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Individual- and county-level predictors of cervical cancer screening: a multi-level analysis

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ABSTRACT

Objectives: Despite the gains in cervical cancer screening, there remain persistent socio-economic, geographical, racial, and ethnic disparities. This study examines the combined effect of individual- and county-level characteristics on the use of cervical cancer screening tests such as Papanicolaou (Pap) tests in Texas.

Study design: Cross-sectional study.

Methods: Individual-level information was obtained from 2014–2015 Texas Behavioral Risk Factor Surveillance System (BRFSS). Using the county of residence of the study population, the BRFSS data were linked to the American Community Survey (2010–2014) and the Area Health Resources File (2015). Women aged between 21 and 65 years, with no history of hysterectomy, and residing in 47 counties in Texas were included in the study ($n = 4276$). Multi-level logistic regression was used to assess the independent influences of individual- and county-level covariates on receipt of a Pap test in the past 3 years.

Results: The odds of timely Pap testing were lower among women aged greater than 50 years, single women, and those with low education and income (<$25,000). Black women who reside in counties with higher percentages of Hispanics (quartile 4) were less likely to be screened compared with black women living in counties with a low Hispanic population (adjusted odds ratio [OR] = 0.08 [95% confidence interval [CI]: 0.02–0.37]). County-level socio-economic status, although associated with timely screening in bivariate analysis, was not a significant predictor of screening after controlling for individual characteristics.

Conclusions: There are significant disparities in the uptake of cervical cancer screening across Texas counties. Individual-level socio-economic disparities as well as the number of obstetric-gynecologic physicians in a county are predictors of these disparities.

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Introduction

Over the past 4 decades, the incidence of cervical cancer and rates of associated mortality have declined steadily in the United States. Incidence rates have dropped by more than 50 percent, from 17.2 cases per 100,000 women in 1973 to 7.6 cases in 2013.[1] Mortality rates associated with cervical cancer have also declined significantly over the past five decades, from 13.1 deaths per 100,000 women in 1950 to 2.3 deaths in 2014.[1,2] These positive gains have been attributed to increased use of cervical cancer screening tests, such as the Papanicolaou (Pap) test, which increases the likelihood of earlier diagnosis, treatment, and survival.[3] The US Preventive Task Force (USPTF) recommends that women aged between 21 and 65 years obtain a Pap test every 3 years.[4] However, it has been shown that Pap testing varies considerably by age, race and ethnicity, socio-economic status (SES), education, and health insurance status.[5–9]

In addition to individual-level characteristics, one's residential cultural environment and local health system capacity, including work force also influences adherence to screening guidelines.[10–14] Across the United States, the southern region of the United States has a higher cervical cancer incidence (8.5 per 100,000), and death rate (2.7 per 100,000) compared to other regions.[15] In terms of Pap testing, Texas ranks near the bottom (48th), for Pap test screening uptake, with an overall screening rate of just 77.7% of all women who should have been screened in 2014. This is 4.7% below the national average of 82.6%.[16] Texas women also are shown to be among the very highest in diagnosed cervical cancer in the US, with an age-adjusted incidence rate of 8.3 per 100,000 population in 2013, compared to the national average of 7.5 per 100,000 women for the same year.[17]

Texas, like many states, has been experiencing a flux of policy changes since the passage of the Affordable Care Act in 2010, which have adversely affected access to women's health services. In 2011, the Texas legislature issued an ‘Affiliate Ban Rule,’ which prohibited organizations performing abortions, including all Planned Parenthood affiliated clinics, from participating in the 1115 Medicaid Waiver program that provided certain women's health services.[18] As a result, the Centers for Medicare and Medicaid Services (CMS) revoked the federal waiver citing the ‘freedom of choice’ policy which permits Medicaid beneficiaries the option of getting their care from any participating Medicaid provider.[18] This forced Texas to transition from a combined state and federally funded Medicaid Waiver program to state-only funding without any federal support for women's health services from Medicaid.[18] The state-funded family planning program, called ‘The Texas Women's Health Program’ replaced the CMS Medicaid family planning program in 2013 but offers only a limited scope of services for women aged between 15 and 44 years.[19] This policy change has created additional challenges for low-income women to access cervical cancer screening.

