

The burden of severe hypertensive disorders of pregnancy on perinatal outcomes: a nationwide case-control study in Suriname



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BACKGROUND: Latin America and the Caribbean is the region with the highest prevalence of hypertensive disorders of pregnancy worldwide. In Suriname, where the stillbirth rate is the second highest in the region, it is not yet known which maternal factors contribute most substantially.

OBJECTIVE: The aims of this study in Suriname were to (1) study the impact of different types of maternal morbidity on adverse perinatal outcomes and (2) study perinatal birth outcomes among women with severe hypertensive disorders of pregnancy.

STUDY DESIGN: A case-control study was conducted between March 2017 and February 2018 during which time all hospital births (86% of total) in Suriname were included. We identified babies with adverse perinatal outcomes (perinatal death or neonatal near miss) and women with severe maternal morbidity (according to the World Health Organization Near Miss tool). Stillbirths and early neonatal deaths (<7 days) were considered perinatal death. We defined a neonatal near miss as a birthweight below 1750 g, gestational age <33 weeks, 5-minute Apgar score <7, and preterm intrauterine growth restriction <p3. Descriptive statistics and multivariate binary logistic regression analyses were conducted.

RESULTS: In the 1-year study period, adverse perinatal outcomes were reported for 638 singleton births of which 120 (18.8%) involved women with severe maternal morbidity. In most of these cases, the mother suffered severe hypertensive disorders of pregnancy (n=95/120, 79.2%). Severe hypertensive disorders of pregnancy were strongly associated with adverse perinatal outcomes (adjusted odds ratio, 11.1; 95% confidence interval, 8.3–14.9). The prevalence of severe hypertensive disorders of pregnancy in Suriname was 2.5% (234/9197). Of the 215 singleton pregnancies complicated by severe hypertensive disorders, adverse perinatal outcomes were reported for 44.2% of them (n=95/215; adjusted odds ratio, 11.1; 95% confidence interval, 8.3–14.9); perinatal death accounted for 18.1% of these cases (n=39/215; adjusted odds ratio, 8.6; 95% confidence interval, 5.8–12.7) and neonatal near miss accounted for another 26.0% (n=56/215). Women with severe hypertensive disorders of pregnancy had a preterm birth (<37 weeks) in 67.1% of the cases (n=143/215; adjusted odds ratio, 14.1; 95% confidence interval, 10.5–19.0), a baby with a low birthweight (<2500 g) in 62.2% of the cases (n=130/215; adjusted odds ratio, 10.8; 95% confidence interval, 8.1–14.5), and a baby with a low 5-minute Apgar score in 20.5% of the cases (n=43/215; adjusted odds ratio, 6.9; 95% confidence interval, 4.8–10.0).

CONCLUSION: In Suriname, severe hypertensive disorders of pregnancy are strongly associated with adverse perinatal outcomes, with an increased risk for preterm birth, low birthweight, low Apgar score, and perinatal mortality. Prevention, early diagnosis, and management of hypertensive disorders of pregnancy are expected to reduce perinatal deaths substantially. Recommendations to reduce perinatal deaths in Suriname include the establishment of a national health plan for the management of severe hypertensive disorders of pregnancy and the introduction of perinatal death and neonatal near miss reviews.

Key words: adverse perinatal outcome, Caribbean, eclampsia, hypertensive disorders of pregnancy, Latin America, perinatal mortality, pre-eclampsia, South America, Suriname

Introduction

Globally, >5 million babies die before or shortly after birth and many more newborns sustain severe morbidity.^{1,2}

Perinatal mortality and severe morbidity are tragic birth outcomes that are often the consequence of maternal morbidity.³ Although it is known that the

complications that cause severe maternal morbidity also contribute to adverse perinatal outcomes, the exact impact of different types of maternal morbidity

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Why was this study conducted?

This study aimed to assess the impact of severe hypertensive disorders of pregnancy on adverse perinatal outcomes in Suriname and to develop recommendations to reduce this burden.

