7-25-2022

Comparing substance use outcomes by sexual identity among women: Differences using propensity score methods

Katherine J. Karriker-Jaffe
Research Triangle Institute

Laurie Drabble
San Jose State University, laurie.drabble@sjsu.edu

Libo Li
Alcohol Research Group

Cat Munroe
Alcohol Research Group

Amy A. Mericle
Alcohol Research Group

See next page for additional authors

Recommended Citation

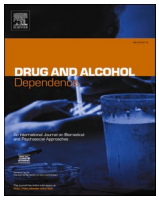
Katherine J. Karriker-Jaffe, Laurie Drabble, Libo Li, Cat Munroe, Amy A. Mericle, Karen F. Trocki, and Tonda L. Hughes. "Comparing substance use outcomes by sexual identity among women: Differences using propensity score methods" *Drug and Alcohol Dependence* (2022). https://doi.org/10.1016/j.drugalcdep.2022.109567

Drug and Alcohol Dependence 238 (2022) 109567

Contents lists available at ScienceDirect

Drug and Alcohol Dependence

journal homepage: www.elsevier.com/locate/drugalcdep



Comparing substance use outcomes by sexual identity among women: Differences using propensity score methods

Katherine J. Karriker-Jaffe [a], Laurie A. Drabble [b,*], Libo Li [c], Cat Munroe [c], Amy A. Mericle [c], Karen F. Trocki [c], Tonda L. Hughes [d]

[a] Research Triangle Institute, 2150 Shattuck Ave, Suite 800, Berkeley, USA
[b] San José State University, College of Health and Human Sciences, One Washington Square, San José, USA
[c] Alcohol Research Group, 6001 Shellmound St, Suite 450, Emeryville, CA 94608, USA
[d] School of Nursing & Department of Psychiatry, Columbia University, 630 West 168th Street, Mail Box Code 6, New York, NY 10032, USA

ARTICLE INFO

Keywords:
Sexual minority women
Alcohol use disorder
Alcohol, tobacco and other drug (ATOD) use
Sampling methodology
Propensity score methods

ABSTRACT

Background: Differences in alcohol, tobacco, and other drug (ATOD) use by sexual identity vary across samples of women recruited using different sampling methods. We used propensity score (PS) weighting methods to address two methodological questions: (1) Do disparities between sexual minority women (SMW) and heterosexual women persist when differences in risk and protective factors are similarly distributed between groups, and (2) Does accounting for SMW-specific resiliency factors impact differences between non-probability samples of SMW? Methods: Four samples included SMW from a longitudinal study with a nonprobability sample (n = 373), a national general population panel sample (n = 373), and a national LGBTQ-specific panel sample (n = 311), as well as a national probability sample of heterosexual women (n = 446). Between-groups analyses using double-robust PS weighted models estimated differences in ATOD use under hypothetical conditions in which samples have similar risk and protective factors. Results: After PS weighting, imbalance in confounders between SMW and heterosexual samples was substantially reduced, but not eliminated. In double-robust PS weighted models, SMW samples consistently had significantly greater odds of drug use than heterosexuals, with odds from 8.8 to 5.6 times greater for frequent marijuana use and 4.8–3.2 greater for other drug use. Few differences between SMW samples in ATOD outcomes or other variables remained after PS weighting. Conclusion: Relative to heterosexual women, disparities in marijuana and other drug use among SMW are evident regardless of sampling strategy. The results provide some reassurance about the validity of large nonprobability samples, which remain an important recruitment strategy in research with SMW.

1. Introduction

Recognition of the need to improve the quantity and quality of research studies on the health of sexual and gender minority (SGM) populations has grown substantially over the past 20–25 years (Institute of Medicine, 2011; National Academies of Sciences, 2020; Solarz, 1999). In addition, there have been calls for research to improve understanding of the disparities in health among SGM subpopulations that have historically been under-represented in research, such as sexual minority women (SMW, e.g., lesbian and bisexual women) (Coulter et al., 2014; Hughes et al., 2020; Institute of Medicine, 2011; Solarz, 1999). Disparities in heavy alcohol use, tobacco use, and other drug use are particularly pronounced among SMW (Blosnich et al., 2013; Hughes et al., 2020; Johnson et al., 2016; Lee et al., 2009; Wheldon et al., 2018), and research suggests that these disparities have persisted over time despite social and policy changes supportive of SGM populations (Drabble et al., 2020; McCabe et al., 2021). Research on factors that may drive health disparities is important for informing the development of interventions to reduce those disparities (Blosnich et al., 2013; Hughes et al., 2020; Kidd et al., 2022). However, methodological challenges, particularly in sampling, have impeded progress in research on sexual orientation-related health disparities, including disparities in alcohol, tobacco, and other drug (ATOD) use.

One important methodological challenge is a gap in understanding

* Corresponding author.
E-mail addresses: laurie.drabble@sjsu.edu (L.A. Drabble), lli@arg.org (L. Li), cmunroe@arg.org (C. Munroe), americle@arg.org (A.A. Mericle), ktrocki@arg.org (K.F. Trocki), Th2696@cumc.columbia.edu (T.L. Hughes).

https://doi.org/10.1016/j.drugalcdep.2022.109567
Received 22 December 2021; Received in revised form 22 May 2022; Accepted 7 July 2022
Available online 11 July 2022

how estimates of adverse health outcomes differ among SMW recruited using different nonprobability sampling strategies. This is important because nonprobability sampling continues to have an important role in reaching SMW in health research. Insights about how different sampling strategies may yield similar or different results are crucial to interpreting study findings and assessing the utility of different sampling strategies in research on specific health outcomes. The current study addresses this critical methodological challenge by examining similarities and differences in estimates of ATOD use among SMW recruited using different nonprobability sampling strategies.

1.1. Methodological challenges

Early research on ATOD use among SMW relied on convenience samples, such as bar patrons or clinical samples, which raised concerns about generalizability and overestimates of problems (Hughes, 2011). Over the last two decades, research with SMW has advanced through studies with more representative sampling designs. A growing number of studies using probability samples have included sexual orientation measures, allowing for greater generalizability and more appropriate comparisons between heterosexual and sexual minority samples (Owens et al., 2020). Although inclusion of sexual orientation measures in health studies using probability samples is crucial for health surveillance, important challenges concerning probability samples in SGM research remain. First, the low base rate of sexual minority respondents in probability samples often limits comparisons across subgroups of sexual minorities (Meyer et al., 2020; Meyer and Wilson, 2009). Second, reaching small or hidden populations using probability sampling methods is often cost prohibitive (National Academies of Sciences, Engineering, and Medicine, 2018). In addition, probability studies of the general population rarely include sexual minority-specific measures that contribute to sexual orientation-related health disparities, such as the extent to which and to whom participants have disclosed their sexual orientation (Hatzenbuehler and Pachankis, 2021).

Because of these challenges, survey research using new methods and strong nonprobability designs is important for understanding factors that underlie sexual orientation-related health disparities (Hatzenbuehler and Pachankis, 2021). Examples of sampling strategies in survey research with SMW include online and social media sampling, as well as outreach through multiple sources such as lesbian, gay, bisexual, transsexual, and queer (LGBTQ) in-person venues, community organizations, social networks, and LGBTQ media (National Academies of Sciences, 2018). Nonprobability studies of SGM individuals are most commonly designed to obtain large enough samples to enable examination of within-group differences (e.g., comparisons across sexual identities or by race/ethnicity), and to include important sexual minority-specific measures (Institute of Medicine, 2011; Meyer and Wilson, 2009).

Alternative strategies, such as respondent-driven sampling (RDS), have been successfully applied in public health research to collect data from hard-to-reach populations, such as men who have sex with men and injection drug users (National Academies of Sciences, 2018). However, recent methodological studies have found that RDS sampling with SMW fails to generate robust chains of referrals, which are necessary to approximate a probability sample (Martin et al., 2015; Michaels et al., 2019; Middleton et al., 2022). Recently, pre-established national web panels have emerged as a potential strategy for reaching large samples of sexual minority respondents, while minimizing potential bias associated with volunteer participants from LGBTQ-specific community venues and networks (Anderssen and Malterud, 2017).

Methodological studies of sexual minority health using different sampling strategies to estimate outcomes are important to guide the interpretation of findings from studies using nonprobability designs and to identify ways to improve the quality of samples. In general, different sampling strategies appear to yield similar results, but effect sizes may differ based on the sampling strategy used (Hottes et al., 2016; Krueger et al., 2020). For example, one methodological study comparing estimates of substance use in samples of SMW recruited using probability and nonprobability sampling methods with a probability sample of heterosexual women found higher rates of substance use in both samples of SMW. However, rates of tobacco use were higher and rates of other drug use were lower among SMW in the probability sample than among SMW in the nonprobability sample (Drabble et al., 2018). A possible reason for these differences is that sexual minority respondents with higher economic status, greater educational attainment, and greater connectedness to LGBTQ communities may be overrepresented in nonprobability samples (Boehmer et al., 2008; Bowen et al., 2007; Drabble et al., 2018; Krueger et al., 2020; Salway et al., 2019).

