Impact of Prenatal Visit Utilization on Pregnancy Outcomes within Differing Risk Populations

A thesis submitted to the University of Arizona College of Medicine – Phoenix
in partial fulfillment of the requirements for the Degree of Doctor of Medicine

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Class of 2021

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Abstract

Objectives: To investigate the association between number and timing of prenatal visits (PNV) and pregnancy outcomes within differing maternal risk populations [non-high-risk ("non-HR") and high-risk ("HR")].
Methods: Retrospective study of mothers who delivered at Banner University Medical Center Phoenix during the 2017 calendar year. Inclusion criteria included maternal documentation at time of delivery of either: complete absence of PNV or complete PNV records. Maternal groups were either classified as "non-HR" or "HR" if received any of the following diagnoses: advanced maternal age (AMA), obesity, diabetic (DM) disorders, hypertensive (HTN) disorders, or asthma. Data collection included total PNV quantity per pregnancy and trimester. Pregnancy outcomes included labor interventions, labor complications, delivery complications, and adverse neonatal outcomes.
Result: Of 503 mothers in the cohort, 324 met inclusion criteria and were evenly split between non-HR (159, 49.07%) and HR mothers (165, 50.93%). Pregnancy outcomes were then compared within same risk group depending on total pregnancy PNV utilization category [low (≤8 PNV), mid (9-11 PNV), and (≥12 PNV] and frequency of PNV per trimester ("T1," "T2," or "T3"). Non-HR mothers with a higher total PNV category were more likely to have labor interventions (odds ratio [OR] 4.02; 95% confidence interval [CI] 1.26-12.9, p = 0.019). Non-HR mothers with higher quantities of PNV in T3 were less likely to have labor interventions (OR 0.69; 95% CI 0.48-0.98, p = 0.039). HR mothers with higher PNV quantities in T1 and T2 were less likely to have labor interventions (T1: OR 0.34; 95% CI 0.13-0.91, p = 0.032) (T2: OR 0.42; 95% CI 0.21-0.84, p = 0.015). HR mothers with higher quantities of PNV in T2 were less likely to have labor complications (OR 0.70; 95% CI 0.51-0.98, p = 0.043).
Conclusions for Practice: Labor interventions were less likely found by non-HR mothers with higher quantities of PNV in T3 and by HR mothers with higher quantities of PNV in T1 and T2. Labor interventions were more likely found by non-HR mothers with a higher total PNV category. Labor complications were less likely found by HR mothers with higher quantities of PNV in T2. Limitations include small sample size and study would therefore benefit from further investigation. Anticipated clinical benefits could include contributing to the development of tailored PNV recommendations dependent on maternal health history ultimately resulting in increased cost savings, decreased unnecessary interventions, and decreased poor outcomes.

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Significance

"What is already known on this subject?
PNV utilization is known to be positively associated with labor interventions and lacks significant association with various pregnancy outcomes within low-risk and all-risk maternal populations, but little is known within the HR maternal populations.

"What this study adds?
This study therefore seeks to close the gaps in the literature by examining a larger breadth of maternal health conditions and pregnancy outcomes than past studies (see methods section).

Keywords Prenatal Care High-Risk Pregnancy Pregnancy Outcomes Obstetric Labor Complications

Objectives

Prenatal Care Defined and Current Recommendations/Guidelines

Prenatal care (PNC) can be defined as specialized medical care provided throughout pregnancy. PNC functions include not only providing education and support for women, but also early detection and management of pregnancy related health problems (ex: gestational diabetes (GDM), hypertensive disorders of pregnancy, etc.) (of Obstetricians et al., 2012). However, the recommended number and frequency of PNV is of some debate. The standard schedule recommended by ACOG (2012), includes a visit before 14 weeks, followed by visits every four weeks for the first 28 weeks, then every two to three weeks until 36 weeks, and finally every week until delivery. This would result in a recommended total range between 12-13 PNV for full term pregnancies. This is in contrast to the World Health Organization (WHO) (2016) who has recently increased their recommended routine PNV from 4-8 over the course of the pregnancy with initial contact <12 weeks, follow up at 20 weeks, and then visits every 4 weeks until delivery.

PNV and Pregnancy Outcomes: Overview

Early and regular PNV has been shown to be globally beneficial with a number of studies demonstrating a correlation between fewer visits and increased poor pregnancy outcomes. For example, a cross-sectional retrospective study in Angola found inadequate PNV (defined as <4 visits) was significantly associated with small for gestational age (SGA) and preterm delivery (Nimi et al., 2016). Additionally, a study in Finland found that pregnancies with PNV ranging from 0-5 had increased risk for SGA, fetal death, and neonatal death compared to pregnancies with ≥6 PNV (Raatikainen et al., 2007).

