Cancer Causes & Control (2018) 29:845–854
https://doi.org/10.1007/s10552-018-1060-x

ORIGINAL PAPER

Cancer diagnoses among lesbian, gay, and bisexual adults: results from the 2013–2016 National Health Interview Survey

Gilbert Gonzales[1] · **Ryan Zinone**[2]

Received: 8 January 2018 / Accepted: 17 July 2018 / Published online: 24 July 2018

Abstract

Purpose The objective of this study was to compare cancer diagnoses by age, gender, and sexual orientation.

Methods This study used data on 129,431 heterosexual adults and 3,357 lesbian, gay, and bisexual (LGB) adults in the 2013–2016 National Health Interview Survey. Logistic regression models compared the prevalence of cancer diagnoses by sexual orientation while controlling for demographics, socioeconomic status, and health profiles. Then, using coefficients from fully adjusted models, we estimated average marginal effects to compare the probability of a cancer diagnosis by sexual orientation across five age categories.

Results After controlling for demographic and socioeconomic characteristics, gay men (odds ratio [OR] 1.54; 95% confidence interval [CI] 1.10–2.18) were more likely to have been diagnosed with cancer compared to heterosexual men, and bisexual women (OR 1.70; 95% CI 1.16–2.48) were more likely to have been diagnosed with cancer compared to heterosexual women. Gay men aged 65 years and older were 6.0% points ($p < 0.05$) more likely to be diagnosed with cancer compared to heterosexual men of the same age. Bisexual women aged 65 years and older were 7.6% points ($p < 0.05$) more likely to be diagnosed with cancer compared to women of the same age.

Conclusions Some sexual minorities may be at greater risk for cancer (or having a personal history of cancer) compared to heterosexuals. More research on cancer detection, treatment, and survivorship in sexual minorities is critically needed. Health care providers and public health practitioners should be aware of the unique health care needs in LGB adults, including their elevated cancer risks.

Keywords LGBT health · Cancer disparities · Cancer diagnosis

Introduction

A large body of public health research has documented health disparities for sexual minorities in the United States [1–4]. Lesbian, gay, and bisexual (LGB) adults are more likely to report worse physical and mental health outcomes, disability, and adverse health behaviors (e.g., cigarette smoking and heavy alcohol consumption) compared to heterosexual adults possibly due to "minority stress," which is considered the additional stress associated with being a member of a marginalized minority community [5, 6]. Discriminatory environments stigmatize sexual minorities and engender feelings of rejection, shame, and low self-esteem, which can negatively shape their health-related behaviors and increase their risk for impaired health and chronic disease [7, 8].

Although numerous studies have examined mental health and substance use in sexual minorities, much less research (but a growing body of research) has focused on physical health outcomes and chronic disease, including cancer—the second leading cause of death in the United States [9–14]. The prevalence of cancer may differ for sexual minorities compared to heterosexual populations for several reasons [15–20]. First, LGB adults are more likely to experience barriers to routine medical care, and they are less likely to receive age- and sex-appropriate cancer screenings [3,

✉ Gilbert Gonzales
gilbert.gonzales@vanderbilt.edu

Ryan Zinone
ryan.zinone@vanderbilt.edu

[1] Department of Health Policy, Vanderbilt University School of Medicine, 2525 West End Suite 1200, Nashville, TN 37203, USA

[2] Vanderbilt University School of Medicine, Nashville, TN 37203, USA

21–24]. Forgone cancer screenings can delay early detection and possibly lead to more severe or fatal cancer diagnoses. Second, sexual minorities are more likely to exhibit behavioral risk factors linked to cancer, including tobacco use, heavy alcohol consumption, and—for sexual minority women—nulliparity and obesity [1, 2, 25, 26]. Finally, viral infections from human papillomavirus (HPV) and human immunodeficiency virus (HIV) increase risk for specific cancer types, including cervical, prostate, colorectal, and lymphatic cancers [27, 28]. Some sexual minorities may not receive timely HPV and HIV screenings while others may be at greater risk of contracting HPV and HIV infections [27, 29–31].

Very few studies have directly compared a variety of cancer outcomes—such as cancer incidence and prevalence, cancer treatment, quality of life, and survivorship—by sexual orientation, primarily due to the lack of sexual orientation data collection in cancer surveillance research [15, 32]. Relatedly, very few datasets on adults aged 65 years and older (who are particularly at risk for cancer) have not yet added questions or measurements of sexual orientation [13]. Meanwhile, cancer registries do not collect information on sexual orientation, and until recently, very few population-based health surveys have ascertained sexual orientation. To circumvent these issues, prior studies have *indirectly* compared population-based cancer incidence to area-level densities of sexual minorities. Specifically, Boehmer *et al*. detected associations between the number of same-sex households in a county—used as a proxy for the density of sexual minorities in a county—to elevated incidence and mortality rates of breast cancer (for sexual minority women), lung cancer (for sexual minority men), and colorectal cancer (for both sexual minority men and women) [33–35]. Other research used data on women in cohabiting same-sex relationships in the National Health Interview Survey—assumed to be sexual minority—and found that women in same-sex couples exhibited elevated odds of breast cancer mortality compared to women in different-sex couples [36].

Recent studies have also *directly* compared cancer prevalence (or having a history of cancer) by sexual orientation using samples from state-based healthy surveys. For instance, data from the California Health Interview Survey found that gay men exhibited greater odds of being diagnosed with cancer compared to heterosexual men. Similar findings were not found among sexual minority women [16, 37]. Another study used data from 27 states in the 2014–2015 Behavioral Risk Factor Surveillance System, and found that gay men were significantly ($p < 0.05$) more likely to be diagnosed with cancer compared to heterosexual men, and bisexual women were marginally ($p < 0.10$) more likely to be diagnosed with cancer compared to heterosexual women after controlling for demographic and socioeconomic status [38].

