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Risk Factors Associated with Unsuccessful Vaginal Birth after One Cesarean (VBAC-1) in Puerto Rico

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Abstract

Background: Cesarean section (CS) has increased steadily over the last decade, with an estimated one-third of women delivering by cesarean section worldwide. **Objective:** Our study aimed to investigate the demographic and associated factors influencing vaginal birth after one cesarean (VBAC-1) success focusing on variables like pre-pregnancy BMI, diabetes, hypertension, education, and smoking. **Study Design and Methods:** In this retrospective study, we analyzed 285 cases (81 unsuccessful VBAC-1, 204 successful VBAC-1) from San Juan City Hospital (Puerto Rico) between January 1, 2019, and December 31, 2020. We used odds ratios and model selection comparison to assess the impact of variables on successful VBAC-1, using a significance threshold of 95% CI. Model selection assessed binomial model combinations using a generalized linear approach to identify key risk factors. **Results:** Unsuccessful VBAC-1 (a repeat cesarean), was associated with diabetes (OR: 0.376, p = 0.086), hypertension (OR: 0.23, p = 0.006), and university-educated women (OR: 1.372, p = 0.711). High school-educated women had an OR of 3.966 (p = 0.105), while overweight women were 0.481 times more likely to have unsuccessful VBAC-1 (p = 0.041). Significant associations were not found with obesity (OR: 0.574, p = 0.122), underweight/normal (OR: 1.01, p = 0.810), or smoking (OR: 1.227, p = 0.990). **Conclusion:** Results revealed women with higher education levels, hypertension, or diabetes are less likely to have a successful VBAC-1. Understanding the complex interactions affecting these outcomes is aimed at establishing guidelines for healthcare professionals to conduct systematic risk/benefit assessments. This study lays a foundation for evidence-based practices and policies, offering initial insights into VBAC-1 success factors in Puerto Rico.

Keywords

Diabetes, Hypertension, Obesity, Trial of Labor, Vaginal Birth after Cesarean

1. Introduction

Cesarean section (CS) has increased steadily over the last decade, with an estimated one-third of women delivering by cesarean section worldwide [1] [2]. In fact, before the 1970s, the standard of obstetric practice was "once a cesarean, always a cesarean." This statement has been largely ingrained into popular belief and obstetric practice today. Unsurprisingly, a common factor responsible for the high increase in CS rates is attributed to the continued CS after a prior CS [3] [4]. When indicated, CS can be effective at preserving neonatal life and preventing life-threatening maternal complications [4] [5] [6]. However, unnecessary or repeated C-sections can increase the maternal risk for uterine rupture, infection, and peripartum hysterectomy [7]. While there have been global efforts to decrease the number of CS, the World Health Organization's (WHO) [6] [8] recommendation that the rate should be around 10% to 15% for the best outcomes for mothers and newborns has not been met, with current rates surpassing the ideal acceptable range. These patterns are expected to persist over the next decade, with unmet needs and overuse anticipated to coexist, resulting in a projected global cesarean section rate of 29% by 2030 [8].

Vaginal birth after a cesarean (VBAC) is a method that has yet to gain familiarity and is an unknown topic for most women who are exploring delivery options. According to the American College of Obstetricians and Gynecologists (ACOG), most women with a previous cesarean delivery and low-transverse incision are candidates for trial of labor after a cesarean (TOLAC) [9] [10]. A TOLAC involves a deliberate effort by a woman with a prior cesarean to attempt a vaginal delivery. Indeed, VBAC has been acknowledged as a viable alternative to opting for another CS. According to the CDC, the VBAC rate for women with a previous cesarean section increased from 12.4% in 2016 to 13.3% in 2018, reflecting a 7% increase over three years [11]. Additionally, a cohort study using natality data files from the US Vital Statistics Data found that VBAC rates rose from 68.5% in 2010 to 74.3% in 2019 [12]. This study also revealed that TOLAC occurred in 21.9%, 7.1%, and 4.8% of deliveries for women with one, two, and more than three previous cesarean sections, respectively. Among those attempting TOLAC, VBAC was achieved in 73.5% of deliveries for women with one previous cesarean, 56.6% for those with two, and 48.6% for those with more than three previous cesarean sections [12].

