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ORIGINAL PAPER

Disparities in Cancer Screening: The Role of County-Level Metropolitan Status and Racial Residential Segregation

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Abstract

Mortality from cervical and colorectal cancers can be reduced through routine screening, which can often be accessed through primary care. However, uptake of screening in the US remains suboptimal, with disparities observed across geographic characteristics, such as metropolitan status or level of racial residential segregation. Little is known about the interaction of metropolitan status and segregation in their relationship with cancer screening. We conducted a quantitative survey of 474 women aged 45–65 in central Pennsylvania. The survey collected county-level characteristics and participant-level demographics, beliefs, cancer screening barriers, and cervical and colorectal cancer screening. We used bivariate and multivariable logistic regression to analyze relationships between metropolitan status and segregation with screening. For cervical cancer screening, 82.8% of participants were up-to-date, which did not differ by county type in the final analysis. Higher healthcare trust, higher cancer fatalism, and reporting cost as a barrier were associated with cervical cancer screening. For colorectal cancer screening, 55.4% of participants were up-to-date, which differed by county type. In metropolitan counties, segregation was not associated with colorectal cancer screening, but in non-metropolitan counties, segregation was associated with greater colorectal cancer screening. The relationship between metropolitan status and being up-to-date with colorectal, but not cervical, cancer screening varied by segregation. Other important beliefs and barriers to screening varied by county type. This research can guide future cancer screening interventions in primary care settings in underserved communities.

Keywords Metropolitan status · Racial residential segregation · Cancer screening · Cervical cancer · Colorectal cancer · Health behavior

While significant progress has been made in decreasing the rates of cervical cancer and colorectal cancer overall, there continues to be significant, unequal burden based on geography, race, and socioeconomic status [1–3]. For example, residents of rural communities in the U.S. have higher cancer mortality rates than their urban counterparts [4–6]. This disparity may be related to lower rates of screening and delays in diagnosis of cancer in rural compared to urban communities [7, 8]. Primary care often serves as the access point for screening, particularly for cervical and colorectal cancer. Higher physician density, which commonly occurs in more urban communities, is associated with lower incidence of late-stage colorectal cancer [9, 10], with similar beneficial effects observed for other healthcare outcomes. [11–14].

Cancer outcomes are also related to other geographic characteristics, such as racial residential segregation [3]. To date, research on segregation has demonstrated that segregation can be both health-promoting (e.g., supporting close social networks) and health-damaging (e.g., linked to lower rates of physical activity) [15]. While some of the poorest cancer outcomes are observed in rural, segregated communities [16], most research on segregation has focused on urban areas. More research is needed to examine the influence of segregation on cancer prevention, particularly in rural communities.

Empirical and theoretical research suggests that geographic characteristics (such as rurality and segregation) and intrapersonal characteristics (such as attitudes and beliefs)

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have independent and interactive relationships with health behaviors and outcomes. Social Cognitive Theory (SCT) proposes that elements of the environment, person, and behavior demonstrate reciprocal determinism, i.e., they all influence each other in complex ways [17]. Studies examining geographic differences in intrapersonal factors associated with cancer screening (e.g., cancer fatalism [7, 18]) have had mixed results. Thus, additional research is needed on the interactions among geographic and intrapersonal factors, and how they are associated with cancer screening.

Before we can intervene to address the disparate burden of cervical and colorectal cancer in different communities, we need to develop a better understanding of screening barriers and behaviors by geography, using a theory-guided approach. The purpose of this study is to give such insights to guide future interventions to increase screening uptake in primary care settings, particularly in underserved communities.

Materials and Methods

Survey Sample

Recruitment focused on women residing in the 28-county catchment area for the Penn State Cancer Institute. Participants were recruited through (1) a Penn State University-wide database of research studies; (2) an on-hold message for people calling Penn State Health Milton S. Hershey Medical Center; (3) postings on city-/region-specific job sites; and (4) paid advertisements on social media, targeted by zip code. Recruitment was stratified by county type, based on metropolitan status and level of racial residential segregation. Metropolitan status was defined using the U.S. Department of Agriculture's rural–urban continuum codes (RUCC) [19]; counties with RUCC ≤ 3 were coded as metropolitan, and counties with RUCC > 3 were coded as non-metropolitan. Level of racial residential segregation was defined using the dissimilarity index (DI) [20] for white versus non-white population living in census tracts within counties; counties with DI less than the national median were coded as less-segregated, and counties with DI greater than or equal to the national median were coded as highly-segregated. By cross-classifying the metropolitan status and segregation variables, we created four county types: (1) metropolitan/less-segregated ($k = 6$ counties in the catchment area), (2) metropolitan/highly-segregated ($k = 12$ counties), (3) non-metropolitan/less-segregated ($k = 6$ counties), and (4) non-metropolitan/highly-segregated ($k = 4$ counties).

