

ORIGINAL RESEARCH

Association of Depression and Gestational Diabetes Mellitus in Mississippi Women: A Cross-Sectional Study Analyzing the Self-Reported Responses to the 2021 Behavioral Risk Factor Surveillance System Survey

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Despite a known association between gestational diabetes mellitus (GDM) and depression, there is a lack of research investigating this association in Mississippi women. This cross-sectional study seeks to identify possible associations between gestational diabetes mellitus and depression in Mississippi women, while controlling for demographic and socioeconomic factors. Data from the 2021 Behavioral Risk Factor Surveillance System Survey was analyzed. At the bivariate level, race ($p < 0.001$), education level ($p < 0.001$), income ($p < 0.001$), and history of gestational diabetes mellitus ($p < 0.001$) were found to be independently associated with depression. Multivariable analysis showed that Mississippi women with a history of gestational diabetes mellitus diagnosis were 1.7 times more likely to have a history of depression diagnosis than those without a history of gestational diabetes mellitus diagnosis, when adjusted for race, education level, and income. Given the increased health burdens that Mississippians face, improved prenatal, perinatal, and postpartum services could potentially reduce the long-term health risks and financial consequences related to gestational diabetes mellitus and depression diagnoses in Mississippi.

INTRODUCTION

In 2020, the prevalence of depression for the overall population in the US was 18.4%, and the prevalence of depression for women in the US was 23.4%.¹ America's Health Rankings reported women in Mississippi experience even higher rates of depression than that of the national average, with a self-reported rate of 28.5% in 2020.² In pregnancy, women experiencing depression are susceptible to pre-eclampsia, suicidal ideology,^{3,4} and gestational diabetes mellitus.⁵

Pregnant individuals are at high risk of gestational diabetes mellitus if they have one of the following characteristics: marked obesity, diabetes mellitus in a first-degree relative, history of glucose intolerance, a previous infant with macrosomia, or current glycosuria.⁶ The American Diabetes Association defines gestational diabetes mellitus as "diabetes diagnosed in the second or third trimester of pregnancy that was not clearly overt diabetes prior to gestation."⁷ From 2016 to 2020, the overall rate of gestational diabetes

mellitus diagnoses across the United States increased by 30%.⁸ Mississippi has the highest percentage of women diagnosed with diabetes mellitus in the US,⁹ and around 4.7% of women in Mississippi have been diagnosed with gestational diabetes mellitus, with an upward trend in rates over the recent years.⁸ Not only can gestational diabetes mellitus increase pregnancy complications such as pre-eclampsia or caesarian delivery, but it may also increase long-term morbidity in the mother as well. A meta-analysis conducted in 2020 found that women with gestational diabetes mellitus are ten times more likely to eventually develop Type II diabetes mellitus.¹⁰ The newborn of a mother with gestational diabetes mellitus faces health risks such as macrosomia which may lead to birth complications such as shoulder dystocia or preterm delivery,¹¹ as well as an array of post-delivery complications ranging from metabolic, hematologic, cardiac, and respiratory disorders to neurological and digestive impairments.¹²

Even though there is a known link between socioeconomic risk factors and depression,¹³ socioeconomic risk factors and diabetes mellitus,¹⁴ and depression and gestational diabetes mellitus,⁵ there is a lack of research investigating the association between gestational diabetes mellitus and depression in Mississippi women. According to the Mississippi State Department of Health, Mississippi has among the lowest rankings for almost every health outcome measured.¹⁵ The objective of this study was to determine if an association exists between gestational diabetes mellitus and depression in Mississippi women, after controlling for demographic and socioeconomic variables.

METHODS

The Behavioral Risk Factor Surveillance System is an annual random-digit-dialed telephone survey of adults at least 18 years of age. It is funded by the Centers for Disease Control and Prevention to collect data about United States residents concerning health-related risk behaviors, chronic health conditions, and use of preventative services.¹⁶ Analysis for this project utilized publicly available data¹⁷ found within the “core component” section, which includes questions “about current health-related perceptions, conditions, and behaviors...as well as demographic questions.” More specifically, our analysis included data from Mississippi participants of the 2021 Behavioral Risk Factor Surveillance System Survey. Questions analyzed were extracted from two Core Sections of the 2021 Behavioral Risk Factor Surveillance System Questionnaire, including Core Section 7: Chronic Health Conditions and Core Section 9: Demographics.

Depression status was determined from the question, “Have you ever been told you had a depressive disorder (including depression, major depression, dysthymia, or minor depression)?” Those responding “Yes” were considered to have a history of depression diagnosis and were included in the analysis.