Use of large online panel samples (volunteer respondents who agree to receive incentivized invitations to complete surveys) appear to be a promising strategy for researchers interested in conducting national surveys with hard-to-reach populations (Boyle et al., 2017). However, there is a paucity of methodological research on the characteristics of online web-panel samples relative to probability samples (Boyle et al., 2017) or nonprobability samples of SMW recruited using other strategies (Canan et al., 2021). To our knowledge, no studies to date have compared substance use outcomes among SMW recruited through online panel samples with outcomes among heterosexual women from a probability sample and with outcomes in other large well-designed nonprobability samples of SMW.

1.2. Risk factors associated with behavioral health outcomes in SMW

Risk and protective factors for ATOD use are not equally distributed across women of differing sexual identities. Several factors linked with greater risk for substance use among women appear to impact SMW disproportionately relative to heterosexual women, and some SMW relative to others (e.g., bisexual women are at higher risk than lesbian women). These risk factors include history of victimization, such as childhood sexual and physical abuse (Drabble et al., 2013; Hughes et al., 2014; Hughes, McCabe et al., 2010; Hughes, Szalacha et al., 2010; McCabe et al., 2022; Wilsnack et al., 2008); early onset of alcohol, tobacco, or marijuana use (Hughes et al., 2007; Talley et al., 2019; Wilsnack et al., 2008); and coping motivations for alcohol or drug use (Lewis et al., 2017; Talley et al., 2012). Demographic factors that often protect against substance use among women also vary by sexual identity. For example, although family composition is changing rapidly in the context of social and political changes (e.g., legalization of same-sex marriage), SMW are less likely to be in committed/married relationships than heterosexual women (Drabble et al., 2020; Hughes et al., 2020), and marital/relationship status may be less consistently protective against substance use, such as hazardous drinking and marijuana use, among SMW relative to heterosexual women (Trocki et al., 2020; Veldhuis et al., 2020). In addition, although some research has found a lower risk of substance use (e.g., alcohol use disorders) among Black, Latinx, or Asian women than among White women, studies with SMW have found no differences, or even greater use, among racially minoritized SMW than in White SMW (Hasin and Grant, 2015; Hughes et al., 2020; Mulia and Bensley, 2020).

Sexual minority-specific factors also influence ATOD use. Social stress frameworks (Thoits, 2010) and minority stress theory (Meyer, 2003, 2013) suggest that differential exposure to stressors is an important contributor to health disparities among sexual minorities. For example, stress related to the disclosure of minority sexual identity—and reactions to disclosure—influence substance use and other health outcomes (Baiocco et al., 2010; Blosnich et al., 2013; Everett et al., 2021; Johnson et al., 2013; Pachankis et al., 2015, 2020; Persson et al., 2015).

1.3. The current study

This study addressed two methodological questions: (1) do

disparities between SMW and heterosexual women persist when differences in risk and protective factors are similarly distributed between groups, and (2) does accounting for SMW-specific resiliency factors impact differences between non-probability samples of SMW? To address the first question, we estimated differences in ATOD use under hypothetical conditions in which SMW and their heterosexual counterparts have similar risk and protective factors. We conducted between-groups analyses using propensity score weighted (PSW) models to account progressively for key individual-level demographics and psychological risk factors, creating analytically comparable SMW samples for comparisons of ATOD use relative to heterosexual women. To address the second question, we used PSW to conduct comparative analyses within SMW to assess SMW-specific resiliency factors that may buffer the effects of risk factors on ATOD use, comparing outcomes among samples recruited using different sampling strategies.

2. Methods

2.1. Datasets and analytic sample

The current study was part of a larger project on ATOD use among SMW which included three SMW samples (SMW from a large non-probability sample, SMW from a national general population web panel sample, and SMW from a national LGBTQ-specific web panel sample) and a fourth comparison probability sample of heterosexual women (each are described in detail below). Human subject protection and oversight was provided by the Institutional Review Boards of the engaged institutions.

2.1.1. Chicago Health & Life Experiences of Women (CHLEW) Study

The Chicago Health and Life Experiences of Women (CHLEW) study is a 21-year longitudinal, community-based study of risk and protective factors associated with alcohol use and alcohol-related problems among an age and racially/ethnically diverse sample of lesbian and bisexual women. The CHLEW includes multiple sexual minority specific measures, and has contributed to understanding differences in harmful alcohol use among SMW based on sexual identity, age, race/ethnicity and other factors (Hughes et al., 2021). The current study used data from SMW interviewed in Wave 4 (2017–2019). See Hughes et al. (2021) for in-depth information about the CHLEW study.

2.1.2. Panel samples

SMW participants also were recruited from two national online panels: a general population panel sample (n = 333) and a targeted panel sample of LGBTQ adults (n = 399). Eligibility requirements for participation included being 18 or older; identification as lesbian, bisexual, or queer; residence in the United States, and identification as female at the time of the screening. Because the aims of the larger study on ATOD use among SMW relied upon having adequate sample sizes for comparisons by race/ethnicity with specific subgroups, recruitment strategies oversampled SMW who identified as Black/African American or Latina/Latinx. Specifically, we randomly selected a sample that was one third Black/African American, one third Latina/Latinx; and one-third unspecified race/ethnicity (of which the majority were non-Hispanic White). Data were collected over the summer and fall of 2019.

2.1.3. Heterosexual comparison sample: National Alcohol Survey

The sample of heterosexual women (n = 623) consisted of participants from the 2014–15 National Alcohol Survey (NAS) who agreed to be recontacted for future research. The NAS involved computer-assisted telephone interviews conducted with English- or Spanish-speaking U.S. adults aged 18 and older. The NAS used a dual-frame sampling design that included randomly selected households with landlines and cellular phone users, and it also oversampled Black/African American and Hispanic/Latinx respondents (Karriker-Jaffe et al., 2017). In 2016, a random sample of 1961 NAS female participants was recontacted and invited to participate in a supplemental telephone survey. Some of the questions in this survey were subsequently used in our surveys with the SMW panel samples, and with all samples we included many of the same ATOD questions as in in the CHLEW study.

2.1.4. Final analytic sample

Our analyses included women who identified as heterosexual in the NAS sample and as bisexual or lesbian in the three SMW samples. To maximize comparability of the four samples and to avoid extreme weights, we excluded women older than 70 (who were overrepresented in the NAS sample) and women who did not identify as White, Black/African American, or Hispanic/Latina (who were not well-represented in the NAS sample due to the sampling design). Thus, we included 1529 women (446 from NAS, 399 from CHLEW, 373 from the general population panel sample of SMW, and 311 from the LGBT panel sample) in our analyses. Table 1 provides unweighted demographics for each sample, along with PS-weighted demographics (methods described below).

2.2. Measures

2.2.1. Alcohol use and problems

We constructed two dichotomous alcohol-related outcomes. One assessed whether participants had consumed four or more drinks in the same day on one or more occasions in the past year (any occasions of 4 + drinking vs. none). The other assessed alcohol use disorder (American Psychiatric Association, 2013) using affirmative responses to two or more or of 11 symptoms in the past year (vs. none or one), corresponding to at least mild alcohol use disorder.

2.2.2. Tobacco use

Tobacco use was assessed using questions about whether and how often participants had tobacco in the past 12 months. Past-year tobacco use was coded as any tobacco use (vs. no use).

2.2.3. Other drug use

A dichotomous measure of frequent marijuana use was constructed based on a question about how often the participant had used marijuana, hash, pot, THC or "weed" in the past 12 months. Frequent past-year use was defined as using once per week or more often (vs. less than once per week or not at all). Any past-year illicit drug use, other than marijuana (i.e., stimulants, cocaine/crack, club drugs, and non-medical use of prescription drugs), was also coded dichotomously (any use of one or more illicit drugs vs. no use).

2.2.4. Demographics and other risk/protective factors

Sexual identity was constructed as a three-category variable: heterosexual, lesbian, bisexual. Participants from the general population panel sample, CHLEW, and probability sample were classified based on a question that asked: "Recognizing that sexual identity is only party of your identity, which of the following statements best describes your sexual orientation?" The LGBTQ-specific panel allowed participants to select multiple categories of sexual identity and these women were classified based on their identification as lesbian, bisexual, or other non-monosexual identity (e.g., women who selected pansexual were classified as bisexual) for comparability. The comparison sample from the national probability survey was selected based on their endorsement of a heterosexual identity; the few participants who selected "mostly heterosexual" were excluded from the current analysis. Other demographics included age (in years), race/ethnicity (non-Hispanic White vs. Black/African American or Latinx/Hispanic), employment status (employed full- or part-time vs. unemployed), educational status (attended at least some college or more vs. attained high-school diploma or less), relationship status (married/cohabitating and separated/divorced/widowed vs. never married), and parenting status (any child under age 18 in the home vs. none).

