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The cross-sectional association between lifestyle behaviors and breast and cervical cancer screening among Hispanic women along the Texas-Mexico border

Paul Gerardo Yeh [a,b,*], Audrey C. Choh [c], Susan P. Fisher-Hoch [c], Joseph B. McCormick [c], David R. Lairson [b], Belinda M. Reininger [d]

[a] Department of Kinesiology, Wiess School of Natural Sciences, Rice University, Houston, TX, USA
[b] Department of Management, Policy, and Community Health, The University of Texas Health Science Center at Houston School of Public Health, Houston, TX, USA
[c] Department of Epidemiology, The University of Texas Health Science Center at Houston School of Public Health in Brownsville, Brownsville, TX, USA
[d] Department of Health Promotion and Behavioral Sciences, The University of Texas Health Science Center at Houston School of Public Health in Brownsville, Brownsville, TX, USA

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ABSTRACT

Objective: Lifestyle behaviors may influence timely cancer screening, but their relationship is unknown among Hispanic women who have low cancer screening rates.
Methods: We used Cameron County Hispanic Cohort data from 2014 to 2022 to evaluate the relationship between lifestyle and compliance with mammography and Papanicolaou (Pap) screening guidelines ("up-to-date") among Hispanic women along the Texas-Mexico border. The 2018 World Cancer Research Fund scoring system characterized cancer-preventive lifestyle adherence. Multivariable logistic regression assessed the association between lifestyle behaviors and mammography and, separately, Pap screening.
Results: Among 385 age-eligible women for mammography and 412 age-eligible women for Pap test screening, up-to-date mammography and Pap screening were seen in 66.7 % (95 % CI: 58.8–73.7 %) and 71.4 % (95 % CI: 63.6–78.0 %) of women, respectively. Compared to non-adherence, adherence to waist circumference (AOR adjusted odds ratio 9.1, 95 % CI: 1.1–77.9; $P = 0.04$) and alcohol guidelines (AOR 9.4, 95 % CI: 1.1–81.6; $P = 0.04$) were associated with up-to-date mammography. Consumption guideline adherence to fruit and vegetable (AOR 4.0, 95 % CI: 1.2–13.4; $P = 0.03$), ultra-processed foods (AOR 7.5, 95 % CI: 1.6–34.7; $P = 0.01$), red meat (AOR 6.8, 95 % CI: 1.3–34.8; $P = 0.02$), and sugary beverages (AOR 16.9, 95 % CI: 2.1–138.4; $P = 0.01$) were associated with up-to-date Pap screening.
Conclusions: Differential factors were associated with increased odds of being up-to-date with mammography versus Pap test screening. Lifestyle behavior promotion complements cancer prevention interventions. Contextual insight into the association between lifestyle and cancer screening provides a foundation for future endeavors to augment these two core components of cancer prevention to address Hispanic women's rising breast and cervical cancer risk.

1. Introduction

From 2000 to 2019, Hispanic women had the fastest growth in breast cancer incidence (National Cancer Institute, 2022) and the highest cervical cancer incidence of any racial/ethnic group (Miller et al., 2021). Based on the cancer control continuum model, breast and cervical cancer outcomes are influenced by lifestyle behaviors and cancer screening applicable to all age-appropriate women (Yabroff et al., 2019). Complying with the recommended frequency of mammography and Papanicolaou (Pap) test screening reduces the incidence and mortality of breast (Park et al., 2021) and cervical cancer (Mann et al., 2015), respectively. Breast and cervical cancer screening guidelines include mammography biennially for all women aged 40–74 and a triannual Pap test for all women aged 21–65 (United States Preventive

* Corresponding author at: Faculty Associate, Department of Management, Policy, and Community Health, UTHealth School of Public Health, 1200 Pressler Street RAS E-311, Houston, TX 77030, T 830-252-8638, Houston, TX, USA.
E-mail address: paul.yeh.1@uth.tmc.edu (P.G. Yeh).

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Services Taskforce, 2022). Only 70.7 % of Hispanic women receive biennial mammography screening compared to 72.7 % of White women (Sabatino et al., 2021). Hispanic women's Pap screening guideline compliance (81 %) was lower compared to White women (83 %) (Miller et al., 2021).

Cancer outcome disparities are heightened among Hispanic women living along the border. Cameron County, one of the largest counties in the United States by Hispanic population (380,000) and proportion (90 %) in 2021 (United States Census Bureau, 2022), is Texas' southernmost county along the Texas-Mexico border. In Cameron County, breast cancer mortality was 40 % and 50 % higher in 2019 than Hispanic adults in Texas (Texas Cancer Registry, 2023) and nationally (National Cancer Institute, 2023a), respectively. Cameron County Hispanic women had a cervical cancer incidence and mortality rate that was 20 % and 30 % higher, respectively, than Hispanic adults nationally (National Cancer Institute, 2023b).

Poor socioeconomic indicators are present in Cameron County, including 60 % of women locally who do not have health insurance (Lopez et al., 2017) and a third living in poverty (Reininger et al., 2021), which are factors associated with decreased cancer-preventive behavior and screening uptake (Chen et al., 2018; Cokkinides et al., 2012; Orji and Yamashita, 2021). Low cancer-preventive lifestyle behavior engagement is prominently seen in Cameron County Hispanic women due to socioeconomic challenges and lack of infrastructure to facilitate lifestyle change (Wu et al., 2019; Wu et al., 2016).

In non-Hispanic populations, increased adherence to lifestyle recommendations is associated with increased cancer screening (Kaluza et al., 2020; Klein et al., 2022); however, this association has not been examined in a large population of Hispanic women, including those living along the Texas-Mexico border region despite their prominent cancer prevention needs.

We characterized lifestyle recommendations and cancer screening in a Hispanic population of women living in one of the largest U.S.-Mexico border county in South Texas. We hypothesized that improved adherence to cancer-preventive lifestyle recommendations would increase the odds of complying with mammography and Pap test screening guidelines in this population.

2. Materials and methods

2.1. Study design and participants

We performed a cross-sectional secondary data analysis of the ongoing Cameron County Hispanic Cohort (CCHC) Study. The CCHC details the behavioral, clinical, and biological characteristics of a population-representative sample of Hispanic women in Cameron County (Fisher-Hoch et al., 2015). The recruitment methods are detailed elsewhere (Fisher-Hoch et al., 2010). Consenting participants of households answered sociodemographic, health behavior, and health care surveys, and underwent physical examinations every five years (Fisher-Hoch et al., 2010). Data was available from 3171 Hispanic women from 2004 to the present, forming our sampling frame. All protocols of this study were approved by the Committee for the Protection of Human Subjects of The University of Texas Health Science Center (HSC-SPH-03-007-B).

The 2018 World Cancer Research Fund/American Institute for Cancer Research (WCRF/AICR) recommendations highlight evidence-based lifestyle behaviors with international consensus for generalized cancer risk reduction (Shams-White et al., 2019). Accordingly, we selected each participant's most recent time point where they answered questions regarding mammography and Pap tests (asked since March 2014) and had data across all WCRF/AICR lifestyle behaviors up to June 2022. As participants only answered screening questions at one time point, we conducted a cross-sectional analysis. Our two samples comprised 385 and 412 women for the mammography and Pap test analysis, respectively (Fig. 1).