PNV and Pregnancy Outcomes: Low Risk Mothers

There still, however, remains controversy in the medical field regarding the effectiveness of the number of recommend PNV. Criticism includes studies which demonstrate that adverse pregnancy outcomes are either not correlated with number of PNV and/or that number of labor interventions increase as number of PNV increase in low-risk pregnancies (Carter et al., 2016; Goss et al., 1997). For example, a retrospective cohort study Carter et al. (2016) of 7256 subjects at Barnes-Jewish Hospital in St. Lewis, Missouri found no difference in adverse pregnancy outcomes such as neonatal intensive care (NICU) admission, low 5 minute APGAR score (<7), and low umbilical cord pH (<7.10) when compared with patients with 10 PNV. This study additionally demonstrated that patients with >10 PNV were more likely to undergo pregnancy interventions such as induction of labor and cesarean delivery. A similar retrospective study Goss et al. (1997) of 783 Hispanic women in California found no statistical difference in number of PNV (defined as ≥ or <4 visits) and pregnancy, labor, or postpartum complications.

PNV and High Risk Mothers: Recommendations/Guidelines

For the high risk/medically complicated pregnancies, ACOG (2012) generally recommends an increase in number and frequency of PNV. However, there currently is no consensus of how many additional PNV should be recommended or how this would change dependent on the patient's medical history (ex: how many additional visits for mother's with GDM versus hypertensive disorders). PNV quantity and frequency is therefore left up to the discretion of the provider.

High Risk Mothers and Pregnancy Outcomes

High risk pregnancy populations are generally associated with increasing adverse labor and neonatal outcomes (Bramham et al., 2014; Blickstein et al., 2018; Marozio et al., 2019). For example, a recent meta-analysis (Bramham et al., 2014) involving 55 studies and 795,221 pregnancies found that women with chronic HTN had high pooled incidences of superimposed preeclampsia, cesarean section (c-section), preterm delivery <37 weeks' gestation, birth weight <2500g, neonatal unit admission, and perinatal death when compared with women without chronic HTN. Additionally, GDM, pre-gravid maternal obesity, and combined "diabesity" are also more frequently associated with adverse pregnancy outcomes such as increased risk of preeclampsia for those with "diabestity" and increased risk of preterm delivery <33 weeks, high birth weight (>4000g), low 5-minute APGAR scores, and NICU admissions (Blickstein et al., 2018). AMA is similarly associated with poor outcomes such as higher rates of early-onset preeclampsia, placenta previa, SGA (<2500g) and GDM when compared to mothers <40 years old (Marozio et al., 2019).

PNV and Pregnancy Outcomes: High Risk Mothers

Due to the general increase in poor outcomes in mother's with higher risk health histories, it follows that increased number of PNV would allow for increased surveillance and management of high risk pregnancy health problems (ex: counseling on weight management for obesity, blood glucose control for DM, and blood pressure control for HTN disorders).

The few studies that have been conducted to examine this relationship show results suggestive of improved outcomes with increased number of PNV for individual medical conditions. For instance, Barbosa et al. (2015) evaluated 1501 women with hypertensive disorders of pregnancy (HDP) and found that mothers with incomplete PNC (defined as <6 PNV) had higher maternal and neonatal mortality rates along with greater frequency of near miss cases when compared to mothers with >6 PNV. Additionally, a 4-year prospective cohort study of women with GDM and DMII found that mother's with higher numbers of PNV (≥15) were 85% less likely to deliver an infant requiring a NICU admission and 59% less likely to undergo a premature delivery when compared to mother's with lower numbers of PNV (≤8) (Carter & et al., 2017).

Significance, Impact, and Rational

It should be noted that complicating the analysis of the outcomes of PNV is the fact that the few studies which examine this question all have differing adverse pregnancy outcome variables (ex: only one study via Goss et al. (1997) included shoulder dystocia and cord prolapse as variables collected) and differing ranges/cutoffs for number of "adequate" PNV (ex: > or ≤ 10 PNV versus ≥ or <4 PNV (Nimi et al., 2016). This study therefore seeks to close the gaps in the literature by examining a larger breadth of maternal health conditions and pregnancy outcomes than past studies (see methods section).