Some notable advantages of VBAC include a reduction in maternal mortality and associated risks related to this procedure, such as infections, thromboembolic events, and transfusions, among others [13] [14] [15] [16]. A successful VBAC occurs after a TOLAC and results in favorable and uncomplicated vaginal

birth [6] [13]. It is also linked to reduced blood loss and fewer respiratory issues in the newborn, along with the benefit of a shorter hospital stay and faster recovery. Contrarily, an unsuccessful VBAC occurs when an attempted TOLAC is not successful, leading to either a CS or requiring a laparotomy due to uterine rupture or the emergence of fetal distress [2] [9] [17]. An unfavorable VBAC is associated with increased risks for both the mother and the fetus [2] [4] [6] [18]. Therefore, it is crucial to investigate which risk factors are associated with unsuccessful VBAC to present VBAC as a safe alternative for delivery.

To date, several practice guidelines have been provided for VBAC; however, these differ across countries [6] [10] [19] [20]. In the United States, the ideal candidates for VBAC, with the lowest risk of uterine scar separation during TOLAC, have one prior low transverse uterine incision [7]. While previous observational studies have coincided that factors such as obesity (body mass index [BMI] > 30), diabetes, and hypertension are associated with an increased risk for unsuccessful VBAC [4] [5] [6], the current American College of Obstetrics and Gynecologists (ACOG) guidelines have not addressed these factors in association with TOLAC or successful VBAC [7] [10]. A retrospective study utilizing data from three Nigerian University Teaching Hospitals found that the lack of previous vaginal birth, induction of labor, and preterm birth were significant risk factors for VBAC failure [21]. In contrast, a study in Iran identified prolonged labor, declining fetal heart rate, and arrest in the second phase as primary reasons for failed VBAC [22]. A retrospective study in China reported an 87.3% success rate for TOLAC, noting that preeclampsia, labor induction, advanced gestational age, and increased fetal weight significantly decreased the chances of successful VBAC [23]. In Ethiopia, where the VBAC rate was 35.07%, fetal distress was a key factor in VBAC failure [23]. Other studies from countries such as Nigeria, India, Thailand, Vietnam, and Iraq reported VBAC success rates exceeding 50% [24]. These variations can be attributed to differences in maternal healthcare services, the availability of necessary supportive materials for immediate management, medical practices or techniques, and the use of epidural analgesia, which is more common in developed countries [24].

Regrettably, the CS rate is experiencing a notable and concerning increase on a global scale [8] [25] [26]. In Latin America and the Caribbean, 40.5% of the births were delivered by CS in 2014 [25]. In Puerto Rico, between 1996 and 2002, there was a significant rise in total and primary cesarean rates by 45%, while the VBAC rate stood at 3.6% [26]. The cesarean delivery rate ranged from 46.3% to 48.4% from 2010 to 2018, and it continued to rise steadily each year (2.5% per year) from 2019 to 2022, reaching 50.5% of all births in 2022 [27]. Medically unnecessary cesarean sections significantly impact both the short-term and long-term health of patients and place a heavy burden on an already strained healthcare system, making this a public health concern. The privatization of the public healthcare system appears to be a driving factor behind the rise in cesarean sections, as epidurals are not routinely covered by health insurance, and