Our study builds on previous research and extends the analysis to all states using representative data in the National Health Interview Survey on cancer diagnoses and sexual orientation. We compare the prevalence of cancer diagnoses (i.e., an indicator of having a personal history of cancer) by gender and sexual orientation, and then we evaluate the relationship between sexual orientation and cancer diagnoses across different age categories. We hypothesize that sexual minorities are more likely to have been diagnosed with cancer compared to heterosexual adults, and differences may vary by gender and sexual orientation due to differences in cancer risks. Previous research has noted important differences in LGB health that vary at the intersections of gender and sexual orientation [1, 2, 4]. Furthermore, we hypothesize that sexual minorities may be at greater risk of cancer diagnoses as they age, as cumulative exposure to minority stress may lead to elevated cancer risks and subsequent diagnoses in later life. This research has far-reaching implications: knowing the specific epidemiology of cancer by age, gender, and sexual orientation can inform best practices for improving cancer-related care, public health campaigns, and cancer prevention services in the United States.

Methods

Data source

This study relied on data from the 2013–2016 National Health Interview Surveys (NHIS), a nationally representative health survey of the civilian, non-institutionalized population. Conducted annually by the National Center for Health Statistics at the Centers for Disease Control and Prevention, the NHIS is one of the most comprehensive resources on the nation's health [39]. The family core questionnaire records basic health and disability information for each household member while a single random adult in each household is selected for a detailed interview on more specific health information that includes medical diagnoses, health behaviors, and access to health care. Our study sample was drawn from the sample adult component in the IPUMS Health Surveys, a harmonized version of the 2013–2016 NHIS [40]. Approximately 75% of the selected households completed the survey, and 81% of selected adults completed the sample adult component [41].

Study sample

Beginning in 2013, a question regarding sexual orientation was added to the sample adult component of the NHIS [35]. Respondents aged 18 years and older were asked which of the following categories best represents how they thought of themselves: lesbian or gay; straight, that is, not gay; bisexual;

something else; I don't know the answer; or refuse. We classified respondents as lesbian ($n=1{,}029$), gay ($n=1{,}213$), bisexual ($n=1{,}115$), and heterosexual ($n=129{,}431$). All analyses were stratified separately for men and women, and we excluded respondents that indicated their sexual orientation as something else ($n=389$), did not know the answer ($n=798$) or refused to answer ($n=808$), as well as respondents missing information on cancer diagnoses ($n=114$). Initial quality assessments conducted by the National Center for Health Statistics found minimal classification error among adults indicating their sexual orientation as something else or did not know the answer, but item non-response (i.e., "refused to answer") was higher among older respondents, respondents with lower levels of education, respondents residing in rural areas, and respondents not completing the survey in English [42].

Statistical analysis

We used descriptive statistics to characterize the study sample by gender and sexual orientation. Pearson Chi square tests were used to compare demographic and socioeconomic characteristics across sexual orientation categories. Then, we estimated the prevalence of cancer diagnoses by gender and sexual orientation. Cancer diagnoses were based on affirmative responses when respondents were asked whether they have ever been told by a doctor or other health professional that they had "cancer or a malignancy of any kind." Next, logistic regression models were used to compare the prevalence of cancer diagnoses. In a series of logistic regression models, we incrementally included additional covariates to determine how the addition of possible confounders (age, race/ethnicity, relationship status, the presence of children in the household, educational attainment, family income relative to poverty, and employment status) and potential mediators (health insurance status, a recent doctor's office visit, body weight, smoking status, and heavy drinking) affected differences in receiving a cancer diagnosis by sexual orientation (final models also included region and year fixed effects without changing the main results) [43–47]. Model 1 did not include any covariates. Model 2 controlled for age and race/ethnicity. Model 3 added covariates for relationship status and the presence of minor children in the households. Model 4 added covariates representing socioeconomic status, including educational attainment, family income relative to poverty, and employment status. Model 5 added covariates representing health profiles that are related to receiving a cancer diagnosis, including health insurance status (if multiple sources of health insurance were reported for an observation, we assigned primary source of coverage in the following order: public, private, and uninsured), having a visit to a provider's office in the previous 12 months, body weight relative to body mass index (BMI), smoking status, and episodes of heavy drinking days (defined as having 5 or more drinks for men and 4 or more drinks for women in one day) [48] in the previous 12 months. Model 6 added covariates for US Census region and survey year. Finally, we used the coefficients from the fully adjusted logistic regression models (Model 6) to estimate average marginal effects of a cancer diagnosis for lesbian, gay, and bisexual adults (compared to a heterosexual adults) across five different age categories (18–25, 26–34, 35–49, 50–64, ≥ 65 years). Results from the logistic regression models are presented as adjusted odds ratios (ORs) with 95% confidence intervals (CIs). Marginal effects are presented in percentage point changes with 95% confidence intervals which indicate the difference in the probability of receiving a cancer diagnosis for each sexual orientation compared to the comparison group (heterosexuals) [49]. We conducted all analyses separately for men and women in Stata version 14 using survey weights and the *svy* command to adjust standard errors for the complex survey design of the NHIS and to generate nationally representative estimates. The *margins* command in Stata was used to estimate average marginal effects with survey weights.

Results

Sociodemographic and health characteristics by sexual orientation

Table 1 presents demographic and socioeconomic characteristics of the U.S. adult population by gender and sexual orientation. Approximately 2.4% of the U.S. adult population identified as lesbian, gay, or bisexual in the NHIS. Compared to heterosexual men, gay, and bisexual men were more likely to be younger, less likely to be married or living with a partner, and less likely to have a child in the household. Gay men reported higher levels of educational attainment and relatively similar levels of employment and poverty compared to heterosexual men. Bisexual men were less likely to work full-time and nearly twice as likely to have family incomes below the federal poverty level compared to heterosexual or gay men. Bisexual men were most likely to be uninsured; gay men were most likely to have an office visit in the prior 12 months compared to heterosexual or bisexual men; and gay and bisexual men were more likely to be current smokers and report a heavy drinking day in the prior 12 months compared to heterosexual men.

