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Predicting preterm birth among participants of North Carolina's Pregnancy Medical Home Program

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Abstract

Objective—To determine which combination of risk factors from Community Care of North Carolina's (CCNC) Pregnancy Medical Home (PMH) risk screening form was most predictive of preterm birth (PTB) by parity and race/ethnicity.

Methods—This retrospective cohort included pregnant Medicaid patients screened by the PMH program before 24 weeks gestation who delivered a live birth in North Carolina between September 2011-September 2012 (N=15,428). Data came from CCNC's Case Management Information System, Medicaid claims, and birth certificates. Logistic regression with backward stepwise elimination was used to arrive at the final models. To internally validate the predictive model, we used bootstrapping techniques.

Results—The prevalence of PTB was 11%. Multifetal gestation, a previous PTB, cervical insufficiency, diabetes, renal disease, and hypertension were the strongest risk factors with odds

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ratios ranging from 2.34 to 10.78. Non-Hispanic black race, underweight, smoking during pregnancy, asthma, other chronic conditions, nulliparity, and a history of a low birth weight infant or fetal death/second trimester loss were additional predictors in the final predictive model. About half of the risk factors prioritized by the PMH program remained in our final model (ROC=0.66). The odds of PTB associated with food insecurity and obesity differed by parity. The influence of unsafe or unstable housing and short interpregnancy interval on PTB differed by race/ethnicity.

Conclusions—Evaluation of the PMH risk screen provides insight to ensure women at highest risk are prioritized for care management. Using multiple data sources, salient risk factors for PTB were identified, allowing for better-targeted approaches for PTB prevention.

Keywords

Preterm Birth; Medicaid; Risk Screening; Race/Ethnic Disparities; North Carolina

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Preterm birth (PTB) prior to 37 weeks completed gestation is the leading cause of infant death and long-term neurological disabilities in the United States (1). In 2013, the National Center for Health Statistics (NCHS) calculated that 12.0% of births in North Carolina were preterm, higher than the national average of 11.4% (2). Racial/ethnic disparities in PTB have persisted for generations with non-Hispanic black (NHB) women having the highest rate (16.3%) (2). In NC, the PTB rate is higher among births covered by Medicaid (3, 4). The concentration of PTB in populations of lower socioeconomic status places a burden on publicly financed health care (5).

To address high rates of PTB, Community Care of North Carolina (CCNC) launched the Pregnancy Medical Home (PMH) program in partnership with the North Carolina Division of Medical Assistance (DMA) in 2011. CCNC, a not-for-profit organization, manages the care of Medicaid recipients statewide. Medicaid covers prenatal care and delivery for 48% of NC births (4). Additionally, NC Medicaid provides emergency coverage of the delivery only for another 8% of births (4).

The PMH program seeks to promote evidence-based, high-quality maternity care to improve birth outcomes in the pregnant Medicaid population (6). 85% percent of NC prenatal care providers serve as PMHs, including obstetricians, family physicians, federally-qualified health centers, rural health clinics, local health departments, and nurse midwives (7, 8). Patients at elevated risk of PTB are identified through a standardized risk screening administered at the first prenatal visit and are referred for pregnancy care management to address modifiable risk factors. Pregnancy care management is provided by county health departments, working in partnership with local CCNC networks. Care managers closely monitor the pregnancy through regular contact with the physician and patient to support the prenatal clinical care plan. The level of service provided is proportional to the individual's identified needs. The care manager can intervene to ensure the patient gets to medical appointments, understands any treatment recommendations, receives needed diagnostics, and alert the care provider if there are barriers interfering with adherence to the clinical care plan. Eligible women with a history of spontaneous PTB who are currently pregnant with a singleton are offered 17alpha hydroxyprogesterone (17p). Pregnancy care management continues through the postpartum period, which is defined by Medicaid as ending on the last day of the month in which the sixtieth postpartum day occurs. More information about the PMH program has been published previously (8).

The risk screening form includes over 40 demographic, psychosocial, current pregnancy and obstetric history risk factors (Appendix A). Several conditions are considered priority and trigger a referral to a pregnancy care manager (8). Priority risk factors include:

- current or recent tobacco or substance use;
- unsafe living environment (e.g., homelessness, inadequate housing, intimate partner violence, sexual abuse);
- chronic disease (e.g., diabetes, hypertension, human immunodeficiency virus, systemic lupus erythematosus, mental illness);
- fetal complication (fetal anomaly, fetal chromosomal abnormality, intrauterine growth restriction, oligohydramnios, polyhdramnios, and others);
- multifetal gestation;
- previous PTB or low birth weight (LBW) infant;
- delayed or inconsistent prenatal care; and
- hospitalization or emergency department use during pregnancy.

The health care provider can also check a box to request pregnancy care management.

The priority risk factors were chosen based on evidence reviewed by a multidisciplinary workgroup. The goal was to identify risk factors with the strongest associations with PTB, with consideration given to modifiable factors that could be addressed through care management.

Between January and June 2012, more than 75% of pregnant Medicaid patients (20,288) were screened, of which two-thirds had at least one priority risk factor (8). This population exceeds the capacity of the pregnancy care management program. Furthermore, it is not known whether the current priority risk factors are identifying those women at highest risk for PTB. The purpose of this analysis is to determine which combination of risk factors from the PMH screening form best predicts PTB among women entering care early enough to benefit from care management, and whether certain risk factors are more predictive by parity and race/ethnicity.

