



Do inequalities add up? Intersectional inequalities in smoking by sexual orientation and education among U.S. adults

Nada Amroussia^{a,*}, Per E. Gustafsson^b, Jennifer L. Pearson^{c,d}

^a Division of Social and Behavioral Health, University of Nevada, Reno, USA

^b Department of Epidemiology and Global Health, Umeå University, Umeå, Sweden

^c Division of Social and Behavioral Health/Health Administration and Policy, University of Nevada, Reno, USA

^d Johns Hopkins Bloomberg School of Public Health, Department of Health, Behavior, and Society, Baltimore, MD, USA

ARTICLE INFO

Keywords:

Sexual and Gender minorities
Cigarette smoking
Intersectionality
Socio-economic status
Health inequality
United States

ABSTRACT

Introduction: Inequalities in smoking by socio-economic status (SES) are well-known. A growing body of literature has demonstrated additional inequalities in smoking by sexual orientation. This study used an intersectional lens to examine smoking at the intersection of sexual orientation and education.

Methods: Data come from 28,362 adult participants in Wave 2 (2014–2015) of the Population Assessment of Tobacco and Health (PATH) Study. We used educational level (less than high school education (HS); HS or more) and sexual orientation (heterosexual; sexual minority) to form four intersectional positions.

We estimated prevalence differences in smoking corresponding to joint, referent, and excess intersectional inequalities using weighted linear binomial regression models. Results were stratified by gender and adjusted for ethnicity and age.

Results: The adjusted joint inequality represented 7.6% points (p.p.) (95% CI: 2.5, 12.8) difference in smoking between the doubly advantaged (heterosexual with HS or more) and doubly disadvantaged (sexual minority with less than HS) positions. Joint inequality was decomposed into referent SES inequality (12.5 p.p. (95% CI: 10.5, 14.4)); referent sexual orientation inequality (9.7 p.p. (95% CI: 6.8, 12.6)); and a substantial negative excess intersectional inequality (−14.6 p.p. (95% CI: −20.8, −8.3)), attributed to an unexpectedly low prevalence of smoking among doubly disadvantaged persons. Similar overall patterns were found in the stratified analyses.

Conclusions: We found that “doubly-disadvantaged” group of low-educated sexual minority adults did not have the greatest burden of smoking; whereas, low-educated heterosexual adults had the highest smoking prevalence. Our findings support tailoring cessation interventions to disadvantaged groups’ different needs.

1. Background

People in the U.S. living below the federal poverty level or with low education have considerably higher rates of cigarette smoking as compared to the general population (U.S. Department of Health and Human Services, 2014; Wang et al., 2018). Such socioeconomic inequalities in smoking are widespread (Nagelhout et al., 2012; Alves et al., 2015; Verlato et al., 2014), and are also reflected in disadvantaged populations bearing a disproportionate burden of smoking-related diseases (Singh et al., 2011). Cigarette smoking is also patterned by other axes of inequalities, such as sexual orientation, an issue that has received growing interest in recent years (Blosnich et al., 2014; McCabe et al., 2018; Wheldon et al., 2018; Rosario et al., 2016; Cochran et al., 2013; Balsam et al., 2012; Boehmer et al., 2012; Matthews et al.,

2011; Pelster et al., 2015; Jannat-Khah et al., 2018; Hughes et al., 2008).

As research has delved into more detailed analyses of sexual orientation (McCabe et al., 2018; Balsam et al., 2012; Matthews et al., 2011; Pelster et al., 2015; Jannat-Khah et al., 2018; Hughes et al., 2008) and socioeconomic (Kim and Tsoh, 2016; Martinez et al., 2018; Karriker-Jaffe et al., 2016) inequalities in smoking, we still know little about how these two dimensions of inequalities act in combination (Pelster et al., 2015; Hughes et al., 2008). Intersectionality has emerged in recent years as a perspective to understand the complexities of interlocking health inequalities (Springer et al., 1982; Hankivsky, 2012). According to an intersectional approach, individuals and groups simultaneously occupy multiple social locations (Springer et al., 1982; Hankivsky, 2012), determined by intersecting systems of power

* Corresponding author.

E-mail address: namroussia@nevada.unr.edu (N. Amroussia).

<https://doi.org/10.1016/j.pmedr.2019.101032>

Received 16 April 2019; Received in revised form 29 November 2019; Accepted 15 December 2019

Available online 23 December 2019

2211-3355/© 2019 Published by Elsevier Inc. This is an open access article under the CC BY-NC-ND license (<http://creativecommons.org/licenses/by-nc-nd/4.0/>).

relations based on, for example, sexual orientation, socio-economic status (SES), gender, and race. The intersections of these power relations create a complex web of social inequalities shaping people's social experiences, including their health experiences (Springer et al., 1982; Hankivsky, 2012). These inequalities might be reinforced or mitigated by different social processes (Bauer, 2014). One such example is *leveraging* (Sen and Iyer, 2012), referring to the social processes by which some groups are able to compensate for their disadvantage in some dimensions (e.g., sexual orientation) through their advantage with respect to other dimensions (e.g., education) (Sen and Iyer, 2012). Leveraging might be translated into health gains among groups with position of mixed advantage and disadvantage (Sen and Iyer, 2012; Gustafsson et al., 2016), such as sexual minority people with high education.

