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Original article

Prevalence and determinants of cervical cancer screening with a combination of cytology and human papillomavirus testing

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ABSTRACT

Purpose: In the United States, recommended options for cervical cancer screening in women aged 30 years or older include cytology alone or a combination of cytology and human papillomavirus (HPV) testing (co-testing). Although there is a body of evidence suggesting that co-testing may be the preferred screening option in this group of women, little is known about the characteristics of women who screen for cervical cancer with co-testing.
Methods: A multistage area probability design-based survey was administered to a representative sample of Texas residents. Of the 1348 female respondents, 572 women aged 30 years or older were included in this analysis. Population-weighted survey logistic regression was used to identify determinants of cervical screening with co-testing versus screening with cytology alone.
Results: Women vaccinated against HPV (aOR: 4.48, 95% CI: 1.25–15.97) or hepatitis B virus [aOR: 2.48 (1.52–4.02)], those with a personal cancer history [aOR: 2.96 (1.29–6.77)], and hormonal contraception users [aOR: 2.03 (1.03–3.97)] were more likely to be screened with co-testing than with cytology alone. Moreover, the likelihood of being screened with co-testing decreased with increasing age and decreasing annual household income.
Conclusions: Benefits and indications of co-testing should be better explained to women and health care providers.

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Introduction

The widespread implementation of cervical cancer screening programs over the past decades has resulted in a significant reduction of cervical cancer burden in the United States. Despite this progress, there still persists geographic, ethnic, and racial disparities in cervical cancer morbidity and mortality [1]. Of particular concern are the declining trends in cervical cancer screening uptake in the United States [2], and the projected failure to meet the Healthy People 2020 national goal of 93% screening rate. In 2018, it was estimated that 13,240 women in the United States would be diagnosed with cervical cancer and 4170 would die from their disease [3]. In Texas, the second most populous State in the United States, incidence (9.2 cases per 100,000 women) and mortality (2.8 deaths per 100,000 women) of cervical cancer are roughly 20% higher than national rates [4]. Furthermore, the statewide mortality from cervical cancer is substantially higher among blacks (4.0 per 100.000) and Hispanics (3.3 per 100.000) than among whites (2.9 per 100.000) [4]. Prophylactic vaccination against human papillomavirus (HPV) may further reduce the incidence of cervical cancer, but its indications are still restricted to certain age groups, and even among the eligible U.S. population, HPV vaccination coverage is suboptimal [5]. In Texas, only 39.7% of adolescents aged 13 to 17 years are up to date with HPV vaccination, leaving this state ranked as 47th nationwide for HPV vaccination [5]. Besides, HPV vaccination does not substitute for screening that will continue to play an important role in the prevention of cervical cancer [6].

Although cytology (Pap test) has traditionally been used as the main method for cervical cancer screening in the United States, the

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development of molecular assays for HPV detection in cervical cells has been a major breakthrough that can enhance the effectiveness of existing screening programs [6]. Since 2012, recommended options for cervical cancer screening in women aged 30 years or older include a combination of cytology and HPV testing (co-testing) every 5 years or the standard cervical cytology alone every 3 years [7–9]. Importantly, the consensus guidelines jointly issued by the American Cancer Society, the American Society of Colposcopy and Cervical Pathology, and the American Society for Clinical Pathology have endorsed co-testing as the preferred approach in this age range [7]. This recommendation is further supported by a recent clinical trial, which concluded that co-testing produces better results than cytology alone [10]. Despite these guidelines, a substantial proportion of women aged 30 years or older are still screened with cytology alone. In a study examining changes in cervical cancer screening practices, only about one-third of women up to date on cervical screening in the United States reported having undergone co-testing during their most recent cervical screening [2].

Given the added value of co-testing, further efforts to understand the determinants of screening with co-testing are warranted to improve the effectiveness of cervical screening programs. Previous studies have examined the predictors of cervical cancer screening in the United States [11, 12]. Because most of these reports have focused on cytology, little is known about the sociodemographic, health-related, and behavioral determinants of cervical cancer screening with co-testing. Using a 2018 population-based statewide survey, the present study aimed to determine the prevalence and predictors of cervical cancer screening with co-testing among women 30 years or older in Texas.

Methods

Study population and recruitment procedure

The study population was selected from a representative sample of the Texas population [13, 14]. A nonprobability sample of 2050 respondents to the Texas health screening survey were collected using strata set to mirror Texas demographics for sex, ethnicity, race, and income. However, oversampling of non-Hispanic blacks (NHBs) was conducted to ensure more accurate comparisons for this minority group. The non-Hispanic white category consisted of those selecting white as the sole race and the NHB category of those selecting black/African American (either alone or in addition to other races). The recruitment target included 60% urban and 40% rural respondents, categorized by matching ZIP code to county designations [15, 16]. This study focused on the 894 female respondents aged 30 years or older.

