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Associations in fetal outcomes from cesarean sections with maternal comorbidities: a cross-sectional study of the Pregnancy Risk Assessment Monitoring System

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Abstract

Context: Cesarean sections (CSs) can reduce maternal and fetal risk in medically necessary cases. However, studies show that CSs are associated with negative fetal outcomes, including birth defects, low birth weight, delayed fetal resuscitation, neonatal acidosis, and even infant mortality. Maternal comorbidities play a role in determining if a CS is necessary and may contribute to negative fetal outcomes following a CS.

Objectives: The primary objective of this study was to determine the prevalence of negative fetal outcomes such as low birth weight, birth defects, prolonged hospital stay, and infant mortality in CS deliveries and their increased risk of occurrence among mothers with comorbidities.

Methods: We conducted a cross-sectional study of the Phase 8 (2016–2019) Pregnancy Risk Assessment Monitoring System (PRAMS) to assess the associations of the aforementioned birth outcomes with pre-existing conditions such as high blood pressure (HBP), depression, and type II diabetes

mellitus, as well as demographic factors in the United States (US).

Results: Our findings showed that mothers who delivered via CS with pre-existing or gestational HBP, or gestational diabetes, were less likely to experience infant mortality (adjusted odds ratio [AOR]: 0.4; confidence interval [CI]: 0.17–0.92, AOR: 0.2; CI: 0.09–0.44, and AOR: 0.09; CI: 0.03–0.33, respectively). However, mothers who delivered via CS with pre-existing or gestational diabetes, pre-existing or gestational HBP, or pre-existing or gestational depression had higher rates of prolonged infant hospital stay (AOR: 1.73; CI: 1.41–2.11, AOR: 1.21; CI: 1.05–1.39, AOR: 1.77; CI: 1.5–2.09, AOR: 2.58; CI: 2.31–2.88, AOR: 1.25; CI: 1.09–1.43 and AOR: 1.33; CI: 1.16–1.52, respectively). Likewise, mothers who delivered via CS with pre-existing or gestational HBP, or pre-existing or gestational depression, were more likely to deliver an infant with low birth weight (AOR: 1.88; CI: 1.62–2.19, AOR: 2.7; CI: 2.45–2.98, AOR: 1.24; CI: 1.09–1.41, and OR: 1.28; CI: 1.14–1.42, respectively).

Conclusions: Our study revealed a lower incidence of infant mortality following CS deliveries among mothers with pre-existing or gestational HBP, or gestational diabetes. This suggests a potential benefit in antenatal testing in mothers experiencing depression or those with no comorbidities. Additionally, infants born to mothers with these comorbidities experienced longer hospital stays, and infants of mothers with pre-existing or gestational HBP and depression had a higher incidence of low birth weight. Given the increasing rates of diabetes, HBP, and depression in the US, it is crucial to provide healthcare professionals with the necessary guidance to prevent and manage these comorbidities and improve fetal outcomes following CS deliveries.

Keywords: cesarean section; geographic disparities; maternal comorbidities; negative fetal outcomes

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The World Health Organization (WHO) emphasizes that Cesarean section (CS) rates above 10 % in any country

annually do not result in improved maternal and fetal outcomes [1]. However, in the United States (US), CS rates have surpassed this threshold since the 1990s, with an annual rate of nearly 20 % in 1996 [2] and peaking at 32.9 % in 2009 [3]. In an effort to reduce the CS rate, the National Institute of Health (NIH) relaxed the restrictions on repeated CS and vaginal birth after cesarean (VBAC) in 2010 [4]. Although the rates have stabilized since then, the 2022 Centers for Disease Control and Prevention (CDC) report shows CS rates remained high at 32 % [3, 5].

The rise in CS rates has been largely attributed to the increasing prevalence of comorbidities within the US population. Women with pre-existing or gestational diabetes mellitus, high blood pressure (HBP), or depression are significantly more likely to undergo CS. [6] As the prevalence of these comorbidities among women of childbearing age in the US continues to increase [7, 8], so does the rate of CS, as has been observed since the 1990s [9]. Moreover, demographic factors such as ethno-racial groupings, household income, and experiences of trauma have been linked to disparately high CS rates. For instance, women of African American, African, South Asian, and Caribbean descent have a higher likelihood of undergoing CS compared to non-Hispanic White women [10], which may be explained by their increased rates of chronic morbidities and obesity [11]. Additionally, trends of chronic comorbidities may vary across US census regions and urbanicity [12, 13]. Because these factors have been shown to increase the risk of pregnancy-related health complications, they ultimately contribute to higher rates of medically necessary CS [14, 15].