2.2. Measurements

2.2.1. Applying the 2018 World Cancer Research Fund composite adherence score

A standardized scoring system (Table 1) can compare adherence levels to the 2018 WCRF/AICR recommendations between populations as a practical tool to epidemiologically quantify cancer preventive behavior associations with cancer screening and risk to guide cancer prevention research efforts (Shams-White et al., 2019). This scoring system calculates a **composite adherence score** *across* nine evidence-based, cancer-preventive lifestyle recommendations (Shams-White

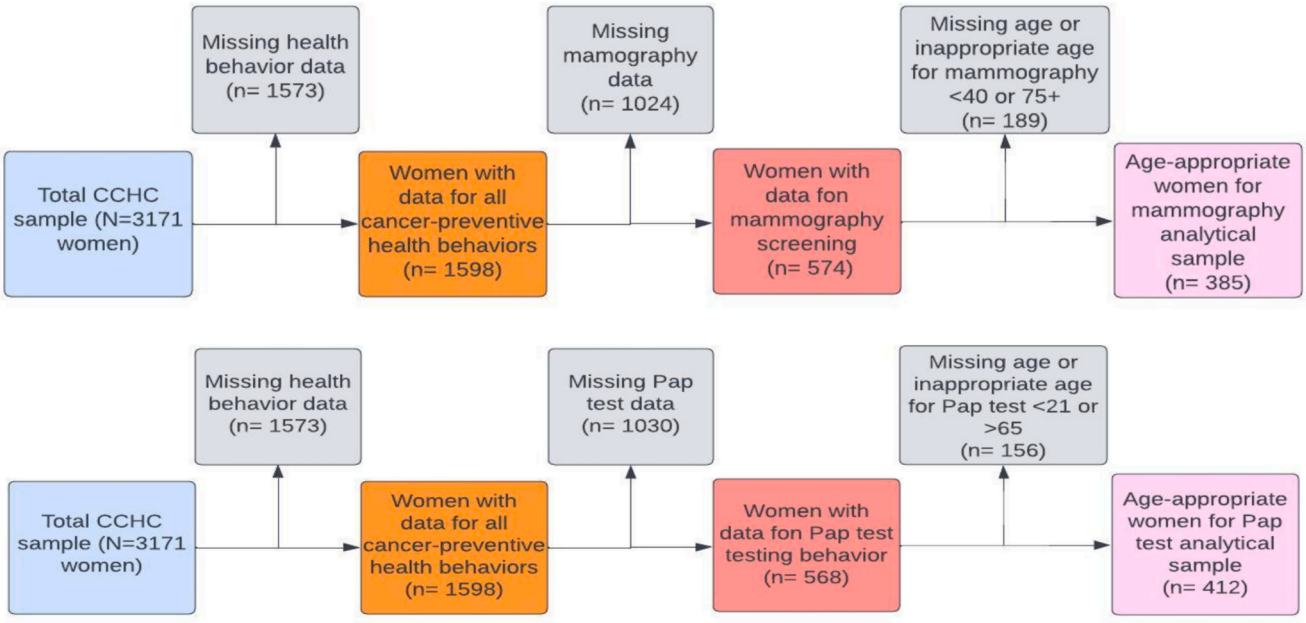

Fig. 1. The figure above demonstrates the selection of our analytical sample for ageappropriate women for mammography (upper) and Pap test (lower) screening.

Table 1
Operationalization of the 2018 World Cancer Research Fund/American Institute for Cancer Research Scale to assess adherence to cancer-preventive lifestyle behaviors.

Category	Recommendation	Operationalization	Behavioral Subcomponent Scores
Weight	BMI (kg/m^2)	BMI 18.5–24.9	0.5
		BMI 25–29.9	0.25
		BMI <18.5 or > 30	0
	Waist Circumference (centimeters)	<80 for women	0.5
		80- < 88 for women	0.25
		>88 for women	0
Physical Activity	Moderate-vigorous physical activity (minutes/week)	≥150	1
		75–150	0.5
		<75	0
Diet	Fruit and vegetable consumption (grams/day)	400	0.5
		200–400	0.25
		<200	0
	Fiber consumption (grams/day)	≥30	0.5
		15 - <30	0.25
		<15	0
	Ultra-processed food calories per day (tercile determined based on sample distribution (Kaluza et al., 2020))	Tercile 1	1
		Tercile 2	0.5
		Tercile 3	0
	Meat consumption (grams/week)	<500 red meat and < 21 processed meat	1
		<500 red meat and 21- < 100 processed meat	0.5
		>500 red meat or ≥ 100 processed meat	0
	Sugar-sweetened beverages (grams/day)	0	1
		>0 – ≤250	0.5
		>250	0
	Alcohol consumption (drink equivalents/day)	0 drinks	1
		1 for women	0.5
		>1 for women	0
Composite adherence score (summation of behavioral subcomponent scores across all recommendations)		The composite adherence score ranges from 0 to 7.	

Abbreviations: BMI, body mass index; kg/m^2, kilograms per meter squared.

et al., 2019). *Within* each recommendation, a three-level **subcomponent score** is given for adherence to each behavior, with intermediate scores for partial adherence (Shams-White et al., 2019).

[place Table 1 about here].

Higher point values within the scoring system indicate greater adherence across nine non-screening lifestyle behavior recommendations for cancer prevention (Shams-White et al., 2019). Table 1 provides each recommendation's point values for full, partial, and no adherence.

Proxy measures for dietary behaviors included fruit and vegetable consumption, which was measured as discrete weekly servings, with each fruit and vegetable serving assumed to be 80 and 75 g, respectively (Mathias et al., 2012). Each serving of "orange," "salad," "beans and legumes," and "other" vegetables was considered equivalent to 7.5 g of fiber (How much fiber is found in common foods?, 2022).

The number of servings of sweet tea, cheese, frozen desserts, pastries, other candy, and fried chips was aggregated to approximate ultra-processed food consumption, with the highest consumption tertile of ≥2 servings given the lowest behavioral subcomponent score, and 0 servings given the highest score (Kaluza et al., 2020). Red and processed meat consumption was estimated with the weekly servings of red meat and fried meat consumption, with each serving assumed to be 85 g and 30 g, respectively (Larsson and Orsini, 2014). Each endorsed serving of sugar-sweetened beverages (soft drinks, sweet drinks, sweet tea, and/or flavored milk) was converted to grams by assuming 1 serving corresponding to 150 g (Imamura et al., 2019). Women consuming a mean of 0, 1, and 2+ standard alcoholic drinks daily were given high, partial, and low scoring for this behavior, respectively. Smoking status is not a current WCRF/AICR recommendation (Shams-White et al., 2019) but was added as a categorical covariate (never/former smoked >100 cigarettes over lifetime/current smoker), given its association with breast and cervical cancer incidence (Bandi et al., 2021).

2.2.2. Dependent variable: Mammography and Pap screening guideline compliance

Mammography compliance was based on two questions: self-reported "ever having mammography," which was a binary yes/no response, combined with the age and year of the last mammography. We based compliance on the American Cancer Society and the American College of Obstetricians and Gynecologists guidelines of mammography screening guidelines biennially from ages 40 to 75 (American College of Obstetricians and Gynecologists, 2017). Respondents compliant with this time interval since their last mammography was considered "up-to-date." Not up-to-date women had no prior mammography or had their last mammography >2 years ago despite qualifying by age for screening.

Similarly, Pap screening compliance was based on the self-reported use of "cervical cytology screening" (Papanicolaou Pap test, yes/no), combined with the self-reported age and year of their last Pap test. A respondent was "up-to-date" if they were aged 21 to 65 years and received a Pap within the past 3 years (United States Preventive Services Task Force et al., 2018; United States Preventive Services Taskforce, 2022). Age-appropriate women without a prior Pap test or one completed >3 years ago were considered not up-to-date. Pap testing was the only cervical cancer screening modality assessed in the CCHC.

2.2.3. Sociodemographic and health covariates

Covariates were selected based on factors influencing lifestyle and healthcare utilization for cancer screening including age, marital status, and the highest level of education (Orji and Yamashita, 2021). Other covariates included family income (below/above the federal poverty line), current employment (yes/no), and health insurance over the past 12 months (yes/no). Location of care when sick (clinic/emergency room/Mexico/none) was assessed as most women in this region are uninsured and reside close to Matamoros, Mexico, where healthcare is cheaper, but lifestyle counseling and screening practices may not be provided (Reininger et al., 2014).

Immigrants form a substantial population of the border region. Less acculturated Hispanic individuals experience healthcare inaccessibility due to linguistic, sociocultural, and economic barriers (Moreno et al., 2019); this can result in less uptake of lifestyle behaviors and cancer screening (Moreno et al., 2019). Nativity by birth and language fluency (English-predominate, biaccultured, or Spanish-predominate) approximated acculturation. Other covariates include the years of residence in Cameron County and the participants' socioeconomic strata quartile.

Metabolic syndrome, an indicator of poor cardiometabolic health, increases susceptibility to breast (Bhandari et al., 2014) and cervical cancer (Penaranda et al., 2013). Metabolic syndrome served as a proxy to assess if physical health is associated with being up-to-date with mammography and Pap tests. We calculated each participant's severity of metabolic abnormalities with validated Hispanic-specific metabolic syndrome severity scores (DeBoer and Gurka, 2017).

$$\textit{Hispanic women}: -7.7516 + (0.0162^{*}(\textit{waist circumference})) - (0.0157^{*}(\textit{HDL})) + (0.0084^{*}(\textit{systolic blood pressure})) + (0.8872^{*}\ln(\textit{triglycerides}) + (0.0206^{*}(\textit{glucose}))$$

This equation calculates a *Z*-score, where each one-unit change represents a standard deviation difference in the overall severity of metabolic abnormalities.