Table 1
Comparing samples of sexual minority women with heterosexual women: Covariate balance before and after propensity score weighted analyses.

	Comparison group	Unweighted			After full PS weighting		
	Hetero-sexual women in NAS	SMW - Longitudinal Chicago sample (CHLEW)	SMW - General population panel sample	SMW - Targeted panel sample	SMW - Longitudinal Chicago sample (CHLEW)	SMW - General population panel sample	SMW - Targeted panel sample
Race/ethnicity							
Non-Hispanic White	58.2%	48.0% *	39.6% *	40.0% *	62.0%	57.9%	60.9%
Black/African American	28.8%	37.8%	25.5%	29.0%	28.9%	26.3%	24.8%
Hispanic/Latinx	13.0%	14.2%	35.0% *	31.0% *	9.1%	15.8%	14.4%
Age (mean, SD)	50.11 (13.65)	47.13 (12.5) *	31.54 (10.20) *	39.05 (13.52) *	51.35 (11.90)	44.19 (12.27) *	49.06 (14.72)
Minor children in home	36.3%	11.4% *	41.5%	12.6% *	31.2%	41.6%	26.7%
Employed	52.5%	75.9% *	74.3% *	81.0% *	61.2%	63.4% *	63.4% *
College education	74.0%	86.8% *	70.7%	93.5% *	88.8% *	83.0% *	94.3% *
Relationship status							
Married/partnered	53.9%	30.5% *	27.4% *	29.0% *	58.6%	59.6%	53.2%
Living with someone as couple	12.8%	34.5% *	46.6% *	37.1% *	13.7%	17.0%	12.8%
Separated, divorced or widowed	14.8%	4.6% *	5.7% *	2.3% *	5.6% *	6.5% *	11.9%
Single/never married							
Substance use to cope (mean, SD)	1.14 (.37)	1.45 (0.75) *	1.79 (1.01) *	1.57 (0.37) *	1.18 (0.42)	1.18 (0.43)	1.16 (0.37)
Childhood physical or sexual abuse	28.8%	45.4% *	45.8% *	48.7% *	31.0%	38.9% *	28.8%
Early onset drinking	7.5%	25.6% *	14.4% *	12.9% *	7.9%	8.0%	6.0%

* Indicates standard mean difference larger than |0.20|. SD = standard deviation. Reference groups: Employment = unemployed; Education = high school or less

We also constructed variables assessing key risk factors for ATOD use, including history of childhood physical or sexual abuse (vs. none), early onset of drinking (first use by age 14 vs. later), and use of substances to cope with stress. Use of substances to cope was based on a subscale (average score across two questions) from the Brief COPE scale (Carver, 1997), with a 4-category response option ranging from "not at all" to "a lot." We also assessed disclosure of sexual orientation to family members in each of the three SMW samples, with four response options: all, most, a few, or none.

2.3. Analysis

We conducted a series of logistic regression and propensity score (PS) weighted analyses to compare outcomes across the four groups one by one while progressively controlling for demographics and other covariates. For comparisons in the PS weighted analysis, we used the average treatment effect among the treated (ATT), where a specific comparison group was weighted to be statistically similar to the target group across covariates that were potential confounders. Given our four samples, we estimated ATT for six pairs of comparisons, with three for the heterosexual-SMW comparisons (NAS vs. CHLEW; NAS vs. general population panel sample; NAS vs. LGBTQ-specific panel sample) and three for the SMW sample comparisons (CHLEW vs. LGBTQ-specific panel sample; CHLEW vs. general population panel sample; and general population panel sample vs. LGBTQ-specific panel sample).

For each pair in the comparison, we progressively included the four sets of covariates described above to estimate their corresponding PS weights. For comparisons between heterosexual and SMW, the first set of PS weights used only age and race/ethnicity demographic covariates to account for oversampling strategies and to address key differences in ATOD use across these demographic groups. The second set of PS weights used the expanded demographic covariates to address differences in risk and protective factors related to socioeconomic status (employment, education), relationship status, and parenting status. The third set of PS weights used demographic covariates and ATOD-specific risk factors that are known to vary by sexual identity, including early onset of drinking, history of child abuse, and using substances to cope with stress. For comparisons between SMW samples, the first three sets of PS weights were calculated as described above, with a fourth set of PS weights that included the SMW-specific protective factor (disclosure of sexual identity) in addition to the full set of demographic characteristics and ATOD risk factors. To be compatible with the PS weighted analyses, we constructed covariate-adjusted logistic regression models that followed the same steps in the four sets of PS weights, progressively including the expanded sets of covariates as adjustments in comparisons of each pair of groups. We also report unadjusted logistic regression results for each comparison. Testing these models provided an opportunity to compare the more complex PSW results with results using the most common regression approaches for addressing covariates that may impact outcomes by sexual identity.

To achieve optimal balance of covariates (potential confounders) across groups, we used generalized boosted models (GBM; McCaffrey et al., 2013) implemented in the TWANG Stata package (Cefalu et al., 2015) to estimate each set of PS weights. PS weighting via GBM models uses iterative procedures based on regression/classification trees and thereby avoids the more subjective model selection process common in traditional parametric logistic regression analysis. Using GBM as an automated data-adaptive algorithm has more desirable properties (McCaffrey et al., 2004) than traditional PS model estimation based on parametric linear logistic regression, especially with higher order

interactions and polynomial terms involved and in terms of prediction error (Friedman, 2001; Madigan and Ridgeway, 2004).

For our GBM models, we allowed up to cubic polynomials and three-way interactions (Elith et al., 2008) and we specified a maximum of 70,000 iterations. For the stopping rule for optimal balancing, we used the absolute standardized mean difference (also called standardized bias or effect size) as our balance metric for each covariate at each iteration, with the mean of those covariate balance metrics calculated across covariates as the summary statistic for measuring model fit. Given a sufficient number of iterations, the mean of the balance metrics will generally reduce to an optimal number of iterations before increasing again; thus, the final model can be determined by the iteration associated with the lowest mean.

For some sets of PS weights estimated by GBM, covariates may not completely balance. We considered a standardized mean difference with absolute value greater than 0.2 after PS weighting as evidence of

Table 2
Estimated treatment effects of sexual minority identity status (versus heterosexual identity) on alcohol, tobacco and other drug outcomes.

