The Relationship between Food Security and Gestational Diabetes among Pregnant Women

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Abstract

The objective were to: (1) evaluate associations between food security and women diagnosed with gestational diabetes mellitus (GDM) and (2) evaluate if women in food insecure (FI) households had adverse maternal and neonatal outcomes. This was an observational study from October 2018 until September 2019. Postpartum resident clinic patients who delivered term, singleton infant at 37 weeks' or longer gestation were screened. Participants completed a survey using the U.S. Household Food Security Survey Module (US HFSSM). Survey responses were classified as: food secure (FS) and FI (marginal, low, very low FS). The primary outcome was GDM. Our secondary outcome was neonatal intensive care unit (NICU) admissions for hypoglycemia. We evaluated the rate of GDM in FS and FI groups. Demographic data included: prepregnancy body mass index, total weight gain during pregnancy, birth weight, and mode of delivery. A logistic regression model was used to analyze the association between food insecurity and GDM. A *p*-value of less than 0.05 was considered statistically significant. There were 150 patients screened to participate; of these, 70 patients were enrolled (36 GDM and 34 without GDM [NGDM]). More patients in FI households, 71% ($n = 17$), were diagnosed with GDM, compared with 33% ($n = 15$) in the FS (FS) households (adjusted odds ratio 7.05; $p < 0.01$). Of patients who reported FI, 50% ($n = 12$) were black, 46% ($n = 11$) Hispanic, and 4% ($n = 1$) Caucasian, compared with 13% ($n = 6$) black, 30% ($n = 14$) Hispanic, and 57% ($n = 26$) Caucasian in patients who reported FS ($p < 0.001$). Although not significant, 25% ($n = 6$) of neonates from an FI household had an NICU admission for hypoglycemia compared with 7% ($n = 3$) from an FS household ($p = 0.054$). Pregnant women with GDM are more likely to experience FI than those with NGDM. Infants of mothers in FI households also had increased rates of NICU admission for hypoglycemia.

Keywords

- food insufficiency
- food security
- gestational diabetes mellitus
- pregnant
- diabetes

Food security is an essential social determinant of health that has been shown to have a direct association with mental, physical, and social health.[1] Food security is defined by the U.S. Department of Agriculture (USDA) as "access by all people at all times to enough food for an active, healthy life." It is an important measurement of nourishment of a population.[2]

Inadequate access to food in pregnancy not only affects the mother's health but it can also limit a patient's ability to

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manage other health conditions during pregnancy, specifically diabetes.[3] The prevalence of diabetes in the United States from 1999 to 2004 was 10.2% in food insecure (FI) households compared with 7.4% in food secure (FS) households. Additionally, research suggests that food insecurity is a risk factor for developing diabetes later in life.[4,5] Over the past decade, there has been an increase in the prevalence of gestational diabetes mellitus (GDM) among pregnant women.[6] A study from 2009 reported that 7% of pregnancies were complicated by diabetes and 86% of those women had GDM.

A disparity between race and GDM has also been noted. Caucasian women have the lowest prevalence of GDM compared with Hispanics, African Americans, Native Americans, and Asian or Pacific Islanders.[7] Previous data have shown that the risk of GDM increases with increasing prepregnancy body mass index (BMI); however, the percentage of GDM attributable to obesity is currently unknown.[8] Additionally, the diagnosis of GDM is a risk factor for pre-eclampsia, cesarean delivery, and diabetes later in life. Seventy percent of women with GDM will develop diabetes within 22 to 28 years after that index pregnancy.[9,10]

Food insecurity is believed to play a role in the health of both the nonpregnant and pregnant populations. It has been associated with weight gain in pregnancy and type II diabetes mellitus (T2DM) within the general population.[11] A systematic review recently reported that individuals who experience food insecurity have approximately 50% higher risk of T2DM compared with individuals who experience food security.[12] Factors that both positively and negatively influence a healthy lifestyle include access to healthy food, availability of grocery stores with healthy foods at economical prices, easy access to fast food restaurants, and large portion sizes at restaurants. Many of the patients who deliver at University of Connecticut Health Center (UConn Health) and Hartford Hospital reside in areas of Connecticut that are defined as areas of low access to grocery stores, especially when factoring in transportation. Studies have shown that women from low income and FI households may become economically dependent on low-cost, processed, high-calorie foods to stretch the household budget.[13–15] Access to healthy, fresh food can become difficult if there are social and economic barriers preventing access. To our knowledge, there have been limited studies, looking at how food security access impacts the diagnosis of GDM. We hypothesize that: (1) women with GDM will have increased rates of food insecurity compared with women without GDM (NGDM) and (2) newborns of pregnant women with food insecurity are more likely to be admitted to the neonatal intensive care unit (NICU) for hypoglycemia, compared with those of pregnant women with adequate food security.