METHODS

Data Source

We conducted a retrospective cohort analysis using data from CCNC's Case Management Information System (CMIS), Medicaid claims, and birth certificates. Birth certificate data are matched to Medicaid delivery claims in the DMA data warehouse using SQL Server Integration Services Fuzzy Lookup component software (95% match rate). The risk screening is administered at the first prenatal visit (median of 13 weeks gestation). The provider collects a medical history and checks a box for the presence of each risk factor;

psychosocial questions are self-administered in English, Spanish, or Russian or may be completed through a patient interview. The risk screening is linked to the index birth via the mother's Medicaid identification number.

All women with a valid risk screening collected between August 31, 2011 and May 20, 2012 and with a corresponding delivery between September 1, 2011 and September 30, 2012, were eligible for this analysis (n=22,612). Women were excluded if they were screened before 6 weeks or at or after 24 weeks gestation (n=6,002), if they had only Emergency Medicaid (n=7), or had a live birth prior to 24 weeks gestation (n=62). Women missing data on risk factors from the screening that could not be substituted with birth certificate data were excluded (n=1,093 or 6.6%). The final sample size was 15,428 women.

All study procedures were reviewed and approved by the Institutional Review Board for the Protection of Human Subjects at the University of North Carolina at Chapel Hill.

Measures

Preterm birth (less than 37 weeks completed gestation) was defined using the obstetric estimate (OE) of gestation from the birth certificate. Several studies have examined the validity of obstetric estimate since its addition to the 2003 revision of the birth certificate and concluded that OE may undercount the rate of PTB (9–13). Although OE may underestimate PTB and yield an estimate of PTB lower than the national prevalence based on last menstrual period (LMP) calculated by the National Center for Health Statistics (NCHS) (14), we use OE because LMP was missing more observations in our sample. Further LMP has its own limitations (10, 13).

We evaluated all of the risk factors collected on the PMH Risk Screening form in relation to PTB and grouped them as follows: psychosocial, current pregnancy, obstetric history and sociodemographic and program characteristics.

Psychosocial Characteristics—Pregnancy intention was collapsed into three categories: intended (wanted to be pregnant sooner/now) [referent], unintended (wanted to be pregnant later/did not want to be pregnant then or any time in future), or don't know. Missing information on smoking (2%) was substituted with values from the birth certificate (kappa for non-missing 3-category smoking 0.69). Smoking was a 4-part categorical variable: never or <100 cigarettes ever [referent], stopped smoking before learning of the pregnancy, stopped smoking after learning of the pregnancy, and smoke now but cut down or smoke same amount since learning of the pregnancy. Questions on whether the participant's parent, friend, and/or partner had a problem with alcohol or other drug use were combined into one substance abuse variable equal to one if any member had a substance problem. Questions assessing drug and alcohol use before pregnancy and in the past month were dichotomized as any (rarely, sometimes, or frequently) [referent] vs. none.

Current Pregnancy Characteristics—Delayed prenatal care was defined as initiation after 14 weeks gestation. A short interpregnancy interval (IPI) was fewer than 12 months between the last live birth and current pregnancy. Recurrent urinary tract infection was defined as more than two in the past six months or more than five in the past two years.

Communication barrier included participants with a disability, literacy issues, or non-English speakers. Hypertensive disorders of pregnancy included eclampsia, preeclampsia, gestational hypertension, and HELLP syndrome. About 18% of women were missing BMI on the risk screening; these data were substituted with BMI calculated from birth certificates (kappa for non-missing 4-category BMI 0.78) and categorized into four groups: underweight (<18.5), normal (18.5–24.9) [referent], overweight (25.0–29.9), or obese (>30).

Obstetric History—For multivariate modeling, fetal death (>20 weeks) and second trimester pregnancy loss were combined into one variable, as was a history of cervical insufficiency and cervical insufficiency in the current pregnancy.

Sociodemographic and Program Characteristics—We used several measures from birth certificates and Medicaid claims including maternal age, race/ethnicity, parity, and Medicaid program status. Age at delivery was calculated by subtracting the mother's date of birth in Medicaid claims from the delivery date on birth certificates and categorized as <18, 19–34 [referent] and >35. Race/ethnicity from the birth certificate was categorized as non-Hispanic white [referent], non-Hispanic Black, Asian/Pacific Islander, American Indian/Alaska Native, and Hispanic. Multiple or "other" race participants were reassigned in the following priority: Hispanic, Black, Asian/Pacific Islander, and American Indian/Alaska Native. Parity from the birth certificate was calculated by adding the number of live births now living and now dead and dichotomized as nulliparous (no previous offspring) vs. parous (previous offspring) [referent]. Medicaid program status was collapsed into Medicaid for Pregnant Women or any other category of Medicaid. Information about whether the participant received care management or 17p treatment came from CMIS.

Analysis

Descriptive statistics and bivariate analyses were used to compare the distributions of all the risk factors from the screening form and PTB. We examined crude associations between all the risk factors and PTB using logistic regression. Any variable from the risk screening that was significant at $p<0.05$ in the Pearson's chi-square tests or in the crude logistic regression models was included in the comprehensive model. Backwards stepwise elimination was used to determine the optimal combination of risk factors for PTB, eliminating variables with a p-value >0.05. All analyses were conducted using Stata version 13.0 (StataCorp. 2013. *Stata Statistical Software: Release 13*. College Station, TX: StataCorp LP.)