Compared to heterosexual women, lesbian and bisexual women were younger, less likely to be married or living with a partner, and less likely to have a child in the household. Lesbian women were more likely to have a college degree but similar levels of poverty compared to heterosexual women. Bisexual women were more likely to have family incomes below the poverty threshold compared to

Table 1 Characteristics of U.S. adults, by gender and sexual orientation ($n = 132{,}788$)

	Men				Women			
	Heterosexual	Gay	Bisexual	*p* Value	Heterosexual	Lesbian	Bisexual	*p* Value
Unweighted sample size (wt%)	58,087 (97.7)	1,213 (1.8)	335 (0.5)	< 0.001	71,344 (97.5)	1,029 (1.4)	780 (1.1)	< 0.001
Age (years)								
18–25	6,643 (14.7)	160 (19.1)	84 (31.9)	< 0.001	7,001 (13.2)	155 (18.2)	241 (37.6)	< 0.001
26–34	8,925 (16.0)	216 (17.5)	66 (17.1)		10,921 (15.5)	197 (18.8)	244 (29.3)	
35–49	13,989 (25.6)	353 (29.7)	68 (20.8)		16,512 (24.9)	270 (25.9)	174 (20.2)	
50–64	15,354 (26.0)	344 (24.5)	74 (19.6)		18,001 (25.8)	287 (28.2)	82 (9.5)	
65+	13,176 (17.7)	140 (9.2)	43 (10.7)		18,909 (20.7)	120 (8.8)	39 (3.5)	
Race/ethnicity								
Non-Hispanic white	38,189 (66.5)	827 (68.1)	227 (64.9)	0.33	44,828 (65.6)	655 (64.4)	528 (69.0)	0.32
Non-Hispanic black	6,831 (11.0)	134 (12.6)	33 (9.0)		10,349 (12.6)	177 (15.2)	110 (12.1)	
Hispanic	8,877 (16.0)	185 (15.0)	49 (18.9)		11,231 (14.9)	144 (15.2)	102 (12.8)	
Non-Hispanic other	4,190 (6.5)	67 (4.3)	26 (7.1)		4,936 (6.9)	53 (5.2)	40 (6.2)	
Relationship status								
Married or living with a partner	28,323 (57.0)	179 (19.4)	50 (16.8)	< 0.001	29,908 (51.8)	217 (24.9)	145 (23.2)	< 0.001
Separated/divorced/widowed	13,044 (14.8)	134 (9.5)	72 (19.7)		24,519 (24.4)	188 (15.4)	197 (17.9)	
Never married	16,625 (28.0)	892 (70.5)	213 (63.5)		16,748 (23.7)	620 (59.6)	434 (58.5)	
Missing data	95 (0.1)	8 (0.6)	0 (0.0)		169 (0.2)	4 (0.2)	4 (0.5)	
Child < 18 years in household	15,204 (33.3)	71 (10.7)	46 (24.4)	< 0.001	23,655 (37.7)	221 (26.5)	275 (35.7)	< 0.001
Educational attainment								
Less than high school	8,276 (13.4)	71 (5.9)	35 (15.7)	< 0.001	9,988 (12.4)	90 (8.1)	84 (12.8)	< 0.001
High school graduate	15,361 (26.4)	206 (18.5)	54 (18.5)		17,677 (24.6)	194 (19.2)	162 (21.3)	
Some college	17,129 (29.5)	361 (32.6)	131 (34.2)		22,846 (31.9)	335 (31.9)	299 (37.3)	
≥Bachelor's degree	17,102 (30.3)	574 (42.8)	115 (31.6)		20,557 (30.6)	409 (40.8)	234 (28.5)	
Missing data	219 (0.5)	1 (0.2)	0 (0.0)		276 (0.4)	1 (0.0)	1 (0.1)	
Family income relative to poverty								
At or above poverty threshold	47,383 (84.1)	1,025 (86.3)	245 (77.8)	0.001	54,634 (80.2)	820 (83.6)	503 (69.6)	< 0.001
Below poverty threshold	7,670 (10.5)	157 (11.1)	79 (18.5)		12,364 (13.5)	177 (13.4)	250 (26.0)	
Missing data	3,034 (5.4)	31 (2.6)	11 (3.7)		4,364 (6.3)	32 (2.9)	27 (4.4)	
Employment status								
Full-time	30,582 (55.5)	664 (53.8)	151 (40.5)	< 0.001	26,097 (38.1)	525 (52.6)	308 (36.7)	< 0.001
Part-time	6,066 (10.9)	174 (14.1)	52 (14.5)		10,715 (16.2)	152 (15.0)	173 (22.8)	
Unemployed	2,537 (4.9)	63 (5.0)	29 (11.4)		2,687 (3.9)	63 (6.0)	77 (12.4)	
Not in labor force	18,318 (27.7)	298 (25.0)	101 (33.1)		31,190 (40.7)	280 (26.0)	210 (26.9)	
Missing data	625 (1.1)	15 (2.1)	2 (0.5)		655 (1.1)	9 (0.5)	12 (1.3)	
Health insurance status								
Private	29,349 (55.5)	753 (64.4)	189 (55.0)	< 0.001	32,892 (52.6)	586 (60.4)	395 (55.3)	< 0.001
Public	20,336 (30.1)	301 (22.4)	100 (26.5)		30,525 (36.3)	317 (26.5)	263 (29.6)	
Uninsured	8,160 (13.9)	153 (12.3)	42 (16.7)		7,680 (10.7)	120 (12.7)	118 (14.7)	
Missing data	242 (0.6)	6 (0.8)	4 (1.8)		247 (0.5)	6 (0.5)	4 (0.4)	
Office visit in prior 12 months								
Yes	44,961 (77.2)	1,017 (83.4)	262 (77.6)	0.01	63,574 (88.9)	877 (84.5)	696 (88.5)	0.01
No	13,010 (22.6)	194 (16.3)	73 (22.4)		7,657 (10.9)	150 (15.4)	83 (11.3)	
Missing data	116 (0.2)	2 (0.4)	0 (0.0)		113 (0.2)	2 (0.1)	1 (0.2)	

heterosexual or lesbian women. Full-time employment was highest among lesbian women. Compared to heterosexual women, lesbian and bisexual women were more likely to report uninsurance. Lesbian women were most likely to have no office visit in the prior 12 months, and lesbian and bisexual women were more likely to be obese, current smokers, and report a heavy drinking day in the prior 12 months compared to heterosexual women.