Methods

This was a prospective observational cohort study approved by the Institutional Review Board of the UConn Health and Hartford Hospital. All postpartum women who had prenatal care at the resident clinics at both UConn Health and Hartford Hospital and delivered term infants, defined as 37 weeks or longer gestation, were eligible. Preterm delivery, pre-GDM, inability to obtain informed consent, and residence in a group home or rehabilitation center were exclusion factors.

All resident clinic postpartum patients with GDM and NGDM who delivered term infants from October 1, 2018, to September 1, 2019, were identified during their delivery admission. While all postpartum patients who met eligibility requirements were eligible to participate, the planned recruitment included 100 women. Not all women were able to be approached due to staff availability. After informed consent was obtained, their charts were reviewed to obtain demographic data including: prepregnancy BMI, total weight gain during pregnancy, birth weight, mode of delivery, and NICU admission for hypoglycemia.

On postpartum day 1, each participant was provided a three-page food security questionnaire (FSQ), which was modified from a previous population-based study—the U.S. HFSSM developed by the USDA. This questionnaire included 18 questions and is provided in ►**Appendix 1**. Food security status was classified into two groups—FS and FI. Participants who answered "no" to all questions were defined as FS. FI households were defined as answering "often true" to one of the two main questions within the 18-item scale questionnaire under the category "Household" (►**Appendix 1**). The two questions were: (1) "The food that I bought just didn't last, and I didn't have money to get more" and (2) "I often worry that my household will not have enough food."

The questionnaire is made up of questions regarding food insecurity in pregnancy, background information, and dietary intake. Both English and Spanish versions were validated through the US HFSSM.

Medical records were reviewed by a single investigator to abstract all covariate data from the medical record, including age, race, parity, gestational age at the time of delivery, prepregnancy BMI, total weight gain during pregnancy, birth weight, mode of delivery, and NICU admission for hypoglycemia.

Baseline characteristics and maternal and neonatal outcomes were descriptively summarized overall and by food security status. Additionally, the distribution of food security status was reported for each subgroup. Statistical significance between independent variables in the FS and FI groups was assessed using a two-sided *t*-tests for continuous variables (e.g., such as total weight gain and prepregnancy BMI) and Fisher's exact test for categorical variables such as GDM and NICU admission for hypoglycemia. A logistic regression model was used to test the association between food security status and GDM, adjusting for age, race, and prepregnancy BMI. Model adjustments were based on information extracted from the patient's medical record. All the statistical analyses were performed in R version 3.6.1. A *p*-value of less than 0.05 was considered statistically significant.

Results

There were 150 patients screened for this study. Seventy patients were enrolled (36 GDM and 34 NGDM). Baseline

Table 1 Baseline characteristics and maternal and neonatal outcomes

	Food insecure ($n = 24$)	Food secure ($n = 46$)	Combined ($n = 70$)	p-Value[a]
Age	30.17 ± 6.51	31.85 ± 6.56	31.27 ± 6.54	0.311
Gestational age	38.38 ± 0.82	38.78 ± 1.03	38.64 ± 0.98	0.078
Gestational weight	3,562.62 ± 534.08	3,257.65 ± 382.21	3,362.21 ± 460.02	**0.018**
Total weight gain	23.54 ± 12.36	20.72 ± 13.36	21.69 ± 13.01	0.382
Prepregnancy BMI	35.43 ± 7.7	30.57 ± 6.3	32.19 ± 7.13	**0.013**
BMI status				
BMI < 30	6 (26%)	17 (37%)	23 (33%)	0.426
BMI ≥ 30	17 (74%)	29 (63%)	46 (67%)	
Site				
HH	15 (62%)	22 (48%)	37 (53%)	0.315
UC	9 (38%)	24 (52%)	33 (47%)	
Race				
Caucasian	1 (4%)	26 (57%)	27 (39%)	< **0.001**
Black	12 (50%)	6 (13%)	18 (26%)	
Hispanic	11 (46%)	14 (30%)	25 (36%)	
Multiparity				
No	7 (29%)	15 (33%)	22 (31%)	1.000
Yes	17 (71%)	31 (67%)	48 (69%)	
Mode of delivery				
C-cesarean	15 (62%)	18 (39%)	33 (47%)	0.080
Vaginal	9 (38%)	28 (61%)	37 (53%)	
Primary outcome				
Gestational diabetes				
No	7 (29%)	31 (67%)	38 (54%)	0.005
Yes	17 (71%)	15 (33%)	32 (46%)	
Secondary outcome				
NICU admission				
No	18 (75%)	43 (93%)	61 (87%)	0.054
Yes	6 (25%)	3 (7%)	9 (13%)	