To obtain an internal assessment of the predictive performance of the final model, we used bootstrapping (15, 16). Bootstrapping is a nonparametric method of evaluating the predictive performance and variability associated with the final model. Bootstrap methods replicate the process of sample generation by drawing samples with replacement from the original data set of the same size as the original sample (17). This allowed us to quantify more precisely the amount of variability associated with our model estimates. After fitting the model in the original dataset, we replicated our model selection process of backwards stepwise deletion in 1,000 bootstrap samples from the original sample and present bias-corrected (BC) confidence intervals (CIs) from the bootstrap results. These confidence intervals allow for the additional variability in any model selection process.

To test whether particular risk factors were predictive for different groups, we conducted stratified analysis and tested for interaction by parity (nulliparous vs. parous) and race/ethnicity (non-Hispanic black and non-Hispanic white). We excluded Hispanic (n=1,243), Asian/Pacific Islander (n=383) and American Indian/Alaska Native (n=436) participants from the latter model due to small numbers. Covariates were included as moderators in the adjusted interaction models if the Wald p-value was less than 0.05 and there were sufficient observations in each cell ($n \geq 10$).

We calculated the predicted probability of PTB for each woman using the linear predictor from the final model. We used receiver operating characteristic (ROC) curve analyses to determine the high-risk threshold for PTB at the point on the curve where the sum of sensitivity and specificity was highest. Using this cutoff, we calculated measures of model performance such as the sensitivity, specificity, and positive and negative predicted values.

In sensitivity analyses, we examined whether the intervention affected associations between risk factors and PTB by comparing model selection in the full sample to women who did not receive care management and women who did not receive 17p treatment.

RESULTS

Sociodemographic and Program Characteristics

The prevalence of PTB was 11.0% (Table 1). Preterm birth was more frequent among NHB women, those 35 years or older, unmarried women and women born in the United States (Table 1). Sixty one percent of women received some dose of care management and had a higher prevalence of PTB than women who were not care managed, which is expected given that care management is targeted to women with priority risk factors. Administration of 17p was documented in 2% of the sample; 23% of those women had a PTB.

Psychosocial Characteristics

Table 2 displays the frequency and odds of experiencing a PTB by psychosocial characteristics. Women who answered “don’t know” about their pregnancy intention, whose living situation was unsafe or unstable, or who used drugs or alcohol in the past month of pregnancy had a higher prevalence of PTB. Over 20% of women continued to smoke after they found out they were pregnant, and among them, the PTB prevalence was 13%.

Current Pregnancy Characteristics

Table 3 displays current pregnancy characteristics including chronic diseases. Nearly 17% of women had a chronic condition. A high percentage of births with multifetal gestation and cervical insufficiency resulted in a PTB. Among the chronic diseases assessed, women with diabetes, hypertension, asthma, renal disease, and other chronic conditions (e.g., thyroid disease and anemia) had a higher prevalence of PTB.

Obstetric History Characteristics

The prevalence of prior adverse pregnancy outcomes ranged from 0.3% for a history of cervical insufficiency to 7.5% for a previous PTB. All of the obstetric history variables assessed affected prevalence and odds of PTB (Table 4) with the exception of postpartum depression.

Predictive Model of Preterm Birth

In Table 5 we report the final predictive model in the full sample. Bias-corrected confidence intervals from model selection generated using 1,000 bootstrap replications are presented and are similar to 95% CIs in the original sample. NHB race (OR=1.40, BC 95% CI: 1.25, 1.56) was the only sociodemographic factor that remained a predictor of PTB. The only psychosocial risk factor that remained in the final model was continuing to smoke throughout pregnancy, while those who quit after finding out they were pregnant were not at increased risk. Underweight remained statistically significant; however obesity was no longer associated with an elevated risk of PTB. Of the chronic diseases, diabetes, hypertension, asthma, renal disease, and "other" remained in the final model. Nulliparous women had 1.20 times the odds of PTB as parous women (BC 95% CI: 1.06, 1.33). Among the adverse obstetric history risk factors, a history of PTB, delivering a LBW infant, and fetal death/second trimester loss remained. Approximately half of the PMH program's prioritized risk factors remained in our final model (Table 6).

Parity and Race/Ethnicity

Two risk factors, food insecurity and BMI, had associations with PTB that differed by parity. Parous women had an elevated risk of PTB associated with food insecurity (OR = 1.41, 95% CI: 1.04, 1.91) but nulliparous women did not. Obesity was associated with a higher risk of PTB only among nulliparous women (OR for obesity = 1.31, 95% CI: 1.07, 1.59).

Two risk factors varied by race/ethnicity. Unsafe or unstable housing was associated with an increased risk of PTB among NHW (OR = 1.46, 95% CI: 1.06, 2.02) but not NHB women. An IPI of less than 12 months was associated with an increased risk of PTB birth among NHB women only (OR =1.39, 95%CI: 1.02, 1.88).

Test Characteristics

The ROC of the final model was 0.66, higher than the PMH priority risk factor model (0.64, $p < 0.0001$). The point on the curve that optimized both sensitivity and specificity was a predicted probability of 0.11. Using this cutoff, 22% of women screened positive and 76% were correctly classified. The sensitivity was 44%, specificity 81%, and positive predictive value (PPV) 22%. However, this risk cutoff is quite restrictive and refers fewer women for care management than the program has resources to serve. Furthermore, among women who have a PTB, 56% screen negative. The ROC for our model including interaction terms for parity and race/ethnicity was slightly improved (0.67, $p<0.05$).

Sensitivity Analyses

We compared model selection in the full sample with women who did not receive care management (n=6,081). Given the smaller sample size, most measures were stronger in magnitude and less precise but all of the confidence intervals overlapped (results not shown). All variables from the final model in the full sample remained statistically significant predictors of PTB at $p<0.05$ except smoking, underweight, asthma, LBW history, and renal disease. Next we excluded women who received 17p treatment (n=339), and model selection yielded results similar to the full sample except that LBW history and "other" chronic conditions were not retained while current pregnancy hypertensive disorders and pregnancy intentions remained.