	Treatment effect when comparing the longitudinal Chicago sample with the heterosexual sample				
Model	Heavy (4 +) drinking OR [95% CI], p-value	DSM-5 AUD[a] OR [95% CI], p-value	Smoking OR [95% CI], p-value	Frequent marijuana use[b] OR [95% CI], p-value	Drug use[c] OR [95% CI], p-value
Unadjusted regression	**3.21 [2.35–4.39], p < .001**	**5.05 [2.99–8.53], p < .001**	**2.06 [1.46–2.92], p < .001**	**13.49 [6.43–28.33], p < .001**	**3.63 [2.14–6.15], p < .001**
Adjusted A	**3.24 [2.32–4.53], p < .001**	**4.94 [2.89–8.45], p < .001**	**1.92 [1.36–2.74], p < .001**	**12.47 [5.89–26.34], p < .001**	**3.41 [2–5.82], p < .001**
Adjusted B	**2.54 [1.73–3.71], p < .001**	**4.11 [2.23–7.56], p < .001**	**2.92 [1.88–4.52], p < .001**	**14.59 [6.44–33.02], p < .001**	**2.73 [1.48–5.03], p = .001**
Adjusted C	**1.74 [1.14–2.65], p = .01**	1.85 [0.94–3.64], p = .074	**1.75 [1.08–2.84], p = .022**	**7.82 [3.36–18.17], p < .001**	1.78 [0.93–3.39], p = .082
PS Weighted A	**2.42 [1.74–3.38], p < .001**	**4.06 [2.35–7.01], p < .001**	**1.76 [1.21–2.56], p = .003**	**10.64 [4.96–22.87], p < .001**	**2.95 [1.68–5.17], p < .001**
Weighted B	**1.71 [1.15–2.54], p = .008**	**2.99 [1.54–5.81], p = .001**	**1.98 [1.25–3.12], p = .004**	**9.21 [4.17–20.33], p < .001**	1.77 [0.96–3.27], p = .066
Weighted C	1.46 [0.93–2.28], p = .10	1.68 [0.84–3.35], p = .144	1.36 [0.8–2.32], p = .258	**4.9 [2.16–11.13], p < .001**	1.36 [0.67–2.75], p = .391
DR Weighted C	1.39 [0.88–2.21], p = .163	1.81 [0.74–4.42], p = .191	**1.9 [1.09–3.3], p = .024**	**5.61 [2.23–14.08], p < .001**	1.29 [0.63–2.61], p = .487
	Treatment effect when comparing the general population panel sample with the heterosexual sample				
Model	Heavy (4 +) drinking OR [95% CI], p-value	DSM-5 AUD[a] OR [95% CI], p-value	Smoking OR [95% CI], p-value	Frequent marijuana use[b] OR [95% CI], p-value	Drug use[c] OR [95% CI], p-value
Unadjusted regression	**5.16 [3.76–7.06], p < .001**	**5.38 [3.17–9.1], p < .001**	**2.59 [1.83–3.67], p < .001**	**16.58 [7.92–34.71], p < .001**	**7.06 [4.26–11.73], p < .001**
Adjusted A	**2.96 [2.01–4.35], p < .001**	**3.81 [2.02–7.21], p < .001**	**3.14 [1.99–4.96], p < .001**	**17.57 [7.47–41.31], p < .001**	**5.82 [3.15–10.77], p < .001**
Adjusted B	**2.92 [1.96–4.36], p < .001**	**3.64 [1.9–6.94], p < .001**	**3.16 [1.95–5.11], p < .001**	**17.18 [7.16–41.22], p < .001**	**5.64 [2.95–10.77], p < .001**
Adjusted C	**1.68 [1.08–2.6], p = .021**	1.69 [0.82–3.46], p = .156	**1.79 [1.05–3.03], p = .031**	**9.36 [3.76–23.24], p < .001**	**2.93 [1.46–5.86], p = .002**
PS Weighted A	**3.37 [2.05–5.56], p < .001**	**4.61 [2.31–9.2], p < .001**	**2.53 [1.44–4.46], p = .001**	**15.13 [6.35–36.05], p < .001**	**6.36 [3.21–12.59], p < .001**
Weighted B	**3.1 [1.83–5.23], p < .001**	**4.12 [2.02–8.42], p < .001**	**2.09 [1.2–3.65], p = .01**	**13.82 [5.64–33.89], p < .001**	**5.96 [2.93–12.12], p < .001**
Weighted C	**2.3 [1.26–4.21], p = .007**	1.63 [0.74–3.58], p = .227	1.08 [0.57–2.04], p = .82	**8.39 [3.23–21.78], p < .001**	**3.6 [1.6–8.08], p = .002**
DR Weighted C	1.87 [0.98–3.55], p = .058	1.33 [0.57–3.11], p = .516	1.13 [0.57–2.25], p = .73	**8.8 [2.88–26.9], p < .001**	**3.21 [1.32–7.83], p = .01**
	Treatment effect when comparing the targeted sexual minority panel sample with the heterosexual sample				
Model	Heavy (4 +) drinking OR [95% CI], p-value	DSM-5 AUD[a] OR [95% CI], p-value	Smoking OR [95% CI], p-value	Frequent marijuana use[b] OR [95% CI], p-value	Drug use[c] OR [95% CI], p-value
Unadjusted regression	**4.77 [3.44–6.63], p < .001**	**4.51 [2.61–7.8], p < .001**	1.23 [0.83–1.83], p = .309	**12.76 [6–27.14], p < .001**	**6.74 [4.01–11.31], p < .001**
Adjusted A	**3.24 [2.25–4.67], p < .001**	**2.89 [1.6–5.21], p < .001**	1.14 [0.73–1.76], p = .567	**8.98 [4.1–19.65], p < .001**	**6.22 [3.57–10.83], p < .001**
Adjusted B	**2.52 [1.65–3.85], p < .001**	**2.38 [1.19–4.74], p = .014**	1.67 [0.98–2.87], p = .061	**7.5 [3.16–17.81], p < .001**	**4.98 [2.65–9.37], p < .001**
Adjusted C	**1.65 [1.03–2.63], p = .036**	1.09 [0.49–2.41], p = .837	1.19 [0.67–2.13], p = .55	**3.82 [1.51–9.62], p = .005**	**3.15 [1.62–6.1], p = .001**
PS Weighted A	**2.42 [1.59–3.68], p < .001**	1.85 [0.96–3.58], p = .066	0.89 [0.52–1.52], p = .665	**8.22 [3.54–19.07], p < .001**	**7.16 [3.93–13.07], p < .001**
Weighted B	**2.83 [1.67–4.8], p < .001**	**2.06 [1.01–4.23], p = .049**	1.02 [0.53–1.97], p = .961	**13.33 [4.95–35.87], p < .001**	**7.2 [3.73–13.89], p < .001**
Weighted C	**2.25 [1.1–4.61], p = .026**	1 [0.41–2.4], p = .992	0.92 [0.41–2.06], p = .845	**9.34 [2.41–36.16], p = .001**	**4.41 [2.08–9.38], p < .001**
DR Weighted C	**2.09 [1.08–4.05], p = .029**	0.92 [0.36–2.3], p = .854	1.36 [0.57–3.23], p = .485	**8.04 [2.27–28.45], p = .001**	**4.82 [2.11–10.99], p < .001**

Adjusted = adjusted multivariable logistic regression model; weighted = propensity score (PS) weighted model; covariates varied by model as follows: A = race/ethnicity and age; B = race/ethnicity, age, minor children in household, employment, education and relationship status; C = race/ethnicity, age, minor children in household, employment, education, relationship status, using substances to cope, childhood physical or sexual abuse, and early onset drinking. The double-robust (DR) propensity score weighted models retained unbalanced covariates with standardized mean difference > |0.20| after propensity score weighted analyses; see Table 1 for the covariates for each of the three comparisons with the heterosexual sample. [a] DSM-5 AUD = Alcohol use disorder as defined by the Diagnostic and Statistical Manual of the American Psychiatric Association (5th edition); [b] frequent marijuana use was indicated by using marijuana at least weekly; [c] other drug use was indicated by using any illicit drug other than marijuana at least once in the past year; OR = odds ratio; ORs with p-values < 0.05 are bolded.

remaining imbalance. For the ATT effects using the third and fourth sets of PS weights in group comparisons, covariates that remained unbalanced after PS weighting were added to the model to estimate their effects. This strategy of accounting for covariates that remain unbalanced after PS weighting is called doubly robust estimation (Kang and Schafer, 2007; Neugebauer and van der Laan, 2005). Doubly robust estimation has advantages over traditional PS weighting, including yielding consistent estimates of the treatment effect if either the model for the outcome or the propensity score model is incorrectly specified (Kang and Schafer, 2007).

Balancing covariates helps elucidate whether and how outcomes may differ between groups if they were exposed to similar risk and protective factors. In addition, covariates that cannot be balanced by simple PS weighting can provide insights about risk factors that may deserve further consideration in future sampling designs and analysis plans, as they are likely to contribute to differences in outcomes by sexual identity.

3. Results

3.1. Comparison of SMW samples to heterosexual sample

3.1.1. Covariate balance before and after PS weighting

Table 1 shows distributions of confounders that were unbalanced between the groups before and after applying the PS weights using the maximal covariate set (e.g., in the comparisons of sexual identity balance is reported after accounting for all demographic variables as well as the ATOD-specific risk factors). As indicated by asterisks in the tables, almost all of the possible confounders (except identification as Black/African American) were initially unbalanced when comparing the SMW samples with the heterosexual sample. After PS weighting, the imbalance was reduced for most confounders. However, across all three comparisons, level of education remained unbalanced, and employment status and relationship status (particularly the proportion separated/divorced/widowed) also remained unbalanced for two of the three comparisons. Further, the weighted general population panel sample of SMW was significantly younger than the heterosexual comparison sample, and the prevalence of childhood physical or sexual abuse also remained higher than the corresponding prevalence among heterosexual women after PS weighting.

3.1.2. Associations of sexual minority status with ATOD outcomes

Tests of the bivariate regression models indicated significantly higher odds among SMW for each of the five ATOD outcomes in all three comparisons with heterosexual women (Table 2, *Unadjusted*). The only exception was tobacco use among SMW from the targeted panel sample, which did not significantly differ from heterosexual women in any models.

Fully adjusted multivariable regression models (*Adjusted C*) showed that many significant associations of SMW identity with the ATOD outcomes remained after including demographics and other confounders. The associations indicated increased odds of heavy drinking (adjusted odds ratios [aORs] ranging from 1.65 for the targeted panel sample to 1.74 for the CHLEW sample in comparison with the heterosexual sample; all $p < .05$), being a smoker (aOR=1.75 for CHLEW and 1.79 for the general population SMW panel sample; both $p < .05$), frequent marijuana use (aORs ranging from 3.82 for the targeted panel sample to 9.36 for the general population panel sample; all $p < .005$), and use of other drugs in the past year (aOR=2.93 for the general population panel sample and 3.15 for the targeted panel sample; both $p < .05$) for SMW compared to heterosexual women.

