Research on the Demographic Variables associated with Diabetes and Fetal Death in the United States

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Abstract. Infant mortality has declined significantly worldwide from the last century to the present. Over the past few decades, however, the decline in neonatal mortality has far outpaced that of fetal mortality. Fetal death accounts for almost 50% of all perinatal deaths, and with intrauterine fetal death ranking in the top five causes worldwide, fetal death remains an important and understudied problem. Diabetes is one of the main reasons and increases fetal mortality risk fivefold. In the United States, from 2014 to 2016, this study compares the disparities in fetal fatalities among women of all races who had gestational diabetes or did not. With a total of 1300 patients reporting a diagnosis of gestational diabetes, statistical significance was shown for the variables of mother education of high school or equivalent, pre-pregnancy body mass index of overweight, and area of fetal birth of the South. The rate of fetal mortality was 16% higher in patients with gestational diabetes than in non-patients without gestational diabetes, according to a negative binomial regression model.

Keywords: Fetal death, gestational diabetes, incidence.

1. Introduction

Data published by the World Health Organization show that infant mortality rates have declined significantly worldwide from the last century to the present. Annual infant deaths have declined from 8.7 million per year to 4 million per year (1990 and 2018, respectively). Seventy-five per cent of all mortality among children under the age of five occurs in infants under one. [1]. Although it has decreased far more slowly over the previous few decades than neonatal mortality, fetal death still accounts for approximately 50% of all perinatal fatalities today [2]. One of the biggest causes of death in the globe continues to be intrauterine fetal death. Fetal loss is one of the most emotionally distressing situations for parents and medical professionals. As a result, fetal death is still a significant problem. The major causes of fetal death include genetic inheritance, placental problems, hypertension, diabetes mellitus, and obstructed labor. Of these causes, diabetes increases the risk of fetal death fivefold compared to other conditions. Diabetes can lead to fetal overweight and placental pathology, and increased blood glucose increases the risk of obstructed labor abruptly [3, 4].

Compared to women without diabetes, the prevalence of fetal mortality is four times greater in diabetic mothers. According to glycemic management, diabetes discovered before becoming pregnant is connected to a noticeably increased risk of fetal mortality [5]. In pregnant diabetic mothers, the risk of intrauterine fetal mortality continues to rise. Women with diabetes both before and during pregnancy had a greater risk of intrauterine fetal mortality than non-diabetic patients, with relative ratios of 4.468 and 2.595, respectively [6]. Given that most diabetes-related stillbirths are caused by poor glycemic control, understanding the status of maternal diabetes infection and developing intervention strategies will advance obstetric and prenatal care. The risk of childbirth in the diabetic population and directing appropriate interventions, such as preventive treatment, may significantly reduce mortality [7, 8]. Implementing appropriate diabetes management strategies for women of childbearing age can help protect them and their newborns. This article will describe the current facts about maternal diabetes and fetal mortality, patterns of association, knowledge gaps in the literature review, and methods for conducting research.

Pre-pregnancy diabetes and gestational diabetes are two different types of diabetes that may emerge before or during pregnancy. Pregnancy-related and gestational diabetes had crude prevalence

rates of 0.9% and 6.0%, correspondingly, in Americans. Contrarily, 2% to 10% of expectant mothers develop gestational diabetes every year. Pregnancy-related diabetes raises the risk of stillbirth and neonatal morbidity. With age, a woman's risk of developing diabetes during pregnancy rises [9]. Mean HbA1c levels were greater in women with type 1 diabetes at all stages, which led to fetal mortality. Despite pertinent data indicating improved blood glucose levels in both categories of pregnant women, the pattern of blood glucose levels appears to be slightly different from that of women with type 2 diabetes who died in the pregnancy. It was common for the causes of fetal death to be unrelated to one another. Maternal blood glucose levels and BMI were the two key modifiable risk factors for stillbirth in diabetic women in this research. The risk was greatest for newborns in the highest percentile of weight [10]. The findings of this study should be taken cautiously due to the limited number of fetal fatalities in the sample, which is crucial to mention.