DISCUSSION

We evaluated the PMH risk screening form to determine the optimal combination of risk factors most predictive of PTB and internally validated our predictive model among a large and diverse cohort of women screened early in pregnancy. The final predictive model in the full sample included: non-Hispanic black race, smoking during pregnancy, underweight, multifetal gestation, chronic diseases (diabetes, hypertension, asthma, renal disease, and "other"), cervical insufficiency, nulliparity, and a history of PTB, LBW, and fetal death/second trimester loss. Our final predictive model improves on the current PMH prioritization scheme, which weighs all priority risk factors equally and screens in 70% of women. The specificity and PPV of our predictive model are higher than those of the priority risk factor model (specificity: 81% vs. 31% and PPV: 22% vs. 12%). The sensitivity is lower than the priority risk factor model (44% vs. 79%), but comparable to the sensitivity of other risk scoring systems, typically below 40%. (18–24)

Previous research suggests that inclusion of endemic risks to specific populations may improve the validity of screening tools (20). Therefore we tested for interaction by parity (because risk scoring tools are more discriminating for multigravid women given the importance of obstetric history (19, 25)), and by race/ethnicity. Addition of variables that were predictive of PTB among sub-groups (obesity, short IPI, food insecurity, and unsafe or unstable housing) slightly improved the predictive ability.

We sought to identify risk factors that might be amenable to intervention among vulnerable subgroups, particularly nulliparous and NHB women. Although obesity did not remain statistically significant in the final predictive model in the full sample, we found that obesity was more strongly predictive of PTB among nulliparous women than among parous women, as has been previously documented (26–28). For nulliparous women, obesity may provide one marker for who may be at higher risk of PTB, and suggests that more research is warranted to inform care management interventions for this high risk group.

Only one risk factor, short interpregnancy interval, increased the odds of PTB differentially for NHB women. Previous studies have shown that black women are 1.8 times more likely to have short IPIs compared to whites (29–32). Our findings are consistent with the "weathering hypothesis," that poorer overall health among black women in the United States contributes to their greater burden of PTB (33). Perhaps a short interval between pregnancies compounds the risk for black women who may have poorer health over the life course (34).

Interaction between short IPI and race has been tested in previous studies but not supported (29–31, 35), with the exception of one study among military women in which Rawlings et al. (1995) documented higher PTB rates among intervals less than nine months for black women (30, 32). Differing results between our findings and those lacking interaction could be because our measure of short IPI (<12 months) is based on physician report versus vital or medical records. Additionally, we include women of higher parity whereas other studies included first and second births only (30). Reducing the risk of short IPIs among NHB women may be one way to reduce racial ethnic disparities in preterm birth (30, 36–39); therefore more research on improving provision of postpartum contraception in publicly funded programs, particularly highly effective methods like intrauterine devices and contraceptive implants, is warranted for this high risk group (40, 41).

The PMH risk screen assesses many psychosocial factors, several of which have never been assessed in previous tools. Although psychosocial factors (aside from smoking) were not significant among the full sample, we found two factors that were predictive of PTB among subgroups — food insecurity and housing. Food insecurity, defined as being hungry from not being able to eat or afford food in the past 12 months, was a significant predictor of PTB among parous women only. To our knowledge, this is a new finding. Our assessment does not account for household size like other measures of food insecurity. We hypothesize that this finding captures the stress associated with having food insecurity in the context of providing for a family compared to food insecurity among nulliparous women without children to feed. In a study conducted among black and white women in Central NC, perceived stress was the predominant psychosocial indicator associated with food insecurity, even when adjusting for demographic and other psychosocial variables (42).

Our study contributes to the emerging literature on the complex influences of the interaction between the social environment and race/ethnicity. Unsafe or unstable housing was associated with PTB among NHW women but not NHB women. This echoes previous work by Dole and colleagues (2004) in NC who found that blacks were more likely than whites to report low perceived neighborhood safety, but had no increased risk associated with it. Similarly, O’Campo and colleagues (2008) found that neighborhood deprivation was more strongly associated with PTB for white women than black women despite black women being more likely to live in deprived areas (43, 44).

There are several limitations to this analysis. We excluded 6.6% of women due to missing data. Excluded women were more likely to be older, parous, non-white, foreign-born, married, less educated, to use substances, smoke, live in unsafe or unstable housing, have a fetal complication, an “other” chronic condition, and have a provider who requested a care management assessment. We substituted missing values for BMI and smoking and used parity and race/ethnicity from the birth certificate because the data were more complete. Inferences for these risk factors are based on reporting from the birth certificate, which may differ from the risk screening form.

Numbers for current pregnancy characteristics were low for conditions that are often not detected until later in pregnancy such as hypertensive disorders of pregnancy, likely due to our 24-week screening cutoff. We were unable to examine two priority risk factors (missed two or more prenatal care appointments and hospital use during pregnancy) due to small numbers. Thus the final predictive model may not capture risk factors that are predictive of

PTB among women screened later in pregnancy. We chose a 24-week cutoff to ensure that measurement of exposures occurred before the outcome and to identify risk factors that were predictive of PTB among women who entered care early enough to benefit from care management. Nearly three-fourths of women were screened prior to 24 weeks and 79% of PTBs occurred to them. By excluding women screened at 24 weeks or beyond, we were more likely to miss lower-risk women.

