Predicting cervical cancer screening among sexual minority women using Classification and Regression Tree analysis

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Abstract

Cervical cancer screening is a critical preventive healthcare service for all women. Sexual minority women (SMW) in the United States experience multiple health disparities including decreased access to and use of cervical cancer screening. The mechanisms driving these disparities are not clear and SMW with multiple marginalized identities may be more likely to miss recommended cervical cancer screening. This study aimed to identify subgroups of SMW that are more and less likely to be screened for cervical cancer according to American Cancer Society guidelines. We used cross-sectional data from the latest (2010–2012) wave of the Chicago Health and Life Experiences of Women (CHLEW) Study (N = 691). Informed by intersectionality theory, we performed classification and regression tree modeling techniques for evaluating how multiple variables interact in complex ways to predict cervical cancer screening.

1. Introduction

Guidelines published by the American Cancer Society (ACS) (2015) specify that anyone with a cervix should be screened regularly for cervical cancer via Papanicolaou (Pap) testing regardless of sexual history, orientation, or identity. However, previous studies have demonstrated that lesbian and bisexual women are less likely to be screened for cervical cancer than their heterosexual counterparts (Agénor et al., 2014a; Charlton et al., 2011, 2014; National Academies of Medicine, 2011). In the United States (US), sexual minority women (SMW), or those who identify as lesbian, gay, bisexual, or queer, experience multiple health disparities including lower rates of preventive healthcare service use (Agénor et al., 2014a; Charlton et al., 2011, 2014; National Academies of Medicine, 2011; Agénor et al., 2014b; Matthews et al., 2004). Sexual orientation-related health disparities are explained by the stigma associated with minority sexual identities. This includes social stigma, which increases health risks, and healthcare-specific stigma, which creates barriers to high-quality care (Meyer, 1995, 2003). However, SMW are not a homogenous group and wide variability in preventive healthcare use suggests that SMW with multiple marginalized identities (e.g., SMW who have a minority racial or ethnic identity or low socioeconomic status) face unique barriers to care (Agénor et al., 2015, 2016; Calabrese et al., 2014, 2015; Szymanski and Meyer, 2008; Bowleg et al., 2003; Wilson et al., 2011).

The mechanisms driving disparities in Pap testing are not clear but misinformation among providers and the public about SMW's sexual health risks may contribute. Most SMW, including lesbian-identified women, are at risk for human papillomavirus (HPV), the most common cause of cervical cancer. Most SMW have some history of sexual contact with men (Mustanski et al., 2013; Diamant et al., 1999) and HPV can be transmitted through female-to-female contact (Anderson et al., 2014; Moszynski, 2009). Other research suggests that “cues to screening” that are common among heterosexual women, such as receiving other sexual and reproductive healthcare services, may be less common among SMW (Charlton et al., 2014; Agénor et al., 2014b, 2015; Greene et al., 2018; Reiter and McRee, 2015; Eaton et al., 2008; Johnson et al., 2016a; Tracy et al., 2010). Healthcare provider- and system-level factors such as provider recommendation of Pap testing (Reiter and McRee, 2015; Johnson et al., 2016a; Marrazzo et al., 2001; Tracy et al., 2013), good communication with providers (Agénor et al., 2015;...
et al., 2013; Clark et al., 2003; Diamant et al., 2000) have been associated with higher rates of screening among SMW. However, the impact of these potential “cues to screening” may vary among groups of SMW with different specific sexual histories, racial or ethnic identities, level of education, and socioeconomic resources (Agénor et al., 2015; Calabrese et al., 2014; Bowleg et al., 2003; Miles-Richardson et al., 2017).

Existing research suggests that trends in some demographic and structural barriers to Pap testing among SMW are similar to those among heterosexual women (Pourdeh et al., 2016; Doeschel and Jackson, 2009; Coughlin et al., 2008; Centers for Disease Control and Prevention, 2012). Nuanced analyses of race and ethnicity and other aspects of identity have been limited among SMW because representative samples of sexual minority populations are difficult to define (National Academies of Medicine, 2011). Additionally, most published studies of SMW include samples that are largely white, well educated, and predominantly lesbian-identified (National Academies of Medicine, 2011). Fewer studies of the sexual and reproductive health of SMW have included bisexual women and racial and ethnic minority SMW (Bostwick et al., 2014), and very few studies have evaluated how individual and system-level factors intersect to drive cervical cancer screening.