CSs have also been associated with negative fetal outcomes such as delay in fetal resuscitation, neonatal acidosis, birth defects or anomalies, low birth weight, and fetal mortality [16, 17]. These outcomes can have lifelong complications, including conditions such as asthma and autism [16]. Infants delivered via CS are more likely to develop transient tachypnea of the newborn (TTN) compared to those delivered vaginally [18, 19]. This condition requires immediate medical attention and often involves further medical interventions such as radiographs, supplemental oxygen, and the potential need for intubation [19]. As a result, infants delivered via CS may require longer hospital stays.

Although CSs can be associated with fetal hypoxia and acidosis, intervening at the appropriate time during fetal distress by delivering via CS can mitigate these negative outcomes [20]. Fetal hypoxia has been linked to various long-term complications, including motor, cognitive, social, behavioral, sensory, and attention deficits [21]. Timely intervention during fetal distress can reduce the risk of post-delivery hypoxia, also known as “birth asphyxia,”

and can lead to lower APGAR (Activity, Pulse, Grimace, Appearance, Respiration) scores and subsequent complications due to a lack of oxygen [20]. These complications may include epilepsy, hypoxic-ischemic encephalopathy, cardiomyopathy, vascular pathology, diabetes mellitus, cancer, senescence, and mortality [22].

Given the persistently high rates of CS in the US and the increasing prevalence of comorbidities, our primary objective was to determine the prevalence of low birth weight, birth defects, prolonged hospital stay, and infant mortality in infants born via CS, and to assess the association of these outcomes with maternal comorbidities such as HBP, depression, and type II diabetes mellitus. We also investigated whether the prevalence of negative fetal outcomes following CS differs based on urbanicity or US region, because comorbidities are higher in the Midwest and South [13].

Methods

Data source

We performed a cross-sectional study of the Pregnancy Risk Assessment Monitoring System (PRAMS) [23] Phase 8 to assess the prevalence of negative fetal outcomes delivered via CS and their potential association with certain comorbidities. PRAMS is a population-based data collection system, initiated by the CDC in 1987, that utilizes mailed or phone-call surveys to capture information on maternal and fetal outcomes and experiences before, during, and up to 6 months after delivery. The data collected includes various factors such as prenatal care, obstetric history, maternal substance use, physical abuse, contraception, economic status, maternal stress, early infant development, and fetal outcomes. The data for this study were obtained between 2016 and 2019, utilizing Phase 8 of PRAMS, which is estimated to cover 83 % of births in the United States. Data were collected from 47 states (AK, AL, AR, AZ, CO, CT, DE, FL, GA, HI, IA, IL, IN, KS, KY, LA, MA, MD, ME, MI, MN, MO, MS, MT, NC, ND, NE, NH, NJ, NM, NV, NY, OK, OR, PA, RI, SC, SD, TN, TX, UT, VA, VT, WA, WI, WV, and WY), as well as Washington DC, Puerto Rico, and the Great Plains Tribal Chairmen’s Health Board. Full PRAMS methodology, and sampling and selection procedures, have been published [24] and are available at: www.cdc.gov/prams/pdf/methodology/PRAMS-Design-Methodology-508.pdf.

Inclusion/exclusion criteria

The participants included in this study were those who gave birth via CS. We included respondents who delivered

between 34 0/7 weeks gestation and 42 6/7 weeks gestation to exclude high-risk preterm deliveries, while still including most cases of preeclampsia. Respondents with missing values were excluded from this analysis, as well as births that did not occur in a hospital.