Intersectional approaches in population health research are relatively new, and a variety of quantitative adaptations of the intersectional theory have been suggested (Bauer, 2014; Jackson et al., 2016). In an effort to assess intersectional inequalities in a policy-relevant manner, Jackson et al. (2016) recently proposed a method based on the absolute (i.e. mean outcome among the multiply marginalized group) and excess (i.e. the prevalence difference between the multiply marginalized group and the multiply advantaged group) risk faced by multiply disadvantaged populations. Their method is based on an additive interaction framework that compares the inequality in the health outcome between those of double disadvantage and double advantage (*joint inequality*), and further decomposes it into inequalities derived from each axis of inequality (*referent inequalities*) and from the combination of multiple axes of inequalities (*excess intersectional inequality*). Results from this approach are interpretable in terms of the potential absolute health gains if the health inequalities were abolished, and in contrast to other measures of additive interaction it provides a comprehensive picture of inequalities involving each social status category and their intersection (Jackson et al., 2016).

A handful of studies have used an intersectional lens to examine inequalities tobacco use at the intersection of sexual orientation and other socio-demographic factors, such as race (Corliss et al., 2014; McCabe et al., 2018), age (Corliss et al., 2014; McCabe et al., 2018), and gender (Corliss et al., 2014). Although previous research has shown that sexual minority people are not socio-economically homogenous, the *myth of gay affluence* that American sexual minority people are "better off" than the general U.S. population is still persistent. This may have led to overlooking the role of SES in sexual minority research (McGarrity, 2014). An intersectional perspective on SES and sexual orientation will improve our understanding of the burden of tobacco use among multiply disadvantaged groups and will contribute to tailoring prevention and cessation interventions to the different needs of these groups. The current study assesses the joint, referent and excess intersectional inequalities in cigarette smoking at the intersection of sexual orientation and educational attainment. Given that inequalities in tobacco use and cigarette smoking differ substantially by gender (Emory et al., 2015; Gonzales and Henning-Smith, 2017), this analysis also considers the effect of gender on inequalities in cigarette smoking.

2. Methods

2.1. Study population

We used adult data from the Wave 2 Population Assessment of Tobacco and Health (PATH) Study. The PATH Study is a nationally representative US longitudinal cohort study launched in 2011 (Hyland et al., 2017). The initial sample included 45,971 non-institutionalized U.S. adults and youth, aged 12 years and older. Wave 2 data were collected from October 2014 to October 2015. Overall, 28,362 adults ages 18 and over completed the Wave 2 interviews. The weighted retention rate of Wave 2 adult interviews was 83.1% (United States, 2017).

The PATH study used a 4-stage, stratified probability sample design with oversampling of adult tobacco users, young adults (aged 18–24 years), and African Americans. Audio-Computer Assisted Self-Interviews were used (ACASI) to collect information on tobacco use behavior, attitudes and beliefs, and tobacco-related health outcomes (Hyland et al., 2017).

3. Measures

3.1. Outcome: Current cigarette smoking

Current cigarette smoking was defined as reporting cigarette use on "every day" or "some days" and having smoked more than 100 cigarettes in the lifetime (United States, 2017).

3.2. Exposure: Intersectional positions by sexual orientation and socio-economic status

Participants were asked "Do you consider yourself to be (1) straight, (2) lesbian or gay, (3) bisexual, or (4) something else?" The sexual orientation variable was created by collapsing the three categories "lesbian or gay", "bisexual", and "something else" into one category to obtain a dichotomous variable: heterosexual adults vs. sexual minority adults.

Education was categorized into two categories: "less than high school education" vs. "high school education and more". The group "high school education and more" was obtained by collapsing the categories "General Educational Development (GED)", "high school graduate", "some college (no degree) or associates degree", "bachelor's degree", and "advanced degree". The category "GED" was included in the group of high school or more as in the U.S. GED is equivalent to a high school diploma and might allow access to similar advantages/privilege (e.g., in terms of employment or income).

Following Jackson et al. approach (Jackson et al., 2016), four mutually exclusive intersectional positions were identified: heterosexual adults with high school education and more (doubly advantaged); heterosexual adults with less than high school education; sexual minority adults with high school education or more; and sexual minority adults with less than high school education (doubly disadvantaged).

3.3. Covariates

We included socio-demographic factors as covariates to adjust for possible confounding effects related to potential self-reporting bias (Pew Research Center N, 2018; Grov et al., 2006). Socio-demographic variables consisted of three variables: gender (women and men), age (18–24, 25–44, and 45+), and race/ethnicity (Non-Hispanic white, Hispanic, and Non-white non-Hispanic).

3.4. Statistical analyses

3.4.1. Overview

First, we conducted descriptive analyses to determine the distributions of socio-demographic characteristics and cigarette smoking across the four intersectional positions, stratified by gender. We used weighted chi-square tests to compare the characteristics of different intersectional groups. Second, we ran unadjusted and adjusted linear binomial regression models (Richardson et al., 2015) to estimate smoking prevalence differences (PD) corresponding to four intersectional inequalities, as proposed by Jackson et al (Jackson et al., 2016). All models were stratified by gender and used complete case analyses. Estimates were weighted to represent the U.S. adult population in 2013 (United States, 2017), and variances were estimated using the balanced repeated replication method with Fay's adjustment to increase estimate stability (Judkins, 1990). All analyses were performed using Stata software, version 14 (StataCorp, 2015), using the *glm* command for

Table 1

Distribution of socio-demographic characteristics and prevalence of cigarette smoking by intersectional positions in the total sample, 2014–2015 U.S. Population Assessment of Tobacco and Health (PATH) Study (N = total unweighted N for Sexual minority and heterosexual).