Survey design and implementation

The Texas health screening survey is a questionnaire that we developed to evaluate sociodemographic and cancer risk factors, beliefs about cancer, and cancer screening behaviors in the Texas population [13]. Most of the questions included in this survey were derived from the National Health Interview Survey, the Health Information National Trends Survey, and the Behavioral Risk Factor Surveillance System Questionnaire. The instrument was prepared in both English and Mexican Spanish using the services of MasterWord Services, Inc. (Houston, Texas) and administered through the Qualtrics online survey platform (Qualtrics International Inc., Provo, Utah and Seattle, Washington). The study population comprised a nonprobability sample restricted to opt-in panelists living in Texas. Thus, strata were set beforehand for sex, ethnicity, race, income and rurality, and the sample size calculated, overall, and per strata. The goal was to meet the sampling targets while ascertaining data from these strata, to obtain a representative sample of the Texas adult population that could allow accurate estimation of health outcome measures. As people were invited to participate and screened for eligibility, they consented to fill out the questionnaire and were surveyed; submitted questionnaires were regularly assessed for completeness and assigned to relevant strata. When the sampling targets were met in a given strata, the subsequent completion of the survey by participants falling into that strata was automatically disabled. In all, 5658 responses (including screeners and over quotas) were attempted including 1600 dropouts. A final total of 2050 complete responses were received. In this survey, we collected a wide range of information including health education and behavior, health information retrieval, health care access and coverage, mental and physical health, cancer screening, cancer history, and area of residence [17–19]. The data collection was conducted between February 5 and March 5, 2018. The study protocol (PA16-0724) was approved by MD Anderson's Institutional Review Board.

Outcome measures

The primary outcome for this study was self-reported cervical cancer screening, and its measure was derived from the cancer screening section of the National Health Interview Survey [18], which includes questions regarding Pap and HPV tests to adult women. Thus, two questions were used to define the outcome variable: 1) *A Pap test is a test for cancer of the cervix. Have you ever had a Pap test?* (Pap_Test) with a binary Yes/No response; and 2) *An HPV test is sometimes given with the Pap test for cervical cancer screening. Have you ever had an HPV test?* (HPV_Test). The response to the latter could be either “Yes,” “No,” or “Don't know/Not sure.” Our outcome variable (self-reported cervical cancer screening) was classified into three categories: co-testing (when the response to both questions was Yes); Pap testing (cytology) alone (when the response to the first question was Yes and the response to the second question was No); and no screening (when the response to both questions was No). A total of 316 eligible respondents (women aged 30 or older) who responded “Don't know/Not sure” to the second question (HPV_Test), as well as the six eligible respondents who had a positive response to the second question (HPV_Test) and a negative response to the first question (Pap_Test), were excluded from the analyzes.

Predictors

Predictor variables were selected from measures collected in the Texas health screening survey. The main explanatory variables for this analysis were cancer risk perceptions and beliefs. Perceived risk of cancer was measured with the following question: *Compared with other people your age, how likely are you to get cancer in your lifetime*? Six measures were used to assess cancer beliefs: 1) *It seems like everything causes cancer*, 2) *There's not much you can do to lower your chances of getting cancer*, 3) *Cancer is most often caused by a person's behavior or lifestyle*, 4) *I'd rather not know my chance of getting cancer*, 5) *When I think about cancer, I automatically think about death*, and 6) *There are so many different recommendations about preventing cancer, it's hard to know which ones to follow*. The responses to these questions were classified into two categories: “Agree/Disagree.”

Other predictors were analyzed based on their potential influence on cervical cancer screening, including sociodemographic factors (age, ethnicity/race, nativity, educational attainment, marital status, occupation status, urban vs. rural residence, home ownership, and household income). Behavioral, mental, and

health-related variables included smoking status, health coverage, depression, vaccination against hepatitis B virus (HBV), vaccination against HPV, hormonal contraception use, body mass index, personal or family history of any cancer, and health literacy.

Statistical analysis

Data were weighted by ICF International, Inc., Fairfax, Virginia, using a three-dimensional raking approach with iterative post-stratification based on sex, age, and race/ethnicity [20]. We used means and standard deviation (continuous variables), and weighted percentages and weighted 95% confidence interval (categorical variables), to describe and compare potential predictors by screening status. Multivariable weighted survey logistic regressions using PROC SURVEYLOGISTIC (SAS for Windows, version 9.4) were used to examine factors associated with co-testing use (vs. screening with cytology alone). For this analysis, the outcome variable and the predictor variables were prespecified. Women who reported having never been screened for cervical cancer were excluded from the logistic regression, and the study outcome was categorized as a binary variable: co-testing versus Pap testing alone (the latter being the reference category). All variables considered to be potential predictors of co-testing were included in the final model.

Considering that the variables “income” and “education” could potentially modify the effect of women's cancer beliefs on the choice of either screening strategy, we conducted further analysis. We first removed these two variables from the full logistic regression model. Furthermore, we assessed the interaction of income and education with the main explanatory variables. These interactions were tested: i) separately in two different models (addition of income × cancer beliefs variables in one model, and education × cancer beliefs variables in the other model) and then ii) combined in a same model (addition of both income × cancer beliefs variables, and education × cancer beliefs variables in the same model).

Results

Characteristics of the study population

Of the 572 women aged 30 years or older included in this analysis, 273 (weighted percentage: 44.8%, weighted 95% confidence interval: 40.4%–49.1%) reported having been screened with co-testing, 242 [45.5% (41.1%–49.9%)] with cytology alone, whereas 57 [9.7% (7.2%–12.3%)] reported having never been screened for cervical cancer.