Thus, this study aimed to identify subgroups of SMW that are more and less likely to be screened for cervical cancer according to ACS guidelines, based on the intersections of demographic characteristics, sexual identity, sexual history, and other known risk factors for poor health outcomes among SMW.

1.1. Theoretical foundation

This study was informed by intersectionality theory, developed from Black feminist scholarship and introduced by Kimberlé Crenshaw. Intersectionality theory proposes that multiple aspects of identity and experience intersect to create unique forms of discrimination (Crenshaw, 1991). The theory explains how individual components of identity intersect in unique ways among individuals with multiple marginalized identities (Crenshaw, 1991). Intersectionality theory also stresses that individual characteristics or identities such as gender, race, class, and sexual orientation are intricately linked with institutional structures (Bradford and van Wagenen, 2012; Bowleg, 2012). Previous researchers have used intersectionality specifically to study Black SMW, as they constitute a population with multiple marginalized identities and who may experience various forms of institutionalized sexism, racism, and homophobia (Bradford and van Wagenen, 2012).

Major gaps in the literature persist in understanding how multiple marginalizations and barriers to care converge to drive lower rates of screening among SMW. Classification and regression tree (CART) modeling is a recursive partitioning method that is uniquely suitable for evaluating how multiple factors intersect to predict cervical cancer screening. We used concepts from intersectionality theory to select variables that have potential to predict cervical cancer screening including race/ethnicity, income and employment status, and experiences of discrimination.

2. Study design and methods

We used existing cross-sectional data from the most recent wave (Wave 3, 2010–12) of the Chicago Health and Life Experiences of Women (CHLEW) study.

2.1. Sample

The CHLEW study is an ongoing longitudinal cohort study of SMW’s health. The CHLEW sample includes a large, diverse, community-based sample that was recruited in the Chicago metropolitan area (Brown and Tracy, 2008; Waterman and Voss, 2015). Recruitment for the study began in 2000 and involved a broad range of strategies including print and online advertisements, networking at social events and community-based organizations, and individual social networks (snowball sampling). Concerted efforts were made to reach subgroups of SMW typically underrepresented in research, such as older (> 50 years) and younger (< 25 years) women, racial and ethnic minorities, and those with lower educational attainment.

Recruitment for the first wave of CHLEW targeted women who identified as exclusively or mostly lesbian, though some of these participants indicated other sexual orientations at subsequent interviews. At the third wave of data collection, 354 of the original 447 participants were re-interviewed (response rate = 79%), and an additional sample of 373 women was recruited using components of respondent-driven sampling (Heckathorn, 1997; Heckathorn, 2002). Recruitment of the new sample focused on African American and Latina, bisexual, and young (18–25 years) women. Data were collected using computer-assisted personal interviewing methods. In the current study we included all women interviewed in Wave 3 who were 21 years old or older and had complete Pap testing data (N = 691).

2.2. Ethical considerations and data management

The Institutional Review Board at the University of Illinois at Chicago approved the parent study and the Institutional Review Board at the University of Pennsylvania approved the current study. All CHLEW data were de-identified before sharing and were password-protected and stored on the research network at the University of Pennsylvania. CHLEW interviewers received 20 h of training in general field-interviewing techniques and study-specific, potentially sensitive topics including discrimination, substance use, and sexual history. Interviewers obtained informed consent during their face-to-face meeting with participants after a review of the purpose and procedures of the study. Participants privately completed sections of the interview that addressed potentially sensitive subjects. During interviews, a distress protocol was in place (though never employed) and every CHLEW participant received a referral list of local and national crisis response agencies and hotlines.