Numerous studies have consistently shown that type 2 diabetic women have higher fetal mortality rates than type 1 diabetic mothers. High maternal BMI and fetal mortality are negatively correlated in the type 2 diabetes group [12]. In further research on pregnant women with gestational diabetes, the delivery method and results of the women whose blood sugar levels stayed normal were comparable to those of all healthy women. The data on fetal mortality among women with diabetes in birthing centers with a controlled diet were similar to the outcomes of low-risk women who did not have the disease. This suggests that one of the best ways to reduce fetal mortality is via birthing facilities [13]. A larger frequency of gestational diabetes mellitus was linked to pre-pregnancy overweight and obesity, older age, and certain other risk factors, according to prospective research by Li G and team. This study established the link between pre-pregnancy obesity and gestational diabetes, with particularly startling findings in the 30-34 age group [14]. Stewart and colleagues' study also supported that an elevated body mass index (BMI) exacerbated the inflammatory state. An important risk factor for gestational diabetes is inflammation, which is linked to older maternal age [15]. Cohort research by Bouthoorn SH and colleagues in Rotterdam, the negative correlation between mother education and gestational diabetes is discussed by the study in Netherlands. Gestational diabetes was more likely to be appeared in mothers who were less educated.

To sum up, the overwhelming majority of research has discovered a link between maternal diabetes diagnosed during pregnancy and fetal death. The present study intends to build on this finding to find any potential association between maternal diabetes diagnosis and exposure factors leading to fetal death in the United States, particularly other covariate and study outcomes. The study's hypotheses were as follows: 1. Fetal fatality and mother gestational diabetes were positively correlated. 2. It was assumed that maternal education, age, pre-pregnancy BMI, and delivery site were essential variables.

2. Method

2.1. Materials

The National Center for Health Statistics (NCHS), state, and federal governments in the United States work together to monitor socioeconomic indicators via the Vital Statistics Collaborative Program (VSCP). In compliance with federal law, NCHS collaborates with regional health agencies to collect and compile pertinent data. The United States' vital statistics system depends on unprocessed data that is sent via various state and local information systems by a large number of contributors who contribute all population health data. A part of the NCHS called the National Vital Statistics System (NVSS) provides comprehensive demographic data for the United States. Infant births, deaths, marriages, and fetal deaths are subject to state and territorial jurisdiction in the United States. To produce yearly national statistics, the NCHS gathers, modifies, and tabulates data obtained via the Centers for Disease Control and Prevention. The NCHS compiles specific data on vital events at the individual-level in the microdata files of the CDC WONDER database. The publicly available microdata birth files for this planned research were created using the fetal mortality records for the United States. Most states have reporting requirements for fetal fatalities that occur after five months of pregnancy or at an estimated weight of five months. The proposed study will analyze the number

of fetal deaths diagnosed with diabetes during pregnancy at the time of reporting from 2014 to 2016. The study will attempt to determine any association between maternal diabetes and fetal deaths. Statistics from 2014 to 2016 show that the median number of fetal deaths registered per year per region for U.S. residents was 37, and the summation of fetal deaths during the three years was 1566.

The outcome of this study was the number of fetal deaths at birth. The main exposed subjects were women with gestational diabetes during pregnancy. The study will investigate the correlation between fetal mortality and the diagnosis of diabetes during pregnancy. Maternal lifestyle and basic health characteristics, such as age and pre-pregnancy BMI, are influential covariates in this model. Demographic variables, such as education level and region of fetal delivery, are also critical to the association effect. These variables shown in Table 1 will be assessed for their effects on direct exposure and outcome associations and adjusted accordingly as necessary in the final model.

Table 1. Outcome, exposure and covariate variables

Outcomes	Exposure	Covariates
Fetal death	Gestional Diabetes	Maternal age, Labor region, Pre-pregnancy BMI, Maternal education level

2.2. Method

Data analysis will be performed through R version 4.2.1. For descriptive statistics, frequency tables will be applied to present basic information on the following variables: demographic variables, maternal gestational diabetes diagnosis, and the corresponding number of fetal deaths. To account for the uncertainty in the distribution of categorical data, a bivariate analysis will be done to recode the categorization of the BMI, maternal education level, mother's age, and place of fetal birth. The Wilcoxon rank sum and Pearson's Chi-squared tests for correlation coefficients will be used to look at the relationships between the main exposures, covariates, and outcomes. In this investigation, the significance threshold will be precisely 5%. To identify any relationships in the covariates that need consideration, outcome and exposure variables will be cross-tabulated with the relevant covariates. Once statistically significant covariates are identified, multivariate statistical analyses will be used to detect any associations between gestational diabetes and fetal death. Given that the primary exposure and outcome variables are categorical, a longitudinal logistic regression model will be chosen for multivariate analysis. Log-likelihood tests, AIC and BIC values will be used to assess the model's fit and find the best model.