Key findings

Severe hypertensive disorders of pregnancy increased the risk for adverse perinatal outcomes by >10 times. Compared with other severe maternal morbidities, severe hypertensive disorders of pregnancy were by far the most frequent contributor to adverse perinatal outcomes in Suriname. In this setting, severe hypertensive disorders of pregnancy increased the risk for preterm birth, low birthweight, low Apgar score, and perinatal mortality to a larger extent than reported previously in low- or middle-income countries.

What does this add to what is known?

Hypertensive disorders of pregnancy have a substantial impact on perinatal outcomes. Early detection, prevention, and management of hypertensive disorders of pregnancy are essential for the reduction of perinatal deaths.

(eg, sepsis, severe hemorrhage, or hypertensive disorders of pregnancy [HDPs]) on perinatal outcomes remains largely unknown, especially in low- and middle-income countries (LMIC).

HDPs are known to significantly increase the risk for adverse perinatal outcomes, such as prematurity, intrauterine growth restriction, and perinatal mortality.^{4–7} HDPs are associated with maternal obesity, chronic hypertension, and diabetes, all of which have been increasing in recent decades, particularly in Latin America and the Caribbean.^{8–10} Latin America and the Caribbean are regions with the highest prevalence of HDPs worldwide and HDPs are therefore expected to have a considerable negative impact on the perinatal outcomes in this region.^{6,11} Despite the magnitude of the problem, HDPs in Latin America and the Caribbean is an understudied topic, and the burden on perinatal health is poorly understood.¹²

Suriname, a middle-income country in South America, is known to have the second highest stillbirth rate (14 per 1000 births) in the region.^{13,14} However, it is not yet known which factors contribute most significantly to the adverse perinatal outcomes (perinatal mortality, preterm birth, low birthweight, low Apgar score) and how perinatal deaths can be reduced further. We hypothesized that severe HDP is the maternal

morbidity that has the largest negative impact on perinatal birth outcomes in Suriname. The objectives of this study were to assess the impact of different maternal morbidities on adverse perinatal outcomes and to study perinatal birth outcomes specifically among women with severe HDPs.

Materials and Methods
Study design

We conducted a nationwide case-control study in Suriname for 1 year from March 2017 to February 2018. We collected data from all the singleton babies with adverse perinatal outcomes and all the women with severe morbidities according to the World Health Organization (WHO) Near Miss tool. In addition, we collected data on all hospital births in Suriname (gestational age ≥ 22 weeks or birthweight ≥ 500 g). Women with and without adverse perinatal outcomes and with and without severe maternal morbidity (including severe HDPs) were studied.

Setting

Suriname is a multiethnic, middle-income country located on the north-east coast of South America with a population of approximately 560,000.¹⁵ Annually, there are about 10,000 live births in Suriname of which 86% occur

in the country's 5 hospitals, 10% occur in primary care, 4% at home, and 4% at unknown locations.¹⁶ Generally, all women with complications during pregnancy or birth are referred to the hospitals. In 2016, national, context-tailored obstetrical guidelines were developed and implemented among which was a guideline for HDPs.¹⁷ A more comprehensive description of the healthcare situation can be found in previous publications.^{14,18}

Variable definitions and outcomes

Adverse perinatal outcome. In this study, an adverse perinatal outcome is defined as a perinatal death or a neonatal near miss. Perinatal death is the sum of stillbirths and early neonatal deaths.¹⁹ A stillbirth is defined as a baby born with no signs of life (gestational age of ≥ 22 weeks or a birthweight ≥ 500 g) and an early neonatal death is defined as a baby who is born alive but then dies within the first 7 days of life.¹⁹ In the existing literature, multiple definitions for neonatal near miss exist. We use the following definition²⁰:

- a birthweight <1750 g and/or;
- a gestational age <33 weeks and/or;
- an Apgar score lower than 7 after 5 minutes and/or;
- a gestational age between 33 and 37 weeks with a birthweight under the third percentile.²¹ For this study, we added the last criterion to the existing neonatal near miss definition, because it was deemed clinically relevant in the assessment of neonatal near miss in Suriname.