Inclusion criteria were female sex, age 45–65 years (inclusive) (i.e., eligible for routine screening for cervical cancer and colorectal cancer, per American Cancer Society (ACS) recommendations [21]), English-speaking, and residing in the catchment area. Of 994 people who responded to study invitations, 773 were eligible (77.8%), and 206 were ineligible. Most ineligible respondents were excluded because of age ($n = 184$). Recruitment was stratified by county type to create approximately equal groups. Thus, of the 773 eligible respondents, 474 participants enrolled and completed the survey ($n = 120$ from metropolitan/less-segregated counties; $n = 118$ from metropolitan/highly-segregated counties; $n = 119$ from non-metropolitan/less-segregated counties; $n = 117$ from non-metropolitan/highly-segregated counties); the remaining 299 respondents were eligible but not enrolled because their county type had already reached its quota. Recruitment took place between March and June 2020.

Survey Instrument

Participants provided verbal or implied consent, and then surveys were administered by a research assistant over the phone or self-administered online. After completing the survey, each participant received a $15 gift card and a thank-you note by mail or e-mail.

Measures

We gathered county-level community characteristics, as well as participants' beliefs and barriers, cancer screening behaviors, and demographics.

Community Characteristics

As indicated above, we collected metropolitan status using RUCC [19] and level of segregation using DI [20], calculated with American Community Survey data. [22] In addition, we used the 2017 Area Health Resource File [23] (most recent data available) to capture the number of primary care providers per 10,000 people in each county. Participants self-reported travel time (in minutes) from their home to primary care provider's office.

Beliefs and Barriers

To capture health-related beliefs, we assessed health self-efficacy and healthcare trust (Supplementary Table S1). Healthcare trust was measured using three items [24], but these items did not achieve adequate internal consistency to justify combining into a scale (Cronbach's $\alpha = 0.39$); therefore, we analyzed items separately.

To capture beliefs about cancer, we assessed cancer fatalism using three items. [25] As in previous studies [26, 27], these items achieved only moderate internal consistency (Cronbach's $\alpha = 0.63$), so we analyzed items separately.

Separately for cervical and colorectal cancer, we assessed if participants agreed or disagreed with statements about

potential barriers to screening: don't know how, don't need to, embarrassing to, afraid of results, cost is too high, or doctor is too far away (Supplementary Table S1). Responses of *agree* or *strongly agree* for a barrier were coded as 'endorsed,' while responses of *disagree* or *strongly disagree* were coded as 'not endorsed.'

Cancer Screening Behaviors

We evaluated whether participants were up-to-date on screening for cervical and colorectal cancer according to ACS guidelines. [21] Specifically, we classified participants as up-to-date with cervical cancer screening if they self-reported having had (1) a Pap test within three years and/or (2) a human papillomavirus (HPV) test within five years. Because most women who have a hysterectomy should discontinue cervical cancer screening (notable exceptions include women who have a hysterectomy due to cervical cancer), we excluded women who self-reported having had a hysterectomy from analysis of this outcome. We classified participants as up-to-date with colorectal cancer screening if they self-reported having had (1) a stool-based test within the last year and/or (2) a visualization test (e.g., colonoscopy, sigmoidoscopy) within five years. As an exploratory outcome, we also assessed whether participants were up-to-date with screening for both cervical and colorectal cancers.

Demographics

We gathered participants' self-reported demographics and health information: age, self-rated health, personal cancer history, if they had had a hysterectomy, insurance status, last-year check-up, annual household income, educational attainment, marital status, and race/ethnicity.

Analysis

First, we generated descriptive statistics about participants' demographics, calculating means and standard errors (*SE*) for continuous variables, and counts and percentages for categorical variables. We calculated these statistics overall and then by county type. To assess differences by county type, we used logistic regression to test associations with metropolitan status, level of segregation, and the interaction of the two variables. For each variable, we report the *p*-value for the Wald chi-square test assessing the joint contribution of the interaction. Next, we repeated this approach for the beliefs and barriers. We retained demographics, beliefs, and barriers with $p < 0.10$ in the multivariable analyses.