Hypotheses:

1. Higher quantities of PNV will be associated with lower number of labor interventions and adverse pregnancy outcomes for HR mothers with past medical histories significant for any of the following: AMA, asthma, DM disorders, hypertensive disorders, and/or obesity.
2. Higher quantities of PNV will be associated with higher number of labor interventions and have no correlation with adverse pregnancy outcomes for non-HR mothers.

Methods

This study utilized retrospective cohort analysis of chart review from mothers delivering at Banner University Medical Center Phoenix (BUMCP) from dates ranging from 1/1/2017 – 12/31/2017. This research was conducted in accord with prevailing ethical principles and has received approval by the Institutional Review Board at University of Arizona College of Medicine Phoenix.

Inclusion criteria included maternal documentation at time of delivery of either one of the following: complete absence of PNV or complete PNV records (either at Banner University Medicine Women's Institute, other clinic, or combination due to transfer of care). Exclusion criteria included: any missing PNC records, multiple gestation pregnancy, maternal age <18 years old, or known fetal anomalies.

Maternal groups were either classified as (1) "non-HR" or (2) "HR" for documentation showing any of the following diagnoses: AMA (defined as maternal age ≥35 at time of due date), obesity (BMI ≥30 pre-pregnancy), DM disorders (DM Type 1 or 2, or GDM), hypertensive disorders (chronic HTN (C-HTN), gestational HTN (G-HTN), preeclampsia (with/without severe features or superimposed CHTN/GHTN), eclampsia) or asthma.

Data collection included number of total PNV, gestation/trimester of initiation of PNV, and frequency of PNV per trimester. Total PNV was additionally stratified into based off (1) missing (≤8 PNV), (2) approaching (9-11 PNV), or (3) meeting (≥12 PNV) total recommended 12-13 PNV by ACOG (2012). A PNV was defined as any scheduled visit with an obstetric provider in an outpatient setting during pregnancy and excluded appointments solely for antenatal testing, ultrasound, or confirmation of pregnancy. Gestational age was determined either by known last menstrual period (LMP) consistent with ultrasound in first-trimester or by earliest ultrasound if LMP unknown or inconsistent with ultrasound (ACOG, 2012).

Pregnancy outcomes collected consisted of labor interventions, labor complications, delivery complications, and adverse neonatal outcomes. Labor interventions included documentation of any of the following: induction of labor (cervical ripening/membrane stripping, foley) augmentation of labor (artificial rupture of membranes, oxytocin, etc.), episiotomy, amnioinfusions, delivery via c-section or use of forceps/vacuum. Labor complications included documentation of any of the following: nonreassuring fetal status, placental abruption, meconium discharge, maternal infection (chorioamnionitis, maternal fever, endometritis), and prolonged rupture of membranes (>24hrs). Delivery complications included documentation of any of the following: shoulder dystocia, 3rd/4th degree perineal laceration/tear, postpartum hemorrhage, manual extraction of placenta/retained placenta, and maternal death, Adverse neonatal outcomes included any of the following documented during newborn hospitalization period: prematurity (<37 weeks gestation), birthweight <10th percentile or >90th percentile), weight loss >10% birthweight, hypoglycemia, hyperbilirubinemia requiring phototherapy, respiratory distress (transient tachypnea of the newborn, respiratory distress syndrome), resuscitation attempts, NICU admission and length of stay, fractured clavicle, infection (neonatal fever, sepsis, meningitis), hypothermia, and fetal demise.

Additional data collected to assess for any confounding variables included: maternal ethnicity/race, insurance status (public vs private), newborn birthweight, additional maternal medical diagnoses, blood type, and GBS status at delivery.

Statistical analysis of continuous variables achieved using means and standard deviations. Categorical variables assessed with frequencies and percentages. Variables were additionally compared with descriptive and bivariate statistics using the Kruskal-Wallis test for continuous variables and Chi-square or Fisher exact tests for categorical variables. Odds ratio with logistical and linear regression was also utilized to adjust for relevant covariates selected based on results of stratified analyses and included: insurance status (public vs private), gravida para, gestational age at first PNV, prematurity, and gestational age at time of delivery.