Over 60% of women received care management versus usual care based on having one or more priority risk factors. The program's care management activities could potentially reduce the association between risk factors and PTB thereby biasing our predictive model (20). To reduce potential intervention effects, we conducted our analysis among women screened at program inception in 2011 when care management activities were just getting underway. Our sensitivity analyses showed slight changes in selected variables for the final predictive model when women receiving care management and 17p treatment were removed likely due to the smaller sample sizes, but otherwise the remaining variables had similar point estimates with overlapping confidence intervals. Based on these analyses, we conclude that the intervention did not alter our interpretation of which risk factors are most predictive of preterm birth.

Despite these limitations, findings from this study are extremely relevant because the Pregnancy Medical Home concept is being developed and tested in numerous environments. In the development of the NC PMH model, program leaders were limited by the lack of available evidence addressing a holistic set of preterm birth risk factors. To our knowledge, this is the first study to apply rigorous analytic methods to evaluate decisions about which risk factors to prioritize. Our analysis provides insight into how the NC PMH, and similar programs across the nation, can ensure that patients with highest risk are prioritized for pregnancy care management using a more accurate scoring system. The improved specificity can help prevent care managers from becoming overburdened serving too many women, which could lead to a "watering down" of the intervention.

Based on linkage from birth certificates, Medicaid claims, and PMH risk screens, our large and diverse sample allowed us to examine the predictive value of over forty risk factors, several which have never been examined before, in the sample as a whole and among certain high risk groups. As a result, salient risk factors for PTB were identified for vulnerable subgroups that will allow for better targeted prevention approaches that could promote equity in birth outcomes.

The risk factors from our final predictive model confirm the importance of care management programs to focus on smoking cessation and chronic disease management, and in the postpartum/interconception period, addressing complications that may have contributed to previous adverse pregnancy outcomes to ensure that women are optimally managed before the next pregnancy. We recognize that identifying women at highest risk is only the first step. The utility of a risk scoring system depends on the prevention and treatment options available to women identified as high risk (25). More evidence on the ability of and mechanisms through which care management reduces poor birth outcomes is needed. In the meantime, this study provides a valuable resource in the development of similar large-scale models in other settings to maximize the utility and positive impact of limited resources for preterm birth prevention.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Table 1

Prevalence of Sociodemographic and Program Characteristics and Crude Odds Ratios for Preterm Birth among Women Screened by the Pregnancy Medical Home Program (n=15,428)

	Total	Term 37–42 weeks		Preterm 24–36 weeks				
	(Col %)	N	%	N	%	OR	(95% CI)	p-value
Sociodemographics Age at Delivery								
≤18	(10.36)	1427	89.30	171	10.70	0.99	(0.83, 1.17)	
19–34	(84.44)	11616	89.16	1412	10.84	---	---	
≥35	(5.20)	687	85.66	115	14.34	1.38	(1.12, 1.69)	***
Race/Ethnicity								
Non-Hispanic White	(46.37)	6461	90.31	693	9.69	---	---	
Non-Hispanic Black	(40.26)	5402	86.96	810	13.04	1.40	(1.26, 1.56)	***
Asian/Pacific Islander	(2.48)	344	89.82	39	10.18	1.06	(0.75, 1.49)	
American Indian/Alaska Native	(2.83)	389	89.22	47	10.78	1.13	(0.82, 1.54)	
Hispanic	(8.06)	1134	91.23	109	8.77	0.90	(0.73, 1.11)	
U.S. Born								
No	(6.44)	909	91.45	85	8.55	---	---	
Yes	(93.56)	12821	88.82	1613	11.18	1.35	(1.07, 1.69)	**
Married at Conception or Birth								
No	(70.92)	9682	88.48	1260	11.52	---	---	
Yes	(28.99)	4035	90.23	437	9.77	0.83	(0.74, 0.93)	***
Missing (n=14)	(0.09)	13	-------	1	-------			
Education Level								
< High School	(25.40)	3468	88.49	451	11.51	1.02	(0.90, 1.16)	
High School Graduate or GED	(35.51)	4912	89.65	567	10.35	0.91	(0.81, 1.02)	
Some College or More	(39.03)	5343	88.72	679	11.28	---	---	
Missing (n=8)	(0.05)	7	-------	1	-------			
Program Characteristics Medicaid for Pregnant Women (MPW)								
No	(34.15)	4602	87.36	666	12.64	---	---	
Yes	(65.85)	9128	89.84	1032	10.16	0.78	(0.70, 0.87)	***

	Total	Term 37–42 weeks		Preterm 24–36 weeks				
	(Col %)	**N**	**%**	**N**	**%**	**OR**	**(95% CI)**	**p-value**
Received Care Management								
No	(39.42)	5522	90.81	559	9.19	---	---	
Yes	(60.58)	8208	87.81	1139	12.19	1.37	(1.23, 1.53)	***
Received 17p[†]								
No	(97.80)	13505	89.50	1584	10.50	---	---	
Yes	(2.20)	225	66.37	114	33.63	4.32	(3.43, 5.44)	***
Sample Size (n)	**100.00**	**13730**	**88.99**	**1698**	**11.01**			

Source: Pregnancy Medical Home Case Management Information System, North Carolina Birth Records, and Medicaid Claims Data from September 1, 2011, to September 30, 2012.

(Col %) = column percent; N = frequency; % = row percent; OR = odds ratio; CI = confidence interval.

[*] $p<0.1$,

[**] $p<0.05$,

[***] $p<0.01$

[†] Eligible women with a history of spontaneous preterm birth or preterm rupture of the membranes who are currently pregnant with a singleton (n = 542) are offered 17alpha hydroxyprogesterone (17p).