scheduling cesarean sections reduces the risk of litigation. In addition, thousands of physicians have migrated off the island for areas with better pay and resources, exacerbating the problem by creating a shortage of personnel to assist with emergent deliveries [28]. Consequently, doctors often prefer scheduling cesarean sections to ensure they have adequate resources and personnel available. In fact, Puerto Rico's health department has reported that more than half of cesarean sections were not medically justified, and 80% of women undergoing a cesarean section had no risk factors [29]. The rise in CS rates for repeat CS prompted our group to investigate whether factors such as pre-pregnancy BMI, diabetes, hypertension, and smoking might be linked to an unsuccessful VBAC after one CS (VBAC-1) in Puerto Rico. This is particularly relevant due to the high prevalence of these health conditions within this population. Until now, limited studies in the USA and Puerto Rico have compared the risks of VBAC and repeat CS [7]. We aim to provide insight into possible risk factors associated with an unsuccessful VBAC in Puerto Rico, thus contributing to the specification of current obstetric guidelines for TOLAC.

2. Methods

2.1. Study Design

This retrospective study compared the outcomes of successful and unsuccessful VBAC attempts in women who expressed a preference for VBAC. A successful VBAC was defined as an uncomplicated vaginal birth after TOLAC in women with one previous CS (VBAC-1), whereas an unsuccessful VBAC-1 was described as a repeat cesarean after TOLAC. The data were obtained from the medical records of the San Juan Medical Hospital (SJCH), located in a large metropolitan area in San Juan, Puerto Rico. We identified 285 records (81 unsuccessful and 204 successful VBACs) from January 1, 2019, to December 31, 2020, for the study, all of which pertain to women who desired VBAC.

2.2. Data Collection

The data was collected from the patient's medical records after approval from the Hospital and the San Juan Bautista IRB # EMSJBIRB-12-2021. The information of interest included the following socio-demographic characteristics: age, level of education (defined as university level or less), behavioral factors impacting pregnancy such as smoking, and medical factors affecting pregnancy: BMI, hypertension, and diabetes. BMI and hypertension data were extracted solely from existing medical records. These measurements were not taken or recorded by the investigators during the study. Pre-pregnancy BMI was categorized into four groups based on the ACOG guidelines for BMI weight categories. BMI is calculated as the weight in kilograms divided by the height in meters squared as the unit of measurement. The pre-pregnancy weight category was also extracted from the medical record. The classifications include underweight, normal weight, overweight, and obese [30], as outlined in **Table 1**.

Table 1. Recommended weight gain for pregnancy [30]

Pre-pregnancy Weight Category	BMI (kg/m²)	Recommended Range of Total Weight Gain (lb)	Recommended Rates of Weight Gain in the Second and Third Trimesters (lb) (Mean Range [lb/wk])
Underweight	<18.5	28 - 40	1 (1 - 1.3)
Normal weight	18.5 - 24.9	25 - 35	1 (0.8 - 1)
Overweight	25 - 29.9	15 - 25	0.6 (0.5 - 0.7)
Obese (of all classes)	≥30	11 - 20	0.5 (0.4 - 0.6)

2.3. Inclusion and Exclusion Criteria

For this retrospective cohort study using medical records to examine the risk factors associated with failed VBAC, the inclusion criteria were as follows: records of women of childbearing age over 19 who attended San Juan City Hospital for a VBAC between January 1, 2019, and December 31, 2020. The medical records needed to include detailed information on maternal demographics such as age, marital status, and education, along with obstetric medical history, BMI, gestational weight change, history of hypertension and diabetes, and tobacco exposure. Only complete records with comprehensive data on both successful and failed VBAC attempts were included.

The exclusion criteria for this study included records of women 18 years old or younger, women who did not undergo a VBAC at San Juan City Hospital between January 1, 2019, and December 31, 2020, and women who underwent VBAC at San Juan City Hospital but did not have complete records with the variables studied in this research. This selection process ensured that the study focused specifically on identifying risk factors pertinent to the success or failure of VBAC attempts based on comprehensive and reliable medical record data.