Demographic variables

Sociodemographic variables extracted from PRAMS included age, race, education, tobacco use, and income. Race groups were collected from birth certificates and included White, Black, American Indian, and Alaska Native, and those identifying as “Chinese,” “Japanese,” and “Filipino” as were categorized as “Asian” within PRAMS, and individuals identifying as “Native Hawaiian” and “Pacific Islander” were merged into the ‘Other race’ category. Income categories were classified as \$0–\$20,000, \$20,001–\$40,000, \$40,001–\$75,000, \$75,001–\$120,000, and more than \$120,000. Maternal age was provided by PRAMS in yearly increments from 18–44, but grouped any mothers less than 17 as 17 and any mothers over 45 as 45. For this analysis, we constructed the following age groups: 0–17, 18–19, 20–24, 25–29, 30–34, 35–39, and 40+ based on sample stratification and the potential for maternal or birth risk factors. Participants who reported utilizing more than one cigarette per day during pregnancy were categorized as having utilized cigarettes, while those who reported no cigarette use, or less frequent use, were classified as not having utilized cigarettes. Additionally, data on the US census region and urbanicity (classified at the county level as *urban* and *rural* based on 2013 National Center for Health Statistics guidelines) [25] were extracted.

Comorbidities and negative fetal outcomes

This study investigated pre-existing comorbidities of type II diabetes mellitus, HBP, and depression, as well as gestational comorbidities. The negative fetal outcomes examined included fetal mortality, birth defects, low birth weight, and duration of hospital stay. Types of birth defects, or anomalies, were not specified by PRAMS and were extracted as present or absent. Low birth weight was defined as <2,500 g. Length of hospital stay was calculated with a binary variable: 5 days or less was categorized as noncritical, and 6 days or more was categorized as critical, consistent with previous research [26].

Statistical analysis

We estimated the number of participants in the study who had CS and reported the sociodemographic characteristics of

the sample. To determine the potential association between comorbidities (or gestational comorbidities) and negative fetal outcomes, we utilized linear regression analyses. Adjusted regression models controlled for race, education, income, and cigarette use. All analyses were conducted with alpha set at 0.05, and 95 % CIs were reported. We utilized Stata 16.1 (StataCorp LLC, College Station, TX) as our statistical software and accounted for survey design and sampling weights provided by PRAMS.

Results

Sociodemographic factors in mothers with a history of CS

A total of 40,766 respondents who had a CS were included in this study (Table 1). The majority were between 25 and 34 years old (23,720, 58.7 %). The sample was composed of mothers who identified as White (22,652; 67.2 %), had 16+ years of education (14,344; 37.4 %), and were in either the lowest-income group of ≤\$20,000 (11,310; 27.91 %) or highest-income groups of >\$120,000 (9,194; 28.6 %). Approximately 3,592 (7.78 %) reported utilizing cigarettes during pregnancy.

Prevalence of comorbidities in mothers and fetal outcomes born to mother with a history of CS

In terms of maternal pre-existing comorbidities, 4.6 % had diabetes, 6.9 % had HBP, and 14.3 % had depression. Participants with gestational diagnoses had slightly higher percentiles for diabetes (12.2 %) and HBP (16.6 %). Gestational depression was diagnosed in 13.5 % of the participants. The most prevalent negative fetal outcome was a hospital stay of more than 5 days (10.2 %), with low birth weight being second at 7.7 %.

Pre-existing and gestational diabetes and associations with negative fetal outcomes

When comparing participants who had a CS with and without gestational diabetes, those with gestational diabetes had significantly lower odds of experiencing infant mortality (AOR: 0.09; 95 % CI, 0.03–0.33; Table 2). Furthermore, those with pre-existing diabetes were significantly more likely to give birth to an infant who required a hospital stay of ≥6 days compared to those without pre-existing diabetes

Table 1: Sociodemographics of participants who gave birth via CS (n=40,766).

	No. (weighted %)
Maternal age (years)	
0–17	275 (0.72)
18–19	926 (2.05)
20–24	6,128 (14.56)
25–29	11,135 (27.57)
30–34	12,585 (31.11)
35–39	7,630 (18.84)
40+	2,087 (5.15)
Maternal race	
Asian	3,023 (6.40)
White	22,653 (67.20)
Black	8,451 (17.40)
American Indian/Alaska native	1,184 (0.64)
Other (non-White) race including native Hawaiian and Pacific Islander	2,215 (5.43)
Multiracial	2,070 (2.93)
Maternal education (years)	
0–8	1,033 (2.47)
9–11	3,441 (8.28)
12	9,522 (23.9)
13–15	12,014 (27.94)
16+	14,344 (37.40)
Smoked cigarettes during pregnancy	
No	36,535 (92.22)
Yes	3,592 (7.78)
Income group	
\$0–\$20,000	11,310 (27.91)
\$20,001–\$40,000	7,853 (19.57)
\$40,0001–\$75,000	6,615 (17.82)
\$75,001–\$120,000	2,354 (6.06)
\$120,000+	9,194 (28.64)
Pre-existing comorbidities	
Diabetes	1,942 (4.60)
HBP	3,205 (6.91)
Depression	6,111 (14.27)
Gestational comorbidities	
Diabetes	5,239 (12.22)
HBP	7,797 (16.55)
Depression	5,896 (13.54)
Negative birth outcomes	
Mortality	96 (0.16)
Defect	265 (0.42)