Then, we calculated the prevalence of being up-to-date with screening for cervical cancer and for colorectal cancer, overall and then by county type. We used logistic regression to assess factors associated with being up-to-date. In the preliminary model (Model 1), we assessed the associations between metropolitan status and segregation with being up-to-date. In the fully-adjusted model (Model 2), we added the demographics, beliefs, and barriers that differed by county type. Finally, we added a multiplicative interaction term for metropolitan status and segregation, using the Wald chi-square test to assess the joint contribution of the interaction. We probed the interactions by evaluating the relationship between level of segregation and being up-to-date, stratified by metropolitan status.

Analyses were conducted using SAS version 9.4 (Cary, NC). The statistical tests used a $p < 0.05$, except where noted. The Penn State College of Medicine Institutional Review Board/Human Subjects Protection Office approved data collection and analysis for this study.

Results

The 474 participants had a mean age of 55.12 years ($SE = 0.26$) (Table 1). Participants reported a moderate level of self-rated health (overall mean = 3.52, $SE = 0.04$, range: 1–5), and 27.2% reported having had a partial or complete hysterectomy. Most participants had private health insurance (72.6%), had a check-up in the last year (75.4%), and had an annual household income of $50,000 or more (74.3%). Only 13 participants (2.7%) reported a race/ethnicity besides non-Hispanic White. Insurance status, household income, and educational attainment varied by county type (all interaction $p < 0.05$), while self-rated health was marginally associated with county type (interaction $p = 0.06$).

In terms of community characteristics, participants lived in counties with a mean of 6.71 ($SE = 0.20$) primary care providers per 10,000 people, and they reported traveling 17.15 min ($SE = 0.62$) to their primary care provider (Table 2). In terms of individual beliefs and barriers, participants had high levels of health self-efficacy (mean = 3.96, $SE = 0.03$, range: 1–5). They had moderate-to-low levels of cancer fatalism (scores on individual items ranged from mean = 0.81, $SE = 0.04$, to mean = 1.80, $SE = 0.04$, range: 0–3). The most commonly-reported barriers to screening were (1) that it is embarrassing to get screened (cervical = 30.5%; colorectal = 41.5%) and (2) that participants are afraid of the results they might receive (cervical = 22.3%; colorectal = 28.0%). Generally, these health-related beliefs and barriers to screening were similar across county types, except for reporting costs as a barrier to cervical cancer screening (interaction $p < 0.01$) and reporting fear of results as a barrier to colorectal cancer screening (interaction $p = 0.02$). In addition, county type was marginally associated with health self-efficacy, belief that healthcare is more concerned about money than patients, and reporting fear of

Table 1 Demographic characteristics among women ages 45–65 years, central Pennsylvania, 2020 ($n = 474$)

	Overall		By county type								
			Metropolitan/highly-segregated		Metropolitan/less-segregated		Non-metropolitan/highly-segregated		Non-metropolitan/less-segregated		
	Mean	*SE*	Mean	*SE*	Mean	*SE*	Mean	*SE*	Mean	*SE*	Int. *p*
Age, years [range: 45–65]	55.12	0.26	54.67	0.52	54.97	0.51	55.75	0.53	55.11	0.50	0.36
Self-rated health [range: 1–5]	3.52	0.04	3.43	0.09	3.66	0.07	3.53	0.06	3.47	0.07	0.06
Primary care physicians per 10,000 population [range: 0.00–51.44]	6.71	0.20	9.37	0.65	7.78	0.19	5.48	0.18	4.21	0.14	0.65
Travel time to PCP office, minutes [range: 1–120]	17.15	0.62	14.96	0.84	16.47	1.38	18.09	1.12	19.03	1.46	0.82
	n	%	*n*	%	*n*	%	*n*	%	*n*	%	Int. *p*
Personal cancer history											0.79
No	389	82.2	101	85.6	97	80.8	97	82.9	94	79.7	
Yes	84	17.8	17	14.4	23	19.2	20	17.1	24	20.3	
Had a hysterectomy											0.15
No	345	72.8	96	81.4	83	69.2	83	70.9	83	69.8	
Yes	129	27.2	22	18.6	37	30.8	34	29.1	36	30.3	
Insurance status											<0.001
Non-private	130	27.4	56	47.5	25	20.8	22	18.8	27	22.7	
Private	344	72.6	62	52.5	95	79.2	95	81.2	92	77.3	
Check-up in last year											0.61
No	116	24.6	25	21.2	30	25.2	30	25.9	31	26.1	
Yes	356	75.4	93	78.8	89	74.8	86	74.1	88	74.0	
Annual household income											0.01
<$50,000	116	25.7	46	40.0	23	20.0	21	19.4	26	22.8	
$50,000 or more	336	74.3	69	60.0	92	80.0	87	80.6	88	77.2	
Educational attainment											0.01
High school degree or less	63	13.8	24	20.7	14	12.1	8	7.1	17	15.2	
More than high school degree	393	86.2	92	79.3	102	87.9	104	92.9	95	84.8	
Marital status											0.15
Not married/living with a partner	123	26.9	51	44.0	28	24.1	24	21.6	20	17.5	
Married/living with a partner	334	73.1	65	56.0	88	75.9	87	78.4	94	82.5	
Race/ethnicity											0.98
Non-Hispanic White	461	97.3	108	91.5	119	99.2	115	98.3	119	100.0	
Other	13	2.7	10	8.5	1	0.8	2	1.7	0	0.0	