Those responding “No” were considered not to have a history of depression diagnosis and were included in the analysis. Those responding “Don’t know/Not sure” or “Refused” were excluded from our analysis to ensure that only definitively known information regarding depression diagnosis was included in the analysis, preventing a potential dilution of results. Descriptive statistics (frequency) revealed that 100% of those responding “Don’t know/Not sure” to the question regarding a history of depression diagnosis did not have a history of gestational diabetes mellitus diagnosis. After exclusion of data, 1,180,997 Mississippi women were represented by the weighted sample as having answered the question, “Have you ever been told you had a depressive disorder (including depression, major depression, dysthymia, or minor depression?)” and were included in the analysis.

Demographic and socioeconomic variables of interest included race, education level, and income. For all demographic and socioeconomic variables, those responding “Don’t know/Not sure/Refused” or “Don’t know/Not sure/Missing” were excluded from the analysis to ensure that only definitively known race, education level, and income information was included in the analysis, preventing a potential dilution of results.

Gestational diabetes mellitus status was determined from the question, “Have you ever been told you had diabetes?”. Those responding “Yes, but female told only during pregnancy” were considered to have a history of gestational diabetes mellitus diagnosis and were included in the analysis. Those responding “No” or “No, pre-diabetes or borderline diabetes” were considered to not have a history of gestational diabetes mellitus diagnosis and were included in the analysis. Those responding “Yes” were excluded from the analysis to ensure that those diagnosed with a type of diabetes mellitus that is not gestational diabetes mellitus (i.e. Type I or Type II diabetes) were not included in the analysis, as the variable of interest is gestational diabetes mellitus. Those responding “Don’t know/Not sure” or “Refused” were excluded from the analysis to ensure that only definitively known information regarding gestational diabetes mellitus diagnosis was included in the analysis, preventing a potential dilution of results.

Statistical analysis was performed using IBM SPSS Statistics (Version 29, Armonk, NY: IBM Corp). Cases were weighted with `_LLCPWT` per instructions provided by Behavioral Risk Factor Surveillance System.¹⁶ Analysis methods included calculating descriptive statistics (frequencies and percentages for categorical variables and mean and standard deviation for continuous variables), bivariate analysis including crosstabs, comparing means and proportions (independent Samples T Test), and binary logistic regression, as appropriate. Bivariate analysis was utilized to determine whether variables were independently associated with the outcome of interest (history of depression diagnosis). Any variables found to be independently associated with the outcome at $p < 0.10$ in the bivariate analysis were

included in a multivariable model; these include: race, education level, income, and a history of gestational diabetes mellitus diagnosis. Using a broader threshold for inclusion ($p < 0.10$ as opposed to $p \leq 0.05$) allows for variables that are impacted by confounding to be included in a multivariable model.

The multivariable analysis was performed using binary logistic regression, with a history of depression diagnosis as the dependent variable (outcome). Covariates included race, education level, income, and a history of a gestational diabetes mellitus diagnosis, all of which were categorical variables and found to be independently associated with the outcome of depression. Those variables with a $p \leq 0.05$ were retained in the final multivariable model.

RESULTS

Overall, 1,180,997 Mississippi women were represented by the weighted sample as having answered the question, “Have you ever been told you had a depressive disorder (including depression, major depression, dysthymia, or minor depression?” and were included in the analysis. The largest proportion of respondents in each demographic or socioeconomic factor analyzed were White only, non-Hispanic (57.9%), attended college or technical school (36.3%), and had an income of \$50,000 to less than \$100,000 (25.9%). In this weighted sample of Mississippi women respondents, 25.9% ($n = 305,401$) represented those having a history of depression diagnosis, and 1.6% ($n = 15,617$) represented those having a history of gestational diabetes mellitus diagnosis. Frequencies and valid percentages (missing excluded) were calculated within each category for each demographic and socioeconomic variable.

At the bivariate level, race ($p < 0.001$), education level ($p < 0.001$), income ($p < 0.001$), and history of gestational diabetes mellitus diagnosis ($p < 0.001$) were found to be independently associated with depression.

At the multivariable level, those with a history of gestational diabetes mellitus diagnosis were 1.7 times more likely to have a history of depression diagnosis (including depression, major depression, dysthymia, or minor depression) than those that did not have a history of gestational diabetes mellitus diagnosis, when the model was adjusted for race, education level, and income. Table 2 displays the results of the multivariable model.