2.3. Measures

2.3.1. Outcomes

The primary outcome was self-report of cervical cancer screening via Pap test within the year prior to interview. Although current ACS guidelines recommend cervical cancer screening every 3–5 years beginning at age 21, at the time of the Wave 3 interviews, consensus guidelines endorsed annual Pap testing for most women (ACS, 2015).

2.3.2. Potential predictors

We included 25 potential covariates (see Table 1). These variables included demographic characteristics (sexual orientation, age, race/ethnicity, income, and education). We created binary income and education variables indicating whether participants’ annual household income and highest level of education were above or below the sample median. Potential covariates also included healthcare-related factors (e.g., insurance status, past-year experiences of discrimination in a healthcare setting) and factors related to sexual minority identity and sexual history (e.g., internalized homonegativity, number of sex partners). The Internalized Homonegativity scale measures the extent to which an individual has internalized negative social messages or stereotypes about sexual minority people and incorporated them into their own self-image (Herek et al., 1997). Internalized Homonegativity scores range from 1 to 5, with higher scores indicating higher levels of internalized homonegativity. This scale has previously been found to have an internal consistency of 0.71 among SMW (Herek et al., 1997).
Table 1
Characteristics of participants who did and did not report a past-year Pap test, including all 25 variables inputted into CART analysis software (N = 691); frequency(percent) or mean ± standard deviation (Chicago, 2010-2012).

| Demographics          | Did not report past-year Pap | Reported past-year Pap | p Value |
|-----------------------|-----------------------------|------------------------|---------|
| Age                   | 43.4 ± 14.5                 | 39.2 ± 12.6            | < 0.0001 | 0.01 |
| Sexual orientation    |                             |                        |         |     |
| Lesbian               | 227 (32.9)                  | 258 (37.3)             |         |     |
| Bisexual              | 53 (7.7)                    | 104 (15.1)             | 0.007   |     |
| Other                 | 19 (2.8)                    | 30 (4.3)               |         |     |
| Race/ethnicity        |                             |                        |         |     |
| White                 | 135 (19.5)                  | 127 (18.4)             |         |     |
| Black/African         | 93 (13.5)                   | 153 (22.1)             |         |     |
| American              | 25 (3.6)                    | 16 (2.3)               |         |     |
| Hispanic/Latina       | 59 (8.5)                    | 97 (14.0)              |         |     |
| Other                 | 12 (1.7)                    | 15 (2.2)               |         |     |
| Education level       |                             |                        |         |     |
| High school diploma or less | 139 (20.1) | 196 (28.4)             | 0.38    |     |
| Bachelor's degree or higher | 159 (23.0) | 196 (28.4)             |         |     |
| Income                |                             |                        |         |     |
| < $40,000/year        | 141 (21.2)                  | 188 (28.3)             |         |     |
| > $40,000/year        | 145 (21.8)                  | 191 (28.7)             | 0.09    |     |
| Income “not enough to meet basic needs” | 101 (14.7) | 166 (24.2)             |         |     |
| Unemployment          | 33 (4.8)                    | 68 (9.8)               | 0.02    |     |
| Healthcare related variables |                   |                        |         |     |
| Has health insurance  | 205 (29.7)                  | 291 (42.2)             | 0.12    |     |
| Any recent discrimination in healthcare | 29 (4.2) | 35 (5.1)               | 0.73    |     |
| Out to all healthcare providers | 204 (29.5) | 267 (38.6)             | 0.97    |     |
| Any previous pregnancy |                             |                        |         |     |
| Sexual identity and history |               |                        |         |     |
| Masculinity score     | 11.3 ± 4.7                  | 11.5 ± 4.6             | 0.65    |     |
| Femininity score      | 12.3 ± 5.0                  | 13.1 ± 4.9             | 0.03    |     |
| Internalized          | 1.36 ± 0.5                  | 1.48 ± 0.6             | 0.004   |     |
| Homonegativity scorea |                             |                        |         |     |
| Age of coming out     | 20.1 ± 8.7                  | 19.3 ± 8.0             | 0.20    |     |
| In a committed relationship | 181 (26.4) | 245 (35.7)             | 0.55    |     |
| Age at sexual debut   | 17.5 ± 4.5                  | 17.0 ± 4.4             | 0.15    |     |
| Lifetime sexual partners (quartiles) |                     |                        | 0.33    |     |
| 0-6                   | 91 (13.2)                   | 96 (13.9)              |         |     |
| 7-11                  | 70 (10.1)                   | 97 (14.0)              |         |     |
| 12-20                 | 67 (9.7)                    | 103 (14.9)             |         |     |
| > 20                  | 71 (10.3)                   | 96 (13.9)              |         |     |
| Lifetime sexual partners (cont.) |              |                        | 0.14    |     |
| > 1 Male sexual partners | 202 (29.3) | 292 (42.3)             | 0.045   |     |
| Lifetime male partners | 7.0 ± 13.9                  | 8.4 ± 16.4             | 0.24    |     |
| Risk factors          |                             |                        |         |     |
| Age at drinking onseta | 16.7 ± 4.1                 | 17.0 ± 3.8             | 0.45    |     |
| Childhood sexual abuse | 114 (20.3)                 | 152 (21.7)             | 0.51    |     |
| Childhood physical abusea | 58 (8.4)                   | 103 (15.0)             | 0.03    |     |
| Adult sexual victimization | 139 (20.1) | 198 (28.7)             | 0.29    |     |