	Total	Sexual minority adults (Unweighted N = 1933)		Heterosexual adults (Unweighted N = 25,965)		p-value ^c
		< HS ^a	HS or more ^b	< HS	HS or more	
	Weighted % (unweighted N)	Weighted % (unweighted N)	Weighted % (unweighted N)	Weighted % (unweighted N)	Weighted % (unweighted N)	
Gender	100 (27,828)	0.8 (332)	4.0 (1597)	10.1 (3332)	85.1 (22,567)	
Women	52.0 (14,296)	59.9 (221)	58.9 (1035)	48.5 (1508)	51.9 (11,262)	< 0.001
Men	48.0 (14,001)	40.1 (108)	41.0 (560)	51.4 (1818)	48.1 (11,293)	
Age						
18–240	12.7 (8171)	22.2 (166)	25.5 (684)	11.6 (999)	12.3 (6,225)	< 0.001
25–440	33.9 (9860)	49.8 (108)	44.3 (617)	26.2 (920)	34.3 (8,061)	
45+	53.4 (10,288)	28.0 (58)	30.1 (296)	62.2 (1413)	53.4 (8277)	
Race/ethnicity						
Non-Hispanic white	65.8 (16,699)	22.1 (110)	63.3 (907)	44.0 (1,464)	69.3 (14,009)	< 0.001
Hispanic	15.3 (5,031)	63.8 (145)	18.9 (326)	36.4 (974)	11.8 (3,429)	
Non-Hispanic non-white	18.9 (6,140)	14.1 (70)	17.8 (346)	19.6 (794)	18.9 (4,828)	
Smoking status						
Current smokers	18.6 (9,694)	22.5 (132)	27.4 (636)	28.6 (1,551)	17.1 (7,224)	< 0.001
Non-smokers	81.4 (18,629)	77.5 (200)	72.6 (961)	71.4 (1,781)	82.9 (15,343)	

NOTE – The following variables had missing data. Individuals with missing data were excluded from analyses. Sexual orientation (1.4% missing); education (0.5% missing); smoking status 0.1% missing); gender (0.1% missing), race/ethnicity (4.0% missing).

^a < HS: with less than high school education;

^b HS or more: with high school education or more.

^c P values obtained using weighted chi-square test.

linear binomial models (Richardson et al., 2015) and *lincom* command for post estimation of excess intersectional inequality.

3.4.2. Detailed explanation of the method

To estimate intersectional inequalities, the method suggested by Jackson et al. (2016) was chosen, it is based on additive rather than multiplicative interaction, which can be expressed in the policy-relevant terms of absolute health gains (Vander Weele and Knol, 2014) and closely corresponds to the notion of “greater than the sum” within intersectionality theory (Crenshaw, 2018). In contrast to other measures of additive interaction, it estimates inequalities in the given outcome involving all social categories using a common reference group (Jackson et al., 2016). The method is based on estimation of the joint inequality, which is subsequently decomposed into two referent and excess intersectional inequality, as follows.

The absolute joint inequality refers to the inequality in cigarette smoking between the doubly disadvantaged versus the doubly advantaged group: sexual minority adults with less than high school education (μ_{11}) as compared to heterosexual adults with high school education or more (μ_{00}). It illustrates the absolute gains in the population health that would be achieved by abolishing the joint inequality (Jackson et al., 2016).

$$\text{Absolute joint inequality} = \mu_{11} - \mu_{00}$$

The absolute joint inequality can be decomposed into referent inequalities and the excess intersectional inequality. The referent inequalities describe the inequalities for singly disadvantaged groups. In this study, the referent educational inequality evaluates inequality among heterosexual adults, the reference category used for sexual orientation, by comparing cigarette smoking for heterosexual adults with less than high school education (μ_{01}) with heterosexual adults with high school education or more (μ_{00}) (Jackson et al., 2016).

$$\text{Referent educational inequality} = \mu_{01} - \mu_{00}$$

The referent sexual orientation inequality correspondingly evaluates sexual orientation among adults with high school education or more,

the reference category used for education, by comparing cigarette smoking for sexual minority adults with high school education or more (μ_{10}) with heterosexual adults with high school education or more (μ_{00}). It describes how cigarette smoking is patterned by sexual orientation among those who do not encounter disadvantage apart from sexual orientation (Jackson et al., 2016).

$$\text{Referent sexual orientation inequality} = \mu_{10} - \mu_{00}$$

The excess intersectional inequality measures the amount by which the joint inequality surpasses the sum of two referent inequalities, and is equivalent to an additive interaction term. If the excess intersectional inequality is greater than zero, its magnitude indicates how the inequality for the doubly disadvantaged population (sexual minority with less than high school education) exceeds what we would expect considering the inequalities of singly disadvantaged populations together (Jackson et al., 2016).

$$\begin{aligned} \text{Excess intersectional inequality} &= \text{the joint inequality} - \sum \text{referent inequalities} \\ &= \mu_{11} - \mu_{00} - (\mu_{01} - \mu_{00}) + (\mu_{10} - \mu_{00}) \end{aligned}$$

4. Sensitivity analyses

We conducted two post-hoc sensitivity analysis to assess whether our results might be affected by how we dichotomized educational attainment (e.g., including “GED” in the “high school or more” category). First, we included the “GED” category in the “less than high school diploma” group. The results indicated that while the magnitude of the intersectional inequalities changed when including the “GED” category in the “less than high education” group, the directions of the inequalities and the overall interpretation remained the same. Second, we excluded those with GED from the models (a total of 1855 participants). The results indicated that in the unadjusted and adjusted models, the magnitudes of inequalities only changed slightly when excluding this category.