2.4. Data Analysis

The study's statistical power was determined using the Open-Epi program to detect an odds ratio greater than two at a 95% confidence level, which would establish a statistically significant difference between the unsuccessful and successful VBACs. The odds ratio for pre-pregnancy BMI, diabetes, hypertension, level of education, and smoking in association with unsuccessful VBAC-1 was calculated with the *odds ratio* function from the R *question* package [31] posterior to evaluating the binomial model with all variables included. We assessed the significance of each variable concerning the success of VBAC-1 through Multinomial Logistic Analysis and a binomial response using generalized linear models (GLM). All combinations of models were compared using the Bayesian Information Criterion (BIC), also known as the Schwarz Information Criterion, to determine the most parsimonious model [32] [33]. This model achieves a balance between simplicity and explanatory power, providing an adequate explanation of the data while using the fewest possible predictor variables or pa-

rameters. To accomplish this, multiple models with a BIC of less than 2 are considered equally parsimonious and significantly different from models with a BIC larger than 2 [26]. The benefit of using an information criterion approach is that it penalizes complex explanations and considers sample size. The most parsimonious model(s) are those that effectively explain the optimal response variable by utilizing the best combination of variables while minimizing unnecessary complexity. Model comparisons were performed in R using the *glm* function with a binomial response variable and the *dredge* function from the MuMIm package for comparing all combinations of models [33] [34].

3. Results

Our study examined 285 medical records, 81 unsuccessful VBAC-1s, and 204 successful VBAC-1s, all of whom expressed a desire for VBAC. Among the 285 women of childbearing age who underwent TOLAC between 2019 and 2020, it is noteworthy that the rate of successful VBAC was significantly higher (72%), compared to the 28% rate of unsuccessful VBAC. Most women fell within the age range of 25 - 30, accounting for 43.9%. Around 50.5% identified themselves as single, while 41.1% were married. Table 2 shows that nearly half of the women (49.8%) had completed high school or attained a higher level of education. After assessing the variables under investigation, we found only three women in our sample were smokers. Due to this extremely limited sample size, we opted not to include this variable in subsequent analyses.

Table 2. Demographic characteristics of unsuccessful and successful VBAC. Data shows frequency and percentage by groups.

	Unsuccessful VBAC	Successful VBAC	Percent of Subject (%)
Age (years)			
19 - 24	13	29	14.0
25 - 30	33	91	43.9
31 - 35	29	53	28.8
36 - 40	4	25	10.2
40 - 44	4	25	2.8
45+	2	6	0
Marital Status			
Married	31	108	41.1
Single	49	95	50.5
Divorced	1	0	0.4
Widowed	0	1	0.4
Education			
High School	28	115	50
Higher Education	53	89	50

In our study, we investigated the impact of pre-pregnancy BMI, hypertension, diabetes, and education level on unsuccessful VBAC-1. Table 3 presents the details of this analysis. We found several factors associated with this outcome. Table 4 illustrates that women with hypertension were 0.231 times more likely to experience an unsuccessful VBAC-1 (CI: 0.084 - 0.061, $p < 0.05$) compared to those without hypertension. Similarly, women with diabetes were 0.376 times more likely to experience an unsuccessful VBAC-1 compared to those without diabetes. Using the definitions presented in Table 1, pre-pregnancy BMI was determined before pregnancy, and women were categorized into BMI groups. Among those attempting a VBAC-1, 42% were classified as underweight or normal weight. Due to the small number of underweight women (11 individuals), we combined them into one group. Additionally, 28% of women were overweight, while 29% were obese within the same cohort.

Table 3. Frequency of unsuccessful and successful VBAC stratified by risk variables. A chi-square test with Yayes's correction and the type alpha error are shown.