DISCUSSION

To our knowledge, our cross-sectional study is the first to explore a possible association between gestational diabetes mellitus and depression in Mississippi women using the 2021 Behavioral Risk Factor Surveillance System data. Our results establish an association between gestational diabetes mellitus and depression in Mississippi women and characterize the accompanying demographic and socioeconomic risk factors. Our analysis

Table 1. Demographics of Women in Mississippi with and without Depression from the 2021 Behavioral Risk Factor Surveillance System

Category	Depression - n (%)	Depression + n (%)	All Female Respondents n (%)
Respondent Sex			
Females only	875,596 (74.1)	305,401 (25.9)	1,180,997 (100.0)
Race			
White only, non-Hispanic	458,616 (53.3)	215,994 (71.4)	675,858 (57.9)
Black only, non-Hispanic	356,489 (41.4)	70,757 (23.4)	429,014 (36.7)
Other race only, non-Hispanic	23,068 (2.7)	4,394 (1.5)	28,799 (2.5)
Multiracial, non-Hispanic	2,612 (0.3)	1,194 (0.4)	3,806 (0.3)
Hispanic	20,314 (2.4)	9,983 (3.3)	30,297 (2.6)
Educational Level			
Did not graduate high school	103,426 (11.8)	49,996 (16.4)	153,422 (13.0)
Graduated high school	244,578 (28.0)	85,629 (28.1)	332,906 (28.1)
Attended college or technical school	314,843 (36.0)	114,192 (37.4)	430,036 (36.3)
Graduated from college or technical school	211,018 (24.1)	55,286 (18.1)	267,352 (22.6)
Income Level			
Less than \$15,000	65,687 (10.1)	32,938 (14.0)	98,914 (11.1)
\$15,000 to < \$25,000	104,276 (16.0)	42,145 (17.9)	146,717 (16.5)
\$25,000 to < \$35,000	123,714 (19.0)	46,892 (19.9)	170,605 (19.2)
\$35,000 to < \$50,000	93,524 (14.3)	33,912 (14.4)	127,751 (14.4)
\$50,000 to < \$100,000	177,439 (27.2)	52,464 (22.3)	230,298 (25.9)
\$100,000 to < \$200,000	75,032 (11.5)	23,826 (10.1)	98,859 (11.1)
\$200,000 or more	12,712 (1.9)	2,898 (1.2)	15,610 (1.8)
Gestational Diabetes Mellitus Status			
- History of GDM	728,379 (98.5)	229,866 (98.2)	962,535 (98.4)
+ History of GDM	11,421 (1.5)	4,196 (1.8)	15,617 (1.6)

Note: Data¹⁷ was weighted with _LLCTW variable per BRFSS analysis guidelines.

indicates that when demographic and socioeconomic factors (race, education level, and income) are controlled in the multivariable model, there is a statistically significant association between gestational diabetes mellitus and depression.

Mississippi is not alone in its associations between gestational diabetes mellitus and depression. A meta-analysis studying over two million women indicates that a gestational diabetes mellitus diagnosis significantly increases the risk of postpartum depression.¹⁸ Discordantly, one study found an association between a history of depression and gestational diabetes mellitus; however, gestational diabetes mellitus was not associated with an increased risk of postpartum depression.¹⁹

While there is conflicting research exploring the link between poor mental health (prenatal and postpartum) and gestational diabetes mellitus,^{5,18,19} the overwhelming majority of research appears to show “a bidirectional association between gestational diabetes and depression in pregnancy.”⁵ In a 2023 systematic review of 22 studies, six studies “showed that women who had depression before pregnancy had a higher risk of developing gestational

Table 2. Multivariable Binary Logistic Regression Results with Outcome (History of Depression Diagnosis) and Independent Variables (Income, Education Level, Race, and History of Gestational Diabetes Mellitus Diagnosis)

	B	S.E.	Wald	df	Sig.	Exp(B)	95% C.I. for EXP(B)	
							Lower	Upper
Income			6782.690	6	0.000			
\$15,000 to < \$25,000	0.115	0.012	96.602	1	0.000	1.122	1.096	1.148
\$25,000 to < \$35,000	-0.005	0.011	0.171	1	0.680	0.995	0.974	1.018
\$35,000 to < \$50,000	-0.111	0.012	84.419	1	0.000	0.895	0.874	0.917
\$50,000 to < \$100,000	-0.461	0.011	1616.601	1	0.000	0.630	0.616	0.645
\$100,000 to < \$200,000	-0.617	0.014	2080.045	1	0.000	0.539	0.525	0.554
\$200,000 or more	-0.752	0.023	1024.351	1	0.000	0.471	0.450	0.494
Education Level			4083.657	3	0.000			
Graduated High School	-0.521	0.010	2503.962	1	0.000	0.594	0.582	0.606
Attended College or Technical School	-0.159	0.010	260.441	1	0.000	0.853	0.837	0.869
Graduated from College or Technical School	-0.430	0.011	1483.461	1	0.000	0.651	0.637	0.665
Race			31493.294	4	0.000			
Black Only, Non-Hispanic	-1.187	0.007	30825.284	1	0.000	0.305	0.301	0.309
Other race only, Non-Hispanic	-0.942	0.024	1600.839	1	0.000	0.390	0.372	0.408
Multiracial, Non Hispanic	0.156	0.047	11.271	1	0.001	1.169	1.067	1.281
Hispanic	-0.422	0.018	574.220	1	0.000	0.656	0.634	0.679
History of Gestational Diabetes Mellitus Diagnosis			707.113	1	0.000	1.714	1.647	1.783
Constant	-0.241	0.012	419.884	1	0.000	0.786		

diabetes”, two studies observed a relationship between depressive symptoms experienced perinatally and the risk of developing gestational diabetes mellitus; four studies established a significant association between gestational diabetes mellitus and a higher risk of depression in pregnancy; and three studies found that gestational diabetes mellitus led to postpartum depression.⁵