Some, but not all, differences in the ATOD outcomes were reduced to non-significance in the PS weighted models (*Weighted C*) and double-robust PS weighted models (*DR Weighted C*), which showed similar findings. Compared to the heterosexual sample, we found elevated odds of heavy drinking for SMW in the targeted panel sample (aOR=2.09, $p < .05$) and elevated odds of being a smoker for SMW in CHLEW (aOR=1.90, $p < .05$) that was maintained even in the double-robust PS weighted models. Despite robust controls for confounders, the initial elevated odds of frequent marijuana use and elevated odds of other drug use persisted even in the double-robust PS weighted models (aORs ranging from 3.2 to 8.8). The only exception was the odds of other drug use among CHLEW SMW compared to heterosexual women. This comparison was non-significant in the PS weighted model that accounted for all demographics and ATOD-specific risk factors (OR=1.36, p = .39).

3.2. Comparisons of sexual minority samples

3.2.1. Covariate balance before and after PS weighting

Table 3 summarizes distributions of confounders across the SMW samples before and after full PS weighting. Most confounders were initially unbalanced when comparing the general population panel sample of SMW with the CHLEW sample. However, after PS weighting, the imbalance was reduced for all potential confounders except age, employment status, and early onset of drinking. Fewer potential confounders were initially unbalanced when comparing the targeted SMW panel sample with the CHLEW sample, and all of the differences were balanced by PS weighting.

3.2.2. Assessment of sample differences in ATOD outcomes for SMW

The bivariate and adjusted multivariable regression models (Table 4) showed only sporadic significant differences in the five ATOD outcomes across the samples of SMW. The most persistent differences (those that remained in the PS weighted models), were lower odds of alcohol use disorder (OR=0.50, p = .005) and smoking (OR=0.53, p = .01) among SMW from the targeted sexual minority panel sample than among the CHLEW sample.

4. Discussion

The current study used PS weighting methods to examine differences in ATOD use among sexual minority and heterosexual women under hypothetical conditions in which three samples of SMW and their heterosexual counterparts have similar risk and protective factors. Almost all possible confounders were initially unbalanced when comparing the SMW samples with the heterosexual sample. After PS weighting the imbalance was substantially reduced, but not eliminated, highlighting key covariates that merit attention in future studies of ATOD among SMW.

In double-robust PS weighted models that accounted for unbalanced covariates, all three SMW samples showed consistently higher odds of drug use than heterosexual women, with odds ratios ranging from 5.6 to 8.8 to times greater for frequent marijuana use and 4.8–3.2 greater for other drug use. Compared with the heterosexual sample, one SMW sample showed higher odds of heavy drinking (the targeted panel sample) and one (CHLEW) showed higher odds of smoking. None of the SMW samples showed higher odds of alcohol use disorder in the double-robust PS weighted models. These findings suggest that even when using rigorous analytic methods to account for differences in demographics and key risk factors (e.g., childhood abuse, early drinking onset) for ATOD use and problems, SMW are significantly more likely than heterosexual women to engage in frequent marijuana and other drug use. These findings highlight the importance of ATOD screening by providers in healthcare and social service agencies serving women and LGBTQ communities to identify SMW who may be in need of brief intervention or referral to more intensive treatment services (Smith et al., 2010).

4.1. Differences between SMW and heterosexual women

Covariate distributions prior to weighting highlighted several demographic differences among the SMW samples relative to the heterosexual sample that had been identified in prior research, such as younger

Table 3
Comparing web panel samples of sexual minority women with longitudinal Chicago study: Covariate balance before and after propensity score weighted analyses.

	Comparison group	Unweighted				After full PS weighting			
	SMW - CHLEW	SMW - General population panel sample		SMW - Targeted panel sample		SMW - General population panel sample		SMW - Targeted panel sample	
Race/ethnicity									
Non-Hispanic White	48.1%	39.6%		40.0%		51.4%		49.3%	
Black/African American	37.9%	25.5%	*	29.0%		34.0%		34.1%	
Hispanic/Latinx	14.1%	35.0%	*	31.0%	*	14.6%		16.6%	
Age (mean, SD)	47.1 (12.51)	31.54 (10.20)	*	39.05 (13.52)	*	41.44 (10.19)	*	46.81 (12.80)	
Minor children in home	11.5%	41.5%	*	12.6%		12.7%		13.8%	
Employed	76.0%	74.3%		81.0%		88.7%	*	80.2%	
College education	86.7%	70.7%	*	93.5%	*	92.2%		92.3%	
Relationship status									
Married	30.4%	27.4%		29.0%		29.7%		32.4%	
Living with someone as couple	34.8%	46.6%	*	37.1%		38.9%		31.3%	
Separated, divorced or widowed	4.6%	5.7%		2.3%		3.3%		3.8%	
Single/never married									
Substance use to cope (mean, SD)	1.455 (0.76)	1.793 (1.01)	*	1.565 (0.37)		1.437 (0.74)		1.418 (0.66)	
Childhood physical or sexual abuse	45.3%	45.8%		48.7%		44.8%		49.7%	
Early onset drinking	25.3%	14.4%	*	12.9%	*	7.2%	*	19.6%	
Disclosure of sexual identity									
Not out to anyone	2.3%	17.9%	*	4.2%		1.6%		2.9%	
Only disclosed to a few people	10.2%	30.4%	*	19.4%	*	9.7%		10.2%	
Disclosed to most people	13.6%	16.5%		24.5%	*	15.6%		15.6%	
Bisexual	22.0%	52.6%	*	24.8%		25.3%		14.5%	

* Indicates standard mean difference larger than |0.20|. SD = standard deviation. Reference groups: Employment = unemployed; Education = high school or less; Relationship status = Single/never married; Disclosure = Has disclosed to all

average age, higher levels of education, lower rates of marriage, and higher rates of being single and never married (Lunn et al., 2017). Also as in prior studies, SMW were more likely than heterosexual women to report childhood physical or sexual abuse and early onset drinking (Hughes, McCabe et al., 2010; Wilsnack et al., 2008), and to endorse substance use as a coping strategy (Talley et al., 2012). These risk factors may be important intervention targets to reduce the burden of ATOD use and associated problems among SMW. In particular, the high prevalence of physical and/or sexual abuse early in life (45–49% across the SMW samples) and greater use of substances to cope with stress may be important foci for both prevention and treatment. Further, qualitative research to understand why these risk factors are elevated for SMW and how they manifest in ATOD use would be informative.

4.2. Differences among the SMW samples

In analyses adding SMW-specific resiliency factors to the set of possible confounders, only a few outcomes differed among the three SMW samples after full weighting, and there were only sporadic differences in outcomes across these samples. This finding is encouraging in relation to the potential utility of different types of samples when investigating substance use outcomes among SMW. Nonprobability samples, such as the CHLEW sample and the web panel samples, allow for recruitment of large numbers of SMW and greater coverage of SMW-specific risk and resiliency factors (Institute of Medicine, 2011; Meyer and Wilson, 2009). Although the panel samples differed from the longitudinal CHLEW sample on a few demographics such as age (the CHLEW sample was older), inclusion of SMW in general population samples along with women identified through LGBTQ-specific web panels or other LGBTQ community resources helped to increase the diversity of demographics and life-experiences, potentially making findings more generalizable. Our findings suggest that panel samples have promise in addressing some of the limitations of other sampling methods such as RDS or probability sampling that are difficult to achieve in a cost-effective manner with SMW (Martin et al., 2015; Michaels et al., 2019; Middleton et al., 2022).

4.3. Study strengths and limitations

This study is unique in its inclusion of three distinct samples of SMW and the use of rigorous double-robust PSW strategies to balance and account for key confounders of the association between sexual identity with and ATOD outcomes, ranging from any smoking to alcohol use disorder. However, the PSW methods did not completely reduce differences in ATOD outcomes across sexual identity to non-significance for all comparisons. This suggests other factors also influence SMW's ATOD use and these should be examined in future studies, particularly in relation to frequent use of marijuana and other drugs. Further, there may be other important behavioral health conditions associated with ATOD use, such as depression and anxiety, as well as experiences of gender- and sexual identity-based discrimination, that could help to explain variability in the outcomes, but these were not available for all four samples. Finally, in comparisons between samples of SMW, measures of gender presentation and associated discrimination may also may illustrate additional factors contributing to differences in ATOD outcomes.

Future research might further explore differences by sexual identity in ATOD outcomes using PSW or matching strategies to balance even more confounders across groups. Some matching strategies, such as coarse exact matching, require large control or comparison groups from which to select respondents that best match the focal treatment group (in our case, SMW). In some instances, it may be possible to use these matching strategies, but in the absence of sufficient sample sizes of comparison groups, PSW strategies provide an effective solution by creating a comparison group that is as similar as possible to the focal group. Another advantage is that PSW affords the benefit of being able to accommodate more covariates and confounders than matching strategies.

4.4. Conclusions

Disparities in substance use, most notably marijuana and other drug use, were evident among SMW relative to heterosexual women across samples recruited using different sampling strategies, although the size of the difference varied by sample. These findings provide some reassurance about the validity of large nonprobability samples, which

Table 4
Estimated treatment effects of web panel status (vs. longitudinal study) on alcohol, tobacco and other drug outcomes.