Results

Of 503 mothers in the cohort, 179 met exclusion criteria most commonly due to missing prenatal documentation. Of the 324 included, non-HR mothers consisted of 159 (49.07%) compared to HR mothers 165 (50.93%) [table 1, pg 9]. Most common HR disorder was obesity at 115 (69.7% of all HR mothers). The following most common HR disorders listed in decreasing order includes: AMA at 52 (31.52%), HTN disorders at 31 (18.79%), DM disorders at 30 (18.18%), and asthma at 24 (14.55%). Utilizing logistic and linear regression, pregnancy outcomes of both risk groups were then compared within same risk group depending on total pregnancy PNV utilization category [low (≤8 PNV), mid (9-11 PNV), and (≥12 PNV] and frequency of PNV per trimester (“T1,” “T2,” or “T3”).

Significant results included [table 2, pg 10]:
(1) Non-HR mothers with a higher total PNV category were more likely to have labor interventions (OR 4.02; 95% confidence interval [CI] 1.26-12.9, p-value = 0.019).
(2) Non-HR mothers with higher quantities of PNV in T3 were less likely to have labor interventions (OR 0.69; 95% CI 0.48-0.98, p-value = 0.039).
(3) HR mothers with higher PNV quantities in T1 and T2 were less likely to have labor interventions (T1: OR 0.34; 95% CI 0.13-0.91, p-value = 0.032) (T2: OR 0.42; 95% CI 0.21-0.84, p-value = 0.015).
(4) HR mothers with higher quantities of PNV in T2 were less likely to have labor complications (OR 0.70; 95% CI 0.51-0.98, p-value = 0.043).

No further differences in likelihood of labor complications, delivery complications, or neonatal adverse outcomes were found with non-HR nor HR mothers when assessing for total PNV per pregnancy or trimester. Additionally, several potentially confounding variables were analyzed including gestational age at time of delivery, SES factors such as insurance coverage, and finally total quantity of HR disorders [table 3, pg 11] [table 4, pg 12]. Most interestingly, increasing number of HR disorders per individual mother showed no significant differences in PNV utilization, including neither by category (p-value =0.89) nor by trimester (T1: p-value = 0.48; T2: p-value = 0.30; T3: p-value = 0.5) [table 4, pg 12]. However, increasing number of HR disorders per individual mother was associated with increased labor interventions (HR1: mean 2.18, SD 1.44) (HR≥2: mean 2.75, SD 1.44, p-value = <0.001) and adverse neonatal outcomes (HR1: mean 0.44, SD 0.84) (HR≥2: mean 1.04, SD 1.25, p-value = <0.001) [table 4, pg 12]. Nevertheless, as previously stated these covariates underwent statistical adjustment and were determined to ultimately have no significant effect on rate of adverse pregnancy outcomes.

Conclusions for Practice

To summarize the main conclusions of this study, it was found that labor interventions were less likely to occur by non-HR mothers with higher quantities of PNV in T3 and by HR mothers with higher quantities of PNV in T1 and T2. Additionally, labor complications were less likely found by HR mothers with higher quantities of PNV in T2. Finally, labor interventions were more likely found by non-HR mothers with a higher total PNV category.

In investigating the potential underlying reasons for these findings, several possible mechanisms deserve further exploration. For example, due to the general increase in poor outcomes within HR populations, it follows that an increase in quantity of PNV within the earlier trimesters allows for increased surveillance, management, and counseling regarding: weight gain for obesity, blood glucose control for DM, and blood pressure control for HTN disorders. This improved management can be theorized to result in decreasing rates of labor interventions due decreasing the common indications for labor inductions within HR groups such as macrosomia and placental insufficiency. When it comes to non-HR mothers, this study's findings remain in alignment with various previous research (Carter et al., 2016; Goss et al., 1997). Furthermore, there is some thought that for non-HR mothers, the total PNV utilization might be driven more from the patient's personal desire, rather than provider discretion or medical necessity. Given this self-selection theory, perhaps it is a subset of non-HR mothers that are responsible for requesting/attending increased quantities of PNV in T3, thereby receiving a higher amount of provider counseling, and subsequently are less likely to request/undergo elective inductions and various other labor interventions.

This study's main limitation surrounds its small sample size and therefore would benefit from further investigation. Other limitations include the analysis of pregnancy outcomes via combination all HR disorders within one group. Future studies should seek to expand the sample size so that direct assessment of individual HR disorders can be compared (ex: pregnancy outcomes of DM mothers with differing PNV utilization categories). In addition, future studies should include direct comparison of comorbid conditions (ex: pregnancy outcomes of HR mothers diagnosed with both DM and obesity). In summary, further investigation has great potential for advancing the development of tailored PNV recommendations dependent on maternal health history, ultimately resulting in various clinical benefits such as increased cost savings, decreased unnecessary interventions, and decreased poor outcomes.