Severe maternal morbidity. Different types of severe maternal morbidity were identified using the WHO maternal near miss tool.²² In concordance with this guideline, we prospectively identified all pregnant women with a potentially life-threatening complication (PLTC). PLTCs are “an extensive category of clinical conditions, including diseases that can threaten a woman's life during pregnancy and labor and after termination of pregnancy” (disease or intervention criteria).²² A PLTC

becomes a life-threatening complication (LTC) (ie, a maternal near miss [MNM]), if there are signs of organ dysfunction²² (Supplemental Table 1 provides all definitions of [P]LTC).

Severe HDP is a (P)LTC and was used as an umbrella term for severe preeclampsia and eclampsia (a more elaborate description can be found in Supplemental Table 1). Severe preeclampsia was defined as a repeated blood pressure above 160/110 mm Hg with clinical or laboratory signs of severe preeclampsia.²³ Eclampsia was defined as seizures during pregnancy and up to 14 days postpartum without another attributable cause and clinical or laboratory signs of preeclampsia.^{24,25}

Data collection

We identified all the babies with adverse perinatal outcomes using the digitalized parturition books of every hospital maternity ward. The medical files were retrieved for all perinatal deaths to extract additional variables and for in-depth case review.

Within the Suriname Obstetrical Surveillance System, all women with (P) LTCs were identified according to the WHO near miss approach.²² Medical doctors from each facility prospectively screened the medical files of discharged patients in the delivery rooms, maternity wards, and the intensive care unit weekly. Data were extracted from the medical files and digitalized anonymously in Microsoft Excel (Microsoft Corporation, Redmond, WA) and SPSS (IBM, Chicago, IL). Retrieved data included demographic information, patient history, and maternal outcomes (eg, blood loss, mode of birth, and WHO near miss organ dysfunction).²² All maternal deaths were identified and reviewed by the expert committee Maternal Mortality Suriname.¹⁸

Data for the control group, all hospital births among women without severe morbidity or without adverse perinatal outcomes, were anonymously extracted from the digitalized parturition books of every hospital maternity ward. The data were cross-checked with the paper parturition books and missing or incorrect data were corrected using the paper

medical file. The retrieved data did not include information on the use of antenatal corticosteroids, however, the administration of corticosteroids in expected premature birth (<34 weeks' gestation) is a routine procedure in Suriname.

Statistical analysis

We used IBM SPSS version 24 (IBM Corp, Armonk, NY) for data analysis. Multiple pregnancies were excluded from the analyses. We conducted descriptive data analyses for frequencies (percentages), means (standard deviation), and medians (interquartile range [IQR]) if not normally distributed. Categorical variables were analyzed using cross-tabulations and chi-square tests for significance ($P < .05$). We performed univariate logistic regression analyses to assess maternal factors associated with adverse perinatal outcomes and reported outcomes in crude odds ratios (cORs) with 95% confidence intervals (95% CIs). Possible confounders were identified by constructing causal diagrams based on existing literature and were included in the multivariable logistic regression. We performed a multivariable logistic regression to consider confounders, reported as adjusted ORs (aORs) with 95% CIs. A similar analysis was conducted to assess perinatal outcomes among women with severe HDPs in comparison with women without severe HDPs.

Ethical approval

This research was reviewed and approved by the ethical review board of the Surinamese Committee on Research Involving Human Subjects (approval number VG21-16) on October 4, 2016. No additional approval was required for the analysis of anonymous data.

Results

Over the 1-year study period, there were 9197 hospital births and 9073 singletons born. There were 445 (4.8%) women with severe morbidity (ie, PTLC) of whom 59 (13.3%, 59/445) were considered MNMs (ie, LTC) (Figure). Of the 9073 singletons, 638 babies (7.0%) experienced an adverse perinatal outcome.

Almost 1 in 5 babies born with an adverse perinatal outcome were born to women with severe morbidity (18.8%, $n=120/638$). Of these women, 79.2% ($n=95/120$) had severe HDPs. Table 1 reports the association between different types of maternal morbidities and adverse perinatal outcomes. Severe HDPs significantly increased the risk for an adverse perinatal outcome (aOR, 11.1; 95% CI, 8.3–14.9).