	Treatment effect when comparing the general population panel sample of sexual minority women with the sexual minority women in the longitudinal Chicago sample				
	Heavy (4 +) drinking	DSM-5 AUD[a]	Smoking	Frequent marijuana use[b]	Drug use[c]
Model	OR [95% CI], p-value	OR [95% CI], p-value	OR [95% CI], p-value	OR [95% CI], p-value	OR [95% CI], p-value
Unadjusted regression	**1.6 [1.21–2.13], p = .001**	1.07 [0.74–1.53], p = .733	1.25 [0.91–1.72], p = .162	1.23 [0.87–1.73], p = .241	**1.95 [1.35–2.8], p < .001**
Adjusted A	0.88 [0.62–1.26], p = .491	0.68 [0.43–1.05], p = .083	1.12 [0.76–1.65], p = .579	0.85 [0.55–1.3], p = .454	1.2 [0.77–1.87], p = .408
Adjusted B	0.94 [0.65–1.37], p = .76	0.68 [0.43–1.09], p = .108	0.99 [0.65–1.5], p = .958	0.77 [0.49–1.21], p = .261	1.27 [0.8–2.02], p = .317
Adjusted C	0.82 [0.55–1.23], p = .337	**0.5 [0.3–0.85], p = .01**	0.93 [0.59–1.47], p = .766	0.69 [0.43–1.12], p = .134	1.09 [0.67–1.79], p = .718
Adjusted D	0.88 [0.57–1.34], p = .542	**0.5 [0.29–0.85], p = .011**	1.01 [0.63–1.62], p = .965	0.69 [0.42–1.14], p = .151	0.96 [0.57–1.6], p = .872
PS Weighted A	1.46 [0.96–2.21], p = .074	1.23 [0.73–2.07], p = .437	1.3 [0.83–2.05], p = .251	1.24 [0.76–2.02], p = .38	**1.68 [1.01–2.77], p = .045**
Weighted B	1.23 [0.74–2.03], p = .424	1.15 [0.63–2.08], p = .655	1.17 [0.69–1.99], p = .552	1.02 [0.56–1.84], p = .95	**1.89 [1.03–3.47], p = .039**
Weighted C	1.03 [0.66–1.61], p = .89	0.9 [0.51–1.59], p = .717	1.09 [0.67–1.78], p = .728	0.98 [0.58–1.66], p = .936	1.54 [0.87–2.71], p = .134
Weighted D	1.32 [0.73–2.38], p = .35	0.98 [0.51–1.89], p = .95	0.98 [0.52–1.82], p = .939	0.83 [0.46–1.5], p = .53	1.22 [0.62–2.41], p = .568
DR Weighted D	0.94 [0.52–1.69], p = .84	0.85 [0.43–1.72], p = .659	1.01 [0.54–1.88], p = .974	0.77 [0.41–1.43], p = .401	1.05 [0.52–2.14], p = .889
	Treatment effect when comparing the targeted sexual minority panel sample with the sexual minority women in the longitudinal Chicago sample				
	Heavy (4 +) drinking	DSM-5 AUD[a]	Smoking	Frequent marijuana use[b]	Drug use[c]
Model	OR [95% CI], p-value	OR [95% CI], p-value	OR [95% CI], p-value	OR [95% CI], p-value	OR [95% CI], p-value
Unadjusted regression	**1.49 [1.1–2], p = .009**	0.89 [0.6–1.32], p = .574	**0.6 [0.41–0.86], p = .006**	0.95 [0.65–1.38], p = .769	**1.86 [1.27–2.72], p = .001**
Adjusted A	0.98 [0.7–1.37], p = .91	**0.58 [0.38–0.9], p = .015**	**0.48 [0.32–0.72], p < .001**	0.66 [0.43–1], p = .048	**1.54 [1.03–2.32], p = .036**
Adjusted B	1.01 [0.72–1.42], p = .958	**0.6 [0.38–0.94], p = .024**	**0.52 [0.34–0.79], p = .002**	0.66 [0.43–1.01], p = .057	**1.6 [1.06–2.42], p = .026**
Adjusted C	1.02 [0.71–1.48], p = .913	**0.59 [0.35–0.98], p = .041**	**0.54 [0.35–0.85], p = .007**	0.65 [0.41–1.03], p = .067	**1.59 [1.03–2.44], p = .037**
Adjusted D	0.95 [0.65–1.4], p = .809	**0.55 [0.32–0.93], p = .026**	**0.55 [0.35–0.86], p = .009**	0.66 [0.41–1.05], p = .079	**1.56 [1–2.42], p = .049**
PS Weighted A	0.97 [0.64–1.45], p = .87	**0.45 [0.27–0.75], p = .002**	**0.47 [0.29–0.77], p = .003**	0.69 [0.43–1.11], p = .126	1.4 [0.85–2.32], p = .188
Weighted B	1.00 [0.7–1.41], p = .977	**0.51 [0.32–0.81], p = .005**	**0.54 [0.34–0.85], p = .008**	0.79 [0.49–1.25], p = .31	**1.57 [1–2.46], p = .048**
Weighted C	0.97 [0.68–1.39], p = .877	**0.53 [0.32–0.86], p = .01**	**0.57 [0.36–0.9], p = .015**	0.71 [0.44–1.15], p = .166	1.35 [0.86–2.12], p = .196
Weighted D	0.94 [0.65–1.35], p = .726	**0.5 [0.31–0.81], p = .005**	**0.53 [0.33–0.86], p = .01**	0.87 [0.52–1.44], p = .587	1.42 [0.89–2.25], p = .14
DR Weighted D[d]	–	–	–	–	–

Adjusted = adjusted multivariable logistic regression model; weighted = propensity score weighted model; covariates varied by model as follows: A = race/ethnicity and age; B = race/ethnicity, age, minor children in household, employment, education and relationship status; C = race/ethnicity, age, minor children in household, employment, education, relationship status, using substances to cope, childhood physical or sexual abuse, and early onset drinking; D = race/ethnicity, age, minor children in household, employment, education, relationship status, using substances to cope, childhood physical or sexual abuse, early onset drinking, identity disclosure status and sexual identity. The double-robust weighted models retained unbalanced covariates with standardized mean difference > |0.20| after propensity score weighted analyses; see Table 2 for the covariates for each of the three comparisons with the longitudinal Chicago sample. [a] DSM-5 AUD = Alcohol use disorder as defined by the Diagnostic and Statistical Manual of the American Psychiatric Association (5th edition); [b] frequent marijuana use was indicated by using marijuana at least weekly; [c] other drug use was indicated by using any illicit drug other than marijuana at least once in the past year; [d] No covariates remained unbalanced for this sample comparison, so the double-robust PS weighted model D is the same as the fully-weighted model D. OR = odds ratio; ORs with p-values < 0.05 are bolded.

remain an important tool in ATOD research with SMW. The use of rigorous methods to account for differences in demographics and key risk factors for ATOD use and problems, including history of childhood physical or sexual abuse, early onset of drinking, and using substances to cope with stress, reduced disparities across seven of 15 comparisons between SMW and heterosexual women. These findings suggest that some factors, such as use of substances to cope with stress, may be particularly salient to interventions with SMW.

Role of funding source

Nothing declared.

Contributors

KJKJ, LAD, KFT, and TLH conceptualized the study. LD and KFT directed the project and coordinated data collection. CM compiled data; LL and KJKJ conducted the primary analyses. KJKJ and LD led the drafting and revision of the manuscript, with contributions from CM, AAM, L.L, and TLH. All authors have seen and approved the final manuscript and contributed significantly to the work.

Ethical approval

All procedures performed in studies involving human participants

were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed consent

Informed consent was obtained from all individual participants included in the study.

Conflict of Interest

No conflict declared.

Acknowledgements

Research reported in this publication was supported by the National Institutes of Health, National Institute on Drug Abuse [grant number R01DA036606; K. Trocki and L. Drabble MPI] and the National Institute on Alcohol Abuse and Alcoholism [grant number R01AA13328; T. Hughes, PI; and P50AA005595 center grant/National Alcohol Survey, W.K. Kerr, PI]. Cat Munroe is supported through the National Institute on Alcohol Abuse and Alcoholism's training grant T32AA007240 (PI: S. Zemore).

References

American Psychiatric Association, 2013. Diagnostic and statistical manual of mental disorders, Fifth ed. American Psychiatric Association.

Anderssen, N., Malterud, K., 2017. Oversampling as a methodological strategy for the study of self-reported health among lesbian, gay and bisexual populations. Scand. J. Public Health 45 (6), 637–646. https://doi.org/10.1177/1403494817717407.

Baiocco, R., D'Alessio, M., Laghi, F., 2010. Binge drinking among gay, and lesbian youths: The role of internalized sexual stigma, self-disclosure, and individuals' sense of connectedness to the gay community. Addict. Behav. 35 (10), 896–899. https://doi.org/10.1016/j.addbeh.2010.06.004.