Acknowledgments

This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

Conflict of Interest

The authors declare that they have no conflict of interest.

References

1. American Academy of Pediatrics & American College of Obstetricians and Gynecologists. (2012). Preconception and antepartum care, intrapartum and postpartum care of the mother. In *Guidelines for Perinatal Care* (7th edition, pp. 95–210). American Academy of Pediatrics and American College of Obstetricians and Gynecologists.
2. World Health Organization. (2016). *WHO recommendations on antenatal care for a positive pregnancy experience*. https://apps.who.int/iris/bitstream/handle/10665/250796/9789241549 912-eng.pdf;jsessionid= 20 B3CDB3725B813A85B5E1F5FA77B19A?sequence=1
3. Nimi T, Fraga S, Costa D, Campos P, Barros H. (2016). Prenatal care and pregnancy outcomes: A cross-sectional study in Luanda, Angola. *International Journal of Gynecology & Obstetrics*. 135(S1). doi:10.1016/j.ijgo.2016.08.013.
4. Raatikainen K, Heiskanen N, Heinonen S. (2007). Under-attending free antenatal care is associated with adverse pregnancy outcomes. *BMC Public Health.* 7(1). doi:10.1186/1471-2458-7-268.
5. Carter EB, Tuuli MG, Caughey AB, Odibo AO, Macones GA, Cahill AG. (2015). Number of prenatal visits and pregnancy outcomes in low-risk women. *Journal of Perinatology*. 36(3):178-181. doi:10.1038/jp.2015.183.
6. Goss GL, Lee K, Koshar J, Heilemann MS, Stinson J. (1997). More Does Not Mean Better: Prenatal Visits and Pregnancy Outcome in the Hispanic Population. *Public Health Nursing.* 14(3):183-188. doi:10.1111/j.1525-1446.1997.tb00290.x.
7. Bramham K, Parnell B, Nelson-Piercy C, Seed PT, Poston L, Chappell LC. (2014). Chronic hypertension and pregnancy outcomes: systematic review and meta-analysis. *Bmj*. 348(apr15 7). doi:10.1136/bmj.g2301.
8. Blickstein I, Doyev R, Bregar AT, Šimenc GB, Verdenik I, Tul N. (2017). The effect of gestational diabetes, pre-gravid maternal obesity, and their combination (‘diabesity’) on outcomes of singleton gestations. *The Journal of Maternal-Fetal & Neonatal Medicine*. 31(5):640-643. doi:10.1080/14767058.2017.1293030.
9. Marozio L, Picardo E, Filippini C, et al. (2017). Maternal age over 40 years and pregnancy outcome: a hospital-based survey. *The Journal of Maternal-Fetal & Neonatal Medicine*. 32(10):1602-1608. doi:10.1080/14767058.2017.1410793.
10. Barbosa IRC, Silva WBM, Cerqueira GSG, Novo NF, Almeida FA, Novo JLVG. (2015). Maternal and fetal outcome in women with hypertensive disorders of pregnancy: the impact of prenatal care. *Therapeutic Advances in Cardiovascular Disease*. 9(4):140-146. doi:10.1177/1753944715597622.
11. Carter EB, Tuuli MG, Odibo AO, Macones GA, Cahill AG. (2016). Prenatal visit utilization and outcomes in pregnant women with type II and gestational diabetes. *Journal of Perinatology*. 37(2):122-126. doi:10.1038/jp.2016.175.

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Table 1 Total PNV utilization (PNV category) vs maternal risk populations

PNV Category[a] **Total PNV**	**Low** **0-8**	**Mid** **9-11**	**High** **≥12**	**All** **≥0**
Total (n)	**120**	**121**	**83**	**324**
Non-HR	58/120 (48.33%)	55/121 (45.45%)	46/83 (55.42%)	159/324 (49.07%)
HR: All	62/120 (51.67%)	66/121 (54.54%)	37/83 (44.58%)	165/324 (50.93%)
HR: AMA	19/120 (15.83%)	23/121 (19.00%)	10/83 (12.05%)	52/324 (16.05%)
HR: Asthma	7/120 (5.83%)	8/121 (6.61%)	9/83 (10.84%)	24/324 (7.41%)
HR: DM	10/120 (8.33%)	12/121 (9.92%)	8/83 (9.64%)	30/324 (9.26%)
HR: HTN	3/120 (2.50%)	20/121 (16.53%)	8/83 (9.64%)	31/324 (9.57%)
HR: Obesity	38/120 (31.67%)	48/121 (39.67%)	29/83 (34.94%)	115/324 (35.49%)