Table 1: (continued)

	No. (weighted %)
Length of stay >5 days	6,367 (10.19)
Low birth weight (<2,500 g)	8,821 (7.70)

CS, cesarean section; HBP, high blood pressure.

(AOR: 1.73; 95 % CI: 1.41–2.11). Similarly, those with gestational diabetes were significantly more likely to have an infant with a hospital stay of ≥ 6 days compared to those who delivered via CS without gestational diabetes (AOR: 1.21; 95 % CI: 1.05–1.39).

Pre-existing and gestational HBP and associations with negative fetal outcomes

Compared to mothers who had a CS without pre-existing HBP, those with pre-existing HBP were significantly less likely to experience infant mortality (AOR: 0.40; 95 % CI: 0.17–0.92). Similarly, participants who delivered via CS with gestational HBP were significantly less likely to experience infant mortality when compared to participants who delivered via CS without gestational HBP (AOR: 0.2; 95 % CI: 0.09–0.44). Mothers who delivered via CS with pre-existing HBP were significantly more likely to give birth to an infant requiring ≥ 6 days in the hospital when compared to mothers who delivered via CS without pre-existing HBP (AOR: 1.77; 95 % CI: 1.50–2.09). Additionally, mothers who delivered via CS with gestational HBP were significantly more likely to give birth to an infant with a hospital stay of ≥ 6 days when compared to mothers who delivered via CS without gestational HBP (AOR: 2.58; 95 % CI: 2.31–2.88). Mothers who delivered via CS with pre-existing HBP were significantly more likely to have an infant with low birth weight when compared to mothers who delivered via CS without pre-existing HBP (AOR: 1.88; 95 % CI: 1.62–2.19). Similarly, participants who delivered via CS with gestational HBP were significantly more likely to have an infant with low birth weight (AOR: 2.7; 95 % CI: 2.45–2.98) compared to those without gestational HBP.

Pre-existing and gestational depression and associations with negative fetal outcomes

After controlling for sociodemographic factors, women who had a CS with either pre-existing or gestational depression

Table 2: Fetal outcomes among women with CS and comorbidities (n=40,766).

	Mortality		Defect		Duration of hospital stay ^a		Low birth weight	
	OR	AOR	OR	AOR	OR	AOR	OR	AOR
Pre-existing comorbidities								
Diabetes	0.42 (0.14–1.27)	0.46 (0.14–1.50)	0.59 (0.21–1.65)	0.65 (0.23–1.87)	1.90 (1.56–2.31)	1.73 (1.41–2.11)	1.13 (0.93–1.37)	1.17 (0.95–1.45)
HBP	0.35 (0.17–0.74)	0.40 (0.17–0.92)	1.22 (0.65–2.29)	1.13 (0.54–2.37)	1.85 (1.59–2.17)	1.77 (1.50–2.09)	2.04 (1.78–2.34)	1.88 (1.62–2.19)
Depression	1.15 (0.50–2.65)	0.90 (0.34–2.41)	1.46 (0.88–2.41)	1.22 (0.70–2.13)	1.36 (1.21–1.54)	1.25 (1.09–1.43)	1.33 (1.19–1.48)	1.24 (1.09–1.41)
Gestational comorbidities								
Diabetes	0.07 (0.02–0.25)	0.09 (0.03–0.33)	0.74 (0.43–1.28)	0.56 (0.30–1.05)	1.24 (1.09–1.42)	1.21 (1.05–1.39)	1.07 (0.95–1.21)	1.11 (0.97–1.27)
HBP	0.19 (0.09–0.42)	0.20 (0.09–0.44)	0.81 (0.50–1.31)	0.83 (0.48–1.41)	2.57 (2.32–2.85)	2.58 (2.31–2.88)	2.75 (2.51–3.01)	2.70 (2.45–2.98)
Depression	1.38 (0.67–2.87)	1.10 (0.50–2.45)	1.10 (0.65–1.84)	0.84 (0.48–1.45)	1.50 (1.33–1.70)	1.33 (1.16–1.52)	1.28 (1.14–1.42)	1.12 (0.99–1.27)