Not only do depression and gestational diabetes mellitus lead to adverse outcomes for the mother and child,^{3,4,11,12} these conditions have the potential for widespread economic implications. In 2023, Mississippi passed Senate Bill 2212, which extended Medicaid coverage for new mothers in Mississippi from two to twelve months.²⁰ As our results show an association to exist between gestational diabetes mellitus and depression in Mississippi, there is now a potential financial incentive for the Mississippi healthcare community to closely monitor, screen, and prevent gestational diabetes mellitus and prenatal, perinatal, and postpartum depression.

A 2020 study utilized claims data from OptumHealth Care Solutions to quantify medical expenses, for one year after childbirth, of commercially insured households that were affected by postpartum depression. Epperson et. al concluded that “households affected by postpartum

depression...incurred 22% higher mean total all-cause medical and pharmaceutical spending than unaffected matched controls during the first year following childbirth.” Mothers experiencing postpartum depression spent \$19,611 annually, versus \$15,410 by those without postpartum depression.²¹ A 2022 study that analyzed the MarketScan Multi-State Medicaid Database found that those who experienced perinatal depression had a higher healthcare utilization and medical expenditure than those without perinatal depression.²² In 2018, 62.6% of births in Mississippi were paid for by Medicaid.²³ Our results, in the context of these economic studies,^{21,22} with the percentage of Mississippi births paid for by Medicaid,²³ as well as the new postpartum Medicaid coverage extension in Mississippi,²⁰ suggest that there may be important implications for patient care delivery.

Understanding these implications may necessitate that healthcare providers implement a more holistic approach to prenatal, perinatal, and postpartum care in Mississippi. By recognizing the increased risk of postpartum depression among women with gestational diabetes mellitus, healthcare professionals can proactively screen and intervene, potentially mitigating the adverse effects on both maternal and infant health outcomes. Moreover, this research provides a pivotal route for advocacy in the state. It highlights the importance of comprehensive healthcare policies that address the multifaceted needs of the mothers in Mississippi. Advocating for increased access to mental health services, Medicaid expansion, and community resources can help empower women to navigate the challenges of gestational diabetes mellitus and postpartum depression more effectively. Ultimately, by integrating research findings into clinical practice and advocating for systemic change, we can strive for better healthcare for the mothers and children of Mississippi.

Limitations to our study include indeterminate chronology of depression onset and gestational diabetes mellitus onset. We, therefore, could not conclude if depression was a risk factor for gestational diabetes mellitus or if gestational diabetes mellitus was a risk factor for depression. Additionally, all data collected from the 2021 Behavioral Risk Factor Surveillance System is self-reported and potentially does not capture all diagnosed cases of gestational diabetes mellitus or depression in Mississippi. The Behavioral Risk Factor Surveillance System not only relies on self-reporting of diagnoses but also self-recall of clinical diagnoses. Respondents may have chosen not to report clinical diagnoses, may have not recalled ever receiving a clinical diagnosis of depression or gestational diabetes mellitus, or may have experienced depression that went undiagnosed and, therefore, did not report a depression diagnosis despite experiencing depression. Furthermore, history of depression diagnosis may be underrepresented in our results because our study population is inclusive of women that have never been pregnant,

for whom gestational diabetes mellitus is improbable and inapplicable; the Behavioral Risk Factor Surveillance System survey questions are not written to exclude this population from the data.

Our results indicate that, in Mississippi women, there is a statistically significant association between gestational diabetes mellitus and depression. Since our analysis used weighted data, we believe our conclusions to be generalizable to the greater population of women in Mississippi. Given the increased health burdens that Mississippians face, improved prenatal, perinatal, and postpartum services could potentially reduce the long-term health risks of depression related to gestational diabetes mellitus and financial implications to state budgets. These findings have implications for the implementation of increased gestational diabetes mellitus risk factor and depression awareness for both patients and physicians, as well as increased mental health monitoring before, during, and after pregnancy. Future research should better characterize the associations between other possible risk factors for depression and emphasize the importance of engaging in prenatal behaviors that reduce the risk of gestational diabetes mellitus.

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CONFLICTS OF INTEREST

We have no conflicts of interest to disclose.

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