REPORT

Fetal Fibronectin Testing and Pregnancy Outcomes Among Texas Medicaid Patients at Risk for Preterm Birth

Jamie C. Barner, PhD; Allison A. Petrilla, MPH; Hyeun Ah Kang, MS; Xian Shen, PhD; Ahmed M. Alshehri, MS, B Pharm; Erin M. Sullivan, PhD, MPH; Kathleen A. Troeger, MPH; Kristin M. Richards, PhD; and Sean C. Blackwell, MD

Infants born prematurely, prior to 37 weeks of gestation, are more likely to experience both acute and long-term health problems, experience higher mortality rates, and incur substantial medical expenses compared with infants delivered at term (weeks 38-41).[1,2] In the United States, it is estimated that approximately 10% of all infants are born prematurely,[3] resulting in an estimated economic burden in excess of $26 billion per year.[4] Medicaid disproportionately covers more preterm births (PTBs) than does private insurance (48.9% vs 42.3% of all PTBs in 2012, respectively).[5] Given the socioeconomic, personal, and population-level health burden associated with PTB, it is imperative to identify and carefully manage patients who are at high risk for spontaneous PTB (sPTB) and/or present with symptoms of preterm labor (PTL), defined as the onset of labor between the 24th and 37th weeks of pregnancy.

Predicting which patients are at high risk for sPTB is a difficult process that involves assessment of the patient for risk factors of sPTB. Some of these risk factors include a history of prior PTB, multiple gestations, maternal infections, vaginal bleeding, use of in vitro fertilization, being either underweight or obese, being younger than 18 years or older than 35 years, maternal history of smoking or of illegal drug or alcohol use, race, and low socioeconomic status.[6] Methods commonly used to assess the risk of sPTB include digital cervical examination, uterine activity monitoring, and transvaginal ultrasound (TVU) cervical length measurement. Additionally, testing for the presence of fetal fibronectin (fFN) in women with signs and symptoms of PTL between weeks 24 and 34 of pregnancy can aid in assessing the risk of preterm delivery within the following 14 days.[7-9] Given the subjective nature of PTL symptoms, differentiation between true and false PTL can be difficult, and errors can lead to risks of overtreatment as well as missed treatment.

Current management strategies for PTL include hospitalization, use of tocolytics, treatment with antibiotics for group beta *streptococcus* prophylaxis, administration of antenatal corticosteroids to increase the rate of fetal organ development, and magnesium sulfate for fetal neuroprotection. Posthospitalization care often includes activity restriction and/or bedrest.[10]

ABSTRACT

Objectives: Fetal fibronectin (fFN) testing between the 24th and 34th weeks of pregnancy in patients with symptomatic preterm labor (PTL) helps assess the risk of spontaneous preterm birth (sPTB), yet the extent of its use is unknown. We assessed use of fFN testing among Texas Medicaid enrollees with symptomatic PTL and evaluated time to infant delivery and healthcare utilization/costs.

Study Design: Retrospective cohort study using medical and pharmacy claims for Texas Medicaid enrollees.

Methods: We identified pregnant women triaged through the emergency department (ED) and hospital labor-and-delivery units with symptomatic PTL between January 1, 2012, and May 31, 2015. Patients with fFN testing prior to delivery were propensity score matched 1:1 to patients without fFN testing. Primary outcomes included time to delivery from initial PTL encounter and all-cause maternal healthcare utilization and costs.

Results: A total of 29,553 women met the criteria for analysis, of whom 14% had a record of receiving fFN testing. Each matched cohort included 4098 patients. Compared with those who did not, patients who underwent fFN testing had significantly more clinical risk factors (mean [SD]: 1.7 [1.1] vs 1.1 [1.0]; P <.0001) and were less likely to deliver during the initial hospital stay (odds ratio [OR], 0.539; 95% CI, 0.489-0.594), deliver ≤3 days following the hospital/ED encounter (OR, 0.499; 95% CI, 0.452-0.551); and receive their first PTL diagnosis during the initial hospital/ED encounter (OR, 0.598; 95% CI, 0.539-0.665). Patients who had an fFN test, compared with those who did not, had 17.5% higher total costs (P <.0001) during the 5 months prior to delivery, but had gestation lengths 9.4 days longer (24.6 vs 15.2 days) than those without testing.

Conclusions: Frequency of fFN testing was low in Texas Medicaid enrollees with symptomatic PTL. Patients with fFN testing had longer gestation periods and were less likely to deliver within ≤3 days of a hospital/ED encounter for PTL. These results support the role of fFN in screening for risk for sPTB among women with symptomatic PTL.