2.3. Statistical analysis

Our analysis plan is portrayed in Fig. 2. We used sampling weights to calculate population-representative prevalence, accounting for unequal sampling, non-response, and clustering effects from census blocks and households (Fisher-Hoch et al., 2010). All tests were based on a 2-sided probability with a 0.05 significance level.

We used non-parametric Wilcoxon and Kruskal-Wallis rank-sum tests to assess for differences in the mean composite adherence score between levels of dichotomous and non-dichotomous categorical variables, respectively. Differences in the weighted prevalence of being up-to-date with mammography and Pap test screening were assessed by adherence levels within individual lifestyle recommendations (behavior subcomponent score), and across all lifestyle recommendations (composite adherence score). Up-to-date prevalence of mammography and Pap test screening were also assessed by levels of sociodemographic/health factors. We used survey-weighted chi-square tests for categorical covariates to obtain Rao-Scott F-adjusted chi-square statistics. Non-parametric Wilcoxon rank-sum tests were used for continuous variables.

We measured the impact of a one-unit increase in the composite adherence score on complying with mammography screening and, separately, with Pap test screening guidelines in a univariate model (Model 1). This association was expanded into a multivariable model adjusting for behavioral, sociodemographic, and physical health variables in Model 2. Models 1 and 2 used survey-weighted Rao-Scott F-adjusted chi-square tests for categorical variables, and non-parametric Wilcoxon rank-sum tests for continuous variables. In lieu of the composite adherence score, Model 3 assessed the association of adherence levels to each lifestyle recommendation (behavioral subcomponent score) while adjusting for the same variables in Model 2. Model 3 used the Wald test to quantify how full and partial adherence to each healthy lifestyle recommendation, compared to non-adherence, influenced the odds of being up-to-date with mammography and, separately, Pap test screening.

Reference groups for covariates were selected based on the variable level presumed a priori to have the most healthcare access barriers (e.g., foreign-born). The final logistic regression model was constructed, checking for influential outliers in the predictor variables, plotting each predictor variable against the logit of the dependent variable to ensure linearity, and assessing that our final model did not have significant multicollinearity among the independent variables using a variance inflation factor (VIF) threshold for each covariate being <10 (Bayman and Dexter, 2021; Craney and Surles, 2002). All statistical analyses were conducted using Stata version 17 (StataCorp LLC, 2021)

3. Results

3.1. Lifestyle behavior adherence score by sociodemographic/health factors

The mean WCRF/AICR composite adherence score in both samples was 2.6 points out of 7 (Supplemental Table S1). Women aged 40–65 years in the mammography sample who were also up-to-date with Pap test screening had higher mean scores than those not up-to-date with Pap test ($P < 0.01$).

In the Pap test sample, an increased proportion of lived years in Cameron County ($P = 0.01$) and increasing metabolic syndrome severity

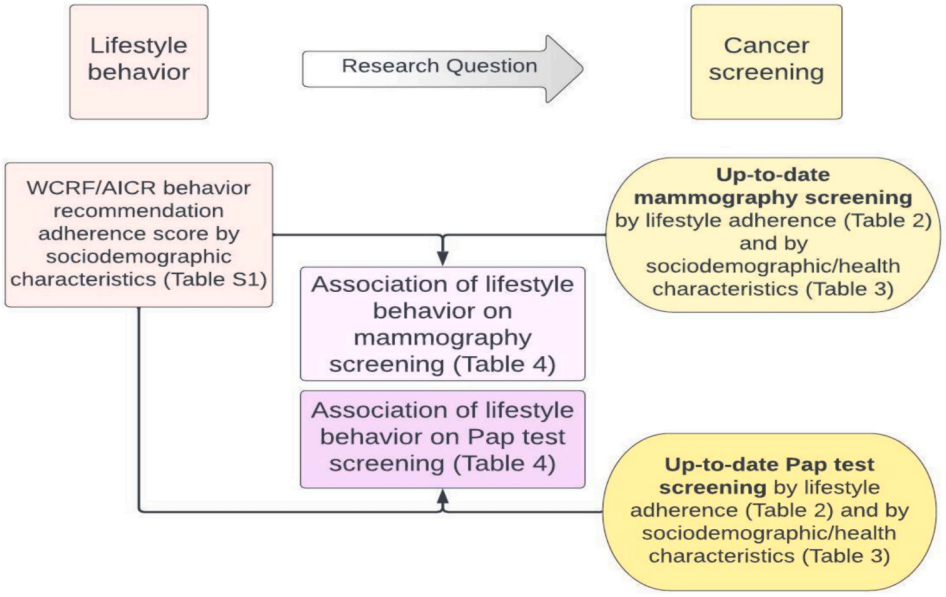

Fig. 2. This study's analysis plan and corresponding tables are depicted in the schematic above.

($P = 0.02$) were associated with a decreased composite adherence score.

3.2. Prevalence of up-to-date mammography and pap test screening by lifestyle behavior

The weighted prevalence of being up-to-date with mammography was 66.7 % (95 % CI: 58.8–73.7 %) (Table 2). Among those with prior mammography, 76.8 % (95 % CI: 64.4–91.4 %) had it within the recommended time interval. The mean composite adherence score did not differ by up-to-date mammography status (2.49 vs. 2.73; $P = 0.76$).

The weighted prevalence of being up-to-date with Pap test screening intervals was 71.4 % (95 % CI: 63.6–78.0 %) (Table 2). Among those with a prior Pap test, 78.0 % (95 % CI: 66.8–91.6 %) were up-to-date with their Pap test. Women up-to-date with Pap tests had significantly increased composite adherence scores compared to those not up-to-date (2.63 vs. 2.54; $P = 0.01$).

Among the 300 women aged 40–65 years who qualified for *both* mammography and Pap test screenings, women up-to-date with Pap test screening had a higher prevalence of up-to-date mammography (77.0 % vs. 23.8 %; $P < 0.001$). Women up-to-date with mammography screening had a higher prevalence of up-to-date Pap test screening (89.3 % vs. 43.9 %; $P < 0.001$).

3.3. Prevalence of up-to-date mammography and pap test by sociodemographic/health variables

In the mammography sample (left side of Table 3), women with insurance (82.4 % vs. 47.5 %; $P < 0.01$) were more likely to be up-to-date with mammography. A higher prevalence of being up-to-date with mammography (70.5 % vs. 40.9 %; $P = 0.05$) and Pap test (78.3 % vs. 47.5 %; $P < 0.01$) was seen in married versus single women (right side of Table 3).

3.4. Association of lifestyle behaviors with up-to-date mammography

Increases in the WCRF/AICR composite adherence score were associated with decreased odds of up-to-date mammography (AOR 0.5, 95 % CI: 0.3–1.0; $P = 0.05$) in the univariate model (model 1 in Table 4). After adjusting for covariates, this negative association with up-to-date mammography marginally persisted (AOR 0.8, 95 % CI: 0.6–1.1; $P = 0.07$) (model 2). Of the individual lifestyle recommendations (model 3), compared to non-adherence, partial adherence to alcohol consumption (AOR 9.4, 95 % CI: 1.1–81.6; $P = 0.04$) and partial adherence with waist circumference recommendations (AOR 9.1; 95 % CI: 1.1–77.9; $P = 0.04$) was associated with increased odds up-to-date mammography. Full adherence to physical activity recommendations compared to non-adherence was associated with decreased odds of up-to-date mammography (AOR 0.1, 95 % CI: 0.1–0.2; $P < 0.01$). Being up-to-date with Pap test screening was associated with increased odds of up-to-date mammography (AOR 58, 95 % CI: 7.5–144; $P < 0.01$).