While the literature has reported troubling findings related to lower rates of Pap testing and higher incidence and mortality associated with cervical cancer in Texas, there is no published literature exploring whether there might be variations in geographical, socio-economic, or work-force shortage-related patterns of Pap testing. If such disparities exist, then factors associated with these disparities, whether at the individual or county level, will help policy-makers in directly addressing factors associated with suboptimal cervical cancer screening use. This study adds to the contextual analysis of health literature by examining variations in the use of cervical cancer screening within the Texas population and the combined associations between individual- and county-level characteristics and uptake of Pap testing in Texas.

Methods

Sample selection and survey administration

We used data from the 2014 and 2015 Texas Behavioral Risk Factor Surveillance System (BRFSS) survey for this study. The BRFSS is a cross-sectional telephone survey consisting of both landline and cellular phone respondents, sponsored by the Centers for Disease Control and Prevention (CDC). To ensure a representative sample, multistage cluster sampling, and random digit dialing are used to survey non-institutionalized US civilians who are 18 years or older. Weighting is used to account for the differences in the probability of selection, non-response bias, non-coverage, and overlapping sample frames. The estimated response rate for the Texas BRFSS was 35.4% for 2014 and 34.4% for 2015. The response rate is the percent of complete or partial interviews out of the entire eligible sample. Although lower than the national average response rates for BRFSS (45.8% in 2014 and 47.1% in 2015), the data are considered appropriate for cross-sectional sampling. The validity and reliability testing of the BRFSS survey supports the utility of the data.[20]

Cross-sectional data were pooled across 2014 and 2015 survey periods to increase the sample size for analysis. Based on USPTF recommendations, we restricted our inclusion criteria to women aged between 21 and 65 years, who had not had a hysterectomy (Fig. 1). There were 18,064 women in the survey, of which 5418 met the criteria. Of the subset sample, 1142 women did not report their county of residence, and thus their information could not be linked to a county, and 53 women had no information on Pap testing. This resulted in a final sample of 4276 women residing in 47 counties.

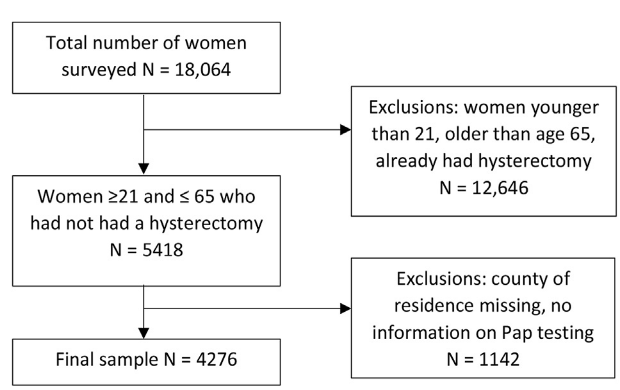

Fig. 1 – Inclusion criteria flowchart.

Measures

Dependent variable: recent Pap testing

Receipt of a Pap test within recommended guidelines was the major outcome in this study. The 2014 and 2015 BRFSS survey includes questions about whether female study population had ever had a Pap test. For women who responded affirmatively, they were then asked when their last Pap test was. They were also asked if they had undergone a hysterectomy. We defined recent cervical cancer screening as having received a Pap test within the past 3 years, the current recommendation of the USPTF.[4] We dichotomized reports on timing of last Pap test into less than 3 years ago versus more than 3 years ago.

County-level measures

Using the county of residence of the study population, the BRFSS data were then linked with county characteristics obtained from the 2010–2014 American Community Survey (ACS) and the 2015 Area Health Resources File (AHRF). The county poverty level and percentage black and Hispanic population were obtained from the American Community Survey (2010–2014). Based on prior research, we used the percentage of county population living below federal poverty levels (FPL) to serve as a contextual measure of socio-economic status,[21] whereas the percentage black and Hispanic population was included to measure racial composition.[22] The county poverty level was initially divided into four categories below FPL suggested by Krieger et al.: <4.9%, 5.0–9.9%, 10.0–19.9%, and 20.0–100%.[21] However, we combined the first and second categories due to insufficient numbers. The criterion for classification of the percentage black and Hispanic county populations is provided in Table 1. The percentages were divided into quartiles, with one being counties in the lowest quartile of the percentage Hispanic population, two being the counties in the second and third quartiles, and three being the counties in the highest quartile of the percentage Hispanic population. The percentage of county residents classified as African-American or black was categorized in a similar manner.[22]

Table 1 – Racial composition of counties of survey population.

