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Discovering Social Determinant of Health Risk Factors for Perinatal Morbidity Through Real World Data

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Abstract. Gestational diabetes and preterm birth are perinatal morbidities that significantly impact women and infants' health. While clinical factors like cesarean delivery, multiple gestation, preeclampsia, and hypertensive disorder are associated with these conditions, it is increasingly recognized that social determinants of health play a crucial role. This study aims to measure the associations between the social vulnerability index (SVI) and these perinatal morbidities using multivariate logistic regression models. The results indicate that factors across all four themes in SVI are significantly associated with these conditions. These findings suggest that interventions targeting these areas are needed to achieve better reproductive health.

Keywords. Preterm birth, gestational diabetes, SDoH, electronic health record

1. Introduction

Gestational diabetes mellitus (GDM) and preterm birth (PB) are major perinatal morbidities that impact the health of women and infants [1,2]. GDM, the most common metabolic disturbance during pregnancy, is associated with risk factors such as obesity, physical inactivity, family history of diabetes mellitus, hypertension, or history of cardiovascular disease. PB, the leading cause of death and disability in newborns, is associated with risk factors such as cervical length, fibronectin protein, diabetes, obesity, or multiple pregnancies [3]. In the United States, GDM affects 2% to 10% of pregnant women, while almost 10% of babies are born prematurely annually [3].

While previous studies have identified clinical risk factors for GDM and PB, most are not modifiable or actionable, limiting the development of effective intervention strategies [1]. Social determinants of health (SDoH) corresponds to environmental conditions and it plays a fundamental role in impacting health outcomes more than clinical risk factors [4,5]. Moreover, SDoH is often associated with disparities in maternal morbidity and mortality [6]. This paper proposes an informatics framework that utilizes a widely adopted SDoH proxy - social vulnerability index (SVI) - to investigate the associations between SDoH and the two main perinatal morbidities.

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2. Methods

This study was conducted at Vanderbilt University Medical Center (VUMC), a private, non-profit institution that locates in middle Tennessee. We collected 3 years of data (from January 1st, 2018 to November 1st, 2021) from VUMC Electronic Health Record (EHR) system, which includes 15,420 patients who gave deliveries during the study period. A summary of patients' diagnosis and demographics is provided in **Table 1**.

Table 1. Summary statistics of patients' demographics and outcomes.

Item	Value
Study Period	01/01/2018 – 11/01/2021
# of deliveries	15,420
Age (IQR, median)	(25 – 33, 29)
Race: N (%)	
White	9457 (61.3%)
Black	2606 (16.9%)
Asian	764 (5.0%)
Other	2593 (16.8%)
Ethnicity	
Non-Hispanic	12861 (83.4%)
Hispanic	2307 (15.0%)
Other	252 (1.6%)
Outcome	
Gestational Diabetes	812 (5.3%)
Preterm Birth	2212 (14.3%)

2.1. Gestational diabetes mellitus

GDM is a type of diabetes that is first recognized during pregnancy and is typically diagnosed between 24-28 weeks of gestation using screening and diagnostic tests. To identify patients with GDM from EHRs, a two-step procedure can be used. The first step involves checking the glucose levels of a patient's 1-hour, 50-gram glucose challenge test (GCT). If the glucose level is above the diagnostic threshold, the patient is considered to have a positive GCT result and may have GDM. The diagnostic threshold varies depending on the diagnostic criteria used and may be 130 mg/dL or higher, according to the International Association of Diabetes and Pregnancy Study Groups (IADPSG), or 140 mg/dL or higher, according to the American College of Obstetricians and Gynecologists (ACOG). In this paper, a threshold of 200 mg/dL was used to diagnose GDM based on the GCT. If the GCT result is not positive, patients with a glucose level below a lower threshold (e.g., 130 mg/dL according to the IADPSG) are considered to have a negative result and are not diagnosed with GDM. For patients with a GCT result between the screening and diagnostic thresholds (between 130-200 mg/dL in this study), the second step involves checking the results of the 100-gram, 3-hour oral glucose tolerance test (OGTT) in the EHRs of patients. If the patient has at least two glucose measurements above the diagnostic thresholds during the OGTT, they are considered to have GDM. The diagnostic thresholds for the OGTT also vary depending on the diagnostic criteria used. In this study, we used 95 mg/dL or higher for fasting glucose, 180 mg/dL or higher for 1-hour glucose, 155 mg/dL or higher for 2-hour glucose, and 140 mg/dL or higher for 3-hour glucose, which is based on the American Diabetes Association.