3.5. Association of sociodemographic and health factors with up-to-date mammography

Increased age (AOR 1.2, 95 % CI: 1.1–1.3; $P < 0.01$), having private insurance versus being uninsured (AOR 63, 95 % CI: 6.3–628.4; $P < 0.01$), having routine medical care in community health clinics versus going to Mexico for care (AOR 6.8, 95 % CI: 2.0–23.4; $P < 0.01$), and having a personal cancer history (AOR 34.8, 95 % CI: 2.7–448; $P < 0.01$) were associated with increased odds of up-to-date mammography (model 3). Women born in Mexico versus native-born women (AOR 0.1, 95 % CI: 0.1–0.6; $P < 0.01$) and being English-predominate versus Spanish-predominate (AOR 0.04, 95 % CI: 0.01–0.5; $P = 0.02$) had decreased odds of up-to-date mammography.

3.6. Association of lifestyle behaviors with an up-to-date pap test

Univariate analysis of the composite adherence score (model 1 in Table 4) shows marginally decreased odds of up-to-date mammography (AOR 0.5, 95 % CI: 0.2–1.0; $P = 0.05$). Adjusting for covariates, the composite adherence score was marginally associated with increased odds of up-to-date Pap test (AOR 1.4, 95 % CI: 0.8–2.4; $P = 0.09$) (model 2). Compared to non-adherence, partial adherence to fruit and vegetable consumption (AOR 4.0, 95 % CI: 1.2–13.4; $P = 0.03$), partial adherence to ultra-processed food consumption (AOR 7.5, 95 % CI: 1.6–34.7; $P = 0.01$), partial adherence to red meat consumption (AOR 6.8, 95 % CI: 1.3–34.8; $P = 0.02$), and full adherence with sugar-sweetened beverage consumption (AOR 16.9, 95 % CI: 2.1–138.4; $P < 0.01$) were associated with increased odds of up-to-date Pap test (model 3). Fully adhering to physical activity recommendations was associated with decreased odds of up-to-date Pap test (AOR 0.1, 95 % CI: 0.03–0.43; $P < 0.01$). Being up-to-date with mammography screening was associated with increased odds of up-to-date Pap test (AOR 27, 95 % CI: 6–118; $P < 0.01$).

3.7. Association of sociodemographic and health factors with an up-to-date Pap test

A $\geq$ college degree education compared to <high school education level (AOR 8.1, 95 % CI: 1.0–64.7; $P = 0.05$) was associated with increased odds of up-to-date Pap test. English-predominate women compared to Spanish-predominate women had decreased odds of up-to-date Pap test (AOR 0.1, 95 % CI: 0.02–0.7; $P = 0.02$).

4. Discussion

This investigation characterized the prevalence of and the association between a healthy lifestyle and cancer screening among border Hispanic women. Adherence within and across all WCRF/AICR lifestyle recommendations was poor in our study population compared to other Spanish-speaking populations (Barrubés et al., 2020; Bostean et al., 2013).

The mammography compliance rate in our sample (66.7 %) was lower than seen in Hispanic women (71 %) and all women (73 %) nationally in 2018 (Sabatino et al., 2021). Fewer women in our sample (71.4 %) complied with Pap screening guidelines compared to Hispanic women (81 %) and all women (83 %) nationally (Miller et al., 2021). As cervical cancer is preventable predominately through Pap screening (Mann et al., 2015), this disparity contributes to Cameron County Hispanic women having high cervical cancer incidence (Texas Cancer Registry, 2023). Our study demonstrated that being up-to-date with one screening (e.g., mammography) was associated with increased odds of being up-to-date with the other screening test (e.g., Pap test). This may reflect a relatively healthy subpopulation of women with access to medical care, knowledge, and resources to incorporate preventive behaviors across different modalities, including different screening exams (Barrubés et al., 2020; Kaluza et al., 2020).

Differential factors influence the odds of being up-to-date with mammography versus Pap test screening. Increased composite adherence score marginally decreased the odds of being up-to-date with mammography and marginally increased the odds of being up-to-date with Pap test screening. Sociodemographic factors facilitating access to care, including being insured, being U.S.-born, or having routine medical care, were associated with increased odds of being up-to-date with mammography. These associations were seen in other Hispanic studies (Chen et al., 2018; Cokkinides et al., 2012). In contrast, increased adherence to dietary recommendations increased the odds of being up-to-date with Pap test screening. Longitudinal studies can elucidate how acute changes within and across lifestyle behaviors may lead to these differential screening effects.

Unexpectedly, *non*-adherence to physical activity recommendations in our study population was associated with increased odds of being up-

Table 2
Prevalence of up-to-date mammography and Pap test screening among age-appropriate Hispanic women ($n = 385$ in the mammography sample, $n = 412$ in the Pap test sample) in the Cameron County Hispanic Cohort (2014–2022), by cancer-preventive lifestyle behavior adherence.

World Cancer Research Fund Scoring System (Shams-White et al., 2019) Behavioral Subcomponents		Overall sample (N = 385)	Up-to-date with mammography ($n = 251$)[a]	Not up-to-date with mammography ($n = 134$)	Overall sample (N = 412)	Up-to-date with Pap test ($n = 291$)[a]	Not up-to-date with Pap test ($n = 121$)
	Behavior recommendation adherence	Overall mean or weighted prevalence, column % (95 % confidence interval)	Mean or weighted prevalence, row % by use of mammography (95 % confidence interval)		Overall mean or weighted prevalence, column % (95 % confidence interval)	Mean or weighted prevalence, row % by use of Pap test (95 % confidence interval)	
Overall prevalence of compliance with screening guideline			66.7 % (58.82–73.72)	33.3 % (26.28–41.18)		71.4 % (63.57–78.04)	28.7 % (21.96–36.43)
Body mass index (kg/m^2)							
18.5–24.99	Full	13.7 (8.43–21.46)	63.8 (36.92–84.13)	36.2 (15.87–63.08)	12.8 (7.99–19.79)	70.4 (42.92–88.27)	29.6 (11.73–57.08)
25–29.99	Partial	26.7 (19.93–34.73)	38.4 (27.04–51.19)	61.6 (48.82–72.96)	27.3 (20.68–35.01)	68.4 (52.39–80.92)	31.7 (19.08–47.62)
<18.5 or ≥ 30	None	59.6 (50.59–68.05)	69.6 (59.16–78.40)	30.4 (21.61–40.85)	60.0 (51.49–67.90)	72.9 (62.94–81.01)	27.1 (18.99–37.06)
Waist circumference (centimeters)							
<80 for women	Full	2.6 (0.93–7.25)	35.6 (7.94–78.05)	64.4 (21.95–92.06)	4.1 (1.83–8.76)	57.5 (23.01–86.00)	42.5 (14.00–76.99)
80- < 88 for women	Partial	12.0 (7.01–19.68)	71.0 (39.89–90.02)	29.0 (9.98–60.11)	14.0 (8.60–21.89)	60.0 (32.68–82.66)	40.0 (17.34–67.32)
≥88 for women	None	85.4 (77.45–90.87)	67.0 (25.78–41.03)	33.0 (25.78–41.03)	82.0 (73.84–87.98)	73.9 (66.26–80.34)	26.1 (19.66–33.74)
Physical activity, moderate-to-vigorous (min/week)							
≥150	Full	14.1 (9.59–20.11)	47.2† (28.58–66.66)	52.8† (33.34–71.42)	18.5 (12.87–25.83)	68.4 (51.39–81.56)	31.6 (18.44–48.61)
75–150	Partial	4.9 (2.20–10.54)	88.2† (61.62–97.20)	11.8† (2.80–38.38)	8.9 (3.80–19.45)	78.1 (34.45–96.05)	21.9 (3.95–65.55)
<75	None	81.1 (74.11–86.49)	68.8† (59.61–76.65)	31.2† (23.35–40.39)	72.6 (63.19–80.38)	71.3 (62.45–78.73)	28.7 (21.27–37.55)
Fruit and vegetable intake (servings/day)							
≥5	Full	16.0 (10.68–23.26)	56.0 (34.66–75.38)	44.0 (24.62–65.34)	17.7 (11.09–27.13)	79.9 (55.87–92.62)	20.1 (7.38–44.13)
3–4	Partial	28.3 (21.20–36.68)	65.9 (52.21–79.51)	34.1 (22.69–47.79)	30.3 (22.78–39.08)	70.6 (55.83–82.01)	29.4 (17.99–44.17)
0–2	None	55.7 (46.97–64.11)	70.2 (58.75–79.51)	29.8 (20.49–41.25)	52.0 (42.88–60.91)	68.9 (58.81–77.41)	31.1 (22.59–41.19)
Fiber intake (grams/day)							
≥30	Full	10.2 (6.53–15.68)	62.5 (41.79–79.41)	37.5 (20.59–58.21)	12.2 (7.49–19.11)	63.7 (37.50–83.66)	36.3 (16.34–62.50)
15 – <30	Partial	38.0 (30.06–46.54)	61.8 (48.91–73.26)	38.2 (26.74–51.09)	38.7 (30.50–47.53)	72.4 (59.06–82.70)	27.6 (17.30–40.94)
<15	None	51.8 (42.94–60.58)	71.1 (59.61–80.36)	28.9 (19.64–40.39)	49.2 (40.67–57.73)	72.4 (61.38–81.25)	27.6 (18.75–38.62)
Ultra-processed food consumption (tertile)							
Tercile 1	Full	29.7 (20.87–40.31)	67.3 (49.52–81.19)	32.7 (18.81–50.48)	26.3 (18.79–35.55)	71.1 (54.96–83.20)	28.9 (16.80–45.04)
Tercile 2	Partial	28.4 (21.74–36.07)	67.1 (51.60–79.66)	32.9 (20.34–48.40)	25.9 (19.76–33.10)	82.5 (67.12–91.60)	17.5 (8.40–32.88)
Tercile 3	None	42.0 (33.94–50.43)	65.9 (54.73–75.61)	34.1 (24.39–45.27)	47.8 (39.23–56.52)	65.5 (52.87–76.19)	34.5 (23.81–47.13)
Red and processed meat (grams/week)							
<500 red meat and < 21 processed meat	Full	30.6 (23.53–38.76)	59.5 (44.12–73.21)	40.5 (26.79–55.88)	32.6 (24.93–41.34)	69.8 (53.39–82.35)	30.2 (17.65–46.61)
<500 red meat and 21- < 100 processed meat	Partial	32.2 (24.92–40.44)	71.0 (57.63–81.43)	29.1 (18.57–42.37)	34.7 (27.40–42.80)	78.5 (65.52–87.47)	21.6 (12.53–34.48)
>500 red meat and/or > 100 processed meat	None	37.2 (28.89–46.33)	68.9 (54.22–80.58)	31.1 (19.42–45.78)	32.7 (25.75–40.49)	65.4 (51.16–77.25)	34.7 (22.75–48.84)
Sugar-sweetened beverage (grams/day)							