County type determined by U.S. Department of Agriculture rural–urban continuum codes [19] and dissimilarity index [20] for assessing racial residential segregation. *SE* Standard error, *int.* Interaction

results as a barrier to cervical cancer screening (all interaction $p < 0.10$).

Cervical Cancer Screening

Excluding women who reported having had a hysterectomy, 82.8% (284/343) of participants were up-to-date on cervical cancer screening. In Model 1, being up-to-date with cervical cancer screening did not differ by metropolitan status ($p = 0.80$) or segregation level ($p = 0.07$) (Table 3). Metropolitan status and segregation level interacted in their relationship with cervical cancer screening ($p < 0.01$) in this preliminary model. In Model 2, being up-to-date again did not differ by metropolitan status or segregation level, but it was associated with healthcare trust (healthcare concerned about money [reverse-coded]: adjusted odds ratio[aOR] = 1.54, 95% CI = 1.00–2.37, $p < 0.05$), cancer fatalism (different cancer prevention recommendations: aOR = 2.44, 95% CI = 1.59–3.74, $p < 0.001$), and reporting cost as a barrier to screening (aOR = 0.36, 95% CI = 0.15–0.84, $p = 0.02$).

Table 2 Health-related beliefs and cancer screening barriers among women ages 45–65 years, central Pennsylvania, 2020 ($n=474$)

	Overall		By county type								
			Metropolitan/highly-segregated		Metropolitan/less-segregated		Non-metropolitan/highly-segregated		Non-metropolitan/less-segregated		
	Mean	*SE*	Mean	*SE*	Mean	*SE*	Mean	*SE*	Mean	*SE*	Int. *p*
Community characteristics											
Primary care physicians per 10,000 population [range: 0.00–51.44]	6.71	0.20	9.37	0.65	7.78	0.19	5.48	0.18	4.21	0.14	0.65
Travel time to PCP office, minutes [range: 1–120]	17.15	0.62	14.96	0.84	16.47	1.38	18.09	1.12	19.03	1.46	0.82
Individual beliefs and barriers											
Health self-efficacy [range: 1–5]	3.96	0.03	3.89	0.08	4.02	0.06	4.02	0.06	3.90	0.07	0.08
Healthcare trust [range: 0–3]											
Healthcare concerned about money[a]	1.35	0.04	1.26	0.09	1.36	0.08	1.48	0.07	1.29	0.07	0.06
Patients should follow advice	1.99	0.03	2.09	0.07	1.97	0.06	1.90	0.07	1.98	0.06	0.13
Would see doctor	2.62	0.03	2.63	0.07	2.66	0.06	2.58	0.06	2.59	0.06	0.88
Cancer fatalism [range: 0–3]											
Everything causes cancer	1.50	0.04	1.43	0.09	1.44	0.08	1.45	0.07	1.67	0.07	0.19
Can't lower cancer chances	0.81	0.04	0.85	0.08	0.86	0.08	0.74	0.07	0.81	0.06	0.71
Different cancer prevention recommendations	1.80	0.04	1.85	0.08	1.70	0.08	1.76	0.07	1.87	0.07	0.10
	n	%	*n*	%	*n*	%	*n*	%	*n*	%	Int. *p*
Barriers to cervical cancer screening											
Don't know how to	19	4.3	5	4.4	5	4.4	3	2.8	6	5.5	0.49
Don't need to	62	14.2	13	11.7	17	15.2	16	15.0	16	15.1	0.60
Embarrassing to	138	30.5	39	33.6	31	27.4	36	32.7	32	28.1	0.86
Afraid of results	99	22.3	41	36.9	27	24.3	13	11.9	18	15.9	0.06
Cost is too high	77	17.5	26	23.6	16	14.4	11	10.2	24	21.6	<0.01
Doctor is too far away	14	3.1	3	2.7	2	1.8	5	4.7	4	3.5	0.91
Barriers to colorectal cancer screening											
Don't know how to	15	3.3	7	6.0	4	3.5	3	3	1	0.9	0.67
Don't need to	33	7.2	7	6.0	9	7.8	9	8.0	8	7.0	0.57
Embarrassing to	189	41.5	44	38.6	45	39.1	50	44.6	50	43.5	0.85
Afraid of results	127	28.0	46	40.0	32	27.6	20	18.2	29	25.7	0.02
Cost is too high	124	27.3	36	31.9	26	22.6	30	26.8	32	27.8	0.22
Doctor is too far away	20	4.4	6	5.2	2	1.7	6	5.5	6	5.3	0.29