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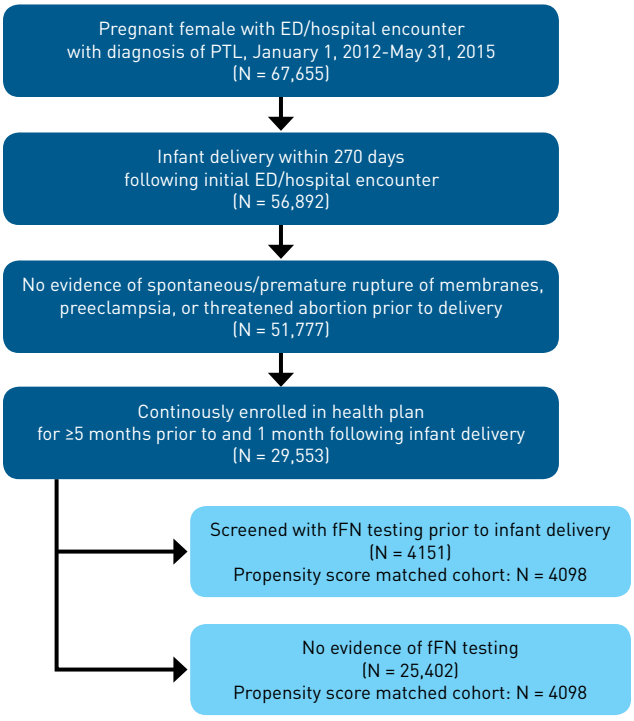
For author information and disclosures, see end of text.

FIGURE 1. Cohort Selection and Attrition



ED indicates emergency department; fFN, fetal fibronectin; PTL, preterm labor.

The objective of this study was to examine the use of diagnostic tools, including fFN testing, to evaluate women diagnosed with PTL or threatened PTL, and to assess delivery outcomes, healthcare utilization, and healthcare costs in a cohort of pregnant Medicaid enrollees. Efforts to more accurately identify patients who are at low risk of sPTB could also help to optimize patient management and potentially reduce healthcare costs, unnecessary treatments, and activity restriction.

Methods

We performed a retrospective cohort study to evaluate medical and pharmacy claims for Texas Medicaid enrollees, including both inpatient and outpatient visits. Information included in the data was extracted from Texas Medicaid claims and eligibility files, and it included: de-identified unique patient identification numbers; year of birth; gender; race/ethnicity; dates of enrollment; *International Classification of Diseases, Ninth Revision, Clinical Modification* (*ICD-9-CM*) codes (diagnostic codes); Diagnosis Related Group (DRG) codes; *Current Procedural Terminology*, 4th edition, codes (procedure codes); Healthcare Common Procedure Coding System codes (supplies and services codes); Generic Code Number; prescription dispense date; hospital admission date; hospital discharge date; date of outpatient visit; cost of drugs; and other medical services received. Costs were defined as paid Medicaid claims.

Eligibility Criteria

Female enrollees at least 21 years of age who were admitted to the hospital or had an emergency department (ED) visit with a diagnosis for PTL in any setting of care (inpatient or outpatient) between January 1, 2012, and May 31, 2015, were included in the analysis. We excluded patients with any of the following: (1 no record of infant delivery within 270 days (9 months) of the initial hospitalization or ED visit; (2 diagnosis of spontaneous/premature rupture of membranes, preeclampsia, or threatened abortion; or (3 not continuously enrolled in Medicaid for 5 months prior to the initial hospital or ED visit and 1 month post delivery. *ICD-9-CM*, Medicare Severity-DRG (prior to September 2012), and All Patients Refined-DRG (from September 2012 on) codes reported in the inpatient or outpatient medical claims files were used to identify women with these conditions. The index date was the date of delivery, and the preindex period was the 5 months prior to delivery.

Study Outcomes

Study outcomes were: (1 time to infant delivery from initial PTL hospital/ED visit, defined as the number of days from initial PTL hospital/ED visit to delivery; (2 proportion of women who delivered during the initial hospitalization/ED visit, defined as the sum of women who delivered during the initial hospitalization/ED visit divided by the total number of women in the initial sample; (3 all-cause healthcare utilization and costs, defined as total utilization and direct costs in the preindex period; (3a number of all-cause inpatient hospitalizations, ED visits, outpatient visits, pharmacy claims, and unique number of medications in the prenatal period (or preindex period); and (3b costs of all-cause inpatient hospitalizations, ED visits, outpatient visits, and pharmacy claims (adjusted to 2015 US dollars using the medical consumer price index from the US Bureau of Labor Statistics' current data[11]).

Secondary outcomes of interest were: (1 hospital length of stay, defined as the number of days from admission to discharge; and (2 PTL type, defined as the proportion of patients who had actual (delivered during initial hospitalization) versus threatened (did not deliver during initial hospitalization) PTL. A sensitivity analysis compared healthcare resource utilization and costs among patients who had undergone any test or procedure for PTL, defined as: (a fFN testing, (b encounter for risk of PTL screening, or (c TVU to patients with no PTL procedures/tests.