Table 2
Distribution of socio-demographic characteristics and prevalence of cigarette smoking by intersectional positions in the stratified subsamples, 2014–2015 U.S. Population Assessment of Tobacco and Health (PATH) Study.

	Women						Men						P value ^c	P value ^{a,b}
	Sexual minority women (unweighted N = 1,262)			Heterosexual women (unweighted N = 12,798)			Sexual minority men (unweighted N = 671)			Heterosexual men (unweighted N = 13,167)				
	< HS	HS or more	Weighted %	< HS ^a	HS or more ^b	Weighted %	< HS	HS or more	Weighted %	< HS	HS or more	Weighted %		
	(unweighted N)	(unweighted N)	(unweighted N)	(unweighted N)	(unweighted N)	(unweighted N)	(unweighted N)	(unweighted N)	(unweighted N)	(unweighted N)	(unweighted N)	(unweighted N)		
Age														
18–24	0.9 (221)	4.6 (1,035)	9.4 (1,508)	85.1 (11,262)			0.7 (108)	3.3 (560)	10.8 (1,818)	85.1 (11,293)			< 0.001	
25–44	26.3 (120)	27.6 (469)	9.7 (430)	11.6 (3,039)			17.7 (46)	22.4 (213)	13.4 (568)	13.1 (3,182)				
45 +	46.0 (69)	48.1 (421)	24.2 (416)	33.4 (4,042)			56.0 (38)	39.0 (196)	28.4 (504)	35.0 (4,017)				
	27.7 (32)	24.3 (145)	66.1 (662)	54.8 (4,179)			26.3 (24)	38.6 (151)	58.4 (746)	51.8 (4,093)				
Race/ethnicity														
Non-Hispanic white	23.2 (76)	63.0 (584)	42.2 (658)	68.9 (6,942)			21.9 (34)	63.8 (322)	45.6 (804)	69.8 (7,061)			< 0.001	
Hispanic	60.2 (85)	17.3 (190)	39.4 (452)	12.6 (1,747)			66.7 (57)	21.3 (136)	33.6 (519)	11.0 (1,680)				
Non-Hispanic non-white	16.6 (56)	19.7 (255)	18.4 (358)	18.6 (2,435)			11.3 (14)	14.9 (90)	20.8 (434)	19.2 (2,390)				
Smoking status														
Current smokers	25.0 (93)	29.3 (434)	23.2 (662)	14.7 (3,478)			20.4 (202)	24.8 (39)	33.8 (888)	19.8 (3,745)			< 0.001	
Non-smokers	75.0 (128)	70.7 (601)	76.8 (846)	85.3 (7,784)			79.6 (358)	75.2 (69)	66.2 (930)	80.2 (7,548)				

NOTE – The following variables had missing data. Individuals with missing data were excluded from analyses. Sexual orientation (1.4% missing); education (0.5% missing); smoking status (0.1% missing); gender (0.1% missing); race/ethnicity (4.0% missing).

^a < HS: with less than high school education;

^b HS or more: with high school education or more.

^c P values obtained using weighted chi-square analysis stratified by gender.

5. Results

5.1. Descriptive characteristics of the population

Of the 27,828 participants, 22,567 (85.0%) were heterosexual adults with high school education or more, 3332 (10.1%) heterosexual adults with less than high school education, 1597 (4.0%) sexual minority adults with high school education or more, and 332 (0.8%) sexual minority adults with less than high school education. The four intersectional groups differed in all measured socio-demographic characteristics (Table 1). Older adults (45 years or older) made the largest proportion of low-educated heterosexual adults (62.2%) and higher educated heterosexual adults (53.4%), while they represented only 28% of low-educated sexual minority adults and 30.1% of higher educated sexual minority adults ($p < 0.001$). Hispanics made up a significantly higher proportion of the doubly disadvantaged group of low-educated sexual minority adults (63.8%), compared to only 11.84% of the doubly advantaged group of heterosexual adults with high school education or more ($p < 0.001$). The same patterns were found when results were stratified by gender (Table 2).

The doubly advantaged group of heterosexual adults with a high school education or more had the lowest prevalence of current smoking as compared to the other intersectional groups (17.1%, $p < 0.001$), while heterosexual adults with less than high school education had the highest prevalence of cigarette smoking (28.6%, $p < 0.001$). Unexpectedly, the doubly disadvantaged group of low-educated sexual minority adults had lower prevalence of cigarette smoking (22.5%) as compared to heterosexual adults with less than high school education (28.6%) and sexual minority with high school education or more (27.4%) ($p < 0.001$). Similar results were found in the men's subsample. However, in the women's subsample the highest prevalence of cigarette smoking was among sexual minority adults with a high school education or more as compared to the other intersectional groups (29.3%, $p < 0.001$).

5.2. Intersectional inequalities in current cigarette smoking

The results were similar in both the adjusted and unadjusted models in terms of the direction and the relative magnitude of the inequalities (Table 3). In the adjusted model, the joint inequality in prevalence of cigarette smoking comparing the doubly disadvantaged group and the doubly advantaged group was 7.6 percent points (p.p.) (95% confidence interval (CI): 2.5, 12.8) education. When decomposed into referent inequalities and excess intersectional inequality, the referent educational inequality was 12.5 p.p. (95% CI: 10.5, 14.4), while the

referent sexual orientation inequality was slightly smaller (9.7 p.p. (95% CI: 6.8, 12.6)), indicating that the magnitude of educational inequality among heterosexual adults was greater than the magnitudes of both the sexual orientation inequality and the inequality between the doubly advantaged/disadvantaged groups. The excess intersectional inequality was negative and of substantial magnitude (PD: -14.6 p.p. (95% CI: -20.8, -8.3)), indicating that the inequalities for the singly disadvantaged groups together surpassed the inequality for the doubly disadvantaged group of low-educated sexual minority adults, with the doubly advantaged group as the reference.