Abbreviations: BMI, body mass index; HH, Hartford Hospital; NICU, neonatal intensive care unit; UC, University of Connecticut.
[a]Two-sided two-sample t-test p-values for comparisons of continuous variables and Fisher's exact test p-values for comparisons of categorical variables between food insecure and food secure groups. Bold values denote clinical significance.

characteristics and study outcomes are listed in ►**Table 1**. There was a significantly higher rate of GDM in the FI group compared with the FS group (71 vs. 33%, $p < 0.001$). A greater percentage of blacks (50%) and Hispanics (46%) were identified in the FI group, compared with the FS group. Fifty-seven percent of the FS group were Caucasians. Twenty-five percent of newborns from FI households were admitted to the NICU for hypoglycemia ($p = 0.054$). The prevalence of food insecurity varied with races; 4% of Caucasians, 67% of blacks, and 44% of Hispanics. Infants admitted to NICU (25%) were more likely to be born in food insecurity households compared with infants who were not admitted to NICU (7%) (►**Table 1**). ►**Fig. 1** shows the distribution food security status for each subgroup. ►**Table 2** displays logistic regression model results for the association between food insecurity and GDM—unadjusted and adjusted for age, race, and prepregnancy BMI. The unadjusted odds ratio (OR) for GDM comparing FI with FS pregnant women was 5.02 (95% confidence interval [CI]: 1.77–15.32) and the adjusted odd ratio was 7.05 (95% CI: 1.78–34.72), adjusting for age, race, and prepregnancy BMI.

Discussion

This study evaluated the association between food security status and GDM. In our diverse population, 53% ($n = 32$) of pregnant women with GDM reported food insecurity versus 18% of those NGDM.

The results of the present study are similar with those of Sholeye et al who showed that urban respondents