Statistical Methods

The primary independent variable for all analyses was fFN testing status. Descriptive statistics were used to describe the characteristics of the study cohort and key study outcomes. Bivariate (unadjusted)

analyses were performed to determine the relationship between fFN test status and age, race/ethnicity, risk factors, and comorbid conditions; bivariate analysis was also used to identify significant covariates to be used in multivariate regression analysis. For bivariate analysis, *t* tests for continuous variables and χ^2 for categorical variables were employed.

Cohorts were matched based on the propensity to receive fFN testing. Propensity scores were calculated using logistic regression with a nearest neighbor match using a caliper set at 0.05 (sensitivity analyses were conducted to identify the most appropriate caliper).[12] A classification of fFN test (1 = yes, 0 = no) served as the binary dependent variable, and independent variables included: delivery type (full term vs preterm), pregnancy-related complications, and presence or absence of risk factors, which included prior PTB, multiple gestation, tocolyzation, cervical incompetence/shortening, systemic infections, genitourinary infections, and other risk factors. To determine whether balance was achieved with propensity score matching and to assess standardized differences, statistical comparisons of baseline characteristics between the matched cohorts were conducted using McNemar's test for categorical variables and 2-sided paired Student's *t* test for continuous variables.

Both bivariate (unadjusted) and multivariate (adjusted) statistical analyses were performed to determine the relationship between fFN testing and delivery outcomes, healthcare utilization, or healthcare costs. Risk factors, comorbid conditions, and age were included as covariates in multivariate analyses. Race/ethnicity was excluded due to limited data availability. Statistical models (conditional logistic regression models, Poisson regression, generalized linear models with gamma distribution and log link, and generalized estimating equation regression) were employed for the adjusted analyses. All statistical analyses were 2-tailed; the significance level was set to $P < .05$ and confidence intervals were set to 95%. Distributions of the outcome variables to decide the statistical models to use were determined by running the modified Park test using STATA 14 (Stata Corp LLC; College Station, Texas). All other data manipulation and statistical analyses were performed using SAS for Windows, version 9.4 (SAS Institute; Cary, North Carolina).

TABLE 1. Bivariate Comparison of Demographics and Clinical Characteristics: Patients With Versus Without fFN Testing

	Total (N = 29,553)	fFN screened (n = 4151)	Not fFN screened (n = 25,402)	*P*
Demographics				
Age, years: mean (SD)[a]	24.5 (5.6)	24.5 (5.2)	24.5 (5.7)	.5931
Race/ethnicity: n (%)[b]				<.0001
Caucasian	1320 (4.5)	276 (6.7)	1044 (4.1)	
African American	2571 (8.7)	451 (10.9)	2120 (8.4)	
Hispanic	5375 (18.2)	615 (14.8)	4760 (18.7)	
Other	320 (1.1)	48 (1.2)	272 (1.1)	
Unknown/unavailable	5427 (66.2)	2712 (66.2)	2715 (66.3)	
Clinical Characteristics				
Risk factors: n (%)				
Prior preterm birth[b]	2065 (7.0)	666 (16.0)	3485 (5.5)	<.0001
Multiple gestation[b]	1627 (5.5)	314 (7.6)	1313 (5.2)	<.0001
Tocolysis[b]	2868 (9.7)	938 (22.6)	1930 (7.6)	<.0001
Cervical incompetence/ shortening[b]	174 (0.6)	32 (0.8)	142 (0.6)	.0981
Infections[b]				
Genitourinary	10,823 (36.6)	1802 (43.4)	9021 (35.5)	<.0001
Systemic[c]	691 (3.0)	108 (2.6)	583 (2.3)	.2254
Other risk factors[d]	1053 (3.6)	200 (4.8)	853 (3.4)	<.001
Other infections/complications[e]				
Other infections[b,f]	2142 (7.3)	322 (7.8)	1820 (7.2)	.1723
Other pregnancy-related complications[b,g]	14,398 (48.7)	2554 (61.5)	11,844 (46.6)	<.0001
Sum of risk factors (SD)[a]	1.2 (1.0)	1.7 (1.1)	1.1 (1.0)	<.0001
Comorbid conditions: n (%)				
Hypertension[b]	3558 (12.0)	480 (11.6)	3078 (12.1)	.3095
Diabetes[b]	1899 (6.4)	249 (6.0)	1650 (6.5)	.2260
Anemia[b]	6903 (23.4)	1080 (26.0)	5823 (22.9)	<.0001
Sum of comorbid conditions (SD)[a]	0.4 (0.6)	0.4 (0.6)	0.4 (0.6)	.0449

fFN indicates fetal fibronectin; SD, standard deviation.
[a]*t* test.
[b]Chi-square.
[c]Pneumonia and asymptomatic bacteriuria.
[d]Hemorrhage.
[e]Exploratory variables.
[f]Tuberculosis, malaria, rubella, other viral/infectious disease.
[g]Other complications: suspected damage to fetus, abnormalities.