[a] PNV category: low (≤8 PNV), mid (9-11 PNV), high (≥11 PNV)] total PNV quantity at time of delivery

Table 2 Non-HR & HR mothers: pregnancy outcomes vs PNV utilization (category, trimester)

	Non-HR n = 158		**HR** n = 166		**HR: Obesity** n = 115	
	OR (95 CI)	p-value	OR (95 CI)	p-value	OR (95 CI)	p-value
Labor Interventions[a]						
PNV Category[b]	**4.02 (1.26, 12.9)**	**0.019***	4.41 (0.47, 40.8)	0.19	1.80 (0.04, 77.1)	0.75
PNV: T1[c]	1.09 (0.60, 1.95)	0.79	**0.34 (0.13, 0.91)**	**0.032***	0.20 (0.03, 1.49)	0.12
PNV: T2[d]	1.09 (0.75, 1.56)	0.66	**0.42 (0.21, 0.84)**	**0.015***	0.37 (0.13, 1.03)	0.056**
PNV: T3[e]	**0.69 (0.48, 0.98)**	**0.039***	0.69 (0.39, 1.25)	0.23	0.74 (0.31, 1.79)	0.51
Labor Complications[a]						
PNV Category[b]	0.91 (0.32, 2.55)	0.85	0.87 (0.33, 2.31)	0.79	1.12 (0.34, 3.65)	0.86
PNV: T1[c]	0.70 (0.41, 1.20)	0.19	0.77 (0.49, 1.21)	0.26	1.20 (0.63, 2.29)	0.57
PNV: T2[d]	1.39 (0.99, 1.95)	0.056**	**0.70 (0.51, 0.98)**	**0.043***	0.87 (0.57, 1.34)	0.55
PNV: T3[e]	0.97 (0.72, 1.32)	0.88	1.06 (0.84, 1.34)	0.59	0.88 (0.65, 1.20)	0.44
Delivery Complications[a]						
PNV Category[b]	1.25 (0.21, 7.20)	0.79	0.83 (0.14, 4.86)	0.84	0.99 (0.09, 10.8)	0.99
PNV: T1[c]	1.05 (0.43, 2.58)	0.91	0.62, 0.25, 1.57)	0.32	0.82 (0.21, 3.15)	0.77
PNV: T2[d]	1.03 (0.58, 1.81)	0.93	1.57 (0.88, 2.79)	0.12	1.31 (0.63, 2.77)	0.47
PNV: T3[e]	0.78 (0.47, 1.31)	0.35	0.91 (0.61, 1.37)	0.66	0.78 (0.43, 1.45)	0.45
Neonatal Adverse Outcomes[a]						
PNV Category[b]	1.08 (0.33, 3.45)	0.89	1.06 (0.38, 2.94)	0.90	0.92 (0.24, 3.60)	0.91
PNV: T1[c]	1.48 (0.81, 2.71)	0.20	0.62 (0.37, 1.05)	0.074**	0.51 (0.24, 1.08)	0.078**
PNV: T2[d]	1.09 (0.75, 1.60)	0.64	0.70 (0.48, 1.02)	0.06**	0.65 (0.38, 1.11)	0.12
PNV: T3[e]	0.85 (0.60, 1.21)	0.38	0.89 (0.69, 1.13)	0.35	0.94 (0.66, 1.34)	0.74

[a] Logistic regression adjusting for insurance status, gravida/para, gestation at 1st PNV, preterm birth, term categories
[b] PNV category: low (≤8 PNV), mid (9-11 PNV), or high (≥11 PNV) total PNV quantity at time of delivery
[c,d,e] PNV utilization per trimester: [c]T1 (<14 weeks), [d]T2 (14-27 weeks), or [e]T3 (≥28 weeks)
*p-value <0.05
**p-value >0.05, <0.10