Table 1 (continued)

	Men				Women			
	Heterosexual	Gay	Bisexual	*p* Value	Heterosexual	Lesbian	Bisexual	*p* Value
Body weight								
Underweight	530 (1.0)	25 (3.2)	10 (3.4)	< 0.001	1,775 (2.5)	18 (1.7)	16 (2.3)	< 0.001
Normal or healthy weight	16,276 (28.0)	464 (38.3)	115 (33.6)		26,106 (37.9)	340 (34.1)	281 (35.0)	
Overweight	23,792 (40.5)	439 (34.2)	104 (31.5)		19,700 (27.3)	272 (25.0)	181 (23.1)	
Obese	16,956 (29.6)	279 (24.0)	105 (31.3)		20,789 (27.8)	376 (36.8)	285 (37.4)	
Missing data	533 (0.9)	6 (0.4)	1 (0.2)		2,974 (4.5)	23 (2.4)	17 (2.2)	
Smoking status								
Never smoked	30,970 (56.1)	634 (54.1)	171 (56.1)	0.003	46,557 (67.0)	526 (53.5)	406 (59.1)	< 0.001
Former smoker	15,926 (25.6)	289 (22.4)	74 (19.3)		14,144 (18.8)	248 (25.0)	163 (18.1)	
Current smoker	11,120 (18.2)	287 (23.3)	90 (24.7)		10,547 (14.1)	254 (21.4)	211 (22.8)	
Missing data	71 (0.1)	3 (0.2)	0 (0.0)		96 (0.1)	1 (0.0)	0 (0.0)	
Any heavy drinking day in prior 12 months								
Yes	17,553 (30.7)	441 (37.0)	140 (45.9)	0.004	11,724 (17.1)	321 (29.1)	342 (40.1)	< 0.001
No	39,333 (67.2)	752 (60.9)	189 (53.2)		58,725 (81.6)	692 (69.1)	422 (58.1)	
Missing data	1,201 (2.1)	20 (2.1)	6 (0.9)		895 (1.3)	16 (1.8)	16 (1.8)	

Data are from the 2013–2016 National Health Interview Surveys, adults 18 or older

Differences in cancer diagnoses by gender and sexual orientation

Table 2 presents the prevalence of cancer diagnoses by sexual orientation for men as well as the results from logistic regression models. Approximately 8.0% of heterosexual men, 8.6% of gay men, and 5.1% of bisexual men have been diagnosed with any cancer in their lifetime. These unadjusted differences were not statistically different, as indicated by the unadjusted odds ratios (ORs) in Model 1 (OR 1.08; 95% CI 0.82–1.43 for gay men and OR 0.62; 95% CI 0.28–1.37 for bisexual men). After controlling for age and race/ethnicity in Model 2, however, gay men (OR 1.59; 95% CI 1.14–2.21) were more likely to be diagnosed with cancer compared to heterosexual men. There were no differences between heterosexual men and

Table 2 Cancer diagnosis prevalence and logistic regression analysis of men by sexual orientation ($n = 59{,}635$)

	Cancer diagnosis	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
	Prevalence (%)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)
Sexual orientation							
Heterosexual ($n = 58{,}087$)	8.0	1.00 [Reference]	1.00 [Reference]	1.00 [Reference]	1.00 [Reference]	1.00 [Reference]	1.00 [Reference]
Gay ($n = 1{,}213$)	8.6	1.08 (0.82–1.43)	1.59 (1.14–2.21)**	1.75 (1.25–2.45)**	1.68 (1.19–2.35)**	1.56 (1.11–2.20)**	1.54 (1.10–2.18)**
Bisexual ($n = 335$)	5.1	0.62 (0.28–1.37)	0.94 (0.43–2.05)	1.06 (0.47–2.40)	0.95 (0.42–2.16)	0.95 (0.42–2.14)	0.96 (0.42–2.19)

Data are from the 2013–2016 National Health Interview Survey, adults aged 18 years and older. Adjusted odds ratios control for the covariates listed in the table. Model 1 did not include any covariates. Model 2 controlled for age and race/ethnicity. Model 3 controlled for age, race/ethnicity, relationship status, and children < 18 years in the household. Model 4 controlled for age, race/ethnicity, relationship status, and children < 18 years in the household, educational attainment, family income relative to poverty, and employment status. Model 5 controlled for age, race/ethnicity, relationship status, and children < 18 years in the household, educational attainment, family income relative to poverty, employment status, health insurance status, no office visit in the prior 12 months, unmet medical care due to cost, body weight, smoking status, and heavy drinking. Model 6 controlled for age, race/ethnicity, relationship status, and children < 18 years in the household, educational attainment, family income relative to poverty, employment status, health insurance status, no office visit in the prior 12 months, unmet medical care due to cost, body weight, smoking status, heavy drinking, US Census region, and survey year. Indicators were included when data were missing for all covariates in order to maintain a robust sample size

OR odds ratio

$^{**}p < 0.05$

bisexual men (OR 0.94; 95% CI 0.43–2.05) in reporting a cancer diagnosis after adjusting for age and race/ethnicity. These patterns remained consistent after adding additional covariates in Models 3–6. After controlling for demographic characteristics, socioeconomic status, and health profiles in a fully adjusted model (Model 6), gay men (OR 1.54; 95% CI 1.10–2.18) reported increased odds of a cancer diagnosis compared to heterosexual men. Odds of a cancer diagnosis between bisexual men (OR 0.96; 95% CI 0.42–2.19) and heterosexual men were not statistically significant.

Table 3 presents the prevalence of cancer diagnoses by sexual orientation and logistic regression results for women. Approximately 9.6% of heterosexual women, 8.9% of lesbian women, and 7.2% of bisexual women have been diagnosed with any type of cancer in their lifetimes. The unadjusted odds ratios in Model 1 indicate similarities in the prevalence of cancer diagnoses between heterosexual women and lesbians (OR 0.93; 95% CI 0.72–1.19) and bisexual women (OR 0.74; 95% CI 0.52–1.04). After controlling for age and race/ethnicity in Model 2, bisexual women (OR 1.86; 95% CI 1.28–2.68) were more likely to report receiving a cancer diagnosis compared to heterosexual women. The adjusted differences between heterosexual women and lesbian women (OR 1.21; 95% CI 0.93–1.58) were not statistically significant. Findings were similar after including additional covariates in Models 3–6: bisexual women (OR 1.70; 95% CI 1.16–2.48) were more likely to be diagnosed with cancer compared to heterosexual women in a fully adjusted model (Model 6).