Table 1 describes the sociodemographic, health-related, mental, and behavioral characteristics of the study sample, stratified by screening status. Compared with women screened with cytology alone, those screened with co-testing were younger [mean age (95% CI): 44.8 years (43.4–46.2) vs. 53.2 years (51.5–54.9)] and more likely to be Hispanics [weighted percentage (weighted 95% CI): 33.9% (27.9–39.8) vs. 24.0% (18.5–29.6)]. They were also more likely to use hormonal contraception [83.9% (79.3–88.5) vs. 75.4% (69.7–81.1)]; be vaccinated against HBV [56.7% (50.3–63.1) vs. 28.9% (22.9–35.0)] and HPV [13.0% (9.1–17.0) vs. 1.5% (0.0–3.1)]; and to have a personal cancer history [12.1% (7.7–16.5) vs. 7.4% (3.7–11.2)] compared with women screened with cytology alone. With regard to cancer beliefs, women screened with co-testing were less likely to agree with the statement “There's not much you can do to lower your chances of getting cancer” [61.5% (55.1–67.8) vs. 66.4% (60.0–72.8)] and less likely to agree with the statement “There are so many different recommendations about preventing cancer, it's hard to know which ones to follow” [76.1% (70.6–81.6) vs. 80.3% (74.9–85.6)] than women who screened with cytology alone.

Determinants of cervical cancer screening with co-testing

Table 2 shows the adjusted odds ratios (aORs) of cervical cancer screening with co-testing, compared with screening with cytology alone, according to sociodemographic, health-related, mental, and behavioral characteristics as reported by screening-eligible women in Texas. The adjusted odds of using hormonal contraception [aOR: 2.03 (1.03–3.97)]; being vaccinated against HBV [aOR: 2.48 (1.52–4.02)]; being vaccinated against HPV (aOR: 4.48, 95% CI: 1.25–15.97); or having a personal history of any cancer [aOR: 2.96 (1.29–6.77)] was higher for women who reported having been screened with co-testing compared with women who reported having had cytology alone. In addition, the odds of being screened with co-testing was lower in age groups (in years) 45–59 and 60 or older, compared with the age group 30–44 [aOR: 0.48 (0.27–0.85) and aOR: 0.14 (0.06–0.32), respectively]; and in women with an annual household income between $20,000 and $49,999 compared with those with an income between $50,000 and $74,999 [aOR: 0.49 (0.25–0.96)]. However, place of birth (in the United States vs. outside), place of residence (urban vs. rural), women's beliefs about cancer, cancer risk perceptions, depression, race, education level, marital status, smoking, body mass index, and health literacy were not significantly associated with cervical screening with co-testing in this population.

In further analyzes, the removal of the variables “income” and education” from the logistic regression model did not significantly alter our main results. Likewise, including the interaction of income and/or education with cancer beliefs variables into the logistic regression model did not change our results, with no significance detected for the interaction terms.

Discussion

In this representative sample of women aged 30 years or older residing in Texas and surveyed about their cervical cancer screening practices, HPV vaccination, HBV vaccination, hormonal contraception use, and personal cancer history were positively associated, whereas older age and lower household income were negatively associated with co-testing. To the best of our knowledge, this is the first study to examine the determinants of using co-testing versus cytology alone for cervical cancer screening in the United States. Our findings provide key information on the use of co-testing for cervical cancer screening in Texas and identify the subsets of women that should be targeted by public health interventions to increase co-testing uptake, thereby improving the effectiveness of cervical screening programs.

Overall, 90.3% of women in this study of Texas residents reported having been screened for cervical cancer. In 2015, it was estimated that one-third of women screened for cervical cancer in the United States had been screened with co-testing [2]. Although these results indicate a progression in the use of co-testing for cervical screening, they reveal that a substantial proportion of women eligible for co-testing continue to be screened with cytology alone. In fact, evidence suggests that cervical screening with co-testing is more accurate than cytology. Not only is co-testing less likely to miss cervical lesions (dysplasia or cancer) than cytology [10], but also it performs better than cytology alone in detecting abnormalities of the endocervix (the inner part of the cervix, lined with glandular cells) [21]. Indeed, cytology screening refers to the morphologic examination of exfoliated cells obtained from the cervical mucosa through Pap smear. Because the endocervix is not easily accessible to clinical examination, cervical cells