3. Results and Discussion

The results are displayed below for the descriptive, bivariate, and multivariate variables. Table 2 demonstrates the descriptive variables table, with a median of 37 fetal deaths in the Interquartile range of 17 to 105 in the US region from 2014 to 2016. Of the total 1566 fetal deaths, the Census South region accounted for one-third of the total number of fetal deaths, occupying the peak with 490 deaths. The Western region, with a number of 425, closely followed it. For pre-pregnancy BMI, 604 mothers had varying degrees of obesity, accounting for 47% of the total. 290 had unknown or unreported pre-pregnancy BMI. This may be because the regional maternal record system does not capture all mothers in a timely manner or mothers do not visit hospitals regularly for preconception checkups frequently. Mothers' educational attainment was more evenly distributed, with a notable breakdown by receipt of Bachelor's or equivalence degree, with over 60% of the population with credit level and less than high school and equivalent education. This shows that more than half of the mothers of fetal deaths have less than a bachelor's degree in education. In addition, 358 had unknown or unreported education. 178 reported gestational diabetes, accounting for 14% of all reported fetal deaths. 75% of the mothers were between the ages 25 to 50, and 564 were unknown.

Table 2. Descriptive table

Characteristic	N = 1566[1]
	358(23%)
Labor Census Region	292(19%)
Midwest	490(31%)
Northeast	425(27%)
South	1
West	
Unknown	87 (6.8%)
Prepregnancy BMI	304(24%)
Underweight <18.5	281(22%)
Normal (18.5-24.9)	604(47%)
Overweight (25.0-29.9)	290
Obesity (> 30)	
Unknown	292(24%)
Mothers Education	
Less than 12th grade	270(22%)
High school graduate or GED completed	
Some college credit, but not a degree	211(17%)
Associate degree or Bachelor's degree	
Master's degree and above	299(25%)
Unknown	136(11%)
Gestational Diabetes	358
Yes	
Unknown	178(14%)
Mothers age	266
15 to 24 years old	
25 to 50 years old	
Unknown	247(25%)
Fetal Deaths	755(75%)
	564
	37(17,105)

[1] n (%); Median (IQR)

Table 3 shows the bivariate analysis of fetal mortality by diagnosis of gestational diabetes in the US region from 2014 to 2016. 1300 instances of gestational diabetes were recorded; 178 of those cases had a confirmed diagnosis, while 1122 did not. The statistical significance of the variables was assessed using the p-values of the Pearson's Chi-squared test and the Wilcoxon rank sum test. Under the circumstances of a verified diagnosis of diabetes during pregnancy, the location of the fetal birth, the mother's pre-pregnancy BMI, and the mother's education all seemed to have an effect on the result. The p-value is 0.001. Maternal age did not show a statistically significant effect at the 5% significance level. The article will be modelled according to statistically significant variables following descriptive and bivariate analysis tables. Fetal death data will be established as continuous outcome variables, the primary exposure variable will be gestational diabetes, and the covariates will be fetal birth region, pre-pregnancy maternal BMI, and maternal education. Given the nature of the outcome variable, the multivariate model will compare Poisson regression and negative binomial regression in the data set.

Table 3. Bivariate analysis by diagnosis of gestational diabetes

Variable (N = 1300)	No, N = 1,122[1]	Yes, N = 178[1]	P-value[2]
Labor Census Region (N = 1300)			<0.001
Midwest	286 (87%)	42 (13%)	
Northeast	207 (93%)	15 (6.8%)	
South	349 (81%)	84 (19%)	
West	280 (88%)	37 (12%)	
Prepregnancy BMI (N = 1114)			<0.001
Underweight <18.5	78 (100%)	0 (0%)	
Normal (18.5-24.9)	217 (89%)	27 (11%)	
Overweight (25.0-29.9)	207 (85%)	36 (15%)	
Obesity (> 30)	450 (82%)	99 (18%)	
Mothers Education (N = 1094)			<0.001
Less than 12th grade	246 (91%)	25 (9.2%)	
High school graduate or GED completed	176 (78%)	49 (22%)	
Some college credit, but not a degree	157 (84%)	31 (16%)	
Associate degree or Bachelor's degree	246 (89%)	31 (11%)	
Master's degree and above	127 (95%)	6 (4.5%)	
Mothers age (N = 909)			0.13
15 to 24 years old	212 (96%)	8 (3.6%)	
25 to 50 years old	645 (94%)	44 (6.4%)	
Fetal Deaths (N = 1300)	154.6 (10.0 - 8329.0)	32.9 (10.0 - 264.0)	<0.001