Cancer diagnoses by sexual orientation and age

We used coefficients from the fully adjusted logistic regression models (Model 6 in Tables 2, 3) to estimate the average marginal effects (presented in percentage point changes) of each sexual orientation (compared to heterosexual) on the probably of a cancer diagnoses by age category. Figure 1 illustrates the change in the probability of a cancer diagnosis for gay and bisexual men relative to heterosexual men by age category. There are no differences in the likelihood of a cancer diagnosis between younger (18–25 years) gay and heterosexual men. As gay men age, their predicted probability of a cancer diagnosis increases relative to heterosexual men, which ranged from a 0.7% point (95% CI 0.01–1.5 pp) increase for gay men aged 26–34 years to a 6.0% point (95% CI 0.7–11.2 pp) increase for gay men aged 65 years and older. Meanwhile, the average marginal effects for bisexual men indicated no differences in likelihood of a cancer diagnosis across different age categories.

Figure 2 illustrates the changes in the probability of a cancer diagnosis for lesbian and bisexual women relative to heterosexual women by age category. Compared to heterosexual women, lesbian women were not more likely to receive a cancer diagnosis in any age category after controlling for sociodemographic characteristics. Bisexual women in every age category, however, were more likely to receive a cancer diagnosis compared to heterosexual women of the same age. Younger bisexual women (18–25 years) were 0.8% points (95% CI 0.05–1.5 pp) more likely to have a cancer diagnosis, and this likelihood increased as bisexual

Table 3 Cancer diagnosis prevalence and logistic regression analysis of women by sexual orientation ($n = 73{,}153$)

	Cancer Diagnosis	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
	Prevalence (%)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)
Sexual orientation							
Heterosexual ($n = 71{,}344$)	9.6	Reference	Reference	Reference	Reference	Reference	Reference
Lesbian ($n = 1{,}029$)	8.9	0.93 (0.72–1.19)	1.21 (0.93–1.58)	1.21 (0.92–1.59)	1.22 (0.93–1.60)	1.17 (0.89–1.54)	1.18 (0.90–1.55)
Bisexual ($n = 780$)	7.2	0.74 (0.52–1.04)	1.86 (1.28–2.68)**	1.81 (1.25–2.62)**	1.80 (1.24–2.61)**	1.72 (1.18–2.51)**	1.70 (1.16–2.48)**

Data are from the 2013–2016 National Health Interview Survey, adults aged 18 years and older. Adjusted odds ratios control for the covariates listed in the table. Model 1 did not include any covariates. Model 2 controlled for age and race/ethnicity. Model 3 controlled for age, race/ethnicity, relationship status, and children < 18 years in the household. Model 4 controlled for age, race/ethnicity, relationship status, and children < 18 years in the household, educational attainment, family income relative to poverty, and employment status. Model 5 controlled for age, race/ethnicity, relationship status, and children < 18 years in the household, educational attainment, family income relative to poverty, employment status, health insurance status, no office visit in the prior 12 months, unmet medical care due to cost, body weight, smoking status, and heavy drinking. Model 6 controlled for age, race/ethnicity, relationship status, and children < 18 years in the household, educational attainment, family income relative to poverty, employment status, health insurance status, no office visit in the prior 12 months, unmet medical care due to cost, body weight, smoking status, heavy drinking, US Census region, and survey year. Indicators were included when data were missing for all covariates in order to maintain a robust sample size

OR odds ratio

**$p < 0.05$

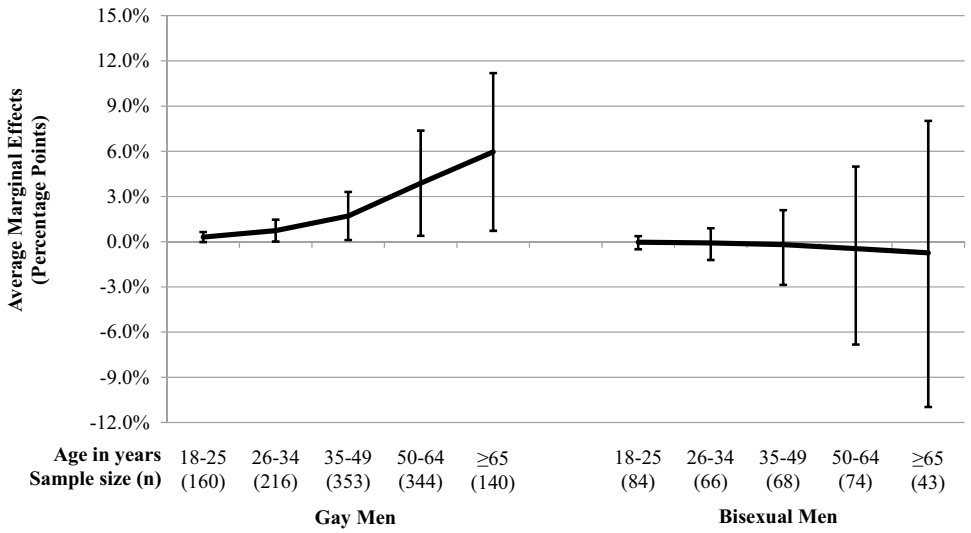

Fig. 1 Changes in the Probability of **a** cancer diagnosis by sexual orientation and age category, compared to heterosexual men. Data are from the 2013–2016 National Health Interview Survey, adults aged 18 years and older. Average marginal effects indicate the change in the probability of receiving a cancer diagnoses compared to the comparison group (heterosexual men). Average marginal effects were obtained from logistic regression models controlling for age, race/ethnicity, relationship status, the presence of a minor child in the household, educational attainment, family income relative to the federal poverty guidelines (FPG), employment status, primary source of health insurance, having a visit to a provider's office in the previous 12 months, body weight, smoking status, heavy drinking days in the previous 12 months, US Census region, and survey year