Table 3 Demographics by medical history vs. PNV category

Variables	Total PNV ≤ 8 N=120	8 - ≤ 11 N=121	>11 N=83	p-value
Age, years (mean, SD)	27.6 (6.00)	28.2 (5.98)	27.9 (5.17	0.67
Race (n, %)				0.67
White	35 (29.2)	48 (39.7)	30 (36.1)	
Hispanic	61 (50.8)	52 (42.9)	36 (43.4)	
Black	15 (12.5)	15 (12.4)	10 (12.1)	
Asian / other	9 (7.50)	6 (4.96)	7 (8.43)	
Insurance (ACCHS, %)	58 (48.3)	**33 (27.3) [a]**	**21 (25.3) [b]**	**<0.001**
ABS Screening (yes, %)	108 (90.0)	110 (90.9)	80 (96.4)	0.21
G (mean, SD)	3.65 (2.33)	**2.85 (2.17) [a]**	**2.45 (1.56) [b]**	**<0.001**
P (T) (mean, SD)	1.72 (1.65)	**1.11 (1.53) [a]**	**0.92 (1.07) [b]**	**<0.001**
P (P) (mean, SD)	0.40 (1.16)	0.16 (0.49)	**0.07 (0.26) [b]**	**0.007**
P (A/M) (mean, SD)	0.59 (0.94)	0.58 (0.98)	0.46 (0.90)	0.55
P (L) (mean, SD)	2.08 (1.89)	**1.27 (1.71) [a]**	**0.96 (1.08) [b]**	**<0.001**
AMA (yes, %)	19 (15.8)	23 (19.0)	10 (12.1)	0.43
Obesity (yes, %)	38 (31.9)	48 (39.7)	29 (34.9)	0.46
DM Disorders (yes, %)	10 (8.33)	12 (9.92)	8 (9.64)	0.91
HTN Disorders (yes, %)	3 (25.8)	20 (16.5)	**8 (9.64) [b]**	**0.011**
Asthma (yes, %)	7 (5.83)	8 (6.61)	9 (10.8)	0.38
Gestational Age at 1st PNV, wks (mean, SD)	15.5 (9.31)	**10.4 (4.09) [a]**	**8.66 (2.38) [b, c]**	**<0.001**
# PNV (mean, SD)	4.38 (3.02)	**10.1 (0.82) [a]**	**13.3 (1.53) [b, c]**	**<0.001**
PNV: T1 (mean, SD)	0.58 (0.93)	**1.42 (0.97) [a]**	**2.06 (0.97) [b, c]**	**<0.001**
PNV: T2 (mean, SD)	1.53 (1.51)	**3.22 (0.95) [a]**	**3.85 (1.07) [b, c]**	**<0.001**
PNV: T3 (mean, SD)	2.35 (2.14)	**5.48 (1.34) [a]**	**7.30 (1.23) [b, c]**	**<0.001**
GBS (yes, %)	18 (15.0)	29 (23.9)	15 (18.1)	0.21
Gestational Age at Delivery, wks (mean, SD)	37.9 (2.71)	38.6 (1.64)	**39.6 (1.03) [b, c]**	**<0.001**
Preterm Births (yes, %)	29 (24.2)	15 (12.4)	**2 (2.41) [b, c]**	**<0.001**
Gestational Term Cat (mean, SD)	5.15 (1.14)	**5.47 (0.82) [a]**	**5.85 (0.59) [b, c]**	**<0.001**
# Interventions (mean, SD)	1.82 (1.43)	2.15 (1.46)	**2.42 (1.57) [b]**	**0.015**
# Labor Complications (mean, SD)	0.48 (0.77)	0.37 (0.67)	0.37 (0.60)	0.38
# Delivery Complications (mean, SD)	0.08 (0.31)	0.08 (0.33)	0.10 (0.43)	0.96
# Neonatal Adverse Outcomes	0.78 (1.16)	**0.43 (0.78) [a]**	**0.19 (0.45) [b, c]**	**<0.001**
Birthweight (mean, SD)	3104.9 (645.6)	3239.7 (502.1)	**3366.8 (429.0) [b]**	**0.003**
SGA (yes, %)	15 (12.5)	10 (8.26)	**1 (1.20) [b]**	**0.007**
LGA (yes, %)	8 (6.67)	7 (5.79)	6 (7.23)	0.92

Kruskal-Wallis Test to compare continuous variables, Chi-squared/Fisher's Exact to compare categorical variables.
[a] Statistically significant pairwise comparison between 0 and 1 groups following Bonferroni Correction (p<0.016)
[b] Statistically significant pairwise comparison between 0 and 2 groups following Bonferroni Correction (p<0.016)
[c] Statistically significant pairwise comparison between 1 and 2 groups following Bonferroni Correction (p<0.016)