2.2. Preterm birth

PB corresponds to deliveries with less than 37 weeks of pregnancy [2]. We manually extracted the gestational week (GW) information from the clinical notes in EHR and marked a delivery as a PB if the corresponding GW was less than 37 weeks.

2.3. Social Vulnerability Index

SVI, one of the most commonly used definitions for SDoH, covers 15 social factors categorized into four themes: socioeconomic status, household composition and disability, minority status and language, and housing type and transportation [7]. SVI measures the potential negative effects on communities caused by external stresses on human health. Six values were used to describe a social factor, including absolute value (with the margin of error (MOE)), percentile (with the MOE), percentile ranking, and flag (whether the percentile is in the 90th percentile). We focus on percentile ranking values in this study because they represent relative vulnerability of an individual tract. The percentile ranking values range from 0 to 1, higher values indicating greater vulnerability.

2.4. Associations between SVI and GDM/PB

Logistic regression was used to test if the association between each SVI variable and GDM/PB is significant or not. A variable was regarded as significant if it has a false discovery rate (FDR)-adjusted p-value < 0.05. Confounders included age and BMI, singleton, and delivery method.

3. Results

Table 2 shows the county distribution of patients included in the study cohort. Over half (53.6%) of the cohort were from Davidson County, where VUMC is located. The rest of the patients reside at the counties surrounding Davidson County. It can be observed that there is a larger discrepancy in GDM and PB between counties. The range for GDM rates is 2.76% - 6.32%, while the range of PB is 9.65% - 29.38%.

Table 2. Number of GDM and PB and SVI for top 10 counties in Tennessee based on the study cohort.

County	# of Deliveries	GDM	PB	SVI
Davidson	8266	501 (6.06%)	827 (10%)	0.69
Williamson	1187	51 (4.30%)	143 (12.05%)	0.05
Rutherford	1186	75 (6.32%)	168 (14.17%)	0.41
Montgomery	1028	32 (3.11%)	302 (29.38%)	0.57
Wilson	881	39 (4.43%)	85 (9.65%)	0.23
Sumner	616	17 (2.76%)	127 (20.62%)	0.34
Robertson	249	15 (6.02%)	55 (22.09%)	0.36
Maury	225	11 (4.89%)	52 (23.11%)	0.33
Cheatham	204	11 (5.39%)	19 (9.31%)	0.31
Dickson	169	8 (4.73%)	16 (9.47%)	0.40

Table 3 shows different racial and ethnical subgroups have different prevalence of GDM and PB. Comparing to White, black patients tended to have a higher rate for PB (18.76%

vs 14.34%) while Asian patients tend to have a higher rate for gestational diabetes (10.99% vs 4.5%) and a lower rate of PB (9.55% vs 14.34%). Similarly, Hispanic patients had a higher rate of gestational diabetes (7.8% vs 4.84%) and a low rate of PB (12.05% vs 14.82%), comparing to non-Hispanic counterpart.

Table 3. GDM and preterm birth prevalence on racial and ethnical subgroups and the average SVI.

	# of Deliveries	GDM	PB	SVI
Race (N (%))				
White	9457	426 (4.5%)	1356 (14.34%)	0.40
Black	2606	105 (4.03%)	489 (**18.76%**)	0.60
Asian	764	84 (**10.99%**)	105 (9.55%)	0.45
Other	2593	197 (7.6%)	294 (11.34%)	0.59
Ethnicity (N (%))				
Non-Hispanic	12861	622 (4.84%)	1906 (**14.82%**)	0.44
Hispanic	2307	180 (**7.8%**)	278 (12.05%)	0.61
Other	252	10 (3.97%)	28 (11.11%)	0.48

Table 4 shows the statistical test results of association between SVI social factors under each theme and GDM/PB. For socioeconomic status variables, women who live in areas with higher income are less likely to experience GDM and PB (OR=0.99). It is observed that women who live in area that are below poverty (OR=1.002) and unemployed (OR=1.009) are more likely to have PB and who do not have high school diplomas (OR=1.003) are more likely to have GDM.