[a]Reverse-coded

County type determined by U.S. Department of Agriculture rural–urban continuum codes [19] and dissimilarity index [20] for assessing racial residential segregation. *SE* Standard error, *int.* Interaction

Controlling for all the variables in Model 2, the interaction between metropolitan status and segregation level was not associated with being up-to-date (interaction $p=0.39$); that is, the association between segregation level and cervical cancer screening did not differ by metropolitan status (Fig. 1A).

Colorectal Cancer Screening

Overall, 55.4% (262/473) of participants were up-to-date on colorectal cancer screening. In Model 1, being up-to-date with colorectal cancer screening did not differ by metropolitan status ($p=0.18$) or segregation level ($p=0.80$) (Table 3). Metropolitan status and segregation level interacted in their relationship with colorectal cancer screening ($p=0.01$) in this preliminary model. In Model 2, being up-to-date was not associated with any of the study variables.

Controlling for all the variables in Model 2, the interaction between metropolitan status and segregation level in their relationship with colorectal cancer screening was statistically significant (interaction $p=0.01$). Specifically, in metropolitan counties, being up-to-date with colorectal cancer screening did not vary by segregation ($p=0.19$), but in non-metropolitan counties, being up-to-date was

Table 3 Multivariable models of the associations of county characteristics, demographics, health-related beliefs, and cancer screening barriers with cervical and colorectal screening behaviors among women ages 45–65 years, central Pennsylvania, 2020 ($n=474$)

	Cervical cancer screening (exc. Hyst)				Colorectal cancer screening			
	Model 1		Model 2		Model 1		Model 2	
	aOR	95% CI	aOR	95% CI	aOR	95% CI	aOR	95% CI
Metropolitan status								
Metropolitan	(ref)		(ref)		(ref)		(ref)	
Non-metropolitan	0.93	(0.53–1.63)	0.64	(0.32–1.30)	1.28	(0.89–1.85)	1.23	(0.83–1.83)
Segregation level								
Less-segregated	(ref)		(ref)		(ref)		(ref)	
Highly-segregated	0.58	(0.33–1.04)	0.59	(0.29–1.19)	1.05	(0.73–1.51)	1.15	(0.78–1.71)
Self-rated health			1.24	(0.77–1.98)			0.85	(0.66–1.11)
Insurance status								
Non-private			(ref)				(ref)	
Private			1.80	(0.80–4.05)			1.43	(0.86–2.37)
Annual household income								
<$50,000			(ref)				(ref)	
$50,000 or more			1.86	(0.85–4.07)			1.04	(0.62–1.75)
Educational attainment								
High school degree or less			(ref)				(ref)	
More than high school degree			1.06	(0.41–2.76)			0.73	(0.40–1.32)
Health self-efficacy			1.05	(0.64–1.73)			1.22	(0.91–1.62)
Healthcare concerned about money[a]			1.54	(1.00–2.37)			1.19	(0.93–1.51)
Different cancer prevention recommendations			2.44	(1.59–3.74)			0.99	(0.77–1.26)
Cancer-specific screening barrier: Afraid of results								
No			(ref)				(ref)	
Yes			0.96	(0.42–2.21)			0.76	(0.49–1.20)
Cancer-specific screening barrier: Cost is too high								
No			(ref)				(ref)	
Yes			0.36	(0.15–0.84)			0.73	(0.46–1.17)

[a]Reverse-coded

aOR Adjusted odds ratio, *CI* Confidence interval, *ref* Reference

more common in highly-segregated counties (68.9%, 95% CI = 67.5–70.3%) than in less-segregated counties (52.8%, 95% CI = 51.1–54.4%) (aOR = 2.01, 95% CI = 1.11–3.61, $p=0.02$) (Fig. 1B).