Kaplan-Meier analysis was used to estimate the fraction of study subjects reaching the study endpoint (time to delivery). The time frame was the first hospitalization/ED visit with symptomatic PTL to delivery. Survival function curves of time to delivery were plotted for those who received fFN testing versus those who did not. Cox proportional hazard regression model was used to further test whether there was a significant difference between time to delivery and fFN test status, while controlling for covariates.

TABLE 2. Bivariate Comparison of Delivery Outcomes and First PTL Diagnosis During Initial Hospitalization/ED Visit, Using Propensity Matched Cohorts: Patients With Versus Without fFN Testing

Primary outcomes	Total (N = 8196)	fFN test (n = 4098)	No fFN test (n = 4098)	*P*
Infant delivery during initial hospitalization/ED encounter				
n (%)[a]	4312 (52.6)	1882 (45.9)	2430 (59.3)	<.0001
First PTL diagnosis during initial hospitalizations/ED encounter				
n (%)[a]	6056 (73.9)	2832 (69.1)	3224 (78.7)	<.0001
Time to delivery following initial hospitalization/ED encounter				
Days: mean (SD)[b,c]	19.9 (32.9)	24.6 (34.8)[c]	15.2 (30.2)[c]	<.0001
Delivered within 3 days: n (%)	4630 (56.5)	2011 (49.1)	2619 (63.9)	<.0001
Time to delivery (among those who did not deliver during initial hospitalization/ED visit)[d]	N = 3884	n = 2216	n = 1668	
Days: mean (SD)[b]	42.0 (36.8)	45.5 (36.0)	37.4 (37.5)	<.0001
Delivered within 3 days: n (%)	318 (8.2)	129 (5.8)	189 (11.3)	<.0001
Secondary outcomes	N = 8196	n = 4098	n = 4098	
Hospital length of stay (initial hospitalization): mean (SD)	2.1 (2.9)	2.0 (2.9)	2.1 (3.0)	.4785
Hospital length of stay (delivery hospitalization): mean (SD)	1.6 (2.2)	1.6 (1.9)	1.7 (2.4)	.2013
Readmissions: mean (SD)	1.5 (2.1)	1.7 (2.2)	1.3 (2.0)	<.0001
PTL type = actual PTL: n (%)	5689 (69.4)	2768 (67.6)	2921 (71.3)	<.0001
Amniotic fluid infection: n (%)	114 (1.4)	70 (1.7)	44 (1.1)	.0149

ED indicates emergency department; fFN, fetal fibronectin; PTL, preterm labor; SD, standard deviation.
[a]Chi-square.
[b]*t* test.
[c]Log rank $\chi^2 = 410.8816$; $P = <.0001$.
[d]Includes patients who did not deliver during initial hospitalization/ED encounter.

Results

After applying all inclusion/exclusion criteria as described in **Figure 1**, 29,553 patients composed the final study cohort. Of these, 74.0% of the patients had an actual PTL diagnosis (early onset delivery) and 26.0% had a diagnosis of threatened PTL (early, threatened, or false labor) during the 5-month period prior to delivery. A total of 14.0% (n = 4151) of patients received fFN testing.

Patient Characteristics

Table 1 compares the demographic and clinical characteristics between women with and without fFN testing. More than 60% of the race/ethnicity data were missing. There were differences in multiple risk factors between groups, with women undergoing fFN testing having higher frequency of prior PTB (16.0% vs 5.5%) and of multiple gestation (7.6 % vs 5.2%). Data regarding tobacco use and history of substance abuse were limited based on diagnosis codes and were therefore not included for further analysis. There were no differences in the prevalence of comorbidities (hypertension, diabetes, or anemia) between the patients who had fFN testing and those who did not. Overall, patients who had fFN testing had more risk factors (mean [SD]: 1.7 [1.1] vs 1.1 [1.0]; *P* <.0001). After applying the 1:1 propensity score matching to account for the differences in baseline risk factors, the new population size was 8196 for fFN testing and no fFN testing (4098 patients in each group) and all subsequent analyses were performed using the propensity score matched cohorts.