[1] Mean (Range) or Frequency (%)
[2] Pearson's Chi-squared test; Wilcoxon rank sum test

Table 4 shows the exponential results for Poisson regression and the exponential results for negative binomial regression. The risk of adjusting variables on the outcome is assessed by comparing the incidence rate ratio (IRR). In both models, it was observed that geographic factors had a higher incident rate of fetal death when the region of fetal birth was located in the south compared to other regions (Poisson regression: 1.76, negative binomial regression: 1.56). In terms of maternal education, the incidence of fetal death was higher among mothers who completed high school and equivalent (Poisson's regression:2.24, negative binomial regression: 2.12) compared to other categories. Overweight had the highest incidence of fetal death in the maternal pre-pregnancy BMI (Poisson regression:0.72, negative binomial regression: 0.71). In contrast to earlier, obesity showed a less significant impact on fetal mortality across all weight categories than did overweight. In terms of the primary risk factor for gestational diabetes, women with the condition had a fetal mortality rate that was 11% and 16% higher than women without the condition (Poisson regression, negative binomial regression, respectively). The models were selected by comparing the log-likelihood, AIC and BIC of the two models in Table 5. The better model is discriminated based on, the greater log-likelihood, smaller AIC and smaller BIC, respectively. The negative binomial regression model was the best model for this data.

Table 4. Multivariate analysis comparison

Poisson regression				Negative binomial regression		
Characteristic	IRR[1]	95% CI[1]	P-value	IRR[1]	95% CI[1]	P-value
(Intercept)	163	160, 166	<0.001	159	134, 190	<0.001
Census Region						
Midwest	0.39	0.38, 0.40	<0.001	0.42	0.35, 0.50	<0.001
Northeast	1.76	1.73, 1.79	<0.001	1.56	1.35, 1.81	<0.001
South	0.96	0.94, 0.97	<0.001	0.94	0.80, 1.10	0.4
West	-	-		-	-	
Mothers Education						
Associate degree or Bachelor's degree	2.24	2.20, 2.28	<0.001	2.12	1.80, 2.50	<0.001
High school graduate or GED completed	0.71	0.70, 0.72	<0.001	0.81	0.69, 0.95	0.009
Less than 12th grade	0.49	0.47, 0.50	<0.001	0.51	0.42, 0.63	<0.001
Master's degree and above	1.54	1.51, 1.57	<0.001	1.54	1.29, 1.83	<0.001
Some college credit, but not a degree						
Prepregnancy BMI						
Normal (18.5-24.9)						
Obesity (> 30)	-	-		-	-	
Overweight (25.0-29.9)	0.38	0.37, 0.38	<0.001	0.40	0.34, 0.46	<0.001
Underweight <18.5	0.72	0.71, 0.73	<0.001	0.71	0.60, 0.83	<0.001
Gestational Diabetes						
No	0.15	0.15, 0.16	<0.001	0.17	0.14, 0.22	<0.001
Yes						
	-	-		-	-	
	0.11	0.11, 0.12	<0.001	0.16	0.14, 0.19	<0.001

[1] IRR = Incidence Rate Ratio, CI = Confidence Interval

Table 5. Model Selection

Model	logLik	AIC	BIC
Poisson	-58191.09	116400.2	116443.9
Neg.Binomial	-4980.416	9984.831	10043.11

4. Conclusion

Due to the absence and uncertainty of the type of diabetes in the data, this proposed study makes preliminary assumptions about the uniformity of data information on diabetes. According to the background presentation, in this proposed study, diabetes mellitus was classified as type 2 diabetes. There is variability in the validity and accuracy of this assumption. In addition, there are few cause-of-death events due to gestational diabetes. Vital statistics records are subject to sampling variability and incomplete statistics, with missing and invalid data.

Furthermore, fetal death data are only recorded after 20 weeks and will be standardized through a standardized approach. Therefore, reporting fetal death data inevitably has quality issues across different regions. By analyzing gestational diabetes and related exposure variables, it was possible to obtain data on fetal deaths published from 2014 to 2016 according to US regions: maternal pre-pregnancy BMI, place of birth and education level had a statistically strong correlation on fetal deaths. Place of birth was not provided due to the level of detail of categorization and was not representative for analysis. Of the models selected for study, the negative binomial regression model provided a more accurate generalization of the data.

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