Table 2

Prevalence of Psychosocial Characteristics and Crude Odds Ratios for Preterm Birth among Women Screened by the Pregnancy Medical Home Program (n=15,428)

	Total	Term 37–42 weeks		Preterm 24–36 weeks				
	(Col %)	N	%	N	%	OR	(95% CI)	p-value
Pregnancy Intention								
Intended	(26.65)	3685	89.64	426	10.36	---	---	
Unintended	(54.81)	7545	89.23	911	10.77	1.04	(0.93, 1.18)	
Don't know	(18.54)	2500	87.38	361	12.62	1.25	(1.08, 1.45)	***
Physical Violence (past year)								
No	(95.97)	13183	89.04	1623	10.96	---	---	
Yes	(4.03)	547	87.94	75	12.06	1.11	(0.87, 1.43)	
Intimate Partner Violence								
No	(99.62)	13680	89.01	1689	10.99	---	---	
Yes	(0.38)	50	84.75	9	15.25	1.46	(0.72, 2.97)	
Forced Sex (ever)								
No	(98.23)	13489	89.01	1666	10.99	---	---	
Yes	(1.77)	241	88.28	32	11.72	1.08	(0.74, 1.56)	
Food Insecurity (past year)								
No	(94.72)	13017	89.07	1597	10.93	---	---	
Yes	(5.28)	713	87.59	101	12.41	1.16	(0.93, 1.43)	
Unsafe or Unstable Housing								
No	(93.80)	12900	89.14	1571	10.86	---	---	
Yes	(6.20)	830	86.73	127	13.27	1.26	(1.04, 1.53)	**
Smoking Status								
Never or Fewer than 100 Cigs	(50.17)	6935	89.60	805	10.40	---	---	
Stopped before Pregnancy	(10.27)	1440	90.85	145	9.15	0.87	(0.72, 1.04)	
Stopped after Pregnancy	(17.17)	2365	89.28	284	10.72	1.04	(0.90, 1.19)	
Cut down since Pregnancy/Smoke Same Amount	(22.39)	2990	86.57	464	13.43	1.34	(1.18, 1.51)	***
Parent/Friend/Partner Substance Problem								

	Total	Term 37–42 weeks		Preterm 24–36 weeks				
	(Col %)	**N**	**%**	**N**	**%**	**OR**	**(95% CI)**	**p-value**
No	(77.70)	10671	89.02	1316	10.98	---	---	
Yes	(22.30)	3059	88.90	382	11.10	1.01	(0.90, 1.14)	
Past Substance Problem								
No	(95.72)	13158	89.10	1610	10.90	---	---	
Yes	(4.28)	572	86.67	88	13.33	1.26	(1.00, 1.58)	*
Alcohol/Drug Use before Pregnancy								
No	(45.31)	6239	89.26	751	10.74	---	---	
Yes	(54.69)	7491	88.78	947	11.22	1.05	(0.95, 1.16)	
Alcohol/Drug Use Past Month								
No	(88.85)	12233	89.24	1475	10.76	---	---	
Yes	(11.15)	1497	87.03	223	12.97	1.24	(1.06, 1.44)	***
Sample Size (n)	**100.00**	**13730**	**88.99**	**1698**	**11.01**			

Source: Pregnancy Medical Home Case Management Information System, North Carolina Birth Records, and Medicaid Claims Data from September 1, 2011, to September 30, 2012.

(Col %) = column percent; N = frequency; % = row percent; OR = odds ratio, CI = confidence interval.

* p<0.1,

** p<0.05,

*** p<0.01

Table 3

Prevalence of Current Pregnancy Characteristics and Crude Odds Ratios for Preterm Birth among Women Screened by the Pregnancy Medical Home Program (n=15,428)

	Total	Term 37–42 weeks		Preterm 24–36 weeks				
	(Col %)	N	%	N	%	OR	(95% CI)	p-value
Body Mass Index								
Underweight	(4.54)	600	85.59	101	14.41	1.48	(1.18, 1.86)	***
Normal weight	(37.92)	5254	89.81	596	10.19	---	---	
Overweight	(24.12)	3310	88.93	412	11.07	1.10	(0.96, 1.25)	
Obese	(33.41)	4566	88.57	589	11.43	1.14	(1.01, 1.28)	**
Multifetal Gestation								
No	(99.03)	13661	89.41	1618	10.59	---	---	
Yes	(0.97)	69	46.31	80	53.69	9.79	(7.07, 13.56)	***
Fetal Complication								
No	(99.63)	13685	89.03	1686	10.97	---	---	
Yes	(0.37)	45	78.95	12	21.05	2.16	(1.14, 4.10)	**
Chronic Conditions Diabetes								
No	(98.53)	13572	89.28	1629	10.72	---	---	
Yes	(1.47)	158	69.60	69	30.40	3.64	(2.73, 4.85)	***
Hypertension								
No	(97.10)	13397	89.43	1583	10.57	---	---	
Yes	(2.90)	333	74.33	115	25.67	2.92	(2.35, 3.64)	***
Asthma								
No	(95.18)	13103	89.23	1582	10.77	---	---	
Yes	(4.82)	627	84.39	116	15.61	1.53	(1.25, 1.88)	***
Mental Illness								
No	(94.53)	12981	89.01	1603	10.99	---	---	
Yes	(5.47)	749	88.74	95	11.26	1.03	(0.83, 1.28)	
HIV								
No	(99.88)	13715	89.00	1695	11.00	---	---	