Delivery Outcomes

Among 8196 patients included in the propensity score matched sample, 4312 (52.6%) delivered during the initial hospital/ED encounter (**Table 2**). A lower proportion of patients in the fFN group experienced this outcome as opposed to those who did not receive fFN testing (45.9% vs 59.3%). Overall, time to delivery was approximately 9 days longer for those who had fFN testing versus no fFN testing (mean [SD]: 24.6 [34.8] vs 15.2 [30.2] days; *P* <.0001). Median time to delivery was 5 days for those with fFN testing versus 0 days for those with no fFN testing. Additionally, a lower proportion of those who had fFN testing for PTL delivered within 3 days of the initial hospitalization/ED visit compared with those who did not (49.1% vs 63.9%; *P* <.0001).

Compared with patients without fFN testing, multivariate regression analyses showed that patients who had fFN testing were: 46.1% less likely to deliver in their first hospital visit (odds ratio [OR], 0.539; 95% CI, 0.489-0.594; *P* <.0001); 50.1% less likely to deliver within 3 days of the initial hospitalization/ED visit (OR, 0.499; 95% CI, 0.452-0.551; *P* <.0001); and 40.2% less likely to be diagnosed with PTL during their initial hospitalization/ED visit (OR, 0.598; 0.539-0.665; *P* <.0001) (**Table 3**). Consistent with the regression analysis, a Kaplan-Meier analysis revealed that patients who had fFN testing remained pregnant longer than those who had no fFN testing (χ^2, 156.2133; *P* <.0001) (**Figure 2**). The mean (SD) length of hospital stay at the initial hospitalization was 2.0 (2.9) days for patients with fFN testing and 2.1 (3.0) days for patients with no fFN testing (*P* = .4785); there was no difference in median days (1 day for both).

Healthcare Utilization

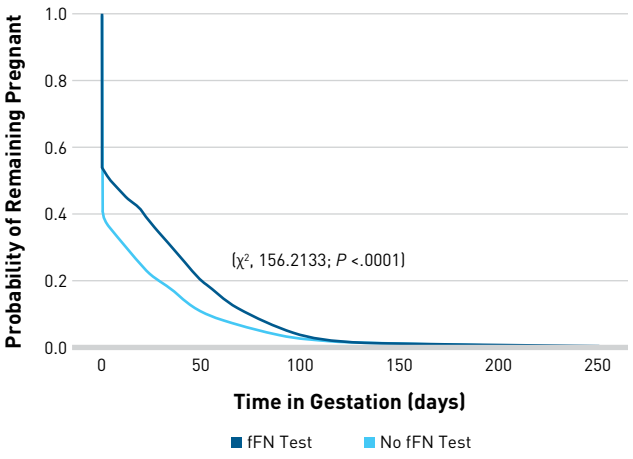
Multivariate regression analysis showed that patients who had fFN testing compared with those who did not had: 39.1% higher risk for hospitalizations/ED visits (incidence rate ratio [IRR], 1.39; 95% CI, 1.33-1.45; *P* <.0001); 18.7% higher risk for outpatient visits (IRR, 1.19; 95% CI, 1.16-1.22; *P* <.0001), and 17.5% higher risk for prescription utilization (IRR, 1.17; 95% CI, 1.12-1.23; *P* <.0001) (**Table 4**). Each unit

TABLE 3. Regression Analyses Comparing Delivery Outcomes and fFN Testing Status (N = 8196)

Time to delivery following initial hospital/ED encounter	Hazard ratio[a]	95% CI		*P*
		Lower	Upper	
fFN testing (ref: no fFN testing)	0.761	0.720	0.804	<.0001
No. of risk factors	0.883	0.668	1.168	.384
No. of comorbid conditions	0.984	0.923	1.049	.620
Age	1.005	0.997	1.013	.207
Delivery within ≤3 days of 1st hospital/ED encounter	**Odds ratio[b]**	**95% CI**		***P***
		Lower	**Upper**	
fFN testing (ref: no fFN testing)	0.499	0.452	0.551	<.0001
No. of risk factors	0.731	0.432	1.237	.243
No. of comorbid conditions	0.972	0.865	1.092	.634
Age	1.012	0.998	1.026	.097
Delivery during 1st hospital/ED encounter	**Odds ratio[a]**	**95% CI**		***P***
		Lower	**Upper**	
fFN testing (ref: no fFN testing)	0.539	0.489	0.594	<.0001
No. of risk factors	0.763	0.471	1.237	.273
No. of comorbid conditions	0.923	0.822	1.036	.172
Age	1.014	1.001	1.028	.038
PTL diagnosis during 1st hospital/ED encounter	**Odds ratio[b]**	**95% CI**		***P***
		Lower	**Upper**	
fFN testing (ref: no fFN testing)	0.598	0.539	0.665	<.0001
No. of risk factors	1.133	0.660	1.875	.689
No. of comorbid conditions	1.011	0.891	1.148	.861
Age	1.002	0.987	1.017	.832

ED indicates emergency department; fFN indicates fetal fibronectin; ref, reference.
[a]Cox proportional hazards model.
[b]Logistic regression.