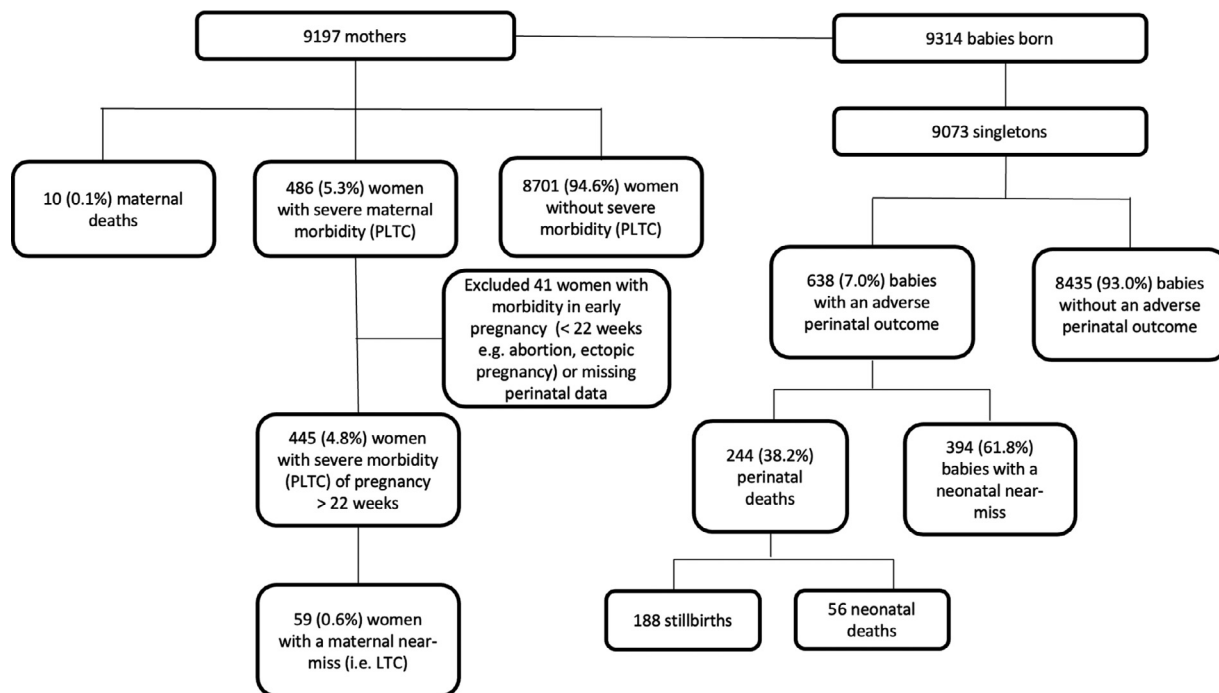
The prevalence of women with severe HDPs in Suriname was 2.5% ($n=234/9197$); severe preeclampsia occurred in 2.1% of the pregnancies ($n=189/9197$) and eclampsia in 0.5% ($n=45/9197$). Three of 10 maternal deaths were caused by severe HDPs. Table 2 presents the birth outcomes for women with a singleton pregnancy who experienced severe HDPs ($n=215$) vs those who did not experience severe HDPs. Women with severe HDPs gave birth to a baby with an adverse perinatal outcome in 44.2% of cases ($n=95/215$; aOR, 11.1; 95% CI, 8.3–14.9); 18.1% suffered a perinatal death ($n=39/215$; aOR, 8.6; 95% CI, 5.8–12.7) and 26.0% ($n=56/215$) experienced a neonatal near miss (Table 2). Stillbirth occurred in 13.5% of cases ($n=29/215$; aOR, 7.8; 95% CI, 5.0–12.2) and early neonatal deaths in 4.7% of cases ($n=10/215$). Women with severe HDPs gave birth to a preterm baby in 67.1% of the cases ($n=143$; aOR, 14.1; 95% CI, 10.5–19.0), a baby with low birthweight in 62.2% of cases ($n=130$; aOR, 10.8; 95% CI, 8.1–14.5), and a baby with a low 5-minute Apgar score in 20.5% of cases ($n=43$; aOR, 6.9; 95% CI, 4.8–10.0).