Reference group for each condition is women without the specified condition. ^aStay ≥6 days, AOR, adjusted odds ratio; CS, cesarean section; OR, odds ratio. Bold values indicate statistical significance (p < .05).

were significantly more likely to have an infant who required a hospital stay of ≥6 days compared to those without depression (AOR: 1.25; 95 % CI: 1.09–1.43 and AOR: 1.33; 95 % CI: 1.16–1.52, respectively). Lastly, compared to mothers without pre-existing depression, mothers with pre-existing depression were significantly more likely to have an infant with low birth weight (AOR: 1.24; 95 % CI: 1.09–1.41). Mothers with gestational depression were also more likely to give birth to an infant with low birth weight (OR: 1.28; 95 % CI: 1.14–1.42) compared to those without the condition, although after adjusting for sociodemographic factors, this association was not significant.

Negative fetal outcomes and association with US census region and urbanicity

Compared to the Northeast region, which had the lowest rates of infant mortality following CS at 6 %, mothers in the Midwest and West regions of the United States experienced significantly higher rates of infant mortality following CS (OR: 4.19; 95 % CI: 1.33–13.19 and OR: 5.20; 95 % CI: 1.74–15.54, respectively; Table 3). Additionally, compared to the Northeast region, the West had significantly higher rates of birth defects, or anomalies, after CS (OR: 1.99; 95 % CI: 1.18–3.34). No significant findings were observed between negative fetal outcomes and urbanicity.

Discussion

Principle findings

This study revealed that CS deliveries for mothers with pre-existing or gestational HBP, or gestational diabetes, were associated with a decreased risk of infant mortality. This highlights the critical role of antenatal testing and additional obstetric appointments during pregnancy, particularly in the third trimester, as recommended by the American College of Obstetricians and Gynecologists (ACOG), to improve fetal outcomes [27]. Furthermore, antenatal fetal surveillance has been shown to significantly reduce the risk of stillbirth by enabling prompt intervention through planned or emergent CS procedures [27]. Conversely, mothers undergoing CS with pre-existing/gestational diabetes, pre-existing/gestational HBP, or pre-existing/gestational depression were more likely to have an infant necessitating a longer hospital stay of ≥6 days. This may be attributed to the secondary consequences of CS, such as TTN and neonatal acidosis, the impact of maternal comorbidities on fetal growth, or the increased

Table 3: Fetal outcomes among women with CS and US region and urbanicity.