Racial/ethnic composition of county	Cut-off points	Weighted percentage (95% CI)	*n*
Percent non-Hispanic Black			
Mean (SD)	13.3% (7.5)		
Range (%)	0.5–34.5		
Low (1st quartile)	Less than 8.5% black	33.4 (30.2–36.8)	1772
Medium (2nd and 3rd quartile)	8.5–19.6% black	49.7 (46.2–53.3)	2054
High (4th quartile)	19.6 or more black	16.9 (14.4–19.7)	450
Percent Hispanic			
Mean (SD)	40.5 (20.9)		
Range (%)	6.4–95.4		
Low (1st quartile)	less than 24.3% Hispanic	25.6 (22.9–28.5)	1324
Medium (2nd and 3rd quartile)	24.3–41.1% Hispanic	51.8 (48.1–55.4)	1683
High (4th quartile)	41.4% or more Hispanic	22.7 (20.1–22.5)	1269

CI, confidence interval.

The number of health centers, primary care physicians, and office-based obstetrician-gynecologists (ob-gyns) were obtained from the AHRF. Although the 2015 AHRF data were used, the number of rural health clinics (RHCs) and federally qualified health centers (FQHCs) represent 2014 totals. We then combined the number of RHCs and FQHCs to obtain the number of health centers. We also combined the number of office-based general practitioners and family medicine physicians to obtain estimates of the numbers of primary care physicians. All measures obtained from the AHRF were standardized to 100,000 female population based on the 2014 census for estimates of the female population residing in the county.[23]

Individual-level measures

Individual-level variables were obtained from the 2014–2015 Texas BRFSS data based on their association with Pap testing in previous research.[6–8] We assessed individual socio-economic measures such as education, household income, insurance status, and routine physical examination in the past year. We also controlled for demographic factors that might confound the effect of socio-economic factors on timely receipt of Pap testing. These demographic factors include age, race/ethnicity, and marital status.

Statistical analysis

We used final population weights provided in the BRFSS data to account for the complex sampling design in univariate and bivariate analysis of recent Pap testing. We used Chi-squared tests to examine if there were differences in screening use by individual demographic and socio-economic characteristics, as well as county characteristics. The multivariate model was built in stages. First, the model was made without any explanatory variables (null model). This was to determine whether the likelihood of screening varied between Texas counties and how much of that variation was within and between counties. Next, individual-level covariates were added to the model to examine their average effect on screening across all counties, and to examine whether inclusion of individual explanatory variables will account for all the variation in screening (model 2). Variables which showed significant odds ratios ($P < 0.05$) for at least one variable level were retained in the model, as was age, which we treated as a categorical variable.

Next, we used multi-level, logistic regression to predict the combined influence of individual- and county-level variables on receipt of a recent or timely Pap test. Multi-level models were suitable for this survey to account for correlation between individuals (level 1) residing within the same county (level 2), thus preventing unreliable variance estimates.[24] We added groups of county-level variables in this order: county poverty level, racial composition, number of health centers, primary care, and ob-gyn physicians (model 3). Finally, we tested for cross-level interactions between individual and county-level covariates. Observations with missing data on individual-level covariates were excluded from the analysis, resulting in 3935 observations with complete information on all variables of interest. In the multi-level model, individual sampling weights were scaled so that the new weights summed up to the level 2 (county) cluster sample size to obtain unbiased standard errors and parameters.[25] Multi-level analyses were conducted using the generalized linear latent and mixed models program (GLLAMM) in STATA 14.1 (StataCorp, College Station, TX). The alpha level for statistical significance was set at 0.05.

Results

A total of 4726 women, living in 47 of 254 Texas counties, met our inclusion criteria. In sensitivity analysis, we found no significant differences in Pap testing between those who had county of residence provided and those whose county of residence was missing. Descriptive characteristics of the study population are presented in Table 2. Based on weighted frequencies, 40% of the study population reported their race as white, 40.8% as Hispanic, and 12.5% self-identified as black. More than one-third of the sample were married or living together. About 20% had less than high school education, and 32% had annual household incomes below $25,000. About one-third had no health insurance and had not seen a physician in the past year.