Both Cervical and Colorectal Cancer Screening

In supplementary analyses, excluding women who reported having had a hysterectomy, 50.7% (175/345) of participants were up-to-date on both cervical and colorectal cancer screening. In the fully-adjusted model, being up-to-date with both screenings was associated with reporting cost as a barrier to cervical cancer screening (aOR = 0.39, 95% CI = 0.17–0.90, $p=0.03$) (Supplementary Table S2). The interaction between metropolitan status and segregation level in their relationship with both cervical and colorectal cancer screening was statistically significant (interaction $p=0.04$). In metropolitan counties, being up-to-date was marginally lower in counties that were also highly-segregated (42.7%, 95% CI = 40.0–45.4%) than in counties that were less-segregated (56.7%, 95% CI = 54.3–59.0%) (aOR = 0.60, 95% CI = 0.30–1.19, $p=0.14$), but in non-metropolitan counties, being up-to-date was marginally higher in counties that were also highly-segregated (61.8%, 95% CI = 59.6–64.1%) than in counties that were less-segregated (46.8%, 95% CI = 44.4–49.3%) (aOR = 1.80, 95% CI = 0.86–3.76, $p=0.12$).

Discussion

Among women in central Pennsylvania, cervical cancer screening was fairly common, with 82.8% of participants reporting being up-to-date. Cervical cancer screening did not vary by county type. We found that women's healthcare trust and cancer fatalism were positively associated with cervical