Comment

Principal findings

This nationwide study in Suriname shows a strong association between different maternal morbidities and adverse perinatal outcomes. One in 5 babies born with an adverse perinatal outcome are born to women with severe morbidities of whom the majority suffer from severe HDPs. Severe HDPs increased the risk for an adverse perinatal outcome by >10 times. In Suriname, 1 in 40 pregnant women experience severe HDPs. These women have an 18% risk

FIGURE
Flowchart of maternal and perinatal mortality and morbidity in Suriname



Overview of the maternal and perinatal mortality and morbidity numbers, of all hospital births in Suriname between March 2017 and February 2018. LTC, life-threatening complication; PLTC, potentially life-threatening complication.

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for perinatal death and 26% risk for neonatal near miss. Therefore, prevention, early detection, and improvement in the management of HDPs are crucial to improve perinatal health and are key to reducing perinatal mortality in LMICs such as Suriname.

Results in context

Previous studies in LMICs reported increased odds of having a low birth-weight neonate (aOR, 2.8–8.0), preterm birth (aOR, 2.5–3.3), neonate with a low Apgar score (aOR, 2.7–2.9), and stillbirth (aOR, 3.3–6.3) among women with HDPs^{6,7,26–28} (Supplemental Table 2). However, these odds are lower than reported in our study in Suriname. The prevalence of preeclampsia in Latin America and the Caribbean is 6.0%.⁶ However, very few studies reported the prevalence of severe HDPs in the region, nor its impact on perinatal outcomes.¹² The heterogeneous definitions

of severe HDPs hamper data comparisons (Supplemental Table 2).^{26,27,29} Nevertheless, even studies using a similar definition of severe HDPs report varying prevalences, from 8.1% (Brazil) to 0.8% (Tanzania), because effective monitoring leads to higher detection rates of severe HDPs.^{29,30}

Studies on perinatal outcomes are crucial to reduce perinatal mortality and work toward the global goal of <12 perinatal deaths per 1000 births by 2030.¹ The number of studies investigating perinatal health is rising rapidly.^{1,2,14} However, because no universal definition or outcome measure of a neonatal near miss is in place, a global data comparison is unfeasible and unachievable.^{31,32} A combined outcome measure for adverse perinatal outcomes and uniform neonatal near miss criteria are crucial for global data comparisons and are particularly useful for countries with a low number of perinatal deaths

(high-income settings and countries with a small population and a low absolute number of perinatal deaths).

Clinical implications

Previous studies showed a strong relationship between MNM and adverse perinatal outcomes and identified the need to incorporate perinatal aspects into the MNM approach.^{3,33} Although women with MNM criteria may have the greatest risk for adverse perinatal outcomes, our study showed that most adverse perinatal outcomes occurred in women who did not meet the PLTC or LTC (MNM) criteria. However, these women might suffer from “milder diseases” such as gestational diabetes or mild preeclampsia. In summary, the MNM approach should indeed integrate adverse perinatal outcomes, but perinatal death and neonatal near miss reviews also need to incorporate all maternal factors to identify both mild