Table 3 shows rates of timely Pap testing by individual characteristics. Overall, 79% of the weighted sample reported receiving Pap screening in the past 3 years as recommended by the USPTF. The Texas cervical screening rates were 78.6% in 2014 and 81.1% in 2015. Only 79.8% of women aged between 50 and 65 years reported receiving a recent Pap test compared to 83.6% of women aged between 40 and 49 years. Hispanic women reported the lowest rates of Pap screening (75.1%) compared to whites (81.7%) and blacks (86.4%). Married women, and those with a college degree, had higher rates of screening (84.4% and 87.4%) compared to their unmarried and less educated counterparts (67.6% and 76.5%). Rates of screening increased with household income. As expected, those without health insurance and women who had not seen a physician in the past year had significantly lower screening rates (67.8% and 62.2%) compared to their peers who had insurance and had seen a physician in the past year (85.4% and 88.6%).

When comparing county-level characteristics (Table 4), screening rates were lowest (71.1%) among women residing in counties where 20% or more of the residents lived below FPL (P value = 0.015). About 74.7% of women living in counties with a low black population reported recent Pap testing compared to 84.8% of women in counties with a high black population (P value = 0.003). Conversely, only 72.2% of women living in counties with a high Hispanic population reported recent Pap testing compared to 80.9% of women in counties with a high Hispanic population (P value = 0.001).

Table 5 shows the results of the predictive model for receipt of a Pap test within the past 3 years. The null model (model 1) indicated that 7.33% of the total variation in Pap testing occurred between Texas counties. In model 2, the inclusion of individual-level demographic, and socio-economic covariates in the null model did not fully account for the variation in Pap testing, as the variance only fell slightly (5.7%).

Model 3 revealed that the addition of county-level characteristics explains about 40% of the remaining variation in Pap testing between counties; as between-county variance fell to 3.40% (Table 5). With the exception of number of ob-gyns per 100,000 population, other county-level characteristics, although associated with screening in bivariate analysis, were not significant predictors of screening independent of individual characteristics. However, we found a cross-level interaction between race and the percentage of county-level Hispanic population. Black women who reside in counties with higher levels of Hispanic population (top quartile) were less likely to receive a Pap test compared to black women living in counties with lower Hispanic population (adjusted

Table 2 – Descriptive characteristics of women aged 21–65 years with no history of hysterectomy, 2014–2015 Texas Behavioral Risk Factor Surveillance System (n = 4276).[a]

Variable	Weighted percentage (95% CI)	Sample size
All eligible women		4276
Year		
2014	51.3 (45.9–56.7)	3086
2015	48.7 (43.3–54.1)	1190
Age (years)		
21–29	20.7 (18.1–23.4)	508
30–39	25.4 (22.8–28.2)	866
40–49	23.4 (21.2–25.7)	979
50–65	30.6 (27.8–33.6)	1923
Race/ethnicity		
Non-Hispanic white	40.0 (36.9–42.5)	2137
Black	12.5 (10.5–14.8)	336
Hispanic	40.8 (37.7–43.9)	1552
Other[b]	7.1 (5.6–9.0)	166
Marital status		
Married/member of an unmarried couple	31.9 (59.1–64.5)	2622
Divorced/separated	15.7 (13.6–17.9)	749
Widowed	3.4 (2.9–5.1)	215
Never married	18.6 (16.5–21.0)	669
Education		
Less than high school	19.8 (17.6–22.1)	636
High school graduate	22.1 (19.9–24.5)	867
Some college	29.5 (26.9–32.2)	1015
College graduate or more	28.7 (26.3–31.2)	1749
Household income		
<$25,000	32.4 (29.5–35.2)	1229
$25,000 to <$49,999	18.3 (16.0–20.6)	743
≥$50,000	37.3 (34.5–40.0)	1763
Unknown	12.0 (10.2–13.9)	538
Insurance status		
Yes	68.5 (65.6–71.3)	3132
No	29.9 (27.1–32.7)	995
Saw physician in past year		
Yes	66.1 (63.4–68.7)	2942
No	32.2 (29.6–34.8)	1273

CI, confidence interval.
[a] Weighted n = 7,716,519.5.
[b] Other: American Indian/Alaska Native, Asian, and two or more races.