FIGURE 2. Kaplan-Meier Log-Rank Curve Comparing Time in Gestation by PTL fFN Testing Versus no fFN Testing (N = 8196)



fFN indicates fetal fibronectin; PTL, preterm labor.
Light blue is patients without fFN testing (N = 4098); dark blue is patients with fFN testing (N = 4098).

increase in sum of risk factors or sum of comorbid conditions (see Table 1 for included risk factors and comorbid conditions) resulted in an increased risk for healthcare utilization (ranges: 9.3%-15.9% for risk factors, 11.9%-23.1% for comorbid conditions). Each year increase in age decreased the risk for hospitalizations/ED visits and outpatient visits (range, 1.2%-1.8%; *P* <.05 for all); the only exception to this was the model predicting the number of prescriptions, in which age was not statistically significant.

All-Cause Maternal Healthcare Costs

Total all-cause maternal costs were $2252.40 higher for patients who had fFN testing compared with patients without fFN testing: $15,238.20 (SD = $12,845.20) versus $12,985.80 (SD = $13,513.70) (*P* <.0001). After multivariate adjustment, patients who had an fFN test had 17.5% higher total costs (OR, 1.18; 95% CI; 1.13-1.22; *P* <.0001), 6.7% higher hospitalization/ED costs (OR, 1.07; 95% CI; 1.01-1.13; *P* = .0263), and 29.4% higher outpatient costs (OR, 1.29; 95% CI, 1.24-1.35; *P* <.0001) than patients without an fFN test.

Prescription costs were not statistically significantly different between patients who had fFN testing and those who did not. Higher numbers of risk factors or comorbid conditions were associated with increased healthcare costs (OR range: 6.7%-19.2% for risk factors and 23.8%-45.4% for comorbid conditions) while older age was associated with a decrease in healthcare costs (OR range: 0.7%-0.9%) (**Table 5**).

Sensitivity Analysis of Healthcare Utilization and Costs Among Patients With Any PTL Screening Versus No Screening

A secondary analysis compared patients who had undergone any test or procedure for PTL—defined as: 1) fFN testing, 2) encounter for risk of PTL screening, or 3) TVU—to patients with no PTL procedures/tests. This analysis yielded similar results. Almost half (49.8%) of the patients had at least 1 procedure, mostly commonly a TVU (44.1% of all patients). Patients who had any test or diagnostic procedure for PTL had, on average, 1.4 (SD = 1.1) times more risk factors compared with those who had no tests or procedures for PTL: (1.4 [1.1] vs 1.0 [0.9] risk factors; *P* <.0001). Despite the greater number of risk factors, patients who had any diagnostic test or procedure for PTL were 28.1% less likely to deliver during their first hospitalization/ED visit (OR, 0.719; 95% CI, 0.678-0.764; *P* <.0001), 33.2% less likely to deliver within 3 days of their first hospitalization/ED visit (OR, 0.668; 95% CI, 0.628-0.711; *P* <.0001), and 20.8% less likely to be diagnosed during their initial hospitalization/ED visit (OR, 0.792; 95% CI, 0.741-0.848; *P* <.0001). Gestation periods were an average 5

TABLE 4. Poisson Regression Analyses Comparing Healthcare Utilization and fFN Testing Status (N = 8196)

		95% CI		
	IRR	Lower	Upper	*P*
Hospital/ED utilization				
fFN testing (ref: no fFN testing)	1.3907	1.3347	1.4490	<.0001
No. of risk factors	1.1588	1.1312	1.1870	<.0001
No. of comorbid conditions	1.1957	1.1442	1.2494	<.0001
Age	0.9817	0.9778	0.9855	<.0001
Outpatient utilization				
fFN testing (ref: no fFN testing)	1.1868	1.1571	1.2174	<.0001
No. of risk factors	1.0925	1.0770	1.1082	<.0001
No. of comorbid conditions	1.1194	1.0907	1.1489	<.0001
Age	0.9876	0.9847	0.9905	<.0001
Prescription utilization				
fFN testing (ref: no fFN testing)	1.1746	1.1214	1.2302	<.0001
No. of risk factors	1.0961	1.0689	1.1242	<.0001
No. of comorbid conditions	1.2306	1.1743	1.2897	<.0001
Age	1.0033	0.9985	1.0081	.1794

fFN indicates fetal fibronectin; IRR, incidence rate ratio; ref, reference.

