-19 severity in pregnancy can be influenced by dynamic factors, and severe Covid-19 symptoms may impact an individual's ability to access healthy foods rather than lack of healthy food access directly leading to more severe disease.

Other limitations include concerns over appropriate representation of the proportion of asymptomatic and symptomatic individuals. By using hospital data which predominantly captures more severe cases requiring medical intervention there is inherent selection bias leading to an overrepresentation of more complicated pregnancies. Underreporting may also be present within the community for those with asymptomatic and mildly affected individuals who were not tested or tested outside of the hospital system. This may lead to an overemphasis on our findings regarding severity of disease and overstating the conclusion those living in food deserts are more likely to be symptomatic. The study is limited by the dependence on medical data collected through the medical record. In addition, we acknowledge that the inherent false negative rate for SARS-CoV-2 testing can also affect our findings (Kucirka et al., 2020). For symptomatic patients, there is an inherent recall bias when reporting potential exposure as well.

It is known that severe maternal morbidity and mortality is disproportionally more prevalent in underserved populations, and the pandemic is no exception. Our study further looked into food desert as an SES determinant in health. Our hospital system has the unique opportunity of caring for both patients who live outside and within food deserts. The COVID-19 pandemic has continued to highlight the existence of health disparities in our country. As maternal mortality has been declining elsewhere in the world the rate in the US is increasing and highlights disparities between SES, racial, and ethnic groups (Alkema et al., 2016; Building U. S. Capacity to Review and Prevent Maternal Deaths, 2018; Center of Disease Control, 2018). Eradicating food deserts is a step in the right direction to confining the pandemic as well as lowering maternal mortality. Factors such as poverty, quality of education, health literacy, neighborhood safety, housing, child care, and healthy food access can all be barriers necessitating a public health response. More information is needed about food access as a reflection of socioeconomic disparities as a potentially modifiable risk factor and offers the opportunity to improve outcomes for a high-risk population.

Addressing socioeconomic disparities is urgently needed to improve patient outcomes, not only in relation to the current COVID-19 pandemic, but further to reduce overall maternal morbidity and mortality.

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Data Availability Data stored in secured university drive.

Code Availability Not Applicable.

Declarations

Competing interests All the authors report no conflicts of interest or financial disclosures.

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References

ACOG. (2015). ACOG Committee Opinion No. 649: Racial and ethnic disparities in obstetrics and gynecology. *Obstetrics and Gynecology, 126*, 130–134.

ACOG. (2018). ACOG Committee Opinion No. 729: Importance of social determinants of health and cultural awareness in the delivery of reproductive healthcare. *Obstetrics and Gynecology, 131*, 343–348.

Alkema, L., Chou, D., Hogan, D., Zhang, S., Moller, A. B., Gemmill, A., Fat, D., Boerma, T., Temmerman, M., Mathers, C., & Say, L. (2016). Global, regional, and national levels and trends in maternal mortality between 1990 and 2015, with scenario-based projections to 2030: A systematic analysis by the UN Maternal Mortality Estimation Inter-Agency Group. *The Lancet, 387*(10017), 462–474.

Beulac, J., Kristhansson, E., & Cummins, S. (2009). A systemic review of food deserts 1966–2007. *Preventing Chronic Disease, 6*, A105.

Block, D., & Kouba, J. (2006). Comparison of the availability and affordability of a market basket in two communities in the Chicago area. *Public Health Nutrition., 9*(837–45), 5.

Bower, K. M., Thorpe, R. J., Rohde, C., & Gaskin, D. J. (2014). The intersection of neighborhood racial segregation, poverty, and urbanicity and its impact on food store availability in the United States. *Preventative Medicine, 58*(33–9), 6.

Building U.S. Capacity to Review and Prevent Maternal Deaths. (2018). Report from nine maternal mortality review committees. http://reviewtoaction.org/Report_from_Nine_MMRCs

Center of Disease Control, Pregnancy Mortality Surveillance System. (2018). https://www.cdc.gov/reproductivehealth/maternalinfanthealth/pregnancy-mortality-surveillance-system.htm

Hager, E. R., Cockerham, A., O'Reilly, N., Harrington, D., Harding, J., Hurley, K. M., & Black, M. M. (2017). Food swamps and food deserts in Baltimore City, MD, USA: Associations with dietary behaviors among urban adolescent girls. *Public Health Nutrition, 20*, 2598–2607.

Kabarriti, R., Brodin, N. P., Maron, M. I., Guha, C., Kalnicki, S., Garg, M. K., & Racine, A. D. (2020). Association of race and ethnicity with comorbidities and survival among patients with COVID-19 at an Urban Medical Center in New York. *JAMA Network Open, 3*(9), e2019795.

Kelli, H. M., Kim, J. H., Hollis-Neely, T., Cambell, R. T., Holmes, N., Watkins, G., Nwankwo, R., & Odoms-Young, A. (2005). Fruit and vegetable intake in African Americans income and store characteristics. *American Journal of Preventative Medicine, 29*, 1–9.