Table 3 – Percentage of women who reported having a Pap test in the past 3 years, according to selected variables from the 2014–2015 Texas Behavioral Risk Factor Surveillance System (BRFSS).

Variable	Weighted Percentage (95% CI)	P-Value	Sample size
All eligible women	79.0 (76.8–81.0)		3390
Year		0.2736	
2014	78.6 (75.8–81.1)		2459
2015	81.1 (77.5–84.1)		931
Individual-level covariates			
Age (years)		0.0051	
21–29	72.4 (65.8–78.1)		378
30–39	82.2 (77.5–86.1)		709
40–49	83.6 (79.5–87.0)		813
50–65	79.8 (76.4–82.8)		1490
Race/ethnicity		0.0028	
Non-Hispanic white	81.7 (77.9–84.9)		1733
Black	86.4 (79.3–91.3)		278
Hispanic	75.1 (71.4–78.5)		1184
Other[a]	88.2 (78.9–93.7)		134
Marital status		0.0000	
Married/member of an unmarried couple	84.4 (81.9–86.6)		2186
Divorced/separated	78.0 (72.5–82.7)		557
Widowed	69.3 (54.1–81.2)		165
Never married	67.6 (60.9–73.6)		465
Education		0.0001	
Less than high school	76.5 (70.7–81.4)		457
High school graduate	72.7 (66.4–78.1)		629
Some college	79.8 (75.5–83.5)		783
College graduate or more	87.4 (84.0–90.1)		1514
Household income		0.0000	
<$25,000	67.9 (63.4–72.1)		830
$25,000 to <$49,999	81.8 (76.0–86.4)		591
≥$50,000	87.0 (83.6–89.8)		1558
Unknown	79.4 (73.6–84.3)		411
Insurance Status		0.0000	
Yes	85.4 (83.1–87.5)		2631
No	67.8 (62.6–72.6)		658
Saw physician in past year			
Yes	88.6 (86.3–90.6)	0.0000	2572
No	62.2 (57.6–66.5)		779

CI, confidence interval.
[a] Other: American Indian/Alaska Native, Asian, and two or more races.

odds ratio [OR] = 0.08 [95% confidence interval [CI]: 0.02–0.37]). Therefore, black women living in a county with high Hispanic composition had lower odds of recent Pap testing.

Discussion

This study examines individual and contextual predictors of variation in Pap testing in Texas. Overall, the average screening rate of 79% in our sample was below the national average of 82.6% in 2014[16] and well below the 'Healthy People 2020' target of 93.0%. This finding is noteworthy, given the policy changes in Texas that adversely affected access to women's health services in the preceding years. In addition, Texas was one of the states that opted not to expand Medicaid under the Affordable Care Act. Consistent with earlier studies, our study showed that individual predictors of Pap screening include age, marital status, routine physical visits, and income.[5,6,8,9] These associations persisted even after including county-level measures of socio-economic status, racial composition, and healthcare provider availability. In addition, it is striking to see that although Hispanics are not a minority group in Texas, they had the lowest screening rates compared to non-Hispanic whites and blacks.

There was modest but significant variation in receipt of a recent Pap test across Texas counties. We note between-county variation which highlights the association between place of residence and the use of Pap tests and the need to take into account both individual and contextual characteristics when planning preventative programs. Since the occurrence of cancer screening, in general, requires that an individual interact with the healthcare system and the provider

Table 4 – Percentage of women who reported having a Pap test in the past 3 years, according to selected variables from the 2010–2014 American Community Survey (ACS) and 2015 Area Health Resources File (ARF).

Variable	Weighted Percentage (95% CI)	P-Value	Sample size
Percentage of county living below federal poverty levels (%)		0.015	
0–9.9	78.8 (72.6–83.9)		582
10.0–19.9	81.5 (78.9–83.9)		2, 339
20–100	71.1 (65.0–76.6)		469
Percentage of county black population		0.003	
Low	74.7 (71.0–78.0)		1351
Medium	81.4 (78.2–84.3)		1679
High	84.8 (79.2–89.1)		360
Percentage of county Hispanic population		0.001	
Low	80.9 (76.3–84.8)		1053
Medium	82.5 (79.3–85.3)		1381
High	72.2 (67.6–76.3)		956
Number of health centers per 100,000 female population		0.025	
<1	82.4 (78.1–86.1)		519
1–2	80.6 (75.9–84.6)		544
2–5	74.9 (70.9–78.5)		1425
>5	82.0 (78.5–85.1)		902
Number of office-based primary care physicians per 100,000 female population		0.042	
<30	70.6 (64.3–76.3)		455
30–40	81.6 (78.1–84.7)		911
40–50	79.8 (71.7–86.0)		367
>50	79.8 (76.1–83.1)		1657
Number of office-based ob-gyns per 100,000 female population		0.063	
<10	67.4 (55.8–77.3)		225
10–20	79.2 (75.3–82.6)		1305
>20	80.8 (77.9–83.3)		1860