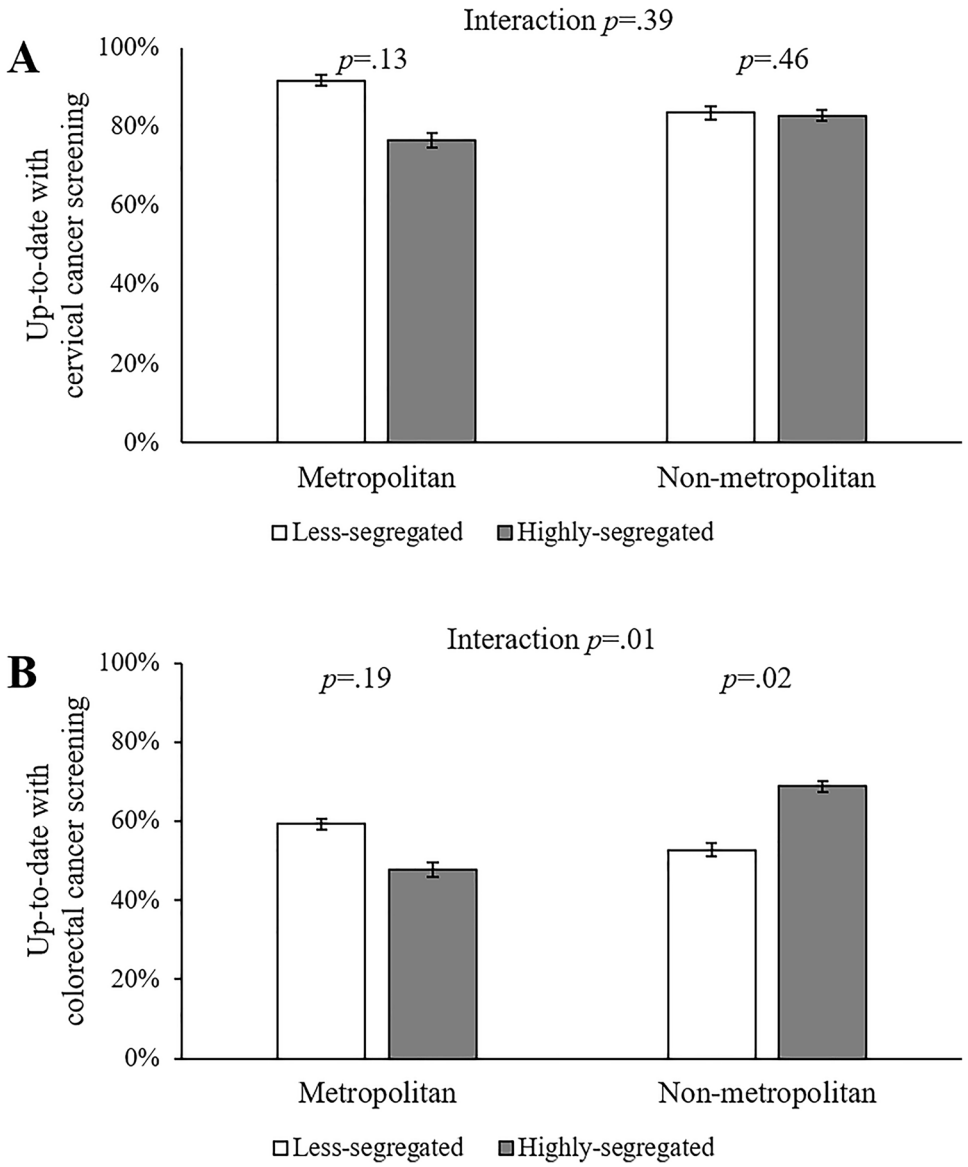

Fig. 1 Associations between county-level racial residential segregation and being up-to-date with (**A**) cervical cancer screening ($n=343$) and (**B**) colorectal cancer screening ($n=473$), by metropolitan status, among women ages 45–65 years, central Pennsylvania, 2020

cancer screening. In contrast, colorectal cancer screening was modest, with 55.4% of participants reporting being up-to-date. Colorectal cancer screening did vary by county type: In metropolitan counties, screening was similar across levels of racial segregation, but in non-metropolitan counties, screening was higher in highly- versus less-segregated counties. This may seem like a nuanced difference, but this finding could have implications for policy changes or interventions to increase cancer screening for these two cancers.

Geography and Cancer Screening

The findings from the current study extend existing knowledge about disparities in cancer burden by geographic factors. Non-metropolitan or rural areas experience higher rates of cancer mortality than metropolitan or urban areas [4, 5]; this pattern is often attributed to factors such as higher poverty rates, lower education levels, and limited access to health resources. [5] In addition, participation in cancer screening and prevention is less common in rural than urban areas. [7, 28] We did not find significant variation in self-reported cancer screening behaviors by metropolitan status among women ages 45–65 in central Pennsylvania, which could be attributable to the relative homogeneity of the sample.

However, not all rural communities have the same characteristics or cancer burden, and the intersection between county-level rurality and racial residential segregation appears to be influential for some individual-level cancer screening behaviors. Our analysis demonstrated that higher levels of segregation were associated with *lower* likelihood of being up-to-date with colorectal cancer screening

in metropolitan areas, but *higher* likelihood in non-metropolitan areas. (This pattern operated similarly for important correlates of cancer screening, e.g., concerns about cost, and for both cervical and colorectal cancer screening.) This finding adds nuance to previous research on racial segregation, which has been demonstrated to have both health-promoting and health-damaging effects. [7, 15] Higher racial segregation has been shown to be associated with higher rates of late-stage cancer diagnosis which is often attributed to lack of regular screening. [3, 28] Importantly, racial segregation can present differently depending on the community. Racial segregation of a community is measured by the homogeneity of race within an area, and higher segregation is associated with high-population urban areas and low-population rural areas [29, 30]; therefore, a highly-segregated county could have large numbers of racial/ethnic minorities living in one area of the county, or it could have vanishingly small numbers of minorities dispersed across the county. In rural counties with relatively low populations, segregation may be associated with increased access to healthcare services, including among racial/ethnic minorities, as a result of increased social support and social cohesion. [29].

Additional Correlates of Cancer Screening and Their Implications

Guided by SCT [17], we examined the relationships of environmental characteristics (i.e., metropolitan status, segregation) and person-level factors (e.g., healthcare trust, cancer fatalism) with behaviors (i.e., screening). In our sample, women living in metropolitan/highly-segregated or non-metropolitan/less-segregated counties had lower levels of healthcare trust, had higher levels of cancer fatalism, and were more likely to report cost as a barrier to screening. In the final model, higher levels of trust and fatalism were associated with higher likelihood of cervical cancer screening, but reporting cost as a barrier associated with lower likelihood of cervical cancer screening. Given that controlling for these beliefs and barriers attenuated the relationship between county type and screening, it is possible that the person-level factors assessed in this study mediated the relationship between metropolitan status, segregation level, and their interaction with cancer screening (albeit only partially for colorectal cancer screening, which was still associated with the interaction between metropolitan status and segregation level after controlling for the person-level factors). [31] That is, these person-level factors may be on the causal pathway that explains why the interaction between geographic characteristics was associated with screening behaviors. Additional research is needed to test whether these findings hold true in longitudinal and experimental frameworks.