	Total	Term 37–42 weeks		Preterm 24–36 weeks				
	(Col %)	N	%	N	%	OR	(95% CI)	p-value
Yes	(0.12)	15	83.33	3	16.67	1.62	(0.47, 5.60)	
Seizure								
No	(99.16)	13617	89.01	1682	10.99	---	---	
Yes	(0.84)	113	87.60	16	12.40	1.15	(0.68, 1.94)	
Renal Disease								
No	(99.82)	13710	89.02	1691	10.98	---	---	
Yes	(0.18)	20	74.07	7	25.93	2.84	(1.20, 6.72)	**
Systemic Lupus Erythematosus								
No	(99.87)	13713	89.00	1695	11.00	---	---	
Yes	(0.13)	17	85.00	3	15.00	1.43	(0.42, 4.88)	
Other Chronic Condition								
No	(95.91)	13193	89.16	1604	10.84	---	---	
Yes	(4.09)	537	85.10	94	14.90	1.44	(1.15, 1.80)	***
Current or Recent Drug/Alcohol Use								
No	(94.09)	12926	89.05	1590	10.95	---	---	
Yes	(5.91)	804	88.16	108	11.84	1.09	(0.89, 1.34)	
Delayed Prenatal Care (>14 weeks)								
No	(79.65)	10883	88.57	1405	11.43	---	---	
Yes	(20.35)	2847	90.67	293	9.33	0.80	(0.70, 0.91)	***
Cervical Insufficiency								
No	(99.47)	13684	89.17	1662	10.83	---	---	
Yes	(0.53)	46	56.10	36	43.90	6.44	(4.15, 10.00)	***
Gestational Diabetes								
No	(99.59)	13675	89.00	1690	11.00	---	---	
Yes	(0.41)	55	87.30	8	12.70	1.18	(0.56, 2.48)	
Vaginal Bleeding in Second Trimester								
No	(99.62)	13682	89.02	1687	10.98	---	---	
Yes	(0.38)	48	81.36	11	18.64	1.86	(0.96, 3.59)	*
Hypertensive Disorders of Pregnancy								

	Total	Term 37–42 weeks		Preterm 24–36 weeks				
	(Col %)	**N**	**%**	**N**	**%**	**OR**	**(95% CI)**	**p-value**
No	(99.28)	13644	89.08	1673	10.92	---	---	
Yes	(0.72)	86	77.48	25	22.52	2.37	(1.51, 3.71)	***
Short Interpregnancy Interval (<12 mos)								
No	(94.51)	12990	89.09	1591	10.91	---	---	
Yes	(5.49)	740	87.37	107	12.63	1.18	(0.96, 1.46)	
Current Sexually Transmitted Infection								
No	(97.82)	13439	89.05	1653	10.95	---	---	
Yes	(2.18)	291	86.61	45	13.39	1.26	(0.92, 1.73)	
Recurrent Urinary Tract Infection								
No	(98.86)	13577	89.02	1675	10.98	---	---	
Yes	(1.14)	153	86.93	23	13.07	1.22	(0.78, 1.89)	
Provider Requests Pregnancy Assessment								
No	(84.93)	11694	89.25	1409	10.75	---	---	
Yes	(15.07)	2036	87.57	289	12.43	1.18	(1.03, 1.35)	**
Communication Barrier								
No	(97.66)	13394	88.90	1673	11.10	---	---	
Yes	(2.34)	336	93.07	25	6.93	0.60	(0.40, 0.90)	**
Sample Size (n)	**100.00**	**13730**	**88.99**	**1698**	**11.01**			

Source: Pregnancy Medical Home Case Management Information System, North Carolina Birth Records, and Medicaid Claims Data from September 1, 2011, to September 30, 2012.

(Col %) = column percent; N = frequency; % = row percent; OR = odds ratio; CI = confidence interval.

* p<0.1,

** p<0.05,

*** p< 0.01

Table 4

Prevalence of Obstetric History Characteristics and Crude Odds Ratios for Preterm Birth among Women Screened by the Pregnancy Medical Home Program (n=15,428)

	Total	Term 37–42 weeks		Preterm 24–36 weeks				
	(Col %)	N	%	N	%	OR	(95% CI)	p - value
Nulliparous								
No	(57.24)	7817	88.52	1014	11.48	---	---	
Yes	(42.76)	5913	89.63	684	10.37	0.89	(0.81, 0.99)	**
Non-spontaneous Preterm Birth								
No	(96.10)	13283	89.59	1543	10.41	---	---	
Yes	(3.90)	447	74.25	155	25.75	2.99	(2.47, 3.61)	***
Spontaneous PTB or Rupture of Membranes								
No	(96.45)	13344	89.68	1536	10.32	---	---	
Yes	(3.55)	386	70.44	162	29.56	3.65	(3.01, 4.41)	***
Low Birth Weight								
No	(98.11)	13514	89.28	1622	10.72	---	---	
Yes	(1.89)	216	73.97	76	26.03	2.93	(2.25, 3.83)	***
Fetal Death								
No	(98.81)	13601	89.22	1643	10.78	---	---	
Yes	(1.19)	129	70.11	55	29.89	3.53	(2.56, 4.86)	***
Neonatal Death								
No	(99.53)	13680	89.09	1675	10.91	---	---	
Yes	(0.47)	50	68.49	23	31.51	3.76	(2.29, 6.17)	***
Second Trimester Pregnancy Loss								
No	(98.94)	13611	89.17	1653	10.83	---	---	
Yes	(1.06)	119	72.56	45	27.44	3.11	(2.20, 4.40)	***
Three or More First Trimester Losses								
No	(98.90)	13588	89.05	1671	10.95	---	---	
Yes	(1.10)	142	84.02	27	15.98	1.55	(1.02, 2.34)	**
Cervical Insufficiency								