CI, confidence interval; ob-gyns, obstetrician-gynecologists.

Table 5 – Multivariate results for Pap testing.

Variables	Model 1 Odds ratio (95% CI)	Model 2 Odds ratio (95% CI)	Model 3 Odds ratio (95% CI)
Intercept β (se)	1.36 (0.09)‡	2.96 (0.33)‡	2.17 (0.44) ‡
Age (years)			
21–29		1.00	1.00
30–39		1.23 (0.83–1.82)	1.23 (0.83–1.83)
40–49		0.86 (0.62–1.19)	0.86 (0.62–1.20)
50–65		0.50 (0.35–0.73)‡	0.50 (0.35–0.73)‡
Race/ethnicity			
Non-Hispanic white		1.00	1.00
Black		1.54 (0.80–2.95)	1.55 (0.81–2.96)
Hispanic		1.06 (0.68–1.66)	1.05 (0.66–1.67)
Other		1.03 (0.48–2.17)	1.01 (0.48–2.13)
Marital status			
Married/member of an unmarried couple		1.00	1.00
Divorced/separated		0.99 (0.67–1.47)	0.98 (0.66–1.46)
Widowed		1.01 (0.59–1.73)	1.01 (0.59–1.74)
Never married		0.39 (0.26–0.58)‡	0.38 (0.25–0.57)‡
Education			
High school graduate		1.00	1.00
Less than high school		1.70 (1.17–2.49)†	1.72 (1.18–2.51)†
Some college		1.57 (1.03–2.40)*	1.58 (1.03–2.42)*
College graduate or more		1.73 (1.11–2.67)*	1.73 (1.12–2.67)*
Household income			
<$25,00		1.00	1.00
$25,000 to <$49,999		2.28 (1.48–3.53)‡	2.27 (1.47–3.51)‡
≥$50,000		2.94 (1.81–4.78)‡	2.95 (1.82–4.79)‡
Unknown		1.89 (1.32–2.70)‡	1.89 (1.32–2.70)‡
Insurance status			
Yes		1.00	1.00
No		0.88 (0.55–1.41)	0.86 (0.54–1.39)
Saw a physician in past year			
Yes		1.00	1.00
No		0.22 (0.18–0.27)‡	0.22 (0.18–0.27)‡
Percentage of county living below federal poverty levels			
0–9.9%			1.00
10.0–19.9%			1.55 (0.93–2.58)
20–100%			1.47 (0.58–3.73)
Percentage of county Black population			
Low			1.00
Medium			0.77 (0.47–1.27)
High			1.16 (0.59–2.26)
Percentage of county Hispanic population			
Low			1.00
Medium			1.24 (0.81–1.90)
High			0.77 (0.34–1.73)
Number of health centers per 100,000 female population			
<1			
1–2			1.30 (0.70–2.43)
2–5			1.04 (0.62–1.76)
>5			1.38 (0.77–2.49)
Number of office-based primary care physicians per 100,000 female population			
<30			1.00
30–40			1.10 (0.66–1.83)
40–50			0.85 (0.43–1.66)
>50			1.15 (0.66–2.00)
Number of office-based ob-gyns per 100,000 female population			
<10			1.00
10–20			2.07 (1.33–3.23)†
>20			1.75 (1.09–2.82)*
Cross-level Interactions			
Black X high percent county black population			2.07 (0.71–6.01)

(*continued on next page*)

Table 5 – (*continued*)

Variables	Model 1 Odds ratio (95% CI)	Model 2 Odds ratio (95% CI)	Model 3 Odds ratio (95% CI)
Black X high percent county Hispanic population			0.08 (0.02–0.37)†
Hispanic X high percent county black population			0.54 (0.25–1.17)
Hispanic X high percent county Hispanic population			1.55 (0.57–4.22)
Level 2 (county variance)[a]	0.26 (0.09)	0.20 (0.08)	0.12 (0.05)
Intra-class correlation coefficient	7.33%	5.71%	3.40%