Notably, we found that concerns about cost of screening were associated with lower odds of being up-to-date with cervical cancer screening. Given the provisions of the Affordable Care Act, most patients should be able to access evidence-based cancer screening for free or low cost. [32] Future studies should explore patients' enduring perceptions about the cost of care, as well as actual out-of-pocket expenses for visiting a provider and accessing care.

The findings of this study have implications for primary care and cancer prevention. Patients who reported higher trust in healthcare were more likely to be up-to-date with cervical cancer screening, which supports previous studies examining the positive relationship between healthcare trust and health outcomes. [33–35] Some methods to increase healthcare trust include highly-organized primary care systems and communications trainings for physicians. [34, 36] A potential intervention that could increase healthcare trust and screening is self-sampling for cervical cancer screening. [37] Women who have less trust in the healthcare system may find self-sampling for cervical cancer screening appealing as it would allow them more autonomy in testing. Future studies should examine methods to increase healthcare trust and whether these efforts increase cancer screening. In particular, studies should incorporate county-level and person-level characteristics into their interventions, for example, by locating interventions to increase access to screening (e.g., through self-sampling for cancer screening) in communities with low availability of primary care and specialty services (e.g., in non-metropolitan, segregated counties).

Study Strengths and Limitations

In terms of strengths, this study extended previous literature on the role of geography in cancer screening by examining simultaneously metropolitan status and racial segregation. In particular, our understanding of the health-promoting and health-damaging influences [15] of segregation in rural communities is poorly understood [29], and this study helps to address that gap. Further, the patterns of cancer screening behaviors, beliefs, and barriers by racial residential segregation are not well studied, especially compared to the rich literature on rural/urban differences in these factors. We used a comprehensive, multilevel framework [17] to guide study design and analysis of both geographic and individual factors related to health behavior. Finally, this study contributes to the literature on multiple health behaviors. [38] In particular, we examined patterns of being up-to-date with two cancer screenings among a sample of women eligible for both, reporting that concerns about cost are a deterrent for both single screening behaviors (i.e., for cervical cancer) and multiple screening behaviors (i.e., for both cervical and colorectal cancer).

In terms of limitations, our study used a cross-sectional design, which precludes causal inferences. Participants self-reported their screening behaviors, and previous studies have

demonstrated [39, 40] that self-report is not always accurate compared to medical records, perhaps as a result of recall bias. In addition, the generalizability of the data may be limited, given the demographics of the participants recruited. Most participants had private insurance, had had a recent check-up, had yearly incomes of at least $50,000, and high levels of trust in their primary care provider; other studies have shown that several of these factors are associated with cancer screening behaviors. [28, 41] Particularly problematic is that less than 3% of the participants reported a race/ethnicity besides non-Hispanic White, resulting in a sample of women who are less at-risk for cervical and/or colorectal cancer than are Latino or African American women. [1, 42, 43] Yu and colleagues [2] noted that the highest rates of cervical cancer in rural settings were observed in Latino and African American women; thus, research recruitment efforts must be improved to enhance representation from these groups. Direct marketing promotion (as used in this study) is likely less effective at recruiting participants from underrepresented minority groups than referrals from other participants and/or community agencies. [44] In future studies, we plan to involve community participatory research strategies to improve recruitment of women from underrepresented minority groups.

Conclusions

In conclusion, we conducted a theory-guided analysis of county-level and individual-level correlates of cervical and colorectal cancer screening. Selected cancer screening beliefs, barriers, and behaviors varied by metropolitan status and racial residential segregation, which could be relevant to geographic disparities in cancer incidence and cancer mortality. Additional research is needed on interactions between patients and their healthcare systems, especially to understand how people from different communities trust their providers and perceive cost as a barrier to care. These findings can help inform future interventions to increase cervical and colorectal cancer screening in underserved communities. A promising future direction is the dissemination and adoption of self-sampling tools in primary care settings, particularly in communities with low access to specialized care, to overcome the multilevel barriers to cancer screening demonstrated in the current study.

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Data Availability Data available from the corresponding author upon request.

Code Availability Code available from the corresponding author upon request.

Declarations

Conflict of Interest The authors have no potential conflicts of interest to disclose.

Ethical Approval The Penn State College of Medicine Institutional Review Board/Human Subjects Protection Office approved data collection and analysis for this study.

Consent to Participate Participants provided verbal or implied consent before completing the survey.

Consent for Publication Not applicable.

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