Region	Experienced infant mortality		Logistic regression		Had birth defect		Logistic regression		Long hospital stay		Logistic regression		Low birth weight		Logistic regression	
	No. (%)	OR (95 % CI)	No. (%)	OR (95 % CI)	No. (%)	OR (95 % CI)	No. (%)	OR (95 % CI)	No. (%)	OR (95 % CI)	No. (%)	OR (95 % CI)	No. (%)	OR (95 % CI)	No. (%)	OR (95 % CI)
Region	Northeast	11 of 11,768 (0.06)	1 (Reference)	1 (Reference)	72 of 11,859 (0.41)	1 (Reference)	1,858 of 11,693 (10.01)	1 (Reference)	2,650 of 11,894 (7.47)	1 (Reference)	2,650 of 11,894 (7.47)	1 (Reference)	1,813 of 9,549 (7.48)	1 (0.93–1.07)	1,813 of 9,549 (7.48)	1 (0.93–1.07)
	Midwest	29 of 9,543 (0.24)	4.19 (1.33–13.19)	1.05 (0.6–1.81)	52 of 9,496 (0.43)	1.05 (0.6–1.81)	1,439 of 9,383 (10.71)	1.08 (0.96–1.21)	1,831 of 11,333 (7.99)	1.01 (0.9–1.14)	1,831 of 11,333 (7.99)	1.07 (0.98–1.18)	1,540 of 8,010 (7.85)	1.05 (0.94–1.19)	1,540 of 8,010 (7.85)	1.05 (0.94–1.19)
	South	32 of 10,441 (0.14)	2.34 (0.75–7.30)	0.64 (0.38–1.08)	72 of 11,301 (0.27)	0.64 (0.38–1.08)	1,901 of 11,163 (10.12)	0.98 (0.86–1.12)	1,169 of 7,898 (9.84)	0.98 (0.86–1.12)	1,169 of 7,898 (9.84)	0.98 (0.86–1.12)	1,169 of 7,898 (9.84)	0.98 (0.86–1.12)	1,169 of 7,898 (9.84)	0.98 (0.86–1.12)
	West	24 of 6,669 (0.30)	5.20 (1.74–15.54)	1.99 (1.18–3.34)	71 of 7,897 (0.82)	1.99 (1.18–3.34)	1,169 of 7,898 (9.84)	0.98 (0.86–1.12)	1,169 of 7,898 (9.84)	0.98 (0.86–1.12)	1,169 of 7,898 (9.84)	0.98 (0.86–1.12)	1,169 of 7,898 (9.84)	0.98 (0.86–1.12)	1,169 of 7,898 (9.84)	0.98 (0.86–1.12)
Urbanicity	Urban	65 of 29,522 (0.14)	1 (Reference)	1 (Reference)	194 of 31,439 (0.41)	1 (Reference)	4,825 of 31,069 (10.28)	1 (Reference)	6,427 of 31,602 (7.73)	1 (Reference)	6,427 of 31,602 (7.73)	1 (Reference)	1,802 of 7,927 (7.43)	0.96 (0.85–1.08)	1,802 of 7,927 (7.43)	0.96 (0.85–1.08)
	Rural	27 of 7,644 (0.24)	1.71 (0.68–4.30)	1.13 (0.68–1.88)	63 of 7,868 (0.46)	1.13 (0.68–1.88)	1,195 of 7,825 (9.35)	0.9 (0.79–1.03)	1,802 of 7,927 (7.43)	0.9 (0.79–1.03)	1,802 of 7,927 (7.43)	0.9 (0.79–1.03)	1,802 of 7,927 (7.43)	0.96 (0.85–1.08)	1,802 of 7,927 (7.43)	0.96 (0.85–1.08)

CS, cesarean section; CI, confidence interval. Bold values indicate statistical significance ($p < .05$).

risk for newborn respiratory distress with prenatal exposure to antidepressants [16, 17, 28]. Thus, such infants may require admission to the neonatal intensive care unit (NICU) and potentially longer hospital stays. Our findings are consistent with previous research showing an increased risk of low birth weight following CS in mothers with pre-existing/gestational HBP or pre-existing/gestational depression [29–31]. There were no significant associations between CS birth defects in any of our comorbidity groups.

Interestingly, our study revealed significant variations in infant mortality and birth defects among CS deliveries by US census region. Compared to the Northeast – which had the lowest rates of infant mortality within PRAMS – mothers in the Midwest and West had significantly higher rates of infant mortality. This is in contrast to previous studies, which have reported a higher overall rate of infant mortality in the South and a higher rate among Black infants in the Midwest. However, those studies included all births, whereas our study focused specifically on CS deliveries [32]. Another study found regional discrepancies in the record keeping of both live births and stillbirths [33]. It is worth noting that the Midwest, particularly rural areas, has a higher prevalence of maternal comorbidities such as HBP and diabetes [34]. This may explain the increased risk of infant mortality in this region, despite our findings suggesting a lower risk of infant mortality among mothers with these comorbidities. In rural areas, access to healthcare, transportation to healthcare facilities, and the number of physicians are all limited, thus making prenatal care limited in these areas [35]. Further research is needed to explore the factors leading to this discrepancy in infant mortality rates following CS. Additionally, the West region had a significantly higher rate of birth defects – almost 200 % greater than any other region. A potential contributing factor is access to healthcare depending on whether the mother is located in an urban or rural area [36]. According to the CDC, as the level of urbanization increased, infant mortality decreased [36]. Although we were unable to identify a clear explanation for this finding, our data showed variations in environmental factors, ethnicity and race, and birth defect classification among different states [37, 38].