Kucirka, L. M., Lauer, S., Laeyendecker, O., & Boon, D. (2020). Variations in false-negative rate of reverse transcriptase polymerase chain reaction-based SARS-CoV-2 tests by time since exposure. *Annals of Internal Medicine, 4*(262), 2020.

Larson, N. I., Story, M. T., & Nelson, M. C. (2009). Neighborhood environments: Disparities in access s to healthy foods in the U.S. *American Journal of Preventative Medicine, 36*, 74–81.

Lokken, E. M., Huebner, E. M., Taylor, G. G., Hendrickson, S., Vanderhoeven, J., Kachikis, A., Coler, B., Walker, C. L., Sheng, J. S., Al-Haddad, B., McCartney, S. A., Kretzer, N. M., Resnick, R., Barnhart, N., Schulte, V., Bergam, B., Ma, K. K., Albright, C., Larios, V., & Waldorf, K. M. (2020). Washington state COVID-19 in pregnancy collaborative: Disease severity, pregnancy outcomes and maternal deaths among pregnant patients with SARS-CoV-2 infection in Washington state. *American Journal of Obstetrics and Gynecology., 10*, 2. https://doi.org/10.1016/j.ajog.2020.12.1221

Lokken, E. M., Taylor, G. G., Huebner, E. M., Vanderhoeve, J., Hendrickson, S., Coeler, B., Sheng, J. S., Walker, C. L., McCarney, S. A., Kretzer, N. M., Resnick, R., Kachikis, A., Barnhart, N., Shculte, V., Berman, B., Ma, K. K., Albright, C., Larios, V., Kelley, L., & Waldorf, K. M. (2021). Higher SARS-CoV-2 infection rate in pregnant patients higher SARS-CoV-2 infection rate in pregnant patients. *American Journal of Obstetrics and Gynecology*. https://doi.org/10.1016/j.ajog.02.011

Moreland, K., Diez Roux, A. V., & Wing, S. (2006). Supermarkets, other food stores, and obesity: The Atherosclerosis R in Communities study. *American Journal of Preventative Medicine., 30*, 4.

Muñoz-Price, L. S., Nattinger, A. B., & Rivera, F. (2020). Racial disparities in incidence and outcomes among patients with COVID-19. *JAMA Network Open, 3*(9), e2021892.

Price-Haywood, E. G., Burton, J., Fort, D., & Seoane, L. (2020). Hospitalization and mortality among black patients and white patients with Covid-19. *New England Journal of Medicine, 382*(26), 2534.

Rohn, A., VerPleog, M., Dicken, C., William, R., & Breneman, V. (2017). Low-income and low-supermarket-access Census tracts, 2010–2015. *Economic Information Bulletin, 2017*, 165.

Society of Maternal Fetal Medicine. (2021). Society of maternal-fetal medicine management considerations for pregnant patients with COVID-19. Society of Maternal Fetal Medicine Task Force 2021.

https://s3.amazonaws.com/cdn.smfm.org/media/2734/SMFM_COVID_Management_of_COVID_pos_preg_patients_2-2-21_(final).pdf

Suarez, J. J., Isakova, T., Anderson, C. A., Boulware, L. E., Wolfe, M., & Scialla, J. J. (2015). Food access, chronic kidney disease and hypertension in the U.S. *American Journal of Preventative Medicine., 49*, 912–920.

Tipton, M., Wagner, S. A., Dixon, A., Westbay, L., Darji, H., & Graziano, S. (2020). Association of living in a food desert with pregnancy morbidity. *Obstetrics and Gynecology., 136*, 1.

Walker, R. E., Keane, C. R., & Burke, J. G. (2010). Disparities and access to healthy food in the United States: A review of food deserts literature. *Health & Place, 16*(876–84), 4.

Williamson, E. J., Walker, A. J., Bhaskaran, K., Bacon, S., Bates, C., Morton, C. E., Curtis, H. J., Mehrkar, A., Evans, D., Inglesby, P., Cockburn, J., McDonald, H. I., MacKenna, B., Tomlinson, L., Douglas, I. J., Rentsch, C. T., Mathur, R., Wong, A. Y., & Goldacre, B. G. (2020). Factors associated with COVID-19-related death using OpenSAFELY. *Nature, 584*(7821), 430.

Zambrano, L. D., Ellington, S., Strid, P., Galang, R. R., Oduyebo, T., Tong, V. T., Woodworth, K. R., Nahabedian, J. F., Azziz-Baumgartner, E., Gilboa, S. M., & Meaney-Delman, D. (2020). Update: Characteristics of symptomatic women of reproductive age with laboratory-confirmed SARS-CoV-2 infection by pregnancy status-United States, January 22-October 3, 2020. *Morbidity and Mortality Weekly Report, 69*, 1641–1647.