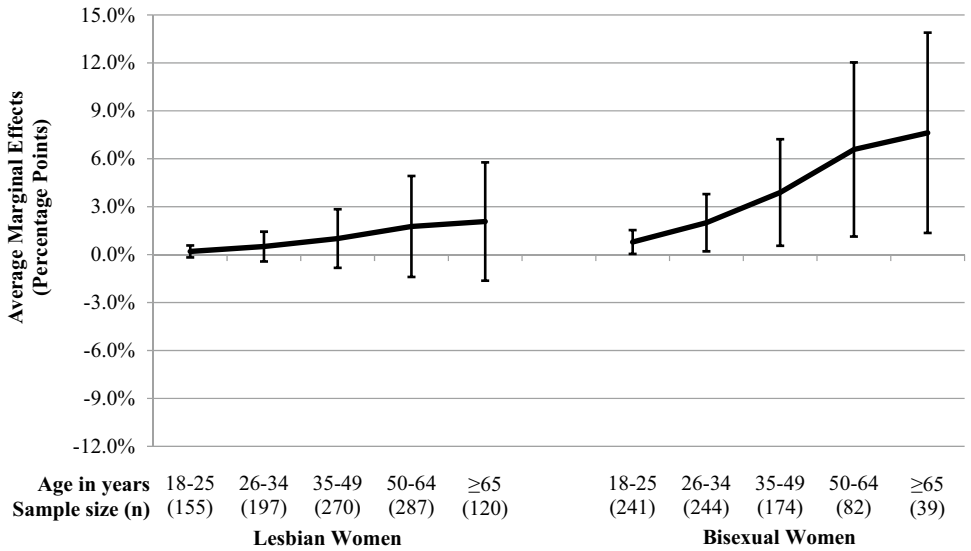

Fig. 2 Changes in the probability of a cancer diagnosis by sexual orientation and age category, compared to heterosexual women. Data are from the 2013–2016 National Health Interview Survey, adults aged 18 years and older. Average marginal effects indicate the change in the probability of receiving a cancer diagnoses compared to the comparison group (heterosexual men). Average marginal effects were obtained from logistic regression models controlling for age, race/ethnicity, relationship status, the presence of a minor child in the household, educational attainment, family income relative to the federal poverty guidelines (FPG), employment status, primary source of health insurance, having a visit to a provider's office in the previous 12 months, body weight, smoking status, heavy drinking days in the previous 12 months, US Census region, and survey year

women aged. Compared to heterosexual women, bisexual women between aged 26–34, 35–49, 50–64, and ≥ 65 years were 2.0 (95% CI 0.2–3.8 pp), 3.9 (95% CI 0.5–7.2 pp), 6.6 (95% CI 1.1–12.0 pp), and 7.6 (95% CI 1.4–13.9 pp) percentage points more likely to receive a cancer diagnosis, respectively.

Discussion

Previous studies have suggested that the prevalence of cancer, or at least having a personal history of cancer, may be higher for some sexual minorities compared to heterosexuals given their greater exposure to cancer risk factors [16, 36–38]. Unfortunately, limited data collection on sexual orientation has prevented research on cancer-related diagnoses, treatment, and survivorship in sexual minorities. We used data from the 2013–2016 NHIS to compare the odds of being diagnosed with cancer by sexual orientation, gender, and age. Consistent with prior population-based research [38], we found gay men were more likely to have been diagnosed with cancer compared to heterosexual men, and bisexual women were more likely to have been diagnosed with cancer compared to heterosexual women after controlling for sociodemographic characteristics. Moreover, we found evidence that the likelihood of a cancer diagnosis increases by age for both gay men and bisexual women relative to their heterosexual peers of the same age. Interestingly, we did not find bisexual men or lesbian women were more likely to report a cancer diagnosis compared to their heterosexual counterparts. This may be due to small sample sizes, the lack of adequate cancer screenings in these populations, or the skewed age distribution of the sexual minority sample (nearly 90% of the sexual minority sample was under 65 years of age, which is approximately the median age [66 years] of cancer patients at first diagnosis) [50]. Much more research should continue to explore whether and why some sexual minorities may be more likely to be told they have cancer compared to heterosexual populations. As more data are collected, other research should study specific cancer types as well as possible differences in cancer treatment, prognosis, and survivorship by sexual orientation.

Limitations

There were numerous limitations to using the NHIS for this study, including relatively small sample sizes for sexual minorities. All responses to the NHIS were self-reported, which can lead to response and recall bias when describing sociodemographic characteristics and cancer diagnoses. For instance, we relied on self-reports of cancer diagnoses rather than cancer information collected in medical records or cancer registries. Some types of cancer may be underreported in health surveys [51, 52], while other cancers may be undiagnosed and unknown to the respondent [53]. Meanwhile, reporting sexual orientation may suffer from selection bias. Lesbian and bisexual women, for instance, may be more likely than gay and bisexual men to disclose their sexual orientation [54]. Ascertaining sexual orientation during in-person interviews with NHIS surveyors may also discourage respondents from reporting accurate sexual orientations, especially among older age groups, rural populations, non-English speakers, and racial and ethnic minorities [55]. The cancer burden may be higher than what we estimated here to the extent that older sexual minorities or sexual minorities from disadvantaged backgrounds were missing from the sample.

Our study would have benefited from additional information missing in the NHIS. For example, transgender status or gender identity was not ascertained. Transgender individuals are often not identified in federally sponsored health surveys. Given this group's high risk of experiencing worse health outcomes and health behaviors, the NHIS should continue its work to incorporate gender identity in future surveys [56]. We were also missing data on important cancer risk factors, including nulliparity and histories of HPV in women and data on HIV or seropositivity in men. Our study also excludes other dimensions of sexual orientation, including same-sex attractions or sexual behaviors. We were unable to describe cancer diagnoses in sexual minorities who do not personally identify as lesbian, gay, or bisexual. While some evidence suggests that measuring single dimensions of sexual orientation may be sufficient for epidemiological studies [14], some individuals not identifying as LGB but engaging in same-sex sexual behaviors may be at risk for HPV and HIV-associated cancers. Our study may be underestimating the prevalence of cancer diagnoses for sexual minorities if the NHIS disproportionately excludes individuals engaging in same-sex sexual behaviors and not identifying as LGB. As more data are collected, future research should continue to study cancer prevalence in different subgroups of the sexual minority population, including the prevalence of cancer at the intersections of sexual orientation, gender, race, ethnicity, geography, and social class.

Future research should also explore other cancer-related outcomes for sexual minorities, including cancer incidence, age at cancer diagnosis, and mortality. Unfortunately, cancer registries, such as the National Cancer Institute's (NCI) Surveillance, Epidemiology, and End Results (SEER) Program, do not routinely collect sexual orientation [32]. The SEER Program maintains cancer incidence, survival data, patient demographics (e.g. age, race, ethnicity, and geography), stage of diagnosis, and first course of treatment from state-based cancer registries. The SEER Program should follow the lead of national health surveys and begin to identify ways to capture sexual orientation from medical records and cancer registries when possible. For instance, cancer registrars could collect information on sexual orientation in follow-up interviews with participants and/or their families to better understand sexuality and family relationships. For example, marital status and the gender of the spouse or partner could

be collected by registry surveyors—which would provide information on a subset of LGB cancer survivors in same-sex relationships. Nevertheless, recent progress towards adding sexual orientation and gender identity to electronic health records will facilitate more cancer research in sexual minority populations [57].