Blosnich, J., Lee, J.G., Horn, K., 2013. A systematic review of the aetiology of tobacco disparities for sexual minorities. Tob. Control 22 (2), 66–73. https://doi.org/10.1136/tobaccocontrol-2011-050181.

Boehmer, U., Clark, M., Timm, A., Ozonoff, A., 2008. Two means of sampling sexual minority women: How different are the samples of women. J. LGBT Health Res. 4 (4), 143–151. https://doi.org/10.1080/15574090903110786.

Bowen, D.J., Bradford, J., Powers, D., 2007. Comparing sexual minority status across sampling methods and populations. Women Health 44 (2), 121–134. https://doi.org/10.1300/J013v44n02_07.

Boyle, J.M., Iachan, R., Freedner-Maguire, N., Fakhouri, T.H., 2017. Characteristics of the population of Internet panel members. Surv. Pract. 10 (4), 2771. https://doi.org/10.29115/SP-2017-0025.

Canan, S.N., Kaplan, A.M., Jozkowski, K.N., 2021. Comparing rates of sexual assault between panel quota and social media samples: Findings across sexual orientation categories. J. Interpers. Violence, Online Adv. Publ. 1–14. https://doi.org/10.1177/08862605211056027.

Carver, C.S., 1997. You want to measure coping but your protocol's too long? Consider the Brief COPE. Int. J. Behav. Med. 4 (1), 92–100. https://doi.org/10.1207/s15327558ijbm0401_6.

Cefalu, M., Liu, S., Marti, C., 2015. Toolkit for Weighting and Analysis of Nonequivalent Groups: A Tutorial on the TWANG Commands for Stata. RAND Corporation,. ⟨https://www.rand.org/pubs/tools/TL170.html⟩.

Coulter, R.W., Kenst, K.S., Bowen, D.J., 2014. Research funded by the National Institutes of Health on the health of Lesbian, Gay, Bisexual, and Transgender populations. Am. J. Public Health 104 (2), e105–e112. https://doi.org/10.2105/AJPH.2013.301501.

Drabble, L., Trocki, K.F., Hughes, T.L., Korcha, R.A., Lown, A.E., 2013. Sexual orientation differences in the relationship between victimization and hazardous drinking among women in the National Alcohol Survey. Psychol. Addict. Behav. 27 (3), 639–648. https://doi.org/10.1037/a0031486.

Drabble, L.A., Mericle, A.A., Karriker-Jaffe, K.J., Trocki, K.F., 2020. Harmful drinking, tobacco, and marijuana use in the 2000–2015 National Alcohol Surveys: Examining differential trends by sexual identity. Subst. Abus. 43 (3), 317–328. https://doi.org/10.1080/08897077.2019.1709251.

Drabble, L.A., Trocki, K.F., Korcha, R.A., Klinger, J.L., Veldhuis, C.B., Hughes, T.L., 2018. Comparing substance use and mental health outcomes among sexual minority and heterosexual women in probability and non-probability samples. Drug Alcohol Depend. 185, 285–292. https://doi.org/10.1016/j.drugalcdep.2017.12.036.

Elith, J., Leathwick, J.R., Hastie, T., 2008. A working guide to boosted regression trees. J. Anim. Ecol. 77 (4), 802–813. https://doi.org/10.1111/j.1365-2656.2008.01390.x.

Everett, B.G., Wall, M., Shea, E., Hughes, T.L., 2021. Mortality risk among a sample of sexual minority women: A focus on the role of sexual identity disclosure. Soc. Sci. Med. 272, 113731 (Article number).

Friedman, J.H., 2001. Greedy function approximation: A gradient boosting machine. Ann. Stat. 29 (5), 1189–1232. ⟨https://www.jstor.org/stable/2699986⟩.

Hasin, D.S., Grant, B.F., 2015. The National Epidemiologic Survey on Alcohol and Related Conditions (NESARC) Waves 1 and 2: review and summary of findings. Soc. Psychiatry Psychiatr. Epidemiol. 50 (11), 1609–1640. https://doi.org/10.1007/s00127-015-1088-0.

Hatzenbuehler, M.L., Pachankis, J.E., 2021. Sexual and gender minority health disparities: Concepts, methods and future directions. In: Dankwa-Mullan, I., Perez-Sable, E.J., Gardner, K.I., Zhang, X., Rosario, A.M. (Eds.), The Science of Health Disparities Research, First edition.,. John Wiley & Sons, pp. 429–444.

Hottes, T.S., Bogaert, L., Rhodes, A.E., Brennan, D.J., Gesink, D., 2016. Lifetime prevalence of suicide attempts among sexual minority adults by study sampling strategies: A systematic review and meta-analysis. Am. J. Public Health, 106(5) e1–e12. https://doi.org/10.2105/AJPH.2016.303088.

Hughes, T., 2011. Alcohol use and alcohol-related problems among sexual minority women. Alcohol. Treat. Q. 29 (4), 403–435. https://doi.org/10.1080/07347324.2011.608336.

Hughes, T., Wilsnack, S., Martin, K., Matthews, A., Johnson, T., 2021. Alcohol use among sexual minority women: Methods used and lessons learned in the 20-Year Chicago Health and Life Experiences of Women Study. Int. J. Alcohol Drug Res. 9 (1), 30–42. https://doi.org/10.7895/ijadr.289.

Hughes, T.L., Johnson, T.P., Steffen, A.D., Wilsnack, S.C., Everett, B., 2014. Lifetime victimization, hazardous drinking, and depression among heterosexual and sexual minority women. LGBT Health 1 (3), 192–203. https://doi.org/10.1089/lgbt.2014.0014.

Hughes, T.L., Johnson, T.P., Wilsnack, S.C., Szalacha, L.A., 2007. Childhood risk factors for alcohol abuse and psychological distress among adult lesbians. Child Abus. Negl. 31 (7), 769–789. https://doi.org/10.1016/j.chiabu.2006.12.014.

Hughes, T.L., McCabe, S.E., Wilsnack, S.C., West, B.T., Boyd, C.J., 2010. Victimization and substance use disorders in a national sample of heterosexual and sexual minority women and men: Sexual identity, victimization and SUDs. [Artic.]. Addict. 105 (12), 2130–2140. https://doi.org/10.1111/j.1360-0443.2010.03088.x.

Hughes, T.L., Szalacha, L.A., Johnson, T.P., Kinnison, K.E., Wilsnack, S.C., Cho, Y., 2010. Sexual victimization and hazardous drinking among heterosexual and sexual minority women. Addict. Behav. 35 (12), 1152–1156. https://doi.org/10.1016/j.addbeh.2010.07.004.

Hughes, T.L., Veldhuis, C.B., Drabble, L.A., Wilsnack, S.C., 2020. Substance use among sexual minority women: A global scoping review (Article). PLOS One 15 (3), e0229869. https://doi.org/10.1371/journal.pone.0229869.

Institute of Medicine, 2011. The Health of Lesbian, Gay, Bisexual, and Transgender. People: Building a Foundation for Better Understanding. National Academies Press,.

Johnson, S.E., Holder-Hayes, E., Tessman, G.K., King, B.A., Alexander, T., Zhao, X., 2016. Tobacco product use among sexual minority adults: Findings from the 2012– 2013 national adult tobacco survey. Am. J. Prev. Med. 50 (4), e91–e100. https://doi.org/10.1016/j.amepre.2015.07.041.

Johnson, T.P., Hughes, T.L., Cho, Y.I., Wilsnack, S.C., Aranda, F., Szalacha, L.A., 2013. Hazardous drinking, depression, and anxiety among sexual-minority women: Self-medication or impaired functioning. J. Stud. Alcohol Drugs 74 (4), 565. https://doi.org/10.15288/jsad.2013.74.565.

Kang, J.D., Schafer, J.L., 2007. Demystifying double robustness: A comparison of alternative strategies for estimating a population mean from incomplete data. Stat. Sci. 22 (4), 523–539. https://doi.org/10.1214/07-STS227.

Karriker-Jaffe, K.J., Greenfield, T.K., Kaplan, L.M., 2017. Distress and alcohol-related harms from intimates, friends, and strangers. J. Subst. Use 22 (4), 434–441. https://doi.org/10.1080/14659891.2016.1232761.

Kidd, J.D., Paschen-Wolff, M.M., Mericle, A.A., Caceres, B.A., Drabble, L.A., Hughes, T.L., 2022. A scoping review of alcohol, tobacco, and other drug use treatment interventions for sexual and gender minority populations. J. Subst. Abus. Treat. (Online Adv. Publ.) 133, 108539. https://doi.org/10.1016/j.jsat.2021.108539.

Krueger, E.A., Fish, J.N., Hammack, P.L., Lightfoot, M., Bishop, M.D., Russell, S.T., 2020. Comparing national probability and community-based samples of sexual minority adults: Implications and recommendations for sampling and measurement. Arch. Sex. Behav. 49, 1463–1475. https://doi.org/10.1007/s10508-020-01724-9.