(continued on next page)

Table 2 (*continued*)

World Cancer Research Fund Scoring System (Shams-White et al., 2019) Behavioral Subcomponents		Overall sample (N = 385)	Up-to-date with mammography (n = 251)[a]	Not up-to-date with mammography (n = 134)	Overall sample (N = 412)	Up-to-date with Pap test (n = 291)[a]	Not up-to-date with Pap test (n = 121)
	Behavior recommendation adherence	Overall mean or weighted prevalence, column % (95 % confidence interval)	Mean or weighted prevalence, row % by use of mammography (95 % confidence interval)		Overall mean or weighted prevalence, column % (95 % confidence interval)	Mean or weighted prevalence, row % by use of Pap test (95 % confidence interval)	
0	Full	10.3 (6.06–16.94)	59.4 (31.17–82.54)	40.6 (17.46–68.83)	14.3 (9.26–21.40)	72.3 (46.05–88.85)	27.7 (11.15–0.53.95
>0 – ≤250	Partial	28.7 (21.10–37.63)	64.0 (50.02–75.94)	36.0 (24.06–49.98)	28.4 (21.34–36.80)	74.6 (58.64–85.87)	25.4 (14.13–41.36)
>250	None	61.1 (52.11–69.31)	69.2 (59.05–77.74)	30.8 (22.26–40.95)	57.3 (48.85–65.29)	69.5 (58.73–78.50)	30.5 (21.50–41.27)
Alcohol consumption (drink equivalents/ day)							
0	Full	65.2 (55.51–73.77)	67.4 (58.09–75.57)	32.6 (24.43–41.91)	54.5 (45.48–63.24)	70.5 (60.96–78.55)	29.5 (21.45–39.04)
1 for women	Partial	24.6 (17.45–33.47)	76.0 (55.10–89.07)	24.0 (10.93–44.90)	28.0 (19.96–37.67)	74.4 (55.61–87.10)	25.6 (12.90–44.39)
>1 for women	None	10.2 (5.34–18.64)	39.5 (20.10–62.94)	60.5 (37.06–79.90)	17.5 (11.27–26.25)	69.1 (51.17–82.65)	30.9 (17.35–48.83)
Compliance with other screening tests age 40–65 (n = 300)							
Compliance with Pap test within mammography sample % (n = 88)		72.1 (63.24–79.59)	77.0† (66.68–84.87)	23.0† (15.13–33.32)			
Non-compliance with Pap test within mammography sample% (n = 212)		27.9 (20.42–36.76)	23.8† (11.37–43.21)	76.2† (56.80–88.63)			
Compliance with mammography within Pap sample % (n = 185)					62.2 (53.02–70.56)	89.3† (78.87–94.95)	10.7† (5.05–21.13)
Non-compliance with mammography within Pap sample % (n = 115)					37.8 (29.44–46.98)	43.9† (29.64–59.16)	56.1† (40.84–70.36)
Mean cancer-preventive lifestyle composite adherence score (range: 0 to 7)[b]		2.6 (2.41–2.72)	2.5 (2.30–2.67)	2.7 (2.45–3.01)	2.6 (2.43–2.77)	2.6† (2.44–2.81)	2.5† (2.17–2.90)

† Indicates statistically significant differences ($P < 0.05$) based on survey-weighted Rao-Scott F-adjusted chi-square tests (categorical variables) or non-parametric Wilcoxon rank-sum tests (continuous variables). As indicated in the table, several variables had smaller sample sizes than the analytical sample.

[a] Up-to-date screening defined as: women aged 40–74 with a mammography within the past two years (mammography sample) or women aged 21–65 with a Pap test within the past three years (Pap test sample) (United States Preventive Services Taskforce, 2022).

[b] The World Cancer Research Fund/American Institute for Cancer Research calculates a composite adherence score from 0 to 7 to assess a population's mean adherence across nine cancer-preventive lifestyle recommendations (Shams-White et al., 2019). A higher score indicates better adherence.

to-date with mammography and Pap tests. This finding may be due to decreased physical activity being associated with a form of increased acculturation, which is linked with higher cancer screening use in Hispanic women (Abraído-Lanza et al., 2005).

Divergent associations discovered in our study sample compared to other Hispanic populations highlight this bicultural border region's unique sociocultural factors. Studies have found that increasing acculturation in Hispanic women decreases lifestyle behaviors (Haile et al., 2012) but increases cancer screening uptake (De Jesus and Miller, 2015). We did not see a difference in lifestyle by our proxy acculturation measures of language use or place of birth. Being native-born increased the odds of being up-to-date with mammography, but being only English-speaking decreased these odds. No association between nativity and Pap test compliance was seen, possibly reflecting that 25 % of our sample were recent Hispanic immigrants who undergo Pap tests at a similar frequency as U.S.-born Hispanic women (La Frinere-Sandoval et al., 2023). In our population, Hispanic women who only speak English were *less* likely to be up-to-date with mammography and Pap test screening, in contrast to the findings seen in other Hispanic studies (Chen et al., 2018; Cokkinides et al., 2012). This discrepancy can be due to our small prevalence of English-only women (12 %) who may face limited ability to engage in health promotion interventions due to the Spanish-predominate nature of many local programs (Reininger et al., 2014).

Cancer screening uptake is the primary modality of cancer risk reduction (Miller et al., 2021). Interventions to augment cancer screening should address access, education, and social support. Community health workers, as facilitators of health education in Hispanic communities (Parra-Medina et al., 2015), can strategically target education in culturally relevant interventions. Social support can incorporate patient navigation and tailored motivational interviewing to promote lifestyle and screening (Reininger et al., 2021).

4.1. Limitations

This cross-sectional analysis cannot establish temporal or causal

Table 3
Prevalence of up-to-date mammography and Pap test screening among age-appropriate Hispanic women ($n = 385$ in the mammography sample, $n = 412$ in the Pap test sample) in the Cameron County Hispanic Cohort (2014–2022), by sociodemographic and health characteristics.