Variable	Unsuccessful VBAC-1	Successful VBAC-1
Diabetic	10	7
Non-Diabetic	71	197
	$x^2 = 6.70$	$p < 0.01$
BMI - Underweight	2	8
BMI - Normal	22	89
BMI - Overweight	25	55
BMI - Obese	32	52
	$x^2 = 8.56$	$p = 0.04$
Hypertension - No	68	195
Hypertension - Yes	13	9
	$x^2 = 9.45$	$p < 0.01$

Table 4. Odds ratio comparing variables and unsuccessful VBAC-1. Variables in bold are significant. The null odds ratio for diabetes is not equal to one, indicating a non-diabetic condition. In contrast, the null for BMI is one, suggesting no significant association. Similarly, the null model for hypertension does not involve having hypertension.

Category	Odds Ratio	95% CI	P value
Diabetes - Yes	0.376	0.118 - 1.136	0.086
Age	1.027	0.971 - 1.088	0.358
High School Education	3.966	0.758 - 21.46	0.105
University Education	1.372	0.252 - 7.37	0.711
BMI - Overweight	0.481	0.236 - 0.969	**0.041**
BMI - Obese	0.574	0.282 - 1.163	0.122
BMI - Underweight and Normal	1.227	0.236 - 8.784	0.810
Hypertension - Yes	0.231	0.084 - 0.061	**0.003**

Table 4 shows that when comparing the variables independently, women with a BMI in the overweight category were 0.481 times more likely to have an unsuccessful VBAC-1 than women with a normal BMI. While the observed odds ratio was 0.574 (p-value: 0.122) for obese women, the study did not reveal significant outcomes for an unsuccessful VBAC-1 among this subgroup. Additionally, we found no significant association with an unsuccessful VBAC-1 for the following variables: smoking and BMI underweight/normal category. Irrelevant to the age of the mothers, having hypertension reduces the likelihood of a successful VBAC (GLM logistic link, df = 283, $p < 0.001$).

Model Selection Analysis of Multinomial Logistic Analysis of Factors Predicting VBAC-1

We assessed 256 distinct models, each comprising various combinations of variables. Among these, only two models were most parsimonious and had a delta BIC (difference from the best model) of less than two. These models exclusively incorporated variables for hypertension, diabetes, and education level. The next model had a delta BIC of 3.23, which was significantly less parsimonious and included only the intercept. The worst model included all of the variables and had a delta BIC of 42.01. The first two models accounted for a total weight (a measure of those models' relative fit compared to all the others) of 54% of the variation, indicating strong support for these two models. Using these two models, we calculated the mean coefficient and its 95% CI.

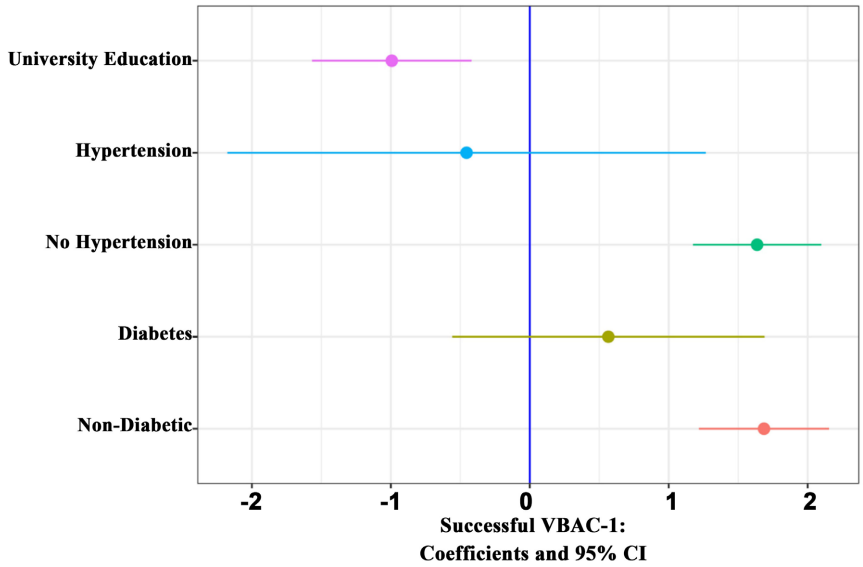

Figure 1. Average coefficients of the two best models from 256 models evaluated and their 95% confidence intervals from a multinomial logistic regression with a response variable having a successful or unsuccessful VBAC. Variables that do not overlap the 0 (the center) are significant.