Implications for clinical practice

This study has important clinical implications of both the prevention and management of maternal comorbidities during pregnancy, as well as the importance of fetal surveillance in pregnant mothers with and without comorbidities. Our results highlight the importance of the effective treatment of maternal comorbidities before and during pregnancy to reduce the need for CS. This is supported by

previous studies showing that appropriate management of diabetes and HBP can significantly decrease the risk of CS [39]. It is noteworthy that unlike HBP and diabetes, which showed a lower rate of fetal mortality, depression had no significant outcome. This suggests that there may be potential benefit for antenatal testing in mothers with symptoms of depression and those with no comorbidities to decrease the fetal mortality rate. Additionally, monitoring for low birth weight is crucial in mothers with depression to ensure timely intervention and reduce the risk of negative fetal outcomes and infant mortality [31]. To mitigate the need for CS, providers should focus on rapid and effective treatment of diabetes, HBP, and depression in pregnant mothers. Previous studies have shown that the adequate treatment of diabetes and HBP during and before pregnancy decreases the risk of needing a CS [40–42]. As noted above, the US Midwest is at higher risk of maternal comorbidity [34]. Our findings suggest that improved treatment and care for mothers with comorbidities in the Midwest region may lead to better fetal outcomes and decrease the risk of infant mortality following CS. Against the backdrop of the recent Supreme Court ruling on *Dobbs v. Jackson Women's Health Organization* (2022), prioritizing access to comprehensive reproductive healthcare, including the management of comorbidities during pregnancy, is crucial to mitigate potential negative impacts on maternal and fetal health [43].

Policy changes to help curtail maternal comorbidities

The rising maternal mortality rates in the United States have brought attention to the urgent need for policy changes to curtail maternal comorbidities, particularly in the postpartum period. The current postpartum care model is not adequately addressing the underlying causes of maternal mortality, such as pre-existing conditions like diabetes, HBP, and depression. This is evident in the low postpartum follow-up rates, especially among marginalized populations, and the failure to effectively manage comorbidities, which can ultimately lead to CS deliveries and negative fetal outcomes. Therefore, targeted policy interventions are imperative to address health disparities and provide comprehensive support and care to marginalized birthing mothers. Timely identification and management of comorbidities, in conjunction with adequate prenatal care and postpartum visits, have the potential to reduce the need for CS and improve fetal outcomes. It is essential to ensure access to comprehensive reproductive healthcare, because this is crucial in improving maternal and fetal health outcomes and reducing health disparities.

Limitations

We acknowledge certain limitations in our study, including potential recall and response biases associated with the survey responses from PRAMS participants [44]. Further, the reason for CS could not be extracted from the PRAMS data; therefore, we were unable to determine if participants underwent an elective or emergency CS. This prevented us from determining if the comorbidity affected the negative fetal outcome or if other factors were involved. Previous studies have found that negative fetal outcomes are more prevalent in emergent CS [45]. Additionally, the low sample sizes for infant mortality may have resulted in a wider CI, potentially affecting our analysis. Furthermore, the documentation of “birth defects” on birth certificates varies among states and may not encompass all defects identifiable at birth. The underreporting of birth defects has been noted for several decades [37, 46]. Because the PRAMS database does not report specific birth defects, we were unable to extract specific defects that may have been caused by injuries due to CSs. Lastly, while our analyses focused on three specific comorbidities (diabetes, HBP, and depression), other comorbidities in the dataset may also have relevance to the risk of negative fetal outcomes following CS.

Conclusions

Our study provides evidence for a decreased risk in infant mortality following CS, but an increased rate of prolonged hospital stays and low birth weight in infants born via CS to mothers with pre-existing or gestational comorbidities. Furthermore, significant regional variations in infant mortality rates and birth defects among CS deliveries were observed, with higher rates in the Midwest and West regions of the United States. These findings underscore the importance of addressing maternal comorbidities and implementing adequate fetal surveillance to improve fetal outcomes following CS. As the prevalence of maternal comorbidities continues to rise in the United States, it is imperative to provide appropriate guidance to healthcare providers to prevent and manage these conditions. Future research in this area should consider a broader range of comorbidities to better inform clinical practice.

Research ethics: This study was not submitted for ethics review to an institutional review board oversight because it did not meet the regulatory definition of human subject research as defined in 45 CFR 46.102(e) of the Department of Health and Human Services' Code of Federal Regulations.

This study adhered to the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines.

Informed consent: Not applicable.

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