Results in the models stratified by gender (Table 3) were similar to those in the total sample with a few exceptions. In the women's subsample, the magnitude of the referent sexual orientation inequality was larger than the referent educational inequality and the joint inequality, while in men's subsample the magnitude of the referent educational inequality surpassed those of the referent sexual orientation inequality and the joint inequality. In the men subsample, the magnitude of the joint inequality was also decidedly insubstantial and non-significant (P.D: 0.2 p.p. (95% CI: -7.5, 7.8)).

6. Discussion

A growing body of literature has focused on investigating factors explaining the disparities in smoking and tobacco use by sexual orientation (McCabe et al., 2018; Schauer et al., 2013; Balsam et al., 2012; Boehmer et al., 2012; Matthews et al., 2011; Pelster et al., 2015; Jannat-Khah et al., 2018; Hughes et al., 2008) and educational inequalities (Kim and Tsoh, 2016; Martinez et al., 2018; Karriker-Jaffe et al., 2016) as separate and disentangled axes of inequality. This study adds to this literature by approaching these two axes as a compound phenomenon.

We found that smoking prevalence in the doubly disadvantaged group of low-educated sexual minority U.S. adults was substantially lower than the smoking prevalence among the singly disadvantaged groups of heterosexual adults with less than high school education and sexual minority adults with high school education or more. This finding illustrates the unique and seemingly paradoxical population patterns that can be revealed by using an intersectional approach and suggests that in combination the inequalities do not act in the more expected additive or positively synergistic manners.

One possible explanation of our unexpected finding is the potential differences in the social processes mitigating inequalities in cigarette smoking between heterosexual and sexual minority adults. Among heterosexual adults, we found that cigarette smoking was more prevalent among low educated compared to high educated adults;

Table 3

Unadjusted and adjusted binomial regression analyses results for the total sample and the subsamples, 2014–2015 U.S. Population Assessment of Tobacco and Health (PATH) Study.

	Total sample		Women		Men	
	Unadjusted model	Adjusted model ^a	Unadjusted model	Adjusted model ^b	Unadjusted model	Adjusted model ^b
	Prevalence difference (95% CI)	Prevalence difference (95% CI)	Prevalence difference (95% CI)	Prevalence difference (95% CI)	Prevalence difference (95% CI)	Prevalence difference (95% CI)
Joint inequality	5.4** (5.6, 10.2)	7.6*** (2.5, 12.8)	10.3** (3.8, 16.7)	12.6** (5.6, 19.6)	0.6* (-7.5, 8.7)	0.2* (-7.5, 7.8)
Referent educational inequality	11.4*** (9.5, 13.3)	12.5*** (10.5, 14.4)	8.5*** (6.1, 10.9)	9.7*** (7.1, 12.3)	14.0*** (11.2, 16.8)	15.2*** (12.3, 18.1)
Referent Sexual orientation inequality	10.3*** (7.4, 13.2)	9.7*** (6.8, 12.6)	14.6*** (11.4, 17.8)	13.7*** (10.4, 17.0)	5.0** (0.3, 9.7)	4.6** (0.0, 9.2)
Excess intersectional inequality	-16.3*** (-22.2, -10.5)	-14.6*** (-20.8, -8.3)	-12.8** (-20.6, -5.0)	-10.8** (-19.2, -2.4)	-18.4*** (-28.5, -8.4)	-19.6*** (-29.1, -10.2)

* $p \geq 0.05$, ** $0.001 \leq p < 0.05$, and *** $p < 0.001$

^a Model adjusted for gender, age, and race/ethnicity.

^b Model adjusted for age and race/ethnicity.

however, the inverse was true among sexual minority adults. This result can be understood using the concept of “leveraging” (Sen and Iyer, 2012), or the process of compensating for disadvantage in some dimensions through their advantage in other dimensions. This finding suggests that education is not a “leverage point” (Sen and Iyer, 2012) that enables sexual minority adults to compensate for their sexual orientation disadvantage to secure health benefits and reduce risky health behaviors. For example, this might be explained by the fact that due to labor market discrimination against sexual minority people, education does not translate into high income and occupational status to the same degree as it does for those of the majority heterosexual orientation (McGarrity, 2014). This context of discrimination might in turn be reflected in poor health outcomes and engagement in health-damaging behavior outcomes among sexual minorities with high education.

Our findings could also be explained by competing cultural discourses at the intersection of sexual orientation and SES. Cigarette smoking and tobacco use are considered forms of resistance to the mainstream culture’s effort to dominate the sexual minority community’s lifestyle (Treiber and Satterlund, 2010), a discourse that in turn has been exploited by market forces (American Lung Association, 2015; Margolies). For example, sexual minority people are strategically targeted by tobacco companies through sponsoring sexual minority events and bar promotions (Schauer et al., 2013; Treiber and Satterlund, 2010). More pertinent for an intersectional approach is that qualitative researchers have pointed out that socioeconomically disadvantaged sexual minority people tend to be relatively disconnected from the “mainstream” sexual minority community (Mallon, 2001; Taylor, 2007). This marginalization could make sexual minority people with low socio-economic status more resilient to the pro-smoking discourses within the sexual minority community, a resilience belied by their position of structural “double jeopardy.”