TABLE 5. Generalized Estimation Equation Regression Analyses Assessing Predictors of Healthcare Costs (N = 8196)

		95% CI		
Measure	IRR	Lower	Upper	*P*
Total healthcare costs				
fFN testing (ref: no fFN testing)	1.1750	1.1307	1.2210	<.0001
No. of risk factors	1.1512	1.1257	1.1772	<.0001
No. of comorbid conditions	1.2521	1.2013	1.3049	<.0001
Age	0.9927	0.9888	0.9968	.0004
Outpatient costs				
fFN testing (ref: no fFN testing)	1.2940	1.2440	1.3461	<.0001
No. of risk factors	1.1924	1.1661	1.2192	<.0001
No. of comorbid conditions	1.2384	1.1891	1.2897	<.0001
Age	0.9906	0.9861	0.9952	<.0001
Hospital/ED costs				
fFN testing (ref: no fFN testing)	1.0668	1.0076	1.1295	.0263
No. of risk factors	1.1164	1.0790	1.1552	<.0001
No. of comorbid conditions	1.2438	1.1746	1.3172	<.0001
Age	0.9933	0.9878	0.9988	.0171
Prescription costs				
fFN testing (ref: no fFN testing)	1.0847	0.9805	1.2000	.1146
No. of risk factors	1.0668	1.0024	1.1355	.0417
No. of comorbid conditions	1.4540	1.3315	1.5877	<.0001
Age	1.0093	0.9990	1.0199	.0777

ED indicates emergency department; fFN, fetal fibronectin; IRR, incidence rate ratio; ref, reference.

days longer for those who had a diagnostic test or procedure for PTL compared with patients without any PTL tests or procedure: 15.9 (32.9) versus 11.1 (26.2) days. Patients with any test or procedure for PTL were also more likely to incur greater healthcare costs (OR, 1.33; 95% CI, 1.30-1.37; P <.0001) and higher healthcare utilization (hospital/ED IRR, 1.56; 95% CI, 1.52-1.60; P <.0001; outpatient IRR, 1.33; 95% CI, 1.31-1.36; P <.0001; and prescriptions (IRR, 1.37; 95% CI, 1.33-1.41; P <.0001) (**Tables 6A** and **6B**). These results are consistent with those of the fFN analysis, in which tests or procedures for PTL were associated with a higher number of risk factors and longer times to delivery. Interestingly, the proportion of patients who delivered within 3 days of the initial hospital/ED visit was the lowest for patients who had both a TVU and an fFN test (47.3%), followed by patients who had only an fFN test (51.9%), and patients with only a TVU (68.8%). The proportion of women who delivered within 3 days was the highest for patients without a TVU or fFN test (74.1%) (**Table 7**).

Discussion

In this analysis of administrative claims data of pregnant women enrolled in a state Medicaid program, approximately 14% of women who presented for hospital evaluation for PTL or threatened PTL had an fFN test performed. Patients who had fFN testing were less likely to deliver within 3 days of initial hospitalization/ED visit for PTL, less likely to deliver during the initial hospitalization/ED visit, and more likely to have been previously diagnosed with PTL prior to the initial hospitalization/ED encounter. These costs are limited to maternal costs; while patients who had fFN testing were more likely to have higher all-cause maternal healthcare utilization and healthcare costs, data on newborn outcomes and associated healthcare costs were not available for this study. It is unknown whether use of fFN testing is associated with improved newborn outcomes; if it is, fFN testing could potentially reduce newborn-incurred costs, offsetting the costs associated with testing. Women who were tested for fFN incurred an additional $2252

compared with those not tested for fFN, but also had, on average, 9 additional days of gestation. The increased costs and healthcare utilization for patients tested for fFN is potentially offset by longer gestation periods. Using a conservative cost estimate of $3000 to $3500 per day for the neonatal intensive care unit (NICU), the additional costs of patients receiving fFN testing is less than the cost of a single day in the NICU.[13,14] An average stay in the NICU has been estimated to be between $40,000 and $114,000, with even greater costs being incurred by infants born at earlier gestational ages.[13-16]

Limitations

This study was a retrospective analysis of data available from administrative Medicaid claims which, unlike data in a full electronic medical record, do not contain clinical information, such as laboratory test or imaging results; force, frequency, or duration of uterine contractions from tocodynamometer readings; cervical length measurements; or stress tests. Additionally, the result of the fFN test was not recorded in the administrative claims record and there was no visibility regarding whether the test result influenced patient management. While all subjects were symptomatic for PTL and triaged in an emergency setting, specific timing of the fFN test in relation to onset of PTL symptoms was not evaluated. The analysis is therefore limited in its ability to determine the underlying causes of the observed improved delivery outcomes in patients who had a record of receiving an fFN test and/or TVU.

Propensity matched cohorts were utilized to mitigate the influence of potential confounding variables. The available variables are, however, limited to those contained within administrative claims and the accuracy with which the data are reported. In this analysis, tobacco use and substance abuse were not included as risk factors due to limited availability of the data. However, despite these limitations, inclusion of most risk factors, along with propensity score matching, should reduce the likelihood that the results are due to a selection bias for testing. Although this type of analysis cannot address the specific cause for improved outcomes in patients tested for fFN, it remains possible that testing provided physicians with additional information, which guided treatment decisions. Consistent with this, the use of any test or procedure for patients with symptoms of PTL (eg, TVU) was also associated with better delivery outcomes compared with patients with no record of interventions, tests, or procedures to assess their risk of sPTB.