TABLE 1
Maternal factors associated with adverse perinatal outcomes

Factors	Total (n)			
Births	9197			
Total singleton babies born	9073			
Singleton live births	8885			
Maternal factors	No adverse perinatal outcomes=8435 (%)	Adverse perinatal outcome ^a n=638 (%)	cOR (95% CI)	aOR (95% CI) ^b
Maternal morbidity ^c				
Severe HDP (vs women without severe HDP)	120 (1.4)	95 (14.9)	12.1 (9.1–16.2)	11.1 (8.3–14.9) ^d
ICU admission (vs women without ICU admission)	57 (0.7)	32 (5.0)	7.8 (5.0–12.1)	7.6 (4.9–12.0) ^d
Severe sepsis (vs women without severe sepsis)	19 (0.2)	13 (2.0)	9.2 (4.5–18.7)	8.2 (3.7–17.9) ^d
Severe PPH (vs women without severe PPH)	152 (1.8)	33 (5.2)	3.0 (2.0–4.4)	2.8 (1.9–4.1) ^d
WHO MNM (vs women without WHO MNM)	34 (0.4)	23 (3.6)	9.2 (5.4–15.8)	8.8 (5.2–15.1) ^d
Maternal death	3 (0.0)	6 (0.9)	—	—
Maternal age (y)				
<20 (vs ≥20)	1134 (13.5)	96 (15.1)	1.1 (0.9–1.4)	—
>35 (vs ≤35)	923 (11.0)	85 (13.4)	1.3 (0.9–1.6)	—
Missing	12	4		
Ethnicity				
African descent (vs other ethnicities)	4169 (50.2)	385 (62.8)	1.7 (1.4–2.0)	1.7 (1.5–2.0) ^d
Asian descent (vs other ethnicities)	2688 (32.4)	141 (23.0)	0.6 (0.5–0.8)	0.6 (0.5–0.8) ^d
Missing	131	25		
Parity				
Nulliparous (vs other)	2886 (34.3)	233 (36.9)	1.1 (0.9–1.3)	—
Grande multiparous (vs other)	1092 (13.0)	107 (16.9)	1.4 (1.1–1.7)	1.2 (0.9–1.5)
Missing	27	6		

aOR, adjusted odds ratio; CI, confidence interval; cOR, crude odds ratio; HDP, hypertensive disorders of pregnancy; ICU, intensive care unit; MNM, maternal near miss; PPH, postpartum hemorrhage; WHO, World Health Organization.

^a Presence of 1 of the following: perinatal death, birthweight <1750 g, gestational age <33 weeks, 5-minute Apgar score <7, or a gestational age between 33 and 37 weeks with a birthweight percentile <p3. Multiple pregnancies excluded; ^b Adjusted for maternal age, ethnicity, and parity; ^c According to WHO Near Miss Tool. Other severe maternal morbidity included cardiac disease (n=7, of which 1 had an adverse perinatal outcome), thrombo-embolism (n=4 of which 1 had an adverse perinatal outcome), and diabetic keto-acidosis (n=1 with adverse perinatal outcome); ^d Significant at a P value <.001.

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and severe maternal complications that impact perinatal health.

Although understanding the rates and trends helps to identify opportunities to prevent and manage pregnancy complications that can lead to perinatal deaths, the next step is to go beyond the numbers and introduce perinatal death reviews among women with severe HDPs. The lessons learned and the recommendations established from systematic, critical analysis of the care received in a no-blame interdisciplinary setting

provide an opportunity to implement new guidelines, improve perinatal health, and reduce adverse outcomes.³⁴

Research implications

Improving perinatal health requires an approach that includes different aspects of maternal and perinatal care. Prevention and adequate management of HDPs are essential to reduce perinatal deaths and enhance perinatal outcomes. Local recommendations based on this study can be found in the [Box](#). In

addition, evidence-based interventions that may help to reduce HDP-related morbidity include (1) improved uptake of aspirin use among high-risk pregnant women, (2) improving access to care, particularly for high-risk women in the third trimester, and (3) optimizing blood pressure management during antenatal and postnatal care.^{35–37} Lastly, we call for a universal definition for an adverse perinatal outcome to harmonize and compare data across and within diverse settings.

TABLE 2

Perinatal outcomes among women with and without severe hypertensive disorder of pregnancy