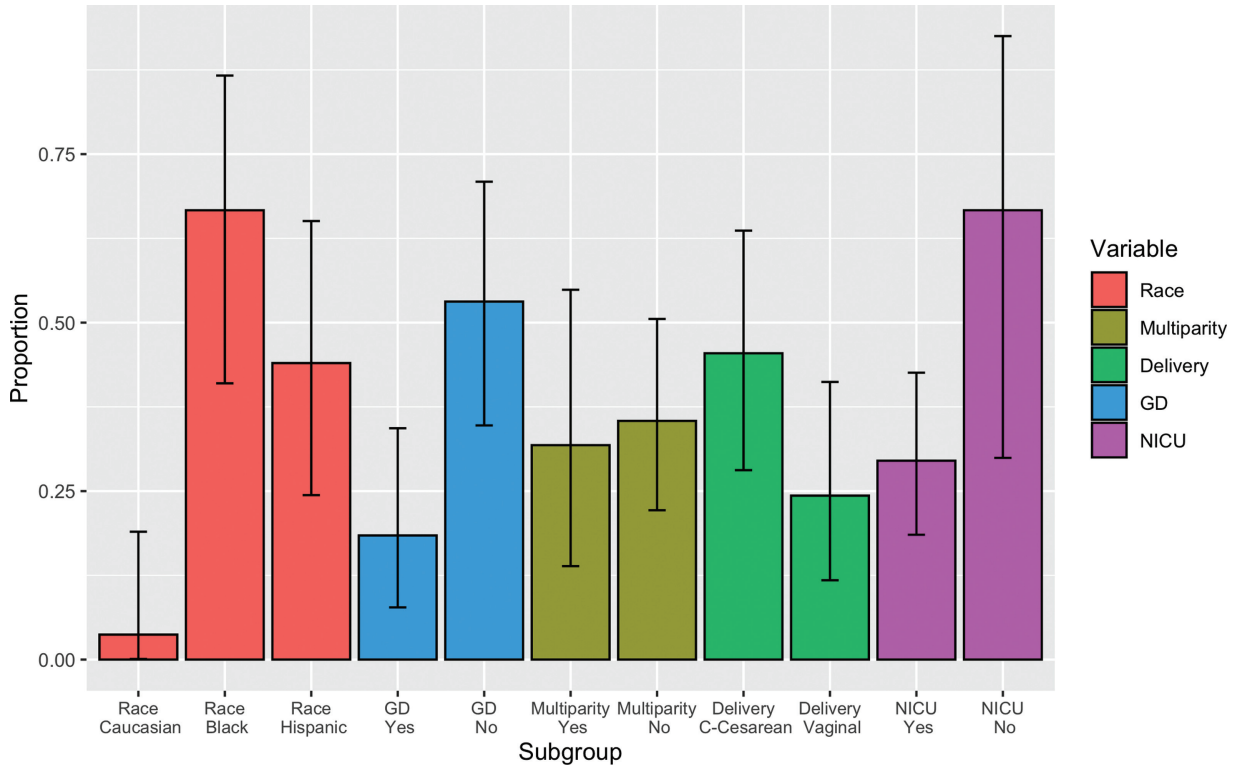

Fig. 1 Maternal and neonatal demographics by subgroups.

experience more food insecurity compared with rural respondents (39.2 vs. 31.4%, respectively).[16] Kahr et al (2016) showed that environmental risk factors such as higher fast food density environment had a 1.63 risk of developing GDM compared with areas with a lower fast food density.[17] This is in contrast to a more recent study by Banner et al, which showed women living in food deserts in Chicago were less likely to develop GDM and did not experience adverse maternal outcomes.[18] Healthy food intake among pregnant women with GDM is important. Women with food insecurity used vegetables 8.8 times less than those with food security (OR = 8.8; 95% CI: 2.6–29.9). This same study also showed a higher percentage of FI individuals as overweight or obese.[19]

Our study differs from the aforementioned studies because in addition to utilizing the US HFSSM FSQ to identify FS and FI households, we also evaluated adverse perinatal outcomes including weight gain and NICU admissions among a pregnant population with GDM.

Our study also found a significant association between food security status and GDM. Food insecurity was also associated with a higher prepregnancy BMI among women with GDM. These findings are consistent with our hypothesis that pregnant women from FI households have more adverse outcomes; more specifically, GDM women had higher food insecurity when compared with NGDM women. And while our study did not show a significant difference in maternal

Table 2 OR for gestational diabetes comparing food insecure with food secure pregnant women

	Unadjusted[a]		Adjusted[b]	
	OR (95% CI)	*p*-Value	OR (95% CI)	*p*-Value
Food insecure[c]	5.02 (1.77, 15.52)	**0.003**	7.05 (1.78, 34.72)	**0.009**
Age			1.06 (0.98, 1.17)	0.159
Race[d]				
Black			0.42 (0.07, 2.07)	0.301
Hispanic			0.68 (0.16, 2.67)	0.584
Prepregnancy BMI			1.05 (0.96, 1.14)	0.302

Abbreviations: BMI, body mass index; CI, confidence interval; OR, odds ratio.
[a]Model for gestational diabetes on food insecure only.
[b]Model for gestational diabetes on food insecure, age, race, and prepregnancy BMI.
[c]Reference group: food secure.
[d]Reference group: Caucasian.

weight gain, we did show that there was a significant increase in prepregnancy BMI among FI groups. This may have played a critical factor in the weight gain among women in our study. Our study showed that patients with FI had a prepregnancy BMI of more than 5 mg/kg^2 compared with FS, *p*-value of 0.01 or lower.

At the time of this writing this, only one prior study had evaluated the association between food insecurity and GDM.[20] Similar results were illustrated by Laraia et al who evaluated 810 pregnant women for food security and showed that living in a FI household was significantly associated with severe pregravid obesity with an adjusted OR of 2.97.[20] This finding supports previous research by Olson and Strawderman et al which obese women who were pregnant and experienced food insecurity retained or gained significant weight at 2 years after pregnancy.[21]

Infants of mothers in FI households were also found to have an increased risk of NICU admission for hypoglycemia. While these results were not statistically significant, clinically this displays an important concept among pregnant women who live in FI households. A cost analysis was performed by Glasgow et al showing one NICU admission for hypoglycemia is estimated to cost $10,709 per encounter.[22] These results show that food insecurity could have an impact on neonatal outcomes. These findings warrant further confirmation.

This is also the first study to show significant racial disparities among pregnant women with GDM who live in FI households. Among our patient populations, the food insecurity group is dominated by blacks (50%) and Hispanics (46%). Future studies are needed that have an adequate sample size of women who are the most at-risk for food insecurity. Additionally, future studies are needed to assess how these associations differ by race/ethnicity and by socioeconomic status.