Women with higher education levels (university and above) exhibit a reduced likelihood of experiencing a successful VBAC. Similarly, women with hyperten-

sion or diabetes also display a decreased probability of achieving a successful VBAC, as illustrated in **Figure 1**. Note that we could not evaluate the interaction among variables because of the limited sample sizes.

4. Discussion

We provide insight into possible risk factors associated with unsuccessful VBAC-1. Our findings suggest that in Puerto Rico, women with diabetes, hypertension, and higher education levels were less likely to have a successful VBAC-1, defined as an uncomplicated vaginal birth after a trial of labor after a cesarean (TOLAC) in women with one previous CS. Previous research has consistently demonstrated an inverse relationship between increasing BMI, particularly pre-pregnancy BMI > 30, and the success of a TOLAC [4] [5] [6] [7]. However, when comparing BMI, smoking status, educational level, history of diabetes, and history of hypertension, our study demonstrates no statistically significant findings regarding the impact of BMI on VBAC success in our population. This finding can be attributed to various factors, such as a limited sample size, dietary variations among women in Puerto Rico, or the influence of specific health conditions that, when stratified by BMI, did not reveal a significant correlation. Furthermore, our results may differ from previously published analyses because of the "omitted variable bias," where the inclusion or exclusion of specific variables may result in an underestimation or overestimation of the relative importance of variables [35] [36] [37].

Our study revealed a notable impact of hypertension on VBAC success rates, consistent with the findings of existing literature emphasizing the influence of health conditions on this outcome [9]. Specifically, hypertension emerged as a significant factor associated with lower TOLAC and VBAC success rates [9]. This observation aligns with a recent study conducted by Levin *et al.*, which reported a 59% lower success rate in hypertensive pregnancies compared to non-hypertensive cases [9]. Notably, Levin *et al.*'s study also highlighted a higher prevalence of elevated BMI and diabetic disorders among hypertensive mothers when contrasted with the non-hypertensive cohort [9]. Their findings suggest that factors such as diabetes, obesity, and hypertension should be taken into account when evaluating a patient's prospects for a successful VBAC, while our results suggest that diabetes and hypertension are the most likely variables that influence a successful VBAC.

Moreover, previous research consistently associates both pregestational and gestational diabetes with lower rates of successful VBAC [6] [38] [39] [40]. In a secondary analysis conducted at 19 medical centers examining women attempting VBAC, over 600 diabetic women were assessed, revealing a VBAC success rate of 64% within this group, in contrast to a higher success rate of 73.6% among non-diabetic women in the initial cohort [40]. Additionally, in a retrospective study, women with pre-existing diabetes and neonates with excessive birth weight had notably reduced odds of attempting TOLAC, with odds ratios

of 0.664 for TOLAC and 0.503 for VBAC [40]. Up until now, ACOG has not addressed the specific issue of TOLAC in patients with diabetes or hypertension. More research is needed to develop specific guidelines to predict the success of TOLAC in women with diabetes and hypertension.

In our study, we identified education level as a key determinant influencing the success of VBAC-1. Notably, women with a high school education were 3.96 times more likely to achieve a successful VBAC-1, whereas those with a university education were 1.372 times less likely. Although there is limited literature on how education may influence VBAC success rates, we believe this discrepancy may be attributed to the healthcare education of prospective mothers, socioeconomic status, and cultural factors affecting access to healthcare delivery systems, particularly in the United States (Puerto Rico), compared to other countries.