Table 1
Characteristics of the study population, by cervical screening status

Variables	Total		Women ever screened				Women never screened	
			Co-testing (cytology and HPV test)		Pap testing (cytology alone)			
	n	%, Weighted (95% CI)	*n*	%, Weighted (95% CI)	*n*	%, Weighted (95% CI)	*n*	%, Weighted (95% CI)
Respondents	572	100.0	273	44.8 (40.4–49.1)	242	45.5 (41.1–49.9)	57	9.7 (7.2–12.3)
1. Sociodemographic factors								
Age (mean)*		48.4 (47.3–49.5)		44.8 (43.4–46.2)		53.2 (51.5–54.9)		42.6 (39.5–45.6)
Age groups (y)								
30–44	283	40.7 (36.5–44.9)	164	50.8 (44.3–57.3)	83	26.9 (21.4–32.5)	36	59.2 (45.2–73.1)
45–59	194	40.6 (36.1–45.0)	84	39.3 (32.8–45.8)	92	43.1 (36.3–49.9)	18	34.4 (20.8–48.0)
≥60	95	18.7 (15.1–22.3)	25	9.9 (5.9–13.9)	67	30.0 (23.6–36.3)	3	6.4 (0.0–14.0)
Ethnicity/race								
Black, non-Hispanic	156	13.0 (10.9–15.2)	80	14.3 (11.0–17.5)	63	12.1 (8.95–15.1)	13	11.9 (5.3–18.5)
Hispanic	167	29.0 (25.1–32.9)	89	33.9 (27.9–39.8)	60	24.0 (18.5–29.6)	18	30.1 (17.9–42.3)
Others	44	7.5 (5.3–9.7)	23	8.6 (5.2–12.0)	17	6.7 (3.6–9.9)	4	5.9 (0.2–11.6)
White, non-Hispanic	205	50.5 (46.1–54.9)	81	43.3 (36.7–49.9)	102	57.2 (50.7–63.7)	22	52.1 (38.4–65.8)
Born in the United States								
No	51	8.7 (6.3–11.1)	25	9.4 (5.7–13.0)	19	7.6 (4.1–11.1)	7	10.6 (3.0–18.1)
Yes	521	91.3 (88.9–93.7)	248	90.6 (87.0–94.3)	223	92.4 (88.9–95.9)	50	89.4 (81.9–97.0)
Education								
No greater than 12 years or completed high school	128	24.0 (20.2–27.8)	47	19.5 (14.2–24.7)	62	26.0 (20.0–31.9)	19	35.6 (22.3–49.1)
Post high school training or some college	208	35.4 (31.2–39.7)	108	39.3 (33.0–45.6)	83	33.7 (27.3–40.1)	17	25.7 (14.2–37.1)
College/postgraduate	236	40.6 (36.2–44.9)	118	41.2 (34.9–47.5)	97	40.3 (33.7–47.0)	21	38.7 (25.1–52.3)
Marital status								
Single/widowed	149	21.9 (18.4–25.5)	66	18.8 (14.1–23.4)	59	21.4 (15.9–26.8)	24	39.4 (25.9–52.9)
Living as married/married	123	21.6 (18.0–25.3)	59	21.3 (16.0–26.6)	58	23.7 (18.0–29.5)	6	13.2 (3.1–23.2)
Divorced/separated	300	56.5 (52.1–60.8)	148	59.9 (53.8–66.2)	125	54.9 (48.1–61.6)	27	47.4 (33.6–61.2)
Occupation								
Employed	304	50.8 (46.4–55.2)	156	52.3 (45.8–58.7)	117	48.6 (41.8–55.4)	31	54.5 (40.7–68.3)
Homemaker/unemployed/disabled	176	32.2 (28.1–36.4)	84	34.4 (28.2–40.6)	69	28.2 (22.1–34.3)	23	40.9 (27.2–54.5)
Student/retired/other	92	17.0 (13.6–20.4)	33	13.3 (8.8–17.9)	56	23.2 (17.4–29.0)	3	4.7 (0.0–10.1)
Income								
≤$19,999	109	17.6 (14.3–21.0)	44	16.0 (11.3–20.8)	46	16.0 (11.2–20.8)	19	32.4 (19.5–45.4)
$20,000–$49,999	197	33.8 (29.6–38.0)	87	28.9 (23.2–34.6)	94	39.7 (33.1–46.4)	16	28.6 (15.9–41.2)
$50,000–$74,999	123	22.6 (18.8–26.3)	59	22.9 (17.4–28.4)	51	22.3 (16.6–27.9)	13	22.8 (11.4–34.1)