Conclusions

Knowing the epidemiology of cancer and cancer risk factors by sexual orientation, gender, and age can inform intervention strategies for public health practitioners and health care providers. For instance, public health campaigns should continue to target health behaviors that expose sexual minorities to cancer risks, including tobacco use, heavy alcohol consumption, and obesity. A multifaceted approach may be needed to address cancer risks and may include community-level interventions specific to the LGB population; insurance-level incentives to modify health behaviors (e.g. wellness and health promotion programs); and policy-level measures that target stress-inducing discrimination and stigma (e.g. nondiscrimination protections in employment, health care, and education). Other approaches may consider monitoring cancer screening rates or cancer prevalence alongside advances in sexual orientation data collection. Health facilities, community-based organizations, and public health departments, for instance, should consider setting goals for cancer screenings (or other cancer-related metrics) for sexual minorities and identify strategies for achieving those goals at the state or local level. For instance, LGBT-serving community organizations should consider working collaboratively with local non-profit hospitals to identify gaps in cancer screenings for sexual minorities using electronic health records. Identifying baseline data and setting benchmarks for sexual minorities in community health needs assessments (a federal requirement for non-profit hospitals) [58] could help advance equity in cancer care for LGB people.

Finally, health care providers will play an important role in preventing, detecting, and treating cancer in sexual minority populations. Providers should be aware and mindful of the unique health care needs in LGB adults, including their elevated cancer risks. Primary care providers must create welcoming and safe environments, build trust with their LGB patients, and encourage routine cancer screenings recommended by the American Cancer Society and the U.S. Preventive Services Task Force. Additionally, oncologists should further enhance the cancer care continuum with culturally-sensitive services and tailored support programs for sexual minority patients [59]. Building a culture of acceptance across our medical system will help advance national priorities for achieving health equity for all populations, including lesbian, gay, and bisexual Americans.

References

1. Institute of Medicine (2011) The health of lesbian, gay, bisexual, and transgender people: building a foundation for better understanding. The National Academies Press, Washington, DC
2. Gonzales G, Przedworski J, Henning-Smith C (2016) Comparison of health and health risk factors between lesbian, gay, and bisexual adults and heterosexual adults in the United States. JAMA Intern Med 176(9):1344–1351
3. Blosnich JR, Farmer GW, Lee JGL, Silenzio VMB, Bowen DJ (2014) Health inequalities among sexual minority adults. Am J Prev Med 46(4):337–349
4. Conron KJ, Mimiaga MJ, Landers SJ (2010) A population-based study of sexual orientation identity and gender differences in adult health. Am J Public Health 100(10):1953–1960
5. Meyer IH (1995) Minority stress and mental health in gay men. J Health Soc Behav 36(1):38–56
6. Meyer IH (2003) Prejudice, social stress, and mental health in lesbian, gay, and bisexual populations: conceptual issues and research evidence. Psychol Bull 129(5):674–697
7. Hatzenbuehler ML (2009) How does sexual minority stigma "get under the skin"? A psychological mediation framework. Psychol Bull 135(5):707–730
8. Lick DJ, Durso LE, Johnson KL (2013) Minority stress and physical health among sexual minorities. Perspect Psychol Sci 8(5):521–548
9. Boehmer U (2002) Twenty years of public health research: inclusion of lesbian, gay, bisexual, and transgender populations. Am J Public Health 92(7):1125–1130
10. Coulter RWS, Kenst KS, Bowen DJ (2014) Scout. Research funded by the National Institutes of Health on the health of lesbian, gay, bisexual, and transgender populations. Am J Public Health 104(2):105–112
11. Heron M. Deaths (2016) Leading causes for 2014. Natl Vital Stat Rep 65(5):1–95
12. Eliason MJ (2014) Chronic physical health problems in sexual minority women: review of the literature. LGBT Health 1(4):259–268
13. Patterson JG, Jabson JM, Bowen DJ (2017) Measuring sexual and gender minority populations in health surveillance. LGBT Health 4(2):82–105
14. Patterson JG, Jabson JM (2017) Sexual orientation measurement and chronic disease disparities: National Health and Nutrition Examination Survey, 2009–2014. Ann Epidemiol 28(2):72–85
15. Boehmer U, Elk R (2015) Cancer and the LGBT Community: unique perspectives from risk to survivorship. Springer, New York
16. Boehmer U, Miao X, Ozonoff A (2011) Cancer survivorship and sexual orientation. Cancer 117(16):3796–3804
17. Quinn GP, Sanchez JA, Sutton SK et al (2015) Cancer and lesbian, gay, bisexual, transgender transsexual, and queer/questioning (LGBTQ) populations. CA Cancer J Clin 65(5):384–400
18. Burkhalter JE, Margolies L, Sigurdsson HO et al (2016) The National LGBT Cancer Action Plan: a white paper of the 2014 National Summit on Cancer in the LGBT Communities. LGBT Health 3(1):19–31
19. Massetti GM, Ragan KR, Thomas CC, Ryerson AB (2016) Public health opportunities for promoting health equity in cancer prevention and control in LGBT populations. LGBT Health 3(1):11–14