Another interesting finding is that compared to the total sample, the referent educational inequality was dominant in men, while the sexual orientation inequalities were more prominent in women. This finding suggests that among men, inequalities in cigarette smoking at the intersection of education and sexual orientation are primarily driven by socio-economic inequalities, while for women, sexual or gender minority status plays a larger role. These results are in accordance with previous studies pointing out that the sexual orientation gap in cigarette smoking is larger among women than men (Emory et al., 2015; Lindley et al., 2012), and illustrate that gender is another important axis of inequality to consider in intersectional analyses of smoking.

7. Limitations

This study has several limitations. First, we relied on self-reported smoking status, which while less desirable than biologically-confirmed smoking status still demonstrates acceptable validity and reliability (Wong et al., 2012; Soulakova et al., 2012). Furthermore, future research is needed to examine intersectional inequalities in other tobacco products such as e-cigarettes, which have complex effects on individual and public health.

Second, one of the main limitations of the study is the operationalization of the exposure variables educational attainment and sexual orientation. Educational attainment was assessed by including “GED” category in the “more than high school education” group. The post hoc sensitivity analyses’ results indicated that including the “GED” category in the “less than high education” group or excluding the “GED” category impact on the magnitude but not direction of the intersectional inequalities or the overall interpretation of the results. Relatedly, results might also vary when studying other indicators of socioeconomic status, such as income or occupation.

The “sexual orientation” variable was constructed by including the “something else” category in the sexual minority adults’ group. The results might differ when excluding this category, which was not

possible in the current dataset. Moreover, differences in disclosing sexual and gender minority status between socio-demographic groups (Pew Research Center N, 2018; Grov et al., 2006) might introduce differential misclassification of the sexual orientation variable.

Third, in this study, we employed complete case analysis. Given the small internal dropout /non-response < 1.5% for key variables (sexual orientation = 1.43%, education = 0.51%, and smoking status = 0.14%), and 0–4% for covariates (0.1% for gender, 4.0% for ethnicity/race, and no for age). it is unlikely that it would introduce serious selection bias. Due to lack of available data we were however not able to assess the extent and impact of the external dropout, which thus remains a potential source of selection bias.

8. Conclusions and public health implications

The combination of sexual orientation and education displayed unexpected and complex population patterns in smoking, whereby the doubly disadvantaged group – low-educated sexual minority people – smoked considerably less than would be expected from their double disadvantage. Additionally, intersectional position operated differently for sexual minority women than men. Our findings emphasize the importance of examining and monitoring how multiple social categories intersect and shape cigarette smoking patterns among U.S. adults. They also illustrate the need for intersectionality-informed public health policy (Hankivsky et al., 2014), specifically when it comes to tobacco prevention and policy aiming for equity. For example, various clinical, media, and policy interventions have been implemented to promote smoking cessation among sexual minority populations without regard for SES (Lee et al., 2014). An intersectional approach could provide “a scalpel for policies rather than the current hatchet” (Sen et al., 2009) by improving the effectiveness of prevention and cessation policy and behavioral interventions that target sexual minority and multiply disadvantaged populations, ultimately yielding a more fruitful approach for achieving equity in smoking and related morbidity and mortality.

Funding

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Availability of data and materials

The dataset analyzed in this study is available from: <https://www.icpsr.umich.edu/icpsrweb/NAHDAP/studies/36498/datadocumentation>.

Authors’ contributions

NA, PEG, and JLP conceived the study. NA conducted the data analysis and interpreted the data with guidance from PEG. NA drafted the manuscript under the supervision of PEG and JLP, and both PEG and JLP revised the manuscript for intellectual content. All authors read and approved the final draft.

Declaration of Competing Interest

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

Acknowledgement

None.