Perinatal outcomes	Women without severe HDPn (%)	Women with severe HDPn (%)	cOR (95% CI)	aOR (95% CI) ^a	P value
Total	8858	215			
Adverse perinatal outcome ^b	543 (6.1)	95 (44.2)	12.1 (9.1–16.1)	11.1 (8.3–14.9)	<.001
Stillbirth					
Total	159 (1.8)	29 (13.5)	8.5 (5.6–13.0)	7.8 (5.0–12.2)	<.001
<28 ⁰ wk	58 (36.5)	9 (31.0)			
28 ⁰ –36 ⁶ wk	68 (42.8)	19 (65.5)			
≥37 ⁰ wk	32 (20.1)	1 (3.4)			
Early neonatal deaths ^c	46 (0.5)	10 (4.7)			
Perinatal deaths ^d	205 (2.3)	39 (18.1)	9.4 (6.4–13.6)	8.6 (5.8–12.7)	<.001
Gestational age at birth					
Median (IQR)					
≤31 ⁶ wk	232 (2.6)	49 (23.0)	23.4 (15.8–34.5)	22.5 (15.1–33.6)	<.001
32 ⁰ –36 ⁶ wk	848 (9.6)	94 (44.1)	12.3 (8.9–16.9)	11.9 (8.6–16.4)	<.001
≥37 ⁰ wk	7753 (87.8)	70 (32.9)	Reference group		
Missing	25	2			
Birthweight					
Median (IQR)					
<1000 g	109 (1.2)	20 (9.6)	17.9 (10.6–30.2)	18.4 (10.7–31.5)	<.001
1000–2499 g	1013 (11.5)	110 (52.6)	10.6 (7.9–14.2)	10.1 (7.4–13.6)	<.001
≥2500 g	7692 (87.3)	79 (37.8)	Reference group		
Missing	44	6			
Apgar 1-min					
<7	427 (4.9)	59 (27.8)	7.5 (5.3–10.7)	6.7 (4.9–9.3)	<.001
>7	8347 (95.1)	153 (72.2)	Reference group		
Missing	84	3			
Apgar 5-min					
<7	291 (3.3)	43 (20.5)	7.5 (5.3–10.7)	6.9 (4.8–10.0)	<.001
≥7	8487 (96.7)	167 (79.5)	Reference group		
Missing	80	5			
Mode of birth					
Vaginal birth	6867 (77.5)	80 (37.2)	Reference group		
Cesarean delivery	11,991 (22.5)	135 (62.8)	5.8 (4.4–7.7)	6.8 (5.1–9.2)	<.001
Missing	0	0			

Data are presented as number (percentage), unless otherwise indicated.

HDP, hypertensive disorders of pregnancy; OR, odds ratio.

^a Adjusted for maternal age, ethnicity, and parity; ^b Presence of 1 of the following: perinatal death, birthweight <1750 g, gestational age <33 weeks, 5-min Apgar <7, or a gestational age between 33 and 37 weeks with a birthweight percentile < p3. Multiple pregnancies excluded; ^c Death within 7 days after birth; ^d Sum of stillbirths (gestational age >22 weeks) and early neonatal death (<7 days after birth).

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Box Local recommendations to improve perinatal health in Suriname based on the study results

- Implementing a nationwide perinatal registry to monitor trends of perinatal outcomes
- Install a perinatal death and near miss audit committee to identify underlying causes, associated maternal conditions, and modifiable factors;
- Study socioeconomic factors associated with adverse perinatal outcomes and target interventions for women at highest risk;
- Perform criteria-based audits and case reviews of severe HDPs at facility and national level to evaluate quality of care and improve outcomes for mother and child; and
- Establish a national health plan for the prevention, early detection, and adequate treatment of HDPs that include monitoring implementation strategies.

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Strengths and limitations

The strength of the study lies in its nationwide design and the prospective data collection with all uncomplicated hospital births being used as a reference group. In addition, we applied international WHO definitions, easing global comparisons. One of our limitations is that risk factors such as body mass index and socioeconomic status were not available and could not be included in the multivariate regression analysis. Another limitation is that underreporting of neonatal deaths is possible, and we could have missed a death if a baby died at home without it being reported to the hospital.

Conclusions

Severe HDPs increase the risk for adverse perinatal outcomes by >10 times. One in 5 women with severe HDPs suffers a perinatal death. These findings emphasize that prevention, early diagnosis, and management of HDPs are key components in the reduction of adverse perinatal outcomes in Suriname. A global consensus is necessary to create a universal definition for adverse perinatal outcome and harmonize data comparisons. In addition,

perinatal death and neonatal near miss audits are necessary to assess factors contributing to the large proportion of poor perinatal outcomes in women without severe maternal morbidity. ■

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Supplementary materials

Supplementary material associated with this article can be found, in the online version, at [doi:10.1016/j.xagr.2021.100027](https://doi.org/10.1016/j.xagr.2021.100027).

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