*P < 0.05, †P < 0.01, ‡P < 0.00.
Other: American Indian/Alaska Native, Asian, and two or more races.
[a] Variance (standard error).

environment in which people receive screening services,[26] it is important to look beyond individual factors to the broader healthcare infrastructure framework, such as work-force professional shortages. Most county-level measures were significantly associated with cervical screening in bivariate analyses. However, with the exception of the number of office-based ob-gyns per 100,000 population, these associations did not remain after adjusting for individual-level covariates. This indicates that although the other county-level variables account for part of the variation in cervical cancer screening, they may not be independent predictors by themselves, when individual characteristics are taken into account.

In the model that included interaction effects (model 3), blacks living in counties with a high percentage of Hispanics were more likely not to have been screened within the past 3 years; whereas Hispanics living in counties with high percentage black residents had higher odds of being current in their screening, (the latter finding was not statistically significant). The exact mechanism for this finding is unclear but may have to do with targeted public prevention programs. Benjamins et al. suggested that cancer screening and prevention programs in minority communities are usually aimed at blacks, and therefore, Hispanics living in such communities are likely to benefit from such programs.[22] Specifically, such programs might have a protective effect on Hispanics if they are also adapted to individuals with limited English-speaking abilities. Conversely, we explored the differences between blacks and Hispanics living in high-Hispanic counties. Blacks in such counties were more likely to report having more education and higher income levels compared to the Hispanics. However, they were less likely to be insured. It is highly probable that Spanish is the primary language spoken in such counties. Therefore, Pap screening programs targeted at the Spanish-speaking population in such counties might inadvertently leave out the non-Spanish speaking black minority. Our findings contribute to the literature that suggests that county racial composition does modify the association between individual race and Pap testing.

This study has several limitations. First, we could not include additional factors that have been correlated with lower screening use. For example, barriers such as fear of finding cancer, language barriers, male physicians, and lack of knowledge are documented barriers to Pap testing.[28–31] In addition, there was a risk of sample bias because the response rate was low, and many of the eligible samples did not take part in the study (response rate: 35.4% for 2014 and 34.4% for 2015). Thus, we were only able to capture 47 of 254 Texas counties. Nonetheless, the weighted sample was similar to the Texas population sociodemographically, and all eleven Texas public health regions were represented in the study. Furthermore, we were constrained to the county-level identifiers in the BRFSS data. Given that the population at the county or zip code level is more likely to be heterogeneous, linking the BRFSS data at the census tract level would have been more representative of neighborhood characteristics.[32] Still, the present study revealed significant variation across Texas counties. In our measures of healthcare provider supply, we did not include other providers such as nurse practitioners, who also provide Pap testing. Also, the analysis of screening uptake was based on self-reported information which could not be validated. Finally, this is a pooled cross-sectional study; therefore, we can only show association, not causation.

Conclusions

In this study, we were able to measure concurrently the individual- and county-level predictors of cervical cancer screening in Texas. Our results show the influence of people and place in explaining the variation in Pap screening, confirming that place of residence may influence the ability of residents to engage in healthy behaviors, such as cervical cancer screening.[33] Identifying characteristics of geospatial areas with low screening rates will assist policy-makers in developing programs and allocating resources on a more local than the state level; while distinguishing individual-level predictors of Pap testing will help stakeholders target specific sub-groups of the population who are less likely to be screened. Programs geared toward improving uptake of cervical cancer screening in Texas should focus on black women living in counties with high Hispanic populations, and fewer primary care providers, particularly ob-gyns. Programs must also target individuals such as older women, single women, those with low income, and women who are unlikely to attend routine healthcare visits. In summary, strategies for improving access to cervical cancer screening must be multi-faceted in addressing individual and environmental factors that impede screening. Such strategies might effectively reduce disparities in cancer screening, and by extension, diminish inequalities in stage at diagnosis, treatment, and survival.

Author statements

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Ethical approval

This research was approved by the Texas A&M University's Institutional Review Board (IRB2017-0130M).

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Competing interests

No competing financial interests exist.

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