For instance, while it may seem counterintuitive, individuals with higher education levels might have access to more healthcare information, including potential risks associated with VBAC. This increased awareness may lead them to opt for repeat cesarean sections rather than attempting VBAC, especially if they perceive the risks to be higher than they actually are. Additionally, there may be biases among healthcare providers towards recommending repeat cesarean sections over VBAC for individuals with higher education levels. Providers might overemphasize the risks of VBAC or lack confidence in their ability to support a successful VBAC attempt, leading to lower rates of VBAC among this demographic.

In Puerto Rican culture, traditional beliefs may favor cesarean sections over VBAC, even among individuals with higher education levels, as observed in the study by Edmonds, Hawkins, and Cohen [41]. Although higher education levels may correlate with proficiency in English, language barriers still exist on the island. Cultural stigma and fear of complications may also lead to a preference for repeat cesarean sections. Additionally, family and community influence can significantly shape childbirth decisions.

Furthermore, this observation may be viewed through a socio-economic lens, considering the social perception of the value of VBAC and potential differences in the education or perception of obstetricians. The decision for more educated women to opt for a cesarean section instead of a VBAC may also be influenced by job constraints among women with lower socioeconomic status. Higher education often correlates with higher socioeconomic status, which can impact healthcare decisions. Individuals with higher income levels might have better access to healthcare resources, including the option for elective cesarean sections. Additionally, they may have more flexible work schedules, allowing them to choose the timing of childbirth, which could influence their decision to attempt VBAC. We also lack information on whether expectant mothers with higher education opted for alternative birthing processes later in pregnancy, potentially contributing to differences in the rates of unsuccessful VBACs.

It is essential to gain a comprehensive understanding of how these factors col-

lectively impact the outcome of TOLAC. Such insights into these influential variables can play a pivotal role in reducing cesarean section rates and mitigating the maternal and fetal comorbidities associated with unnecessary surgical procedures.

Study Limitations

Finally, although our study adds valuable insights to the existing body of knowledge on risk factors for unsuccessful VBAC, it is constrained by certain limitations. When investigating the risks associated with failed VBAC using data obtained from medical records, both selection bias and informational bias can significantly influence the study's findings. This study has potential selection bias, as the data were derived from a single hospital in Puerto Rico, out of the twenty-eight available on the island [42]. Additionally, if the records primarily include patients who regularly seek medical care, the data might miss out on those who avoid or have limited access to healthcare, potentially underestimating risks in less monitored populations. This small sample size may not accurately reflect the associated risk factors for successful VBAC-1 in Puerto Rican women.

Furthermore, medical records were exclusively used to obtain weight measurements, leading to potential information bias, including self-reported and measurement biases, which could limit the accuracy of the BMI results. Therefore, selection and informational biases must be carefully addressed to ensure the study accurately reflects the true risks associated with failed VBAC. Additionally, the absence of a one-to-one ratio between cases and controls, along with the relatively modest sample size, inherently constrained the statistical power of our study.

5. Conclusions

In conclusion, our study sheds light on several risk factors associated with unsuccessful VBAC-1 in Puerto Rico, including variables such as hypertension, diabetes, and educational level that emerged as key determinants of VBAC success. These findings underscore the importance of considering specific health conditions and socio-economic factors when evaluating a patient's likelihood of a successful VBAC. However, our study's reliance on data from a single hospital in Puerto Rico and its modest sample size limit the generalizability of our findings. Further research with a larger, more diverse population is needed to develop more precise guidelines for predicting VBAC success in women with comorbidities, including a closer understanding of the impact of educational status on VBAC outcomes.

Additionally, future longitudinal studies tracking VBAC outcomes over time could provide more insight into the factors that most significantly impact VBAC success rates. Another approach worth exploring is the impact of strengthening pelvic floor muscles to increase VBAC success rates in different populations. This technique can help treat residual tissue along the cesarean scar, reduce the

chances of vaginal tearing during delivery, and give women better control over those muscles during delivery, making it easier for them to relax that region [43]. This intervention could potentially reduce one of the contributing factors to unsuccessful VBACs.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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