Note. STI: sexually transmitted infection.
* p-Value < 0.05 based on Chi square or t-test.
** p-Value < 0.01 based on Chi square or t-test.
* Variable appeared in CART model.
at drinking onset, health insurance status, internalized homonegativity score, childhood physical abuse, and number of lifetime sexual partners. Thus, among women in this sample, these six of the 25 inputted potential variables were most important in predicting the Pap test outcome.

There were three terminal nodes that predicted low probability of screening (25% to 33%) and four terminal nodes that predicted high probability of screening (62% to 73%). Relatively good accuracy in individual terminal nodes allowed us to identify specific subgroups of SMW that may be more or less likely to receive recommended Pap testing. Participants who were age 62 or older were not likely to receive a Pap test in the previous year (25%). Other subgroups with high accuracy among women younger than 62 years were also identified. Participants younger than 62, who began drinking before age 14, were insured, and reported higher internalized homonegativity scores were more likely to have received a past-year Pap test (73%). In contrast, women younger than 62, who began drinking before age 14, were insured, reported lower internalized homonegativity, did not report any childhood abuse, and had fewer than 28 lifetime sexual partners were less likely to have had a past-year Pap test (30%). However, in this group, women who had 28 or more sexual partners were more likely to have had a past-year Pap test (70%).

4. Discussion

Although it made a statistically significant improvement over the error in the full sample, or the root node error (p = 8.5e−06), the CART model predicting Pap test use had moderate accuracy. This

| Statistic                  | Value       |
|----------------------------|-------------|
| Root node error            | 0.433       |
| Accuracy                   | 0.648       |
| 95% CI                     | (0.611, 0.684) |
| p-Value [Acc > NIR]        | 8.5e−06     |
| Sensitivity                | 0.898       |
| 95% CI                     | (0.864, 0.926) |
| Specificity                | 0.321       |
| 95% CI                     | (0.268, 0.377) |
| Positive predictive value  | 0.634       |
| 95% CI                     | (0.614, 0.654) |
| Negative predictive value  | 0.706       |
| 95% CI                     | (0.632, 0.771) |

Note. In this model, Sensitivity represents the proportion of participants that were correctly identified in the model as having received Pap testing. Specificity represents the proportion of participants that did not receive a Pap test in the previous year and were correctly identified in the model. Positive predictive value is the proportion of participants who actually received Pap testing out of all those identified as having received Pap testing in the model. Negative predictive value of the model is the proportion of participants who actually did not receive Pap testing out of all those identified as not having received Pap testing in the model. The p-value represents the probability that the model accuracy is higher than the no information rate.
suggests that the set of potential covariates included in our analysis did not completely explain patterns of cervical cancer screening in this diverse sample of SMW. Future studies should include other potential correlates of cervical cancer screening among SMW. These may include additional measures of experiences of discrimination in healthcare and elsewhere, low perception of risk for cervical cancer, or elevated discomfort with the Pap test procedure. Since public health and clinical interventions designed to increase screening will be concerned about women most likely to miss recommended screening, the relatively low specificity of the model, or higher rate of “false negatives” may be an acceptable feature of the model. Our findings confirm that many factors intersect in complex ways to predict cervical cancer screening among SMW.