≥$75,000	143	26.0 (22.1–29.9)	83	32.2 (26.1–38.2)	51	22.0 (16.3–27.6)	9	16.2 (6.0–26.5)
Residence								
Rural	236	50.9 (46.4–55.3)	103	47.9 (41.4–54.3)	112	54.8 (48.1–61.4)	21	46.4 (32.5–60.4)
Urban	336	49.1 (44.7–53.6)	170	52.1 (45.7–58.6)	130	45.2 (38.6–51.9)	36	53.6 (39.6–67.5)
Home ownership ($n = 571$)								
Own	309	58.7 (54.4–63.0)	133	54.3 (48.0–60.7)	150	65.0 (58.6–71.4)	26	49.0 (35.1–63.1)
Rent/occupied without paying monetary rent	262	41.3 (37.0–45.6)	140	45.7 (39.3–52.0)	92	35.0 (28.6–41.4)	30	51.0 (37.0–65.0)
2. Health behavior, access, and coverage								
Hormonal contraception								
No	148	24.5 (20.7–28.2)	47	16.1 (11.5–20.7)	65	24.6 (18.9–30.3)	36	62.4 (49.0–75.9)
Yes	424	75.5 (71.8–79.3)	226	83.9 (79.3–88.5)	177	75.4 (69.7–81.1)	21	37.6 (24.1–51.0)
Smoking								
Current smokers	108	19.1 (15.6–22.6)	58	22.0 (16.7–27.4)	41	16.3 (11.3–21.3)	9	18.6 (7.5–29.7)
Former smokers	100	20.4 (16.7–24.2)	44	20.1 (14.6–25.6)	51	23.4 (17.5–29.3)	5	8.3 (0.9–15.6)
Never smokers	364	60.5 (56.1–64.9)	171	57.9 (51.4–64.3)	150	60.3 (53.6–67.0)	43	73.1 (60.7–85.5)
Health care coverage ($n = 571$)								
No	136	22.3 (18.6–25.9)	60	21.4 (16.1–26.6)	52	18.6 (13.5–23.7)	24	43.5 (29.8–57.3)
Yes	435	77.7 (74.1–81.4)	212	78.6 (73.4–83.9)	190	81.4 (76.3–86.5)	33	56.5 (42.7–70.2)
Last routine checkup								
Never/unknown	23	3.9 (2.3–5.6)	10	3.8 (1.4–6.2)	7	2.8 (0.6–5.1)	6	9.7 (2.0–17.8)
Within the past year	398	70.9 (66.9–74.9)	205	76.2 (70.9–81.6)	169	71.9 (65.9–78.0)	24	42.0 (28.3–55.7)
One year ago or more	151	25.2 (21.4–28.9)	58	20.0 (15.0–25.0)	66	25.3 (19.4–31.1)	27	48.2 (34.3–62.0)
Hepatitis B virus vaccination								
No	334	59.8 (55.4–64.1)	117	43.3 (36.9–49.7)	170	71.1 (65.0–77.1)	47	82.5 (72.1–93.0)
Yes	238	40.2 (35.9–44.6)	156	56.7 (50.3–63.1)	72	28.9 (22.9–35.0)	10	17.5 (7.0–27.9)
Human papillomavirus vaccination								
No	485	86.5 (83.7–89.4)	209	78.8 (73.8–83.8)	229	95.2 (92.4–97.9)	47	81.9 (71.2–92.6)
Do not know	37	6.2 (4.1–8.2)	22	8.2 (4.7–11.8)	9	3.3 (1.0–5.6)	6	10.1 (2.0–18.1)
Yes	50	7.3 (5.2–9.4)	42	13.0 (9.1–17.0)	4	1.5 (0.0–3.1)	4	8.0 (0.2–15.9)
How difficulty to understand information that doctors, nurses, and other professional tell you?								
Easy	521	91.0 (88.5–93.5)	252	92.2 (88.8–95.6)	222	92.1 (88.6–95.7)	47	79.6 (68.0–91.2)
Difficult	51	9.0 (6.5–11.5)	21	7.8 (4.4–11.2)	20	7.9 (4.4–11.4)	10	20.4 (8.8–32.0)
3. Mental and physical health								
Depression								
Never	159	25.6 (21.8–29.3)	73	25.0 (19.5–30.5)	64	23.9 (18.2–29.6)	22	35.8 (22.7–48.8)
A few times a year	195	32.9 (28.8–37.1)	98	34.1 (28.0–40.1)	83	33.4 (27.0–39.7)	14	25.8 (13.5–38.0)