20. Margolies L, Brown CG (2017) Current state of knowledge about cancer in lesbians, gay, bisexual, and transgender (LGBT) people. Semin Oncol Nurs 34(1):3–11
21. Bazzi AR, Whorms DS, King DS, Potter J (2015) Adherence to mammography screening guidelines among transgender persons and sexual minority women. Am J Public Health 105(11):2356–2358
22. Fredriksen-Goldsen KI, Kim H-J, Barkan SE, Muraco A, Hoy-Ellis CP (2013) Health disparities among lesbian, gay, and bisexual older adults: results from a population-based study. Am J Public Health 103(10):1802–1809
23. Cochran SD, Mays VM, Bowen D et al (2001) Cancer-related risk indicators and preventive screening behaviors among lesbians and bisexual women. Am J Public Health 91(4):591–597
24. Buchmueller T, Carpenter CS (2010) Disparities in health insurance coverage, access, and outcomes for individuals in same-sex versus different-sex relationships, 2000–2007. Am J Public Health 100(3):489–495
25. Boehmer U, Bowen DJ, Bauer GR (2007) Overweight and obesity in sexual-minority women: Evidence from population-based data. Am J Public Health 97(6):1134–1140
26. Meads C, Moore D (2013) Breast cancer in lesbians and bisexual women: systematic review of incidence, prevalence and risk studies. BMC Public Health 13:1127
27. Marrazzo JM, Koutsky L, Stine KL et al (2000) Genital human papillomavirus infection in women who have sex with women. Am J Obstet Gynecol 183(3):770–774
28. Rosser BRS, Merengwa E, Capistrant BD et al (2016) Prostate cancer in gay, bisexual, and other men who have sex with men: a review. LGBT Health 3(1):32–41
29. Machalek DA, Poynten M, Jin F et al (2012) Anal human papillomavirus infection and associated neoplastic lesions in men who have sex with men: a systematic review and meta-analysis. Lancet Oncol 13(5):487–500
30. Charlton BM, Corliss HL, Missmer SA et al (2011) Reproductive health screening disparities and sexual orientation in a cohort study of U.S. adolescent and young adult females. J Adolesc Health 49(5):505–510
31. Boehmer U, Cooley TP, Clark MA (2012) Cancer and men who have sex with men: a systematic review. Lancet Oncol 13(12):e545–e553
32. Bowen DJ, Boehmer U (2007) The lack of cancer surveillance data on sexual minorities and strategies for change. Cancer Causes Control 18(4):343–349
33. Boehmer U, Ozonoff A, Miao X (2011) An ecological analysis of colorectal cancer incidence and mortality: differences by sexual orientation. BMC Cancer 11(1):400
34. Boehmer U, Miao X, Maxwell NI, Ozonoff A (2014) Sexual minority population density and incidence of lung, colorectal and female breast cancer in California. BMJ Open 4(3):1–7
35. Boehmer U, Ozonoff A, Miao X (2012) An ecological approach to examine lung cancer disparities due to sexual orientation. Public Health 126(7):605–612
36. Cochran SD, Mays VM (2012) Risk of breast cancer mortality among women cohabiting with same sex partners: findings from the National Health Interview Survey, 1997–2003. J Women's Health 21(5):528–533
37. Mansh M, Katz KA, Linos E, Chren M-M, Arron S (2015) Association of skin cancer and indoor tanning in sexual minority men and women. JAMA Dermatol 94115(12):1
38. Gonzales G, Henning-Smith C (2017) Health disparities by sexual orientation: results and implications from the Behavioral Risk Factor Surveillance System. J Community Health 42(6):1163–1172
39. National Center for Health Statistics (2017) Health, United States, 2016: with chartbook on long-term trends in health. National Center for Health Statistics, Hyattsville
40. Blewett LA, Drew JAR, Griffin R, King ML, Williams KCW, IPUMS Health Surveys (2016) National Health Interview Survey, version 6.2. University of Minnesota, Minneapolis
41. National Center for Health Statistics (2016) National Health Interview Survey: survey description. National Center for Health Statistics, Hyattsville
42. Ward BW, Dahlhamer JM, Galinsky AM, Joestl SS (2014) Sexual orientation and health among U.S. adults: National Health Interview Survey, 2013. Natl Health Stat Report 2(77):1–12
43. Brenes GA, Paskett ED (2000) Predictors of stage of adoption for colorectal cancer screening. Prev Med 31(4):410–416
44. Tucker CM, Wippold GM, Guastello AD et al (2016) Predictors of cancer screening among culturally diverse men. Am J Men's Health 12(4):837–843
45. Selvin E, Brett KM (2003) Breast and cervical cancer screening: sociodemographic predictors among White, Black, and Hispanic women. Am J Public Health 93(4):618–623
46. Beydoun HA, Beydoun MA (2008) Predictors of colorectal cancer screening behaviors among average-risk older adults in the United States. Cancer Causes Control 19(4):339–359
47. Ioannou GN, Chapko MK, Dominitz JA (2003) Predictors of colorectal cancer screening participation in the United States. Am J Gastroenterol 98(9):2082–2091
48. Ward BW, Clarke TC, Nugent CN, Schiller JS (2016) Early release of selected estimates based on data from the 2015 National Health Interview Survey. National Center for Health Statistics, Bethesda
49. Williams R (2016) Using Stata's margins command to estimate and interpret adjusted predictions and marginal effects. Stata J 12(2):308–331
50. Howlader N, Noone A, Krapcho M et al (2017) SEER cancer statistics review, 1975–2014. National Cancer Institute, Bethesda
51. Bergmann MM, Calle EE, Mervis CA, Miracle-McMahill HL, Thun MJ, Heath CW (1998) Validity of self-reported cancers in a prospective cohort study in comparison with data from state cancer registries. Am J Epidemiol 147(6):556–562
52. Desai MM, Bruce ML, Desai RA, Druss BG (2001) Validity of self-reported cancer history: a comparison of health interview data and cancer registry records. Am J Epidemiol 153(3):299–306
53. Jahn JL, Giovannucci EL, Stampfer MJ (2015) The high prevalence of undiagnosed prostate cancer at autopsy: implications for epidemiology and treatment of prostate cancer in the prostate-specific antigen-era. Int J Cancer 137(12):2795–2802
54. Carpenter C, Gates GJ (2008) Gay and lesbian partnership: evidence from California. Demography 45(3):573–590
55. National Center for Health Statistics (2014) A brief quality assessment of the NHIS sexual orientation data. National Center for Health Statistics, Atlanta
56. James SE, Herman JL, Rankin S, Keisling M, Mottet L, Anafi M (2016) The report of the 2015 US transgender survey, Washington, DC
57. Cahill S, Makadon H (2014) Sexual orientation and gender identity data collection in clinical settings and in electronic health records: a key to ending LGBT health disparities. LGBT Health 1(1):34–41
58. Young GJ, Chou C-H, Alexander J, Lee S-YD, Raver E (2013) Provision of community benefits by tax-exempt U.S. hospitals. N Engl J Med 368(16):1519–1527
59. Kamen C (2017) Lesbian, gay, bisexual, and transgender (LGBT) survivorship. Semin Oncol Nurs 34(1):52–59