Two variables were consistent with previous research on preventive healthcare seeking among SMW: age and health insurance status. First, only 25% of women over age 62 in the sample had been screened. This likely includes participants who had multiple previous normal Pap tests and were not recommended for further annual testing (ACS, 2015). However, research on aging within sexual minority communities has demonstrated unique risks and needs among sexual minorities as they age, including limited access to safe and affirming healthcare (Fredriksen-Goldsen and Muraco, 2010). The relative invisibility of aging SMW may contribute to low rates of preventive screening in this population. Health insurance status also distinguished between groups with low and high rates of past-year Pap testing in our sample; those with no health insurance were part of a subgroup with a low rate of screening. Despite federal funding that supports free or low-cost sexual and reproductive health services, insurance status continues to be a barrier to seeking preventive healthcare services in the general public and among SMW in particular (U. S. Department of Health and Human Services, 2017; Centers for Disease Control and Prevention Division of Cancer Prevention and Control, 2017).

Several specific variables emerged from this analysis that contradict or add to existing research. Specifically, race/ethnicity and sexual identity, which have been previously identified as predictors of screening, did not appear in our CART model. While race/ethnicity did not appear in our model, racial and ethnic identity are deeply intertwined with multiple socioeconomic indicators and access to healthcare services in the US (Jackson et al., 2016; Williams and Purdie-Vaughns, 2016; Williams et al., 2016). Race/ethnicity tends to act as a proxy for a confluence of factors including economic status and opportunity, experiences of bias and discrimination, and social mobility (Roberts, 2011). Therefore it is likely that it is related to SMW’s use of preventive care both independently and through other variables in our model (e.g., health insurance status).

Our analysis also revealed other variables that have not been tested in more traditional studies of screening, including number of sexual partners, age at drinking onset, childhood physical abuse, and internalized homonegativity. First, our findings suggest that having > 28 lifetime sexual partners may predict Pap testing among SMW. This may reflect an accurate understanding of the increased risk of HPV infection from multiple sexual partners, or the misunderstanding that SMW—especially those with primarily or exclusively female partner—have low or no risk. In reality, SMW with fewer than 28 sexual partners (regardless of partner gender) are still at risk for HPV infection and cervical cancer and should be screened according to guidelines.

Other novel variables point to the importance of early life and developmental experiences in SMW’s lives. The predictive value of these variables suggests a need to examine patterns of sexual identity development among SMW to understand variation in perceived need for and actual use of preventive health services such as Pap testing. Previous research has established that experiencing childhood trauma including physical abuse is a predictor of multiple negative health outcomes in adulthood (Gilbert et al., 2015; Felitti et al., 1998), and significant evidence exists to suggest that sexual minority youth may be at increased risk for sexual, physical, and emotional abuse (Roberts et al., 2010). Early age of drinking onset is associated with alcohol dependence in adulthood (Hingson et al., 2006), and a large body of research has demonstrated disproportionate rates of problematic alcohol use among SMW, including early age of drinking onset (Hughes, 2003; Hughes et al., 2010; Talley et al., 2014; Wilson et al., 2016). Among some SMW, drinking problems may be a response to minority stress or discrimination (Hughes, 2003; Everett et al., 2016). Avoidance of or lack of access to preventive healthcare services including Pap testing may be a measurable consequence of this combination of childhood abuse, early drinking, and subsequent problematic drinking.