Sociodemographic and health variables	Overall sample (N = 385)	Up-to-date with mammography (n = 251)[a][b]	Not up-to-date with mammography (n = 134)	Overall sample (N = 412)	Up-to-date with Pap test (n = 291)[a]	Not up-to-date with Pap test (n = 121)
	Overall mean or weighted prevalence, column % (95 % confidence interval)	Mean or weighted prevalence, row % by use of mammography (95 % confidence interval)		Overall mean or weighted prevalence, column % (95 % confidence interval)	Mean or weighted prevalence, row % by use of Pap test (95 % confidence interval)	
Overall prevalence of compliance to screening guideline		66.7 % (58.82–73.72)	33.3 % (26.28–41.18)		71.4 % (63.57–78.04)	28.7 % (21.96–36.43)
Age, mean	55.5 (54.00–57.03)	57.7† (55.83–59.54)	51.2† (48.64–53.70)	45.8 (43.74–47.87)	46.9 (44.52–49.20)	43.2 (39.05–47.26)
Marital status %						
Married	66.1 (56.93–74.23)	70.5† (61.24–78.28)	29.5† (21.72–38.76)	63.0 (53.87–71.20)	78.3† (69.21–85.27)	21.7† (14.73–30.79)
Single/never married	14.2 (8.94–21.70)	40.9† (21.17–63.98)	59.2† (36.02–78.83)	22.1 (15.37–30.58)	47.5† (30.94–64.60)	52.5† (35.40–69.06)
Divorced	12.6 (7.89–19.38)	70.7† (47.28–86.68)	29.3† (13.32–52.72)	10.9 (6.77–17.04)	75.8† (51.49–90.24)	24.2† (9.76–48.51)
Widowed	7.2 (4.54–11.17)	75.74† (57.97–87.61)	24.3† (12.39–42.03)	4.1 (2.20–7.60)	81.2† (56.84–93.43)	18.8† (6.57–43.16)
Educational attainment %						
<High school graduate	45.0 (36.44–53.92)	65.9 (54.06–75.95)	34.2 (24.05–45.94)	42.2 (34.32–50.44)	74.4 (62.57–83.41)	25.7 (16.59–37.43)
High school graduate	30.7 (22.68–40.15)	69.6 (54.81–81.18)	30.4 (18.82–45.19)	26.1 (19.86–33.44)	68.4 (56.97–77.93)	31.6 (22.07–43.03)
Some college	7.3 (3.77–13.69)	63.6 (30.84–87.23)	36.4 (12.77–69.16)	11.6 (7.03–18.66)	59.9 (32.98–81.96)	40.1 (18.04–67.02)
≥College degree	16.93 (10.67–25.81)	65.0 (43.28–81.88)	35.0 (18.12–56.72)	20.1 (12.92–29.91)	75.1 (48.78–90.53)	24.9 (9.47–51.22)
Currently employment status						
Currently employed	44.2 (36.11–52.58)	67.5 (54.66–78.13)	32.5 (21.87–45.34)	53.8 (45.56–61.79)	68.6 (55.94–79.02)	31.4 (20.98–44.06)
Currently not employed	55.8 (47.42–63.89)	66.1 (54.99–75.60)	34.0 (24.40–45.01)	46.2 (38.21–54.44)	74.5 (64.59–82.43)	25.5 (17.57–35.41)
Current insurance status						
Currently insured	55.0 (45.72–63.94)	82.4† (72.47–89.27)	17.6† (10.73–27.53)	43.4 (34.97–52.30)	74.6 (60.09–85.13)	25.4 (14.87–39.91)
Currently uninsured	45.0 (36.06–54.28)	47.5† (36.33–58.90)	52.5† (41.10–63.67)	56.6 (47.70–65.03)	68.8 (59.86–76.61)	31.2 (23.39–40.14)
Typical setting for routine medical care % ($n = 337$)				($n = 347$)		
Doctor's office	46.5 (36.49–56.78)	70.8 (55.78–82.37)	29.2 (17.63–44.22)	35.6 (26.66–46.27)	70.2 (51.36–84.05)	29.8 (15.95–48.64)
Community health center	21.9 (15.33–30.24)	67.9 (53.88–79.27)	32.1 (20.73–46.12)	27.5 (19.96–36.48)	71.7 (58.67–81.86)	28.3 (18.14–41.33)
Emergency room	7.3 (3.34–15.26)	77.0 (40.64–94.21)	23.1 (5.79–59.36)	8.6 (4.54–15.57)	90.5 (68.47–97.66)	9.5 (2.34–31.53)
Mexico	24.1 (17.52–32.29)	59.3 (43.31–73.59)	40.7 (26.41–56.69)	27.8 (21.02–35.73)	78.3 (66.41–86.85)	21.7 (13.15–33.59)
No regular care	0.2 (0.02–1.22)	100	0	0.3 (0.09–1.16)	100	0
Place of birth						
Mexico	68.9 (58.49–77.68)	64.8 (55.49–73.04)	35.2 (26.96–44.51)	64.2 (55.02–72.44)	73.9 (65.38–80.97)	26.1 (19.03–34.62)
United States	31.1 (22.32–41.51)	71.0 (54.52–83.27)	29.1 (16.73–45.48)	35.8 (27.56–44.98)	66.7 (49.84–80.21)	33.3 (19.79–50.16)
Language acculturation						
Spanish-predominate %	75.0 (63.80–83.62)	68.1 (59.97–75.31)	31.9 (24.69–40.03)	70.8 (61.51–78.69)	73.2 (64.82–80.18)	26.8 (19.82–35.18)
Bi-accultured %	13.0 (6.82–23.37)	73.2 (41.07–91.49)	26.8 (8.51–58.93)	14.1 (9.26–20.86)	65.0 (40.76–83.31)	35.1 (16.69–59.24)
English-predominate %	12.0 (6.03–22.50)	50.6 (29.16–71.76)	49.4 (28.24–70.84)	15.1 (8.51–25.28)	68.7 (38.89–88.32)	31.3 (11.68–61.11)
Proportion of lived years in Cameron County	0.5 (0.46–0.60)	0.6† (0.48–0.64)	0.5† (0.37–0.57)	0.5 (0.47–0.59)	0.5 (0.46–0.57)	0.6 (0.44–0.69)
Socioeconomic strata quartile %						
Quartile 1 (high)	24.2 (18.06–31.56)	76.6 (64.67–85.43)	23.4 (14.57–35.33)	32.1 (24.98–40.13)	73.7 (62.38–82.58)	26.3 (17.42–37.62)
Quartile 2	29.1 (22.23–37.13)	59.1 (44.18–72.51)	40.9 (27.49–55.82)	29.7 (22.53–38.02)	70.8 (57.03–81.64)	29.2 (18.36–42.97)
Quartile 3	11.3 (7.10–17.47)	63.2 (37.03–83.35)	36.8 (16.65–62.97)	11.6 (7.13–18.33)	55.2 (28.81–78.98)	44.8 (21.02–71.19)

(*continued on next page*)

Table 3 (*continued*)

Sociodemographic and health variables	Overall sample (N = 385)	Up-to-date with mammography (n = 251)[a][b]	Not up-to-date with mammography (n = 134)	Overall sample (N = 412)	Up-to-date with Pap test (n = 291)[a]	Not up-to-date with Pap test (n = 121)
	Overall mean or weighted prevalence, column % (95 % confidence interval)	Mean or weighted prevalence, row % by use of mammography (95 % confidence interval)		Overall mean or weighted prevalence, column % (95 % confidence interval)	Mean or weighted prevalence, row % by use of Pap test (95 % confidence interval)	
Quartile 4 (lowest)	35.4 (26.28–45.77)	67.3 (53.27–78.74)	32.7 (21.26–46.73)	26.6 (18.80–36.24)	75.5 (58.99–86.79)	24.6 (13.21–41.01)
Current smoking status % (n = 293)				(n = 325)		
Current smoker	6.1 (2.72–13.11)	34.1 (10.58–69.37)	65.9 (30.63–89.42)	12.3 (7.10–20.57)	66.1 (37.33–86.44)	33.9 (13.56–62.67)
Former smoker	25.1 (16.73–35.83)	63.9 (43.97–80.02)	36.1 (19.98–56.03)	23.3 (14.35–35.52)	74.2 (50.63–88.94)	25.8 (11.06–49.37)
Non-smoker	68.8 (58.15–77.80)	73.7 (64.26–81.38)	26.3 (18.62–35.74)	64.4 (53.29–74.08)	69.7 (59.23–78.49)	30.3 (21.51–40.77)
Metabolic syndrome severity score (DeBoer and Gurka, 2017)[b] (n = 375)	0.6 (0.40–0.70)	0.6 (0.41–0.74)	0.5 (0.19–0.81)	(n = 397) 0.4 (0.28–0.57)	0.4 (0.27–0.58)	0.4 (0.12–0.72)

† Indicates statistically significant differences ($P < 0.05$) based on survey-weighted Rao-Scott F-adjusted chi-square tests (categorical variables) or non-parametric Wilcoxon rank-sum tests (continuous variables). As indicated in the table, several variables had smaller sample sizes than the overall analytical sample.