References

- Alves, J., Kunst, A.E., Perelman, J., 2015. Evolution of socioeconomic inequalities in smoking: results from the Portuguese national health interview surveys. *BMC Public Health* 15 (1), 311.
- American Lung Association. The LGBT community: a priority population for tobacco control. 2015, pp. 1–6.
- Balsam, K.F., Beadnell, B., Riggs, K.R., 2012. Understanding sexual orientation health disparities in smoking: a population-based analysis. *Am. J. Orthopsychiatry* 82 (4), 482.
- Bauer, G.R., 2014. Incorporating intersectionality theory into population health research methodology: Challenges and the potential to advance health equity. *Soc. Sci. Med.* 1 (110), 10–17.
- Blosnich, J.R., Farmer, G.W., Lee, J.G., Silenzio, V.M., Bowen, D.J., 2014. Health inequalities among sexual minority adults: evidence from ten US states, 2010. *Am. J. Prev. Med.* 46 (4), 337–349.
- Boehmer, U., Miao, X., Linkletter, C., Clark, M.A., 2012. Adult health behaviors over the life course by sexual orientation. *Am. J. Public Health* 102 (2), 292–300.
- Cochran, S.D., Bandiera, F.C., Mays, V.M., 2013. Sexual orientation–related differences in tobacco use and secondhand smoke exposure among US adults aged 20 to 59 years: 2003–2010 National Health and Nutrition Examination Surveys. *Am. J. Public Health* 103 (10), 1837–1844.
- Corliss, H.L., Rosario, M., Birkett, M.A., Newcomb, M.E., Buchting, F.O., Matthews, A.K., 2014 Jun. Sexual orientation disparities in adolescent cigarette smoking: intersections with race/ethnicity, gender, and age. *Am. J. Public Health* 104 (6), 1137–1147.
- Crenshaw, K., 2018 Feb 19. Demarginalizing the intersection of race and sex: A Black feminist critique of antidiscrimination doctrine, feminist theory, and antiracist politics [1989]. In: *Feminist legal theory*. Routledge, pp. 57–80.
- Emory, K., Kim, Y., Buchting, F., Vera, L., Huang, J., Emery, S.L., 2015. Intragroup variance in lesbian, gay, and bisexual tobacco use behaviors: evidence that subgroups matter, notably bisexual women. *Nicotine Tob. Res.* 18 (6), 1494–1501.
- 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.
- Grov, C., Bimbi, D.S., Nanin, J.E., Parsons, J.T., 2006. Race, ethnicity, gender, and generational factors associated with the coming-out process among gay, lesbian, and bisexual individuals. *J. Sex Res.* 43 (2), 115–121.
- Gustafsson, P.E., Sebastian, M.S., Mosquera, P.A., 2016 Dec 1. Meddling with middle modalities: a decomposition approach to mental health inequalities between intersectional gender and economic middle groups in northern Sweden. *Global Health Action.* 9 (1), 32819.
- Hankivsky, O., 2012. Women's health, men's health, and gender and health: implications of intersectionality. *Soc. Sci. Med.* 74 (11), 1712–1720.
- Hankivsky, O., Grace, D., Hunting, G., Giesbrecht, M., Fridkin, A., Rudrum, S., Ferlatte, O., Clark, N., 2014. An intersectionality-based policy analysis framework: critical reflections on a methodology for advancing equity. *Int. J. Equity Health* 13 (1), 119.
- Hughes, T.L., Johnson, T.P., Matthews, A.K., 2008. Sexual orientation and smoking: Results from a multisite women's health study. *Subst. Use Misuse* 43 (8–9), 1218–1239.
- Hyland, A., Ambrose, B.K., Conway, K.P., Borek, N., Lambert, E., Carusi, C., Taylor, K., Crosse, S., Fong, G.T., Cummings, K.M., Abrams, D., 2017. Design and methods of the Population Assessment of Tobacco and Health (PATH) study. *Tob. Control.* 26 (4), 371–378.
- Jackson, J.W., Williams, D.R., VanderWeele, T.J., 2016. Disparities at the intersection of marginalized groups. *Soc. Psychiatry Psychiatr. Epidemiol.* 51 (10), 1349–1359.
- Jannat-Khah, D.P., Dill, L.J., Reynolds, S.A., Joseph, M.A., 2018. Stress, socializing, and other motivations for smoking among the lesbian, gay, bisexual, transgender, and queer community in New York City. *Am. J. Health Promot.* 32 (5), 1178–1186.
- Judkins, D.R., 1990. Fay's method for variance estimation. *J. Off. Stat.* 6 (3), 223–239.
- Karriker-Jaffe, K.J., Liu, H., Johnson, R.M., 2016. Racial/ethnic differences in associations between neighborhood socioeconomic status, distress, and smoking among US adults. *J. Ethn. Subst. Abuse.* 15 (1), 73–91.
- Kim, J.E., Tsoh, J.Y., 2016. Peer reviewed: cigarette smoking among socioeconomically disadvantaged young adults in association with food insecurity and other factors. *Prev. Chron. Dis.* 13.
- Lee, J.G., Matthews, A.K., McCullen, C.A., Melvin, C.L., 2014. Promotion of tobacco use cessation for lesbian, gay, bisexual, and transgender people: a systematic review. *Am. J. Prev. Med.* 47 (6), 823–831.
- Lindley, L.L., Walsemann, K.M., Carter Jr, J.W., 2012. The association of sexual orientation measures with young adults' health-related outcomes. *Am. J. Public Health* 102 (6), 1177–1185.
- Mallon, G.P., 2001. Oh, Canada: the experience of working-class gay men in Toronto. *J. Gay Lesbian Soc. Services* 12 (3–4), 103–117.
- Margolies, L. The same, only scarier—The LGBT cancer experience. Expert Voices Blog. Available from: <http://blogs.cancer.org/expertvoices/2014/06/05/the-same-only-scarier-the-lgbt-cancer-experience/>.
- Martinez, S.A., Beebe, L.A., Thompson, D.M., Wagener, T.L., Terrell, D.R., Campbell, J.E., 2018. A structural equation modeling approach to understanding pathways that connect socioeconomic status and smoking. *PLoS One* 13 (2), e0192451.
- Matthews, A.K., Hotton, A., DuBois, S., Fingerhut, D., Kuhns, L.M., 2011. Demographic, psychosocial, and contextual correlates of tobacco use in sexual minority women. *Res. Nurs. Health* 34 (2), 141–152.