	Total	Term 37–42 weeks		Preterm 24–36 weeks				
	(Col %)	**N**	**%**	**N**	**%**	**OR**	**(95% CI)**	**p - value**
No	(99.69)	13704	89.10	1676	10.90	---	---	
Yes	(0.31)	26	54.17	22	45.83	6.92	(3.91, 12.23)	***
Gestational Diabetes								
No	(98.42)	13521	89.05	1663	10.95	---	---	
Yes	(1.58)	209	85.66	35	14.34	1.36	(0.95, 1.96)	*
Postpartum Depression								
No	(98.59)	13539	89.01	1672	10.99	---	---	
Yes	(1.41)	191	88.02	26	11.98	1.10	(0.73, 1.67)	
Hypertensive Disorders of Pregnancy								
No	(96.16)	13227	89.16	1608	10.84	---	---	
Yes	(3.84)	503	84.82	90	15.18	1.47	(1.17, 1.85)	***
Sample size (n)	**100.00**	**13730**	**88.99**	**1698**	**11.01**			

Source: Pregnancy Medical Home Case Management Information System, North Carolina Birth Records, and Medicaid Claims Data from September 1, 2011, to September 30, 2012.

(Col %) = column percent; N = frequency; % = row percent; OR = odds ratio; CI = confidence interval.

* p<0.1,

** p<0.05,

*** p< 0.01

Table 5

Final Predictive Model for Preterm Birth with Bias Corrected Confidence Intervals from Bootstrapping among Women Screened by the Pregnancy Medical Home Program (n=15,428)

	OR	BC (95% CI)	p-value
Characteristics			
Non-Hispanic White	---	---	
Non-Hispanic Black	1.40	(1.25, 1.56)	***
Asian/Pacific Islander	1.20	(0.82, 1.65)	
American Indian/Alaska Native	1.10	(0.82, 1.53)	
Hispanic	1.02	(0.81, 1.24)	
Never or Fewer than 100 Cigarettes	---	---	
Stopped Smoking before Pregnancy	0.90	(0.73, 1.08)	
Stopped Smoking after Pregnancy	1.04	(0.88, 1.20)	
Cut Down since Pregnancy/Smoke Same Amount	1.37	(1.21, 1.57)	***
Underweight	1.55	(1.21, 1.93)	***
Normal weight	---	---	
Overweight	1.06	(0.91, 1.21)	
Obese	0.93	(0.83, 1.08)	
Multifetal Gestation	10.78	(7.66, 16.22)	***
Chronic Diabetes	3.04	(2.20, 4.08)	***
Chronic Hypertension	2.34	(1.82, 2.98)	***
Asthma	1.36	(1.07, 1.68)	***
Renal Disease	2.58	(0.81, 6.45)	**
Other Chronic Condition	1.30	(1.00, 1.63)	**
Cervical Insufficiency (current or history)	2.87	(1.72, 4.43)	***
Nulliparous	1.20	(1.06, 1.33)	***
Parous	---	---	
Non-spontaneous Preterm Birth History	2.76	(2.18, 3.39)	***
Spontaneous Preterm Birth or Rupture of Membranes History	3.39	(2.71, 4.28)	***
Low Birth Weight History	1.35	(0.97, 1.84)	**
Fetal Death/Second Trimester Loss History	1.73	(1.24, 2.35)	***

Source: Pregnancy Medical Home Case Management Information System, North Carolina Birth Records, and Medicaid Claims Data from September 1, 2011, to September 30, 2012.

** $p < 0.05$,

*** $p < 0.01$.

All variables in the model are significant at $p<0.05$ unless they are part of a group of indicators in which not all indicators are statistically significant.

OR = odds ratio; BC = bias corrected; CI = confidence interval

Table 6

Comparison of Risk Factors Prioritized by the Pregnancy Medical Home Program to Risk Factors in the Final Predictive Model in the Full Sample and Subgroup Analyses

A. Current PMH Priority Risk Factors	B. Priority Risk Factors in Final Models	C. Non-Priority Risk Factors in Final Models	D. Priority Risk Factors not in Final Models
Current or Recent Smoking	Current Smoking		Recent Smoking
Current or Recent Substance Use			Current or Recent Substance Use
Unsafe or Unstable housing, IPV, Sexual Abuse	Unsafe or Unstable Housing (White)		IPV, Sexual Abuse
All Chronic Diseases	Diabetes, Hypertension, Asthma, Renal, Other (White)		HIV, Lupus, Seizure, Mental illness
Fetal Complications			Fetal Complications
Multiple Gestation	Multiple Gestation		
Previous Preterm Birth or Low Birth Weight	Previous Preterm Birth or Low Birth Weight		
Delayed or *Missed Prenatal Care*			Delayed Prenatal Care
Hospitalization or Emergency Department Use			
Provider Requests Care Management			Provider Requests Care Management
		Non-Hispanic Black	
		Nulliparity	
		Underweight	
		Cervical Insufficiency	
		Fetal Death/Second Trimester Loss	
		Food Insecurity (Parous)	
		Obesity (Nulliparous)	
		Short Interpregnancy Interval (Black)	

Italics denotes factors from the Pregnancy Medical Home (PMH) risk screen that were not evaluated. Parentheses denotes the subgroup for which this risk factor was a significant predictor of preterm birth.