[a] Up-to-date screening defined as: women aged 40–74 with a mammography within the past two years (mammography sample) or women aged 21–65 with a Pap test within the past three years (Pap test sample) (United States Preventive Services Taskforce, 2022).

[b] The Metabolic syndrome severity equation provides a z-score standardized scoring and is gender-specific for the Hispanic population (DeBoer and Gurka, 2017).

directionality (Wang and Cheng, 2020). This exploratory analysis was not intended to establish causal definitive relationships between lifestyle behaviors and cancer screening uptake. Cautiously, this study does not demonstrate an association between increased adherence to a healthy lifestyle and higher cancer screening compliance. Future studies should explore whether a causal relationship exists between increased lifestyle behavior adherence and cancer-preventive screening compliance.

Lifestyle enhancement is not the only mechanism that facilitates cancer screening. Mammography and Pap tests are relatively high-cost procedures that require specialized equipment, and screenings must be done frequently for optimal risk reduction (Barrubés et al., 2020; Kaluza et al., 2020; Shams-White et al., 2020). Lifestyle improvements can complement, not supplant, multi-component interventions for Hispanic women that enhance screening uptake by addressing access barriers.

We are not suggesting that risk reduction between breast and cervical cancer is equivalent due to lifestyle adherence; lifestyle adherence will likely impact breast cancer incidence to a greater magnitude (Katzke et al., 2015). However, lifestyle behaviors may be one of *many* factors that can facilitate increased cancer screening in the study region, which is our primary goal. The WCRF/AICR scoring system did not operationalize, nor did the CCHC measure breastfeeding (Shams-White et al., 2019) or the number of sexual partners (Pimple and Mishra, 2022), and thus, they were not assessed despite their influence on breast and cervical cancer incidence, respectively.

The CCHC survey did not assess Pap-Human Papillomavirus co-testing, which decreases the frequency of cervical cancer screening to every five years (United States Preventive Services Taskforce, 2022). However, we are minimally underestimating the prevalence of up-to-date cervical cancer screening, as only a fifth of Hispanic women in the study region utilize Pap- Human Papilloma Virus co-testing (Johnson et al., 2020). Human Papillomavirus vaccination status is not assessed in the CCHC despite mitigating cervical cancer incidence (United States Preventive Services Taskforce, 2022).

Social desirability bias may lead to underreporting of negative dietary behaviors (e.g., alcohol) use and over-reporting of mammogram and Pap screening use, which can bias our associations (Kim and Han, 2016; Levine et al., 2019). There may be discrepancies in the status of self-reported sociodemographic factors, such as routine medical care settings, between the time of data collection and when respondents received their last screening.

Due to a lack of data, our study variables miss intrapersonal behavioral barriers related to self-efficacy and knowledge of screening. This includes a common belief among Hispanic women of cancer fatalism, which curtails partaking in a healthy lifestyle and screening as cancer is perceived as predetermined (De Jesus and Miller, 2015; Moreno et al., 2019).

5. Conclusions

This study provided contextual insight into the uptake of and association between lifestyle behavior and cancer screening in border Hispanic women. Healthy lifestyle adherence and cancer screening compliance in this study population was poor, particularly among those who were uninsured, relying on medical care in Mexico, and English-only speakers. Sociodemographic factors reflecting access to care and adherence to dietary recommendations were associated with increased odds of up-to-date mammography and Pap test screening, respectively. Lifestyle behavior promotion may potentially be leveraged to enhance cancer screening among border Hispanic women.

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Ethics statement

This study was conducted with deidentified data with the approval of the UTHealth Institutional Review Board Committee (HSC-SPH-03-007-B).

Fig 1: Selection of age-appropriate women (n = 385 for the mammography sample, n = 412 for the Pap test sample) from the Cameron County Hispanic Cohort (2004–2022) for examining the prevalence of and associations between lifestyle, mammography, and Papanicolaou (Pap) test screening.

Fig. 2: Analysis plan to examine the prevalence of and associations between cancer-preventive lifestyle behaviors, up-to-date mammography (n = 385), and up-to-date Pap test screening (n = 412) among

Table 4
Logistic regression results for the association between lifestyle behaviors and sociodemographic factors with the odds of being up-to-date with mammography and Pap test screening among age-appropriate Hispanic women ($n = 239$ in the mammography sample, $n = 248$ in the Pap test sample) in the Cameron County Hispanic Cohort (2014–2022).

	Overall mammography sample (N = 239)			Overall Pap test sample (N = 248)		
Behavioral or sociodemographic variable	Model 1[a]: up-to-date with mammography	Model 2[a]: up-to-date with mammography	Model 3[a]: up-to-date with mammography	Model 1[a]: up-to-date with Pap test	Model 2[a]: up-to-date with Pap test	Model 3[a]: up-to-date with Pap test
	Odds ratio (95 % CI)	Adjusted odds ratio (95 % CI)	Adjusted odds ratio (95 % CI)	Odds ratio (95 % CI)	*p*-value	Adjusted odds ratio (95 % CI)
Univariate one-point increase in cancer-preventive lifestyle composite adherence score (range: 0 to 7)[b]	0.5† (0.28–1.00)			0.5 (0.20–1.01)		
Adjusted model for a one-point increase in cancer-preventive lifestyle composite adherence score		0.8 (0.56–1.10)			1.4 (0.82–2.37)	
World Cancer Research Fund/American Institute for Cancer Research Scoring System (Shams-White et al., 2019) Behavioral Subcomponents	Behavior recommendation adherence					
Body mass index (kg/m^2)						
18.5–24.99	Full		0.2 (0.01–3.18)			4.1 (0.18–95.4)
25–29.99	Partial		0.5 (0.14–1.97)			0.9 (0.22–3.65)
<18.5 or ≥ 30	None		Reference			Reference
Waist circumference (centimeters)						
<80 for women	Full		0.5 (0.01–29.12)			0.3 (0.01–12.18)
80- < 88 for women	Partial		9.1† (1.07–77.93)			1.5 (0.23–10.05)
≥88 for women	None		Reference			Reference
Physical activity, moderate-to-vigorous (min/week)						
≥150	Full		0.1† (0.01–0.20)			0.1† (0.03–0.43)
75–150	Partial		3.0 (0.07–133.3)			1.1 (0.02–57.4)
<75	None		Reference			Reference
Fruit and vegetable intake (servings/day)						
≥5	Full		0.7 (0.17–3.08)			6.7 (0.69–65.7)
3–4	Partial		0.9 (0.32–2.71)			4.0† (1.17–13.4)
0–2	None		Reference			Reference
Fiber intake (grams/day)						
≥30	Full		0.8 (0.05–12.13)			6.4 (0.79–51.1)
15 – <30	Partial		0.7 (0.26–2.00)			2.2 (0.73–6.69)
<15	None		Reference			Reference
Ultra-processed food consumption (tercile)						
Tertile 1	Full		0.7 (0.24–2.02)			0.7 (0.24–2.07)
Tertile 2	Partial		0.7 (0.19–2.45)			7.5† (1.63–34.7)
Tertile 3	None		Reference			Reference
Red and processed meat (grams/week)						
<500 red meat and < 21 processed meat	Full		1.5 (0.36–6.12)			1.4 (0.33–5.50)
<500 red meat and 21- < 100 processed meat	Partial		1.8 (0.53–5.96)			6.8† (1.32–34.8)
>500 red meat and/or > 100 processed meat	None		Reference			Reference
Sugar-sweetened beverage (grams/day)						
0	Full		0.7 (0.13–3.78)			16.9† (2.07–138.4)
>0 – ≤250	Partial		3.4 (0.91–12.91)			5.9† (1.64–21.3)
>250	None		Reference			Reference
Alcohol consumption (drink equivalents/day)						
0	Full		1.4 (0.24–7.78)			1.6 (0.38–6.70)
1 for women	Partial		9.4† (1.08–81.6)			0.4 (0.05–2.35)