While the use of a single state's Medicaid population may limit the generalizability of the findings to states with similar

TABLE 6A. Sensitivity Analysis Results Comparing Healthcare Utilization While Controlling for Covariates[a]: Patients Who Did Versus Did Not Have Any Test/Procedure for PTL (N = 23,886)

Healthcare utilization	IRR[b]: PTL screened vs not screened	95% CI		*P*
Hospitalization/ED visits	1.5622	1.5242	1.6010	<.0001
Outpatient visits	1.3339	1.3114	1.3569	<.0001
Prescription utilization	1.3683	1.3306	1.4072	<.0001

ED indicates emergency department; IRR, incidence rate ratio; PTL, preterm labor.
[a]Regression analysis. Covariates: risk factors, comorbid conditions, age, propensity score.
[b]Reference is no test/procedure.

TABLE 6B. Sensitivity Analysis Results Comparing Healthcare Costs While Controlling for Covariates[a]: Patients Who Did Versus Did Not Have Any Test/Procedure for PTL (N = 23,886)

Healthcare costs	IRR[b]: PTL screened vs not screened	95% CI		*P*
Total costs	1.3331	1.3016	1.3655	<.0001
Hospitalization/ED costs	1.2368	1.1959	1.2790	<.0001
Outpatient costs	1.4303	1.3935	1.4683	<.0001
Prescription costs	1.3515	1.2452	1.4668	<.0001

ED indicates emergency department; IRR, incidence rate ratio; PTL, preterm labor.
[a]Generalized estimating equation regression covariates: risk factors, comorbid conditions, age, propensity score.
[b]Reference is no test/procedure.

TABLE 7. Proportion of Women Who Delivered Within 3 Days of the Initial Hospital/ED Encounter (N = 29,553)[a]

Received TVU	Received fFN test	Infant delivery within 3 days of hospital/ED encounter: No n	No %	Yes n	Yes %	Total n
No	No	3857	25.9%	11,047	74.1%	14,907
	Yes	725	48.1%	782	51.9%	1507
	Subtotal	4582	27.9%	11,829	72.1%	16,414
Yes	No	3276	31.2%	7222	68.8%	10,498
	Yes	1393	52.9%	1251	47.3%	2644
	Subtotal	4669	35.5%	8473	64.5%	13,142
Total	No	7133	25.3%	18,269	71.9%	25,402
	Yes	2133	51.4%	2033	49.0%	4151
	Total	**9251**	**31.3%**	**20,302**	**68.7%**	**29,553**

ED indicates emergency department; fFN, fetal fibronectin; TVU, transvaginal ultrasound.
[a]Original sample taken prior to propensity score matching.

demographics, similar findings were reported in a multistate analysis using a nationwide claims database containing information from patients with private insurance, health exchange programs, or managed Medicaid.[17] In the nationwide sample, 12% of patients triaged through the ED or labor-and-delivery for symptoms of PTL had fFN testing, compared with 14% of patients in the present study. In both studies, delivery outcomes were better and healthcare utilization was higher in patients tested for fFN.[17] One advantage of the present study was the ability to assess the relationship between healthcare costs and use of fFN testing among patients. While testing was associated with higher costs, the analysis was limited in its ability to determine the relationship between test result and costs associated with neonatal outcomes.

Conclusions

PTB imposes a significant economic and societal burden on the United States, much of which is shouldered by government-funded programs. Medicaid disproportionally covers almost 50% of all PTBs, yet Medicaid enrollees account for only 40% of all births.[5] In this study of Medicaid patients, fFN testing was associated with positive delivery outcomes, consistent with the ability of fFN testing to predict patients at risk for sPTB. Accurate stratification of patients at low or high risk of sPTB is necessary to ensure that patients at high risk are monitored carefully, transferred to facilities equipped to treat premature infants, and given appropriate treatment (eg, steroids); it also ensures that patients at low risk are not subject to unnecessary interventions. However, despite the advantages of testing for risk of sPTB, only about half of all patients with symptoms of PTL in this study had any procedure or test for PTL, and only 14% had fFN testing. The low use of testing in this symptomatic Medicaid population demonstrates a need for interventions such as fFN testing to optimize care decisions for patients with symptoms of PTL and at risk of sPTB.

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Address correspondence to: Jamie C. Barner, PhD, 2409 University Ave, MC A1930, Austin, TX 78712-1120, E-mail: jbarner@austin.utexas.edu.

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