(*continued on next page*)

Table 1 (*continued*)

Variables	Total		Women ever screened				Women never screened	
			Co-testing (cytology and HPV test)		Pap testing (cytology alone)			
	n	%, Weighted (95% CI)	*n*	%, Weighted (95% CI)	*n*	%, Weighted (95% CI)	*n*	%, Weighted (95% CI)
Daily, weekly, or monthly	218	41.5 (37.1–45.9)	102	41.0 (34.6–47.3)	95	42.8 (36.0–49.5)	21	38.5 (24.9–52.0)
BMI ($n = 568$)								
Underweight to normal (<25)	164	29.9 (25.8–34.0)	72	27.2 (21.4–33.1)	76	32.1 (25.8–38.5)	16	31.9 (18.3–45.5)
Overweight (25 to <30)	149	24.8 (21.0–28.6)	79	27.9 (22.1–33.6)	54	21.4 (15.8–27.0)	16	26.3 (14.5–38.1)
Obesity (≥30)	255	45.3 (40.9–49.7)	121	44.9 (38.5–51.3)	112	46.5 (39.7–53.2)	22	41.8 (27.7–55.9)
Personal history of any cancer								
No	526	90.7 (88.0–93.4)	246	87.9 (83.5–92.3)	226	92.6 (88.8–96.3)	54	94.7 (88.4–100.0)
Yes	46	9.3 (6.6–12.0)	27	12.1 (7.7–16.5)	16	7.4 (3.7–11.2)	3	5.3 (0.0–11.6)
Family history of any cancer								
No	150	23.9 (20.2–27.6)	68	22.4 (17.1–27.6)	54	20.3 (15.0–25.7)	28	47.3 (33.6–61.1)
Not sure	41	8.2 (5.7–10.7)	19	8.2 (4.6–11.9)	16	7.3 (3.7–10.9)	6	12.4 (2.8–21.9)
Yes	381	67.9 (63.8–72.0)	186	69.4 (63.5–75.3)	172	72.4 (66.4–78.4)	23	40.3 (26.6–54.0)
4. Perceived risk and beliefs about cancer								
Compared with other people your age, how likely are you to get cancer in your lifetime?								
Likely	152	27.5 (23.5–31.4)	78	29.9 (24.0–35.8)	65	27.9 (21.8–34.0)	9	14.4 (5.3–23.4)
Neutral	283	50.5 (46.1–54.9)	135	51.0 (44.6–57.4)	120	50.9 (44.1–57.7)	28	46.3 (32.6–60.1)
Unlikely	137	22.0 (18.4–25.7)	60	19.1 (14.2–24.1)	57	21.2 (15.8–26.6)	20	39.3 (25.5–53.1)
It seems everything causes cancer								
Agree	161	26.9 (23.0–30.8)	75	26.6 (20.9–32.3)	64	24.2 (18.5–29.9)	22	40.8 (27.1–54.4)
Disagree	411	73.1 (69.2–77.0)	198	73.4 (67.7–79.1)	178	75.8 (70.1–81.5)	35	59.3 (45.6–72.9)
There's not much you can do to lower your chances of getting cancer								
Agree	362	62.6 (58.3–66.9)	174	61.5 (55.1–67.8)	161	66.4 (60.0–72.8)	27	49.9 (36.1–63.8)
Disagree	210	37.4 (33.1–41.7)	99	38.5 (32.2–44.9)	81	33.6 (27.2–40.0)	30	50.1 (36.3–63.9)
Cancer is most often caused by a person's behavior or lifestyle ($n = 570$)								
Agree	356	62.4 (58.1–66.7)	165	60.7 (54.5–67.0)	156	64.6 (58.1–71.2)	35	59.6 (46.0–73.2)
Disagree	214	37.6 (33.3–41.9)	107	39.3 (33.0–45.5)	85	35.4 (28.9–41.9)	22	40.4 (26.8–54.0)
I'd rather not know my chance of getting cancer ($n = 571$)								
Agree	310	54.3 (49.9–58.7)	160	58.7 (52.3–65.0)	129	52.6 (45.9–59.4)	21	41.6 (27.6–55.6)
Disagree	261	45.7 (41.3–50.1)	113	41.3 (35.0–47.7)	113	47.4 (40.6–54.2)	35	58.4 (44.4–72.4)
When I think about cancer, I automatically think about death								
Agree	219	38.5 (34.2–42.8)	102	38.3 (32.0–44.6)	93	37.4 (30.8–43.9)	24	44.5 (30.7–58.3)
Disagree	353	61.5 (57.2–65.8)	171	61.7 (55.4–68.0)	149	62.6 (56.1–69.2)	33	55.5 (41.7–69.3)
There are so many different recommendations about preventing cancer, it's hard to know which ones to follow ($n = 570$)								
Agree	436	77.1 (73.4–80.8)	207	76.1 (70.6–81.6)	191	80.3 (74.9–85.6)	38	66.5 (53.1–79.9)
Disagree	134	22.9 (19.2–26.6)	66	23.9 (18.4–29.4)	50	19.7 (14.3–25.1)	18	33.5 (20.1–46.9)

* mean age instead of weighted percentage, with the 95% confidence interval (CI).

collected through Pap smear mainly stem from exocervix. Thus, cytology may miss a lesion in the endocervical canal that does not extend to the exocervix [21]. HPV test, however, detects the presence of HPV's genome within cervical cells. It is now established that HPV infection is a multifocal infection, as viruses that enter cervical cells in the transformation zone generally spread to the entire anogenital region, including to the vagina, the vulva, and the endocervical canal [22, 23]. This is the reason why a positive HPV test on cervical specimen (or even vaginal specimen) is correlated with the presence of the virus in the endocervix canal, and colposcopic examination based on a positive HPV test is more likely to detect endocervical lesions. Interestingly, the 5-year cumulative risk of CIN3+ in women screened with co-testing was found to be lower than the 3-year cumulative risk of CIN3+ in women screened with cytology alone, when the screening result is negative or normal [24]. As a result, the recommended cervical screening interval with co-testing (5 years) is longer than with cytology alone (3 years) [25], a consideration that is not negligible, especially in underserved populations. In addition to reducing the rates of women's absence from their workplace, longer screening intervals may reduce the number/frequency of visits to health care facilities, the cost of transportation to and from health care facilities for women, and providers' workload. Therefore, emphasis should be made on promoting co-testing as the preferred option for cervical cancer screening in women aged 30 years and older, particularly in hard-to-reach communities. In this regard, it is imperative to improve awareness of providers and patients on the indications and benefits of co-testing over cytology alone. Alternatively, screening guidelines should be simplified to endorse co-testing as the only recommended option for cervical screening in the appropriate age group.

In a previous study assessing cervical screening changes in the United States, co-testing and cytology were compared each with no screening [2]. These authors reported that the odds of having undergone co-testing were similar to those for having been screened with cytology, with a few exceptions. Hispanics and NHBs had higher odds of being screened with co-testing than whites, as did U.S.-born compared with foreign-born women [2]. In accordance with our results, these findings suggest the existence of sociodemographic disparities in the use of co-testing for cervical screening among eligible women in the United States and stress the need for decision-makers to implement adequate policies aimed at reducing these inequalities.