Few studies have evaluated food security and GDM. Our study is an important contribution to the ongoing literature concerning access to food in pregnancy for GDM. In addition, our sampling was performed in both rural and urban health centers, which makes data more generalizable. To our knowledge, our study is among the limited studies which evaluate food insufficiency in GDM. However, the study involves some limitations. Food insufficiency is self-reported in the US HFSSM; therefore, there are some detailed information that we were unable to account for. For example, we were unable to assess for cultural or environment practices around eating and food purchasing habits. We were also not able to account for explanations on how the convenience of certain food purchasing may have played a role in data obtained from the survey. We also did not analyze other potential confounders such as other comorbidities or socioeconomic status. Other limitations of this study include our small sample size and only including NICU admissions secondary to hypoglycemia.

Conclusion

In summary, our study found that there is an association between food insecurity and GDM. Further studies are needed to determine if screening early in pregnancy for food insecurity and provision of resources to improve access to food impacts development of GDM and NICU admission for hypoglycemia.

Conflict of Interest

None declared.

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Appendix 1

U.S. Household Food Security Survey Module

1. What is the zip code that you lived in for the majority of time in your pregnancy?
2. Where do you do most of your grocery shopping?
   [ ] Grocery store or supermarket
   [ ] Corner store
   [ ] Farmer's market
   [ ] Discount store (Family Dollar, Dollar General, etc.)
   [ ] Restaurants or take-out
3. What was the distance between your house and the nearest grocery store or supermarket?
   [ ] Less than 1 mile
   [ ] 1 to 5 miles
   [ ] More than 5 miles
4. What was the distance between your house and the nearest corner store?
   [ ] Less than 1 mile
   [ ] 1 to 5 miles
   [ ] More than 5 miles
5. What means of transportation do you use to get food?
   [ ] Walking
   [ ] Public transportation (bus, subway, train)
   [ ] Personal car/Uber
   [ ] Bike
6. Does transportation make it difficult for you to get your groceries?
   [ ] Yes
   [ ] No
7. Do you receive public assistance for food?
   [ ] WIC
   [ ] Farmer's market vouchers
   [ ] Food stamps (SNAP)
   [ ] Food pantry

Household Questions

8. Now I am going to read you several statements that people have made about their food situation. For these statements, please tell me whether the statement was *often* true, *sometimes* true, or *never* true for (you/your household) in the last 12 months—that is, since last (name of current month).
   The first statement is "I worried whether my food would run out before we got money to buy more." Was that *often* true, *sometimes* true, or *never* true for you/your household in the last 12 months?
   [ ] Often true
   [ ] Sometimes true
   [ ] Never true
   [ ] DK or refused
9. "The food that I bought just did not last, and I did not have money to get more." Was that *often*, *sometimes*, or *never* true for (you/your household) in the last 12 months?
   [ ] Often true
   [ ] Sometimes true
   [ ] Never true
   [ ] DK or refused
10. "I could not afford to eat balanced meals." Was that *often*, *sometimes*, or *never* true for (you/your household) in the last 12 months?
    [ ] Often true
    [ ] Sometimes true
    [ ] Never true
    [ ] DK or refused
11. "I often worry that my household will not have enough food."
    [ ] Often true
    [ ] Sometimes true
    [ ] Never true
    [ ] DK or refused
12. How often does this happen?
    [ ] Almost every month
    [ ] Some months but not every month
    [ ] Only 1 or 2 months
    [ ] DK

Adult Stage

13. In the past 12 months, and more recently since last month, did you ever cut the size of your meals or skip meals because there was not enough money for food?
    [ ] Yes
    [ ] No
    [ ] DK
14. How often did this happen—almost every month, some months but not every month, or in only 1 or 2 months?
    [ ] Almost every month
    [ ] Some months but not every month
    [ ] Only 1 or 2 months
    [ ] DK
15. In the last 12 months, did you ever eat less than you felt you should because there was not enough money for food?
    [ ] Yes
    [ ] No
    [ ] DK
16. In the last 12 months, were you every hungry but did not eat because there was not enough money for food?
    [ ] Yes
    [ ] No
    [ ] DK

17. In the last 12 months, did you lose weight because there was not enough money for food?
    [ ] Yes
    [ ] No
    [ ] DK
18. In the last 12 months, did you ever not eat for a whole day because there was not enough money for food?
    [ ] Yes
    [ ] No
    [ ] DK

End of food security module.