Lee, J.G., Griffin, G.K., Melvin, C.L., 2009. Tobacco use among sexual minorities, USA, 1987-2007: A Systematic Review. Tob. Control 18, 275–282. https://doi.org/10.1136/tc.2008.028241.

Lewis, R.J., Winstead, B.A., Lau-Barraco, C., Mason, T.B., 2017. Social factors linking stigma-related stress with alcohol use among lesbians. J. Soc. Issues 73 (3), 545–562. https://doi.org/10.1111/josi.12231.

Lunn, M.R., Cui, W., Zack, M.M., Thompson, W.W., Blank, M.B., Yehia, B.R., 2017. Sociodemographic characteristics and health outcomes among lesbian, gay, and bisexual US adults using Healthy People 2020 leading health indicators. LGBT Health 4 (4), 283–294. https://doi.org/10.1089/lgbt.2016.0087.

Madigan, D., Ridgeway, G., 2004. Discussion of "Leeast angle Regression" by Efron et al. Ann. Stat. 32 (2), 465–469. https://doi.org/10.1214/009053604000000067.

Martin, K.R., Johnson, T.P., Hughes, T.L., 2015. Using respondent driven sampling to recruit sexual minority women (Article). Surv. Pract. 8 (1), 2842. https://doi.org/10.29115/SP-2015-0004.

McCabe, S.E., Engstrom, C.W., Kcomt, L., Evans-Polce, R., West, B.T., 2021. Trends in binge drinking, marijuana use, illicit drug use, and polysubstance use by sexual identity in the United States (2006–2017. Subst. Abus. 1–10. https://doi.org/10.1080/08897077.2021.1913696.

McCabe, S.E., Hughes, T.L., Beal, S., Evans-Polce, R.J., Kcomt, L., Engstrom, C., West, B.T., Veliz, P., Leary, K., McCabe, V.V., 2022. Sexual orientation differences in childhood sexual abuse, suicide attempts, and DSM-5 alcohol, tobacco, other drug

use, and mental health disorders in the US (article). Child Abus. Negl. 123, 105377. https://doi.org/10.1016/j.chiabu.2021.105377.
McCaffrey, D.F., Griffin, B.A., Almirall, D., Slaughter, M.E., Ramchand, R., Burgette, L.F., 2013. A tutorial on propensity score estimation for multiple treatments using generalized boosted models. Stat. Med. 32 (19), 3388–3414. https://doi.org/10.1002/sim.5753.
McCaffrey, D.F., Ridgeway, G., Morral, A.R., 2004. Propensity score estimation with boosted regression for evaluating causal effects in observational studies. Psychol. Methods 9 (4), 403–425. https://doi.org/10.1037/1082-989X.9.4.403.
Meyer, I.H., 2003. Prejudice, social stress, and mental health in lesbian, gay, and bisexual populations: Conceptual issues and research evidence (Article). Psychol. Bull. 129 (5), 674–697. https://doi.org/10.1037/0033-2909.129.5.674.
Meyer, I.H., 2013. Prejudice, social stress, and mental health in lesbian, gay, and bisexual populations. Psychol. Sex. Orientat. Gend. Divers. 1 (S), 3–26. https://doi.org/10.1037/2329-0382.1.S.3.
Meyer, I.H., Marken, S., Russell, S.T., Frost, D.M., Wilson, B.D., 2020. An innovative approach to the design of a national probability sample of sexual minority adults. LGBT Health 7 (2), 101–108. https://doi.org/10.1089/lgbt.2019.0145.
Meyer, I.H., Wilson, P.A., 2009. Sampling lesbian, gay, and bisexual populations. J. Couns. Psychol. 56 (1), 23–31. https://doi.org/10.1037/a0014587.
Michaels, S., Pineau, V., Reimer, B., Ganesh, N., Dennis, J.M., 2019. Test of a hybrid method of sampling the LGBT population: Web respondent driven sampling with seeds from a probability sample. J. Off. Stat. 35 (4), 731–752. ⟨https://content.sciendo.com/view/journals/jos/35/4/article-p731.xml⟩.
Middleton, D., Drabble, L.A., Krug, D., Karriker-Jaffe, K.J., Mericle, A.A., Hughes, T.L., Iachan, R., Trocki, K.F., 2022. Challenges of virtual RDS for recruitment of sexual minority women for a behavioral health study. J. Surv. Stat. Methodol. 10 (2), 466—88. https://doi.org/10.1093/jssam/smab039.
Mulia, N., Bensley, K.M., 2020. Alcohol-related disparities among women: Evidence and potential explanations. Alcohol Res.: Curr. Rev. 40 (2), 09. https://doi.org/10.35946/arcr.v40.2.09.
National Academies of Sciences, E., Medicine, 2020. Understanding the Well-Being of LGBTQI+ Populations. The National Academies Press,. https://doi.org/10.17226/25877.
National Academies of Sciences, Engineering, and Medicine, 2018. Improving Health Research on Small Populations: Proceedings of a Workshop. The National Academies Press,.
Neugebauer, R., van der Laan, M., 2005. Why prefer double robust estimators in causal inference. J. Stat. Plan. Inference 129 (1–2), 405–426. https://doi.org/10.1016/j.jspi.2004.06.060.
Owens, C., Stall, R., Dodge, B., 2020. Sampling considerations for LGBTQ health research. In: Stall, R., Dodge, B., Bauermeister, J.A., Poteat, T., Beyrer, C. (Eds.), LGBTQ Health Research: Theory, Methods, Practice. Johns Hopkins University Press, pp. 99–103.
Pachankis, J.E., Cochran, S.D., Mays, V.M., 2015. The mental health of sexual minority adults in and out of the closet: A population-based study. J. Consult. Clin. Psychol. 83 (5), 890. https://doi.org/10.1037/ccp0000047.
Pachankis, J.E., Mahon, C.P., Jackson, S.D., Fetzner, B.K., Bränström, R., 2020. Sexual orientation concealment and mental health: A conceptual and meta-analytic review. Psychol. Bull. 146 (10), 831–871. https://doi.org/10.1037/bul0000271.
Persson, T.J., Pfaus, J.G., Ryder, A.G., 2015. Explaining mental health disparities for non-monosexual women: Abuse history and risky sex, or the burdens of non-disclosure. Soc. Sci. Med. 128, 366–373. https://doi.org/10.1016/j.socscimed.2014.08.038.
Salway, T.J., Morgan, J., Ferlatte, O., Hawkins, B., Lachowsky, N.J., Gilbert, M., 2019. A systematic review of characteristics of nonprobability community venue samples of sexual minority individuals and associated methods for assessing selection bias. LGBT Health 6 (5), 205–215. https://doi.org/10.1089/lgbt.2018.0241.
Smith, P.C., Schmidt, S.M., Allensworth-Davies, D., Saitz, R., 2010. A single-question screening test for drug use in primary care. Arch. Intern. Med. 170 (13), 1155–1160. https://doi.org/10.1001/archinternmed.2010.140.
Lesbian health: Current assessment and directions for the future. In: Solarz, A.L. (Ed.), 1999. Institute of Medicine Committee on Lesbian Health Research Priorities. National Academy Press.
Talley, A.E., Sher, K.J., Steinley, D., Wood, P.K., Littlefield, A.K., 2012. Patterns of alcohol use and consequences among empirically derived sexual minority subgroups. J. Stud. Alcohol Drugs 73 (2), 290–302. https://doi.org/10.15288/jsad.2012.73.290.
Talley, A.E., Turner, B., Foster, A.M., Phillips, G., 2019. Sexual minority youth at risk of early and persistent alcohol, tobacco, and marijuana use. Arch. Sex. Behav. 48 (4), 1073–1086.
Thoits, P.A., 2010. Stress and health: Major findings and policy implications. J. Health Soc. Behav. 51 (1_suppl), S41–S53. https://doi.org/10.1177/0022146510383499.
Trocki, K.F., Mericle, A.A., Drabble, L.A., Klinger, J.L., Veldhuis, C.B., Hughes, T.L., Karriker-Jaffe, K., 2020. Investigating differential protective effects of marriage on substance use by sexual identity status. Int. J. Alcohol Drug Res. 8 (2), 69–80. https://doi.org/10.7895/ijadr.267.
Veldhuis, C.B., Hughes, T.L., Drabble, L.A., Wilsnack, S.C., Matthews, A.K., 2020. Do relationships provide the same levels of protection against heavy drinking for lesbian and bisexual women? An intersectional approach. Psychol. Sex. Orientat. Gend. Divers. 7 (3), 337–352. https://doi.org/10.1037/sgd0000383.
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.
Wilsnack, S.C., Hughes, T.L., Johnson, T.P., Bostwick, W.B., Szalacha, L.A., Benson, P., Aranda, F., Kinnison, K.E., 2008. Drinking and drinking-related problems among heterosexual and sexual minority women. J. Stud. Alcohol Drugs 69, 129–139. https://doi.org/10.15288/jsad.2008.69.129.