In the digital era, younger people are more likely than older people to use the internet for health information seeking [26], which may be reflected in lower odds of using co-testing for cervical screening among older women. In addition, older women may be seen by older providers who may not be following the most recent recommendations. Owing to the increased risk of developing second primary cancers among cancer survivors, people with personal cancer history are more likely than people without cancer to receive cervical cancer screening [27]. Our finding of higher odds of cervical screening with co-testing among cancer survivors indicates a higher utilization of more effective screening tools in this high-risk group to prevent subsequent development of cancer. Interestingly, cancer risk perceptions and beliefs were not

Table 2
Factors associated with cervical cancer screening with co-testing, compared with screening with cytology alone in Texas

Characteristics	Adjusted OR* (95% CI)	*P*-value
1. Sociodemographic factors		
Age group (y)		
30–44	Ref	
45–59	0.48 (0.27–0.85)	**.011**
≥60	0.14 (0.06–0.32)	**<.001**
Ethnicity/race		
White, non-Hispanic	Ref	
Black, non-Hispanic	1.74 (0.78–3.85)	.173
Hispanic	1.52 (0.73–3.15)	.260
Other	1.74 (0.65–4.65)	.271
Born in the United States		
No	Ref	
Yes	1.21 (0.55–2.70)	.633
Education		
No greater than 12 years or completed high school	Ref	
Post high school training or some college	1.45 (0.73–2.86)	.284
College/postgraduate	1.23 (0.59–2.57)	.587
Marital status		
Single/widowed	Ref	
Divorced/separated	1.00 (0.55–1.84)	.995
Living as married/married	1.28 (0.64–2.58)	.490
Occupation		
Employed	Ref	
Homemaker, unemployed, disabled	1.32 (0.72–2.43)	.362
Other, retired, student	1.79 (0.82–3.91)	.143
Income		
≤$19,999	0.67 (0.28–1.60)	.363
$20,000–$49,999	0.49 (0.25–0.96)	**.037**
$50,000–$74,999	Ref	
≥$75,000	1.28 (0.64–2.58)	.488
Residence		
Urban	Ref	
Rural	1.07 (0.57–2.03)	.829
Home ownership		
Own	Ref	
Rent/occupied without paying monetary rent	1.10 (0.66–1.83)	.724
2. Health behavior, access, and coverage		
Hormonal contraception		
No	Ref	
Yes	2.03 (1.03–3.97)	**.040**
Smoking		
Never	Ref	
Former	0.95 (0.48–1.86)	.877
Current	1.10 (0.58–2.12)	.765
Health care coverage		
No	Ref	
Yes	0.92 (0.51–1.69)	.793
Last routine checkup		
Unknown/never	Ref	
Within the past year	0.50 (0.14–1.79)	.289
One year ago or more	0.31 (0.08–1.17)	.083
Hepatitis B virus vaccination		
No	Ref	
Yes	2.48 (1.52–4.02)	**<.001**
Human papillomavirus vaccination		
No	Ref	
Unknown	2.58 (0.90–7.43)	.079
Yes	4.48 (1.25–15.97)	**.021**
How difficulty to understand information that doctors, nurses, and other professional tell you?		
Easy	Ref	
Difficult	0.98 (0.45–2.13)	.958
3. Mental and physical health		
Depression		
Never	Ref	
A few times a year	1.05 (0.57–1.93)	.880
Daily, weekly, or monthly	1.02 (0.57–1.85)	.937
BMI		
Underweight to normal (<25)	Ref	
Overweight (25 to <30)	1.33 (0.68–2.60)	.408
Obesity (≥30)	0.84 (0.47–1.50)	.555
Personal history of any cancer		
No	Ref	
Yes	2.96 (1.29–6.77)	**.010**
Family history of any cancer		
No	Ref	
Not sure	0.76 (0.27–2.11)	.596
Yes	0.74 (0.41–1.32)	.299
4. Perceived risk and beliefs about cancer		
Compared with other people your age, how likely are you to get cancer in your lifetime?		
Unlikely	Ref	
Neutral	1.29 (0.50–2.05)	.416
Likely	1.01 (0.70–2.35)	.974
Cancer is most often caused by a person's behavior or lifestyle		
Disagree	Ref	
Agree	0.99 (0.59–1.65)	.959
When I think about cancer, I automatically think about death		
Disagree	Ref	
Agree	1.18 (0.70–1.98)	.531
It seems everything causes cancer		
Disagree	Ref	
Agree	1.15 (0.63–2.08)	.654
There's not much you can do to lower your chances of getting cancer		
Disagree	Ref	
Agree	0.67 (0.39–1.14)	.140
I'd rather not know my chance of getting cancer		
Disagree	Ref	
Agree	1.00 (0.60–1.65)	.990
There are so many different recommendations about preventing cancer, it's hard to know which ones to follow		
Disagree	Ref	
Agree	0.66 (0.36–1.24)	.196

All *P*-value in bold are ≤.05, and indicates statistical significance.
* women who reported having never been screened where not included.

associated with cervical screening with co-testing in Texas. Although avoiding information on personal risk of cancer has been linked to lower intent to engage in cancer screening [28, 29] and fatalistic beliefs about cancer associated with reduced screening rates [30, 31], our findings suggest that these factors do not predict the use of co-testing for cervical screening.