- McCabe, S.E., Matthews, A.K., Lee, J.G., Veliz, P., Hughes, T.L., Boyd, C.J., 2018. Tobacco use and sexual orientation in a national cross-sectional study: age, race/ethnicity, and sexual identity-attraction differences. *Am. J. Prev. Med.* 54 (6), 736–745.
- McCabe, S.E., Matthews, A.K., Lee, J.G., Veliz, P., Hughes, T.L., Boyd, C.J., 2018 Jun 1. Tobacco use and sexual orientation in a national cross-sectional study: age, race/ethnicity, and sexual identity-attraction differences. *Am. J. Prev. Med.* 54 (6), 736–745.
- McGarry, L.A., 2014 Dec Dec. Socioeconomic status as context for minority stress and health disparities among lesbian, gay, and bisexual individuals. *Psychol. Sexual Orientation Gender Diversity* 1 (4), 383.
- Nagelhout, G.E., de Korte-de Boer D, Kunst, A.E., van der Meer, R.M., de Vries, H., van Gelder, B.M., 2012. Trends in socioeconomic inequalities in smoking prevalence, consumption, initiation, and cessation between 2001 and 2008 in the Netherlands. Findings from a national population survey. *BMC Public Health* 12 (1), 303.
- Pelster, A.D., Fisher, C.M., Irwin, J.A., Coleman, J.D., McCarthy, M.A., 2015. Tobacco use and its relationship to social determinants of health in LGBT populations of a Midwestern state. *LGBT Health* 2 (1), 71–76.
- Pew Research Center N. A survey of LGBT Americans [Internet]. Pew Research Center's social & demographic trends project, 2018. Available from: <http://www.pewsocialtrends.org/2013/06/13/a-survey-of-lgbt-americans/>.
- Richardson, D.B., Kinlaw, A.C., MacLehose, R.F., Cole, S.R., 2015. Standardized binomial models for risk or prevalence ratios and differences. *Int. J. Epidemiol.* 44 (5), 1660–1672.
- Rosario, M., Li, F., Wypij, D., Roberts, A.L., Corliss, H.L., Charlton, B.M., Frazier, A.L., Austin, S.B., 2016. Disparities by sexual orientation in frequent engagement in cancer-related risk behaviors: a 12-year follow-up. *Am. J. Public Health* 106 (4), 698–706.
- Schauer, G.L., Berg, C.J., Bryant, L.O., 2013. Sex differences in psychosocial correlates of concurrent substance use among heterosexual, homosexual and bisexual college students. *Am. J. Drug Alcohol Abuse* 39 (4), 252–258.
- Sen, G., Iyer, A., 2012. Who gains, who loses and how: leveraging gender and class intersections to secure health entitlements. *Soc. Sci. Med.* 74 (11), 1802–1811.
- Sen, G., Iyer, A., Mukherjee, C., 2009. A methodology to analyse the intersections of social inequalities in health. *J. Human Dev. Capabil.* 10 (3), 397–415.
- Singh, G.K., Williams, S.D., Siahpush, M., Mulhollen, A., 2011. Socioeconomic, rural-urban, and racial inequalities in US cancer mortality: part I—all cancers and lung cancer and part ii—colorectal, prostate, breast, and cervical cancers. *J. Cancer Epidemiol.* 2011, 1–27. <https://doi.org/10.1155/2011/107497>.
- Soulakova, J.N., Hartman, A.M., Liu, B., Willis, G.B., Augustine, S., 2012. Reliability of adult self-reported smoking history: data from the tobacco use supplement to the current population survey 2002–2003 cohort. *Nicotine Tob. Res.* 14 (8), 952–960.
- Springer, K.W., Hankivsky, O., Bates, L.M., 2012. Gender and health: relational, intersectional, and biosocial approaches. *Soc. Sci. Med.* (1982) 74 (11), 1661.
- StataCorp, 2015. Stata Statistical Software: Release 14. StataCorp LP, College Station, TX.
- Taylor, Y., 2007. Working-class lesbian life: classed outsiders. Springer, New York.
- Treiber, J., Satterlund, T.D. Culture in Evaluation # 1: LGBT. Tobacco control evaluation with the Lesbian/Gay/Bisexual/Transgender (LGBT) communities. Cultural competency in evaluation series. Tobacco Control Evaluation Center, U.C. Davis. http://tobaccoeval.ucdavis.edu/documents/culture_lgbt.pdf. 2010.
- U.S. Department of Health and Human Services, 2014. The health consequences of smoking—50 years of progress: a report of the surgeon general. U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Center for Chronic Disease Prevention and Health Promotion, Office on Smoking and Health, Atlanta.
- United States Department of Health and Human Services, National Institutes of Health, National Institute on Drug Abuse, and United States Department of Health and Human Services, Food and Drug Administration, Center for Tobacco Products, 2017 June 14. In: Population assessment of Tobacco and Health (PATH) study [United States] Public-Use Files, User Guide. ICPSR36498-v6. Inter-university Consortium for Political and Social Research [distributor], Ann Arbor, MI. <https://doi.org/10.3886/ICPSR36498.userguide> 34.
- Vander Weele, T.J., Knol, M.J., 2014 Dec 1. A tutorial on interaction. *Epidemiol. Methods* 3 (1), 33–72.
- Verlato, G., Accordini, S., Nguyen, G., Marchetti, P., Cazzoletti, L., Ferrari, M., Antonicelli, L., Attina, F., Bellisario, V., Bono, R., Briziarelli, L., 2014. Socioeconomic inequalities in smoking habits are still increasing in Italy. *BMC Public Health* 14 (1), 879.
- Wang, T.W., Asman, K., Gentzke, A.S., Cullen, K.A., Holder-Hayes, E., Reyes-Guzman, C., Jamal, A., Neff, L., King, B.A., 2018 Nov 9. Tobacco product use among adults—United States, 2017. *Morbidity Mortal. Weekly Rep.* 67 (44), 1225.
- Wheldon, C.W., Kaufman, A.R., Kasza, K.A., Moser, R.P., 2018. Tobacco use among adults by sexual orientation: findings from the population assessment of tobacco and health study. *LGBT Health* 5 (1), 33–44.
- Wong, S.L., Shields, M., Leatherdale, S., Malaisson, E., Hammond, D., 2012. Assessment of validity of self-reported smoking status. *Health Rep.* 23 (1), D1.