Table 4 Demographics by medical history vs. quantity of HR disorders

Variables	# HR Diagnosis 0 N=158	1 N=88	2 or more N=78	p-value
Age, years (mean, SD)	25.9 (4.51)	**28.5 (6.33)** [a]	**31.1 (5.89)** [b, c]	**<0.001**
Race (n, %)				0.27
White	65 (41.1)	22 (25.0)	26 (33.3)	
Hispanic	63 (39.9)	48 (54.6)	38 (48.7)	
Black	20 (12.7)	11 (12.5)	9 (11.5)	
Asian / other	10 (6.33)	7 (7.95)	5 (6.41)	
Insurance (ACCHS, %)	51 (32.3)	37 (42.1)	24 (30.8)	0.22
ABS Screening (yes, %)	142 (89.9)	85 (96.6)	71 (91.0)	0.15
G (mean, SD)	2.63 (1.93)	**3.36 (2.19)** [a]	**3.51 (2.36)** [b]	**0.003**
P (T) (mean, SD)	1.01 (1.29)	**1.52 (1.62)** [a]	**1.56 (1.71)** [b]	**0.006**
P (P) (mean, SD)	0.13 (0.46)	0.36 (1.22)	0.28 (0.66)	0.062
P (A/M) (mean, SD)	0.50 (0.96)	0.52 (0.84)	0.69 (1.02)	0.34
P (L) (mean, SD)	1.11 (1.39)	**1.92 (2.00)** [a]	**1.78 (1.76)** [b]	**<0.001**
AMA (yes, %)	0 (0.0)	**24 (27.3)** [a]	**28 (35.9)** [b]	**<0.001**
Obesity (yes, %)	0 (0.0)	**48 (54.6)** [a]	**67 (85.9)** [b, c]	**<0.001**
Diabetic Disorders (yes, %)	0 (0.0)	3 (3.41)	**27 (34.6)** [b, c]	**<0.001**
HTN Disorders(yes, %)	0 (0.0)	**11 (12.5)** [a]	**48 (61.5)** [b, c]	**<0.001**
Asthma (yes, %)	0 (0.0)	1 (1.14)	**23 (29.5)** [b, c]	**<0.001**
Gestational Age at 1st PNV, wks (mean, SD)	10.9 (5.74)	12.2 (8.05)	**13.4 (7.44)** [b]	**0.024**
# PNV (mean, SD)	8.69 (4.24)	8.88 (3.85)	8.94 (4.33)	0.89
PNV: T1 (mean, SD)	1.20 (0.99)	1.38 (1.14)	1.32 (1.33)	0.48
PNV: T2 (mean, SD)	2.87 (1.57)	2.55 (1.53)	2.74 (1.53)	0.30
PNV: T3 (mean, SD)	4.62 (2.61)	4.93 (2.39)	4.98 (2.79)	0.50
GBS (yes, %)	26 (16.5)	16 (10.2)	20 (25.6)	0.23
Gestational Age at Delivery, wks (mean, SD)	38.9 (1.68)	38.8 (2.25)	**37.8 (2.46)** [b, c]	**<0.001**
Preterm Births (yes, %)	22 (13.9)	9 (10.2)	15 (19.2)	0.25
Gestational Term Cat (mean, SD)	5.54 (0.86)	5.54 (0.99)	**5.16 (1.01)** [b, c]	**0.008**
# Interventions (mean, SD)	1.72 (1.32)	**2.18 (1.44)** [a]	**2.75 (1.66)** [b]	**<0.001**
# Labor Complications (mean, SD)	0.38 (0.69)	0.39 (0.65)	0.50 (0.73)	0.44
# Delivery Complications (mean, SD)	0.08 (0.35)	0.13 (0.42)	0.06 (0.25)	0.47
# Neonatal Adverse Outcomes	0.27 (0.60)	0.44 (0.84)	**1.04 (1.25)** [b, c]	**<0.001**
Birthweight (mean, SD)	3228.9 (465.6)	3298.1 (528.4)	**3123.3 (709.5)** [c]	**0.12**
SGA (yes, %)	10 (6.33)	3 (3.41)	**13 (16.7)** [c]	**0.006**
LGA (yes, %)	5 (3.16)	7 (7.95)	9 (11.5)	0.031

Kruskal-Wallis Test to compare continuous variables, Chi-squared/Fisher's Exact to compare categorical variables.
[a] Statistically significant pairwise comparison between 0 and 1 groups following Bonferroni Correction (p<0.016)
[b] Statistically significant pairwise comparison between 0 and 2 groups following Bonferroni Correction (p<0.016)
[c] Statistically significant pairwise comparison between 1 and 2 groups following Bonferroni Correction (p<0.016)