(*continued on next page*)

Table 4 (*continued*)

Behavioral or sociodemographic variable	Overall mammography sample (N = 239)			Overall Pap test sample (N = 248)		
	Model 1[a]: up-to-date with mammography	Model 2[a]: up-to-date with mammography	Model 3[a]: up-to-date with mammography	Model 1[a]: up-to-date with Pap test	Model 2[a]: up-to-date with Pap test	Model 3[a]: up-to-date with Pap test
>1 for women	None		Reference			Reference
Sociodemographic Variables						
Age (per year increase)		1.2† (1.08–1.28)	1.2† (1.07–1.25)		1.0 (0.93–1.06)	1.0 (0.90–1.04)
Marital status						
Single/never married		Reference	Reference		Reference	Reference
Married		0.2 (0.04–1.03)	0.5 (0.10–2.51)		1.5 (0.36–6.10)	1.9 (0.43–8.66)
Divorced/separated		0.2 (0.02–1.72)	0.2 (0.02–2.13)		1.8 (0.26–12.33)	4.1 (0.56–30.4)
Widowed		0.2 (0.02–1.65)	0.4 (0.04–4.19)		3.9 (0.38–39.2)	3.6 (0.11–121.8)
Educational attainment level						
<High school		Reference	Reference		Reference	Reference
High school graduate		1.4 (0.41–4.86)	2.7 (0.77–9.35)		0.3† (0.10–0.89)	0.1† (0.03–0.54)
Some college		3.0 (0.42–21.8)	3.2 (0.10–100.8)		0.2 (0.03–1.25)	0.3 (0.03–3.09)
College degree or higher		4.1 (0.57–29.5)	3.1 (0.43–22.0)		1.3 (0.20–7.95)	8.1† (1.02–64.7)
Current employment status						
Employed		1.4 (0.57–3.63)	1.6 (0.52–5.06)		0.5 (0.19–1.41)	0.5 (0.14–1.95)
Unemployed/retired		Reference	Reference		Reference	Reference
Health insurance coverage (current)						
Insured						
Medicaid		0.6 (0.10–3.23)	1.4 (0.19–10.50)		0.4 (0.04–3.77)	0.6 (0.01–38.1)
Medicare		6.1† (1.03–36.5)	11.3† (1.01–125.7)		3.6 (0.44–29.9)	5.2 (0.43–62.2)
Private insurance		67.0 (0.49–537.0)	63.0† (6.32–628.4)		2.9 (0.67–12.9)	1.9 (0.24–14.8)
Uninsured		Reference	Reference		Reference	Reference
Typical setting for routine medical care						
Doctor's/provider clinic		0.7 (0.17–3.10)	1.0 (0.15–6.44)		0.5 (0.12–2.21)	0.5 (0.06–3.30)
Community health clinic		4.6† (1.32–15.7)	6.8† (2.00–23.4)		0.9 (0.25–3.06)	0.5 (0.10–2.00)
Emergency room		3.7 (0.45–30.4)	1.2 (0.11–12.82)		6.8 (0.94–48.5)	4.8 (0.27–85.8)
Go to Mexico		Reference	Reference		Reference	Reference
Location of birth						
Mexico		0.2† (0.07–0.80)	0.1† (0.03–0.57)		0.7 (0.17–2.69)	0.4 (0.11–1.70)
United States		Reference	Reference		Reference	Reference
Language acculturation						
Spanish-predominate		Reference	Reference		Reference	Reference
Bilingual Spanish/English		0.8 (0.10–5.69)	0.8 (0.06–11.48)		0.5 (0.08–3.26)	0.3 (0.05–2.48)
English-predominate		0.1† (0.01–0.43)	0.1† (0.01–0.53)		0.2 (0.02–1.56)	0.1† (0.02–0.69)
Socioeconomic quartile based on income of census tract						
Quartile 1 (highest)		2.1 (0.49–9.01)	3.6 (0.69–18.69)		1.2 (0.30–4.54)	2.9 (0.44–18.6)
Quartile 2		1.2 (0.31–4.75)	1.5 (0.36–6.20)		2.0 (0.53–7.84)	4.5 (0.72–27.7)
Quartile 3		2.3 (0.45–11.72)	1.7 (0.21–13.92)		2.6 (0.50–12.93)	2.1 (0.16–27.7)
Quartile 4 (lowest)		Reference	Reference		Reference	Reference
Smoking status						
Current smoker		Reference	Reference		Reference	Reference
Former smoker		0.4 (0.04–4.60)	0.8 (0.07–8.63)		0.4 (0.05–2.86)	0.6 (0.09–3.75)
Non-smoker		2.1 (0.22–19.3)	5.8 (0.52–66.2)		0.4 (0.06–2.30)	0.8 (0.18–3.72)
Personal cancer history (reference: no cancer)		12.3† (1.23–122.2)	34.8† (2.70–448.0)		0.5 (0.09–3.14)	0.6 (0.06–5.95)
Family history of cancer (reference: no family history)		0.9 (0.33–2.21)	0.7 (0.21–2.44)		0.8 (0.30–1.96)	0.4 (0.11–1.13)

(*continued on next page*)

Table 4 (*continued*)

Behavioral or sociodemographic variable	Overall mammography sample (N = 239)			Overall Pap test sample (N = 248)		
	Model 1[a]: up-to-date with mammography	Model 2[a]: up-to-date with mammography	Model 3[a]: up-to-date with mammography	Model 1[a]: up-to-date with Pap test	Model 2[a]: up-to-date with Pap test	Model 3[a]: up-to-date with Pap test
Metabolic syndrome severity score[c]		0.8 (0.51–1.15)	0.7 (0.46–1.12)		0.9 (0.62–1.29)	0.9 (0.56–1.38)
Up-to-date with Pap test in mammography sample		24.3† (6.15–96.17)	57.9† (7.54–144.0)			
Up-to-date with mammography in Pap test sample					11.2† (2.89–43.20)	26.6† (6.00–118.0)

† Indicates significant ($P < 0.05$) coefficients from: survey-weighted Rao-Scott F-adjusted chi-square tests (categorical variables) and Wilcoxon rank-sum tests (continuous variables) in Models 1 and 2; and Wald tests in Model 3.

Up-to-date screening defined as: women aged 40–74 with a mammography within the past two years (mammography sample) or women aged 21–65 with a Pap test within the past three years (Pap test sample) (United States Preventive Services Taskforce, 2022).

[a] **Model 1**: Unadjusted association of the World Cancer Research Fund/American Institute for Cancer Research composite adherence score (range: 0 to 7) on the odds of being up-to-date with mammography (left side of the table) and Pap test (right side of the table) screening. **Model 2** adjusts Model 1 for age, proportion of life in Brownsville, marital status, education, employment, insurance, care, nativity, language acculturation, income, smoking status, cancer history, and metabolic syndrome severity. **Model 3** examines individual World Cancer Research Fund/American Institute for Cancer Research subcomponent behavior scores adjusted for Model 2 covariates.

[b] The World Cancer Research Fund/American Institute for Cancer Research calculates a composite adherence score from 0 to 7 to assess a population's mean adherence across nine cancer-preventive lifestyle recommendations (Shams-White et al., 2019). A higher score indicates better adherence.

[c] A Hispanic- and gender-specific metabolic syndrome severity score (DeBoer and Gurka, 2017) shows the odds of mammography (left side of the table) or Pap test (right side of the table) guideline compliance per standard deviation increase in metabolic syndrome severity.

women in the Cameron County Hispanic Cohort (2014–2022).

CRediT authorship contribution statement

Paul Gerardo Yeh: Writing – review & editing, Writing – original draft, Resources, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization. **Audrey C. Choh:** Writing – review & editing, Validation, Methodology, Formal analysis. **Susan P. Fisher-Hoch:** Writing – review & editing, Data curation. **Joseph B. McCormick:** Writing – review & editing, Data curation. **David R. Lairson:** Writing – review & editing, Conceptualization. **Belinda M. Reininger:** Writing – review & editing, Writing – original draft, Supervision, Resources, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.pmedr.2025.103007.

Data availability

Data will be made available on request.

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