Table 4. Association between the percentile ranking values of 15 social variables and GDM/PB. *, **, and *** indicates that the results are statistically significant at p<0.05, p<0.01, and p<0.001 level, respectively.

Theme	Variable	GDM	PB
Theme 1 Socioeconomic status	Below poverty	1.000 (0.999-1.001)	1.002 (1.001-1.003)***
	Unemployed	1.000 (0.996-1.003)	1.009 (1.003-1.014)**
	Income	0.998 (0.997-0.998)***	0.996 (0.995-0.997)***
	No high school diploma	1.003 (1.002-1.004)***	1.001 (0.999-1.003)
Theme 2 Household composition and disability	Aged 65 and older	0.998 (0.997 -0.999)**	1.003 (1.001-1.004)***
	Aged 17 and younger	1.001 (1.000-1.002)*	1.001 (0.998-1.003)
	Disability	0.999 (0.998-1.000)	1.006 (1.004-1.008)***
	Single-parent household	1.002 (1.000-1.002)*	1.006 (1.003-1.010)***
Theme 3 Race/ethnicity/language	Minority	1.003 (1.002-1.004)***	0.997 (0.995-0.999)*
	Speak English "less than well"	1.005 (1.004-1.006)***	0.994 (0.992-0.996)***
Theme 4 Housing type and transportation	Multi-unit structures	1.000 (0.999-1.001)	0.997 (0.996-0.998)***
	Mobile homes	0.997 (0.995-0.999)*	1.013 (1.010-1.016)***
	Crowding	1.017 (1.010-1.023)***	0.991 (0.982-1.001)
	No vehicle	0.999 (0.996-1.002)	1.002 (0.997-1.007)
	Group quarters	0.998 (0.996-0.999)*	1.001 (0.999-1.004)

For household composition and disability variables, women who live in areas where there are more people less than 17 years old (OR=1.001) are more likely to experience GDM. Women from areas where there are more people who are older than 65 (OR=1.003) or with a disability (OR=1.006) or single parent household (OR=1.006) are more likely to have PB. Minority (OR=1.003) and persons who speak English less than well (OR=1.005) are significant associated with GDM. For housing type and transportation variables, women who live in areas where there is more crowded living space (more people than the number of rooms) (OR=1.017) have a higher chance to experience GDM. Women who live in areas with more mobile homes (OR=1.013) are more likely to deliver a baby prematurely.

4. Discussion

We found all the four SVI themes were significantly associated with GDM and PB. These associations suggest that it is essential to consider social risk factors in addition to clinical risk factors when providing health care or making decisions to pregnant women. Several limitations also need to be acknowledged. First, there may exist bias in patient population from a single institute. As most patients in this study were from Davidson County, where VUMC is located, patients who were from surrounding counties and seeking care at our facility may be at high risks during their pregnancy, otherwise they chose community hospitals for their maternal care. Thus, a large-scale study (i.e., state level) is suggested to alleviate the bias of selecting patients. Second, it's important to note that the diagnostic criteria for GDM vary between organizations and countries, which can affect the specific thresholds used to identify GDM patients from EHRs. Finally, although SVI was investigated in this study to characterize social status, more social factors, such as environmental exposome, food accessibility, and education attainment need to be included in the future study.

5. Conclusions

Our methodology offers a groundbreaking means of quantifying the relationships between SDoH risk factors and two key perinatal outcomes: PB and GDM, utilizing real-world data from EHRs and the community-level SDoH SVI. The findings indicate that the four themes of SVI are significantly linked with PB and GDM. This underscores the need for strategies focused on socioeconomic status, household composition, minority status and language, and housing type to enhance reproductive health outcomes.

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