HPV vaccination was one of the strongest predictors of screening with co-testing in this study. This finding may reflect a higher health education of HPV-vaccinated women in general, and in particular, their better knowledge of the role of HPV in the genesis of cervical cancer. In an analysis of the predictors of HPV vaccination uptake among female high-school students, women empowered about their health care had a higher chance of being vaccinated for HPV [32]. After HPV vaccination was approved in the United States for cervical cancer prevention [33], there were fears that women who had received HPV immunization might be unwilling to get screened for cervical cancer [34]. Adding to the existing evidence that women vaccinated against HPV are more likely to undergo cervical screening than unvaccinated women [2, 35, 36], our results further indicate that HPV-vaccinated women who screen for cervical cancer are more likely to use co-testing.

Our finding that HBV vaccination is a positive predictor of cervical cancer screening with co-testing was unforeseen, as HBV vaccination has been universally (at any age) recommended in the United States since 2006, per the Advisory Committee on Immunization Practices' guidelines [37]. However, our study sample consisted of women aged 30 years or older, that is, who were born when HBV vaccine was either unavailable or recommended only for certain adult populations. As a result, women vaccinated against HBV in our report were more likely to have received HBV vaccine at teenage or adult age, which could reflect a better health-related knowledge compared with non–HBV-vaccinated women.

The lower odds of screening with co-testing among lower-income women may be attributable to the higher cost of co-testing, compared with cytology alone. In the United States, the rate and quality of insurance coverage increases with income level [38]. Specifically, low-income women are more likely to be uninsured or underinsured, and even when insured, they are less likely to be enrolled in health insurance plans that cover clinical preventive services [39]. As a result, it is possible that lower-income women who go for cervical screening get screened with the most affordable strategy recommended by their provider.

In our analysis, hormonal contraception use was found to be a predictor of cervical screening with co-testing. Contraception use and access is recognized as an indicator of women's empowerment and autonomy [40]. This autonomy in decision-making about their health is reflected in the use of co-testing by women who screen for cervical cancer. The association between hormonal contraception and cervical cancer screening with co-testing could also be explained by the fact that women who utilize health care to acquire contraception are more likely to have frequent interaction with providers and thus to be exposed to more effective screening tools.

In addition to women's characteristics, institutional factors and interaction with health care providers play a critical role in the choice of the cervical cancer screening option women receive. In health care facilities where equipment for HPV testing is not readily available, cytology screening may be the only option proposed to clients. Even when both screening options are available, patients who usually look for the best care possible may get confused when many screening options are recommended and often rely on their health care providers to make the right decision [41]. To improve cancer screening effectiveness, the United States Preventive Services Task Force suggests that health care professionals use the shared decision-making (SDM) approach when recommending cancer screening to patients [42]. The principle of the SDM states that patients and clinicians work together and jointly make an informed health care decision [42]. The SDM has gained significant attention as a means for incorporating patient-centeredness into a health care decision, one of the six dimensions of health care performance proposed by the 2001 Institute of Medicine report [43]. As noted by the United States Preventive Services Task Force, the SDM (joint participation) is clearly differentiated from the informed consent (clinician disclosure) in terms of the degree of patient involvement and should satisfy both the “informed” and “joint” elements in the decision [42].

Henceforth, our findings highlight the importance to further explore the influence of these key factors on the type of cervical cancer screening women aged 30 years or older receive in the United States. Further investigations are needed to understand the interactions that occur between health care providers and women that ultimately lead to the use of co-testing, particularly among older and lower-income women. Also, it is important to identify barriers to co-testing in populations found to be more inclined to receive cytology screening.

Limitations

Our study had some limitations. First, this study used self-reported data. Although most questions related to cervical cancer have been validated with medical records data, women who usually confuse pelvic examination with cervical screening tend to over-report cervical screening [44]. Also, because screening intervals differ based on the screening strategy, more appropriate approaches to examine cervical cancer screening practices are needed. An option could be to ask women i) whether they have ever undergone screening, ii) the date of the last screening, and iii) the screening tool used [45].

Second, the wording of the question on HPV testing did not allow us to determine if it was used concurrently with cytology in all women surveyed, although those indicating no Pap testing were excluded from the analysis. In our study population, HPV testing may have been performed as a reflex test in some women with abnormal cytology, per the American Society of Colposcopy and Cervical Pathology's guidelines [7]. However, the proportion of women with abnormal cytology (atypical squamous cells of undetermined significance) that can be followed up with reflex HPV testing both in the United States and Texas is very low [46, 47], making its potential contribution to the definition of our outcome measure (co-testing) minimal. On the other hand, an HPV assay was approved by the Food and Drug Administration in 2014 for primary cervical screening of women aged 25 and older [48]. However, most U.S. guidelines do not recommend primary screening with HPV testing, although several organizations including the American Cancer Society, the American Society of Colposcopy and Cervical Pathology, and the American Society for Clinical Pathology have released interim guidance for clinicians interested in primary screening with HPV testing [49, 50]. Because interim guidelines are not definitive and generally uncovered by health insurance, it is probable that most women in our study sample had HPV testing as part of co-testing.

Third, because our data were based on a survey directed toward women, we could not explore the effect of health care providers and health system's characteristics that contribute to the choice of either cervical screening method.

Conclusion

This study assessed the prevalence and correlates of cervical cancer screening with co-testing in Texas. Although about half of eligible women in Texas reported having ever been screened with co-testing, certain groups were less likely to have benefited from this preferred method. It is imperative to improve awareness among providers and populations on the benefits and indications of co-testing. To that end, public policies should develop and implement appropriate interventions focusing on older and lower-income women.

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