Although internalized homonegativity may also be considered a consequence of early adverse experiences related to sexual identity, higher levels of internalized homonegativity were associated with a higher likelihood of receiving Pap testing. This may suggest that the more proximate consequences of internalized homonegativity, such as more sexual partners, riskier sexual encounters, or earlier and more problematic drinking (Berg et al., 2016) may actually promote regular Pap testing.

4.1. Study limitations

This study had several notable limitations. First, CART methods do not identify causal relationships. However, these methods facilitate the generation of new hypotheses. Second, we conducted a secondary data analysis and while the CHLEW study includes many variables likely to be important in predicting Pap testing, our analysis was limited to measures included in the parent study. Additionally, the CHLEW sample is not a random sample and therefore we cannot generalize our findings to all SMW. Specifically, the CHLEW sample is comprised of women who are “out” as sexual minorities and resided in or near Chicago, IL in 2000. Patterns of preventive sexual healthcare usage may be different among SMW living in more rural and other geographic areas and who have not disclosed their minority sexual identity.

Our CART model predicting Pap test use has limited clinical or practical utility. However, findings imply that investigators should continue to examine other factors that may better predict regular cervical cancer screening among SMW. Additionally, our measure of cervical cancer screening does not reflect newer screening guidelines, which extend the length of time between recommended Pap tests, or regular use of Pap testing over time. Recent guideline changes may significantly affect rates of screening among SMW, who may already be less likely to seek regular healthcare. However, using guidelines that were current at the time of interview best reflects guideline-adherent screening. We were also unable to measure patterns of cervical cancer screening over time. The Pap testing outcome in this study reflects screening at one time in participants’ lives. While one incidence of Pap testing can act as a proxy for regular screening, regular and repeated screening is crucial for effectively preventing cervical cancer. Notwithstanding these limitations, our study included age- and race-diverse SMW and a novel analytical method allows for generating nuanced hypotheses about on how early experiences including sexual identity development influence future health and healthcare outcomes can be generated from these findings.

4.2. Recommendations for future study

Future studies should examine Pap test use among SMW longitudinally, and in the context of other life events and health behaviors. This study provides further evidence that early experiences such as childhood abuse, early drinking, and the formation of internalized homonegativity are important in predicting future use of Pap testing. Longitudinal studies can also contribute to understanding causal relationships between life experiences, sexual identity, and healthcare service use among SMW.

Future studies should also gather system- and provider-level data on where and how SMW seek cervical cancer screening. Recent studies of
the general population of women (Plourde et al., 2016) as well as SMW (Reiter and McRee, 2015; Plourde et al., 2016) have shown that providers’ specific recommendation for Pap testing is highly correlated with receiving a Pap test. SMW may seek other kinds of sexual and reproductive healthcare during which Pap testing is discussed less frequently (Agénor et al., 2014a, 2014b; Charlton et al., 2014), and experiences of discrimination and discomfort in healthcare settings can influence SMW’s decisions about seeking preventive care (Li et al., 2015; Macapagal et al., 2016). Importantly, future investigators should recruit samples diverse in race/ethnicity, socioeconomic status, age, and sexual identity to further illuminate how multiple minority identities intersect in SMW’s lives to impact their utilization of preventive healthcare.

5. Conclusions

Our findings demonstrate that intersecting components of individual and structural factors impact cervical cancer screening among SMW. Health insurance status was the variable most explicitly tied to structural inequality in our model, but experiences such as childhood physical abuse, early drinking, and internalized homonegativity also reflect structural influences on individuals’ experiences. Our findings also highlight the significance of early life experiences in shaping patterns of health and preventive healthcare utilization in adulthood.

This study demonstrated the potential value of CART analysis in identifying population subgroups that may be at higher or lower risk of preventive care outcomes. Because CART models and other recursive partitioning strategies are data-driven and do not rely on theoretical explanations of healthcare use, they may help uncover novel predictors of screening outcomes. Ultimately, findings from this study and other studies can help guide the distribution of public health and research resources to population subgroups that are at highest risk of missing cervical cancer screening and other critical preventive health services.

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Conflicts of interest

The authors have no conflicts of interest to report.

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