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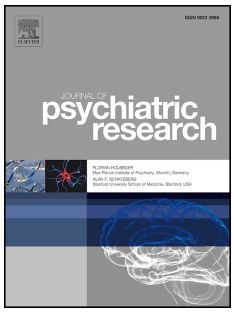

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Substance use among sexual minorities in the US – Linked to inequalities and unmet need for mental health treatment?

Results from the National Survey on Drug Use and Health (NSDUH).

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Abstract

Background: A social group found to be particularly burdened by disparities in substance use is the group of sexual minorities (SM). We investigated the potential association between substance use among SM adults in the United States (US) and social inequality, with an additional focus on disparities in unmet need for mental health treatment.

Methods: A secondary cross-sectional data analysis was performed using National Survey on Drug Use and Health (NSDUH) data from 2015 to 2017 and including 126,463 individuals with 8,241 identifying as SM. Multivariable logistic regression models were implemented to quantify disparities in substance use, to calculate the effect of sociodemographic variables on substance use, and to examine associations to socioeconomic vulnerability.

Findings: SM showed higher odds of past-year substance use and lifetime chemsex drugs use. All SM except for bisexual men exhibited higher odds of past-month binge drinking relative to heterosexuals. Bisexual women had higher odds for use of all analysed substances relative to heterosexual women. Being older and being a woman were shown to be protective factors. Urbanity, being uninsured, and unmet need for mental health treatment were associated with significantly higher odds of substance use, chemsex drugs use and binge drinking. A link was established between drug use and health, with higher odds of drug use for lower health ratings. SM experienced significantly higher levels of socioeconomic vulnerability. Higher vulnerability indices were associated with increased odds for drug use.

Interpretation: This study is among the first nationally representative samples that analysed the effect of sociodemographic determinants and unmet need for mental health treatment on substance use in SM. It emphasises the multifactorial aetiology of vulnerability to substance use and highlights the distinct disparities in, and underlying mechanisms for substance use among SM. Approaches tailored to SM subgroups may be needed to address the problems of

increased substance use for this population in the long-term. However, critical gaps in the literature remain and large-scale studies inclusive of SM individuals are needed to present causal links.

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Introduction

Substance use has a multifactorial aetiology (Frisher et al., 2007; Galea et al., 2004). Genetic, psychological and social factors, as well as membership in certain societal minority groups have been shown to be important determinants of substance use and the subsequent development of substance use disorders (Galea et al., 2004). The predictive value of specific risk factors varies throughout life and with various stages of substance use (Frisher et al., 2007). A group shown to be heavily burdened by disparities in substance use is the group of sexual minorities (SM), including individuals identifying as gay, lesbian, or bisexual (Allen and Mowbray, 2016; Demant et al., 2017; McCabe et al., 2009; Schuler et al., 2018). According to the Institute of Medicine in the US, SM experience unique health disparities and worse health outcomes (e.g., being at higher risk for HIV and other sexually transmitted infections (STIs), mental health problems, discrimination and stigmatisation; less frequent use of preventive health services) than their heterosexual counterparts (Institute of Medicine Committee on Lesbian et al., 2011). Additionally, it has been shown that SM face elevated rates of substance use and substance use disorders, with differences not only occurring early in life but also persisting in adulthood (Allen and Mowbray, 2016; Institute of Medicine Committee on Lesbian et al., 2011; McCabe et al., 2009; Pakula et al., 2016).

There are several theories about potential reasons for those observed disparities, with the minority stress model by Ilan Meyer being the most commonly used framework (Green and Feinstein, 2012; Meyer, 2003). According to Meyer, 'stigma, prejudice, and discrimination create a hostile and stressful social environment', adding to internal stressors such as low self-esteem, shame, guilt, and internalised stigma, which are already elevating the risk of substance use disorders and other mental health problems (Meyer, 2003; Schuler et al., 2018). Of particular interest is the use of drugs (mostly stimulants such methamphetamine, poppers, GHB/GBL and also stimulant-type NPS), in sexual settings by men who have sex with men (MSM); also known as "chemsex", this practice, aimed at facilitating interaction and enhancing sexual pleasure, has become an issue of concern over the last decade, due to its associated health harms, notably an increased exposure to sexually transmitted diseases (HIV, HCV)(McCarty-Caplan et al., 2014; Schecke et al., 2019). Because of higher rates of substance use among SM, several studies have raised concerns about an unmet need for mental health treatment in the SM community (McCabe et al., 2013). Non-heterosexual sexual orientation, as a minority status, may have a negative impact on psychological wellbeing, triggering mental health problems and problematic drug use. Moreover, SM may

be reluctant to seek for specialised care due to the fear of rejection or stigmatization by services‘ staff (Schecke et al., 2019).With the evidence shown, it is no surprise that the Institute of Medicine in the United States (US) demanded a greater focus on SM health research, especially using nationally representative data (Institute of Medicine Committee on Lesbian et al., 2011).

Only few national studies have examined disparities in substance use among sexual minorities, with most of them exclusively focusing on opioid misuse (Duncan et al., 2019; Schuler et al., 2019). Therefore, the aim of this study was to explore a wider range of substance use patterns among SM adults and to investigate the potential association between substance use and socioeconomic vulnerability from a population-based survey in the US. We therefore focussed on past-month binge alcohol consumption, past-year cocaine, crack cocaine, heroin and methamphetamine use, as well as on the misuse of OxyContin and the lifetime use of chemsex drugs. Additionally, we examined demographic, socioeconomic and health-related factors (including unmet mental health need) associated with substance use and how they differed by gender and sexual identity. Lastly, we assessed variations on substance use based on levels of socioeconomic vulnerability among SM and disparities in unmet need for mental health treatment between sexual identity groups. To our knowledge, this is the first study that examines the association between disparities in substance use and socioeconomic vulnerability among a nationally representative sample of adults in the U.S.

Methods

Survey design, setting and participants

All analyses were based on data from the 2015-2017 National Survey on Drug Use and Health (NSDUH) for adults 18 or older. The NSDUH is an annual, nationally representative survey of the civilian, non-institutionalised US population aged twelve or older which estimates the prevalence and associated determinants of substance use and mental illness (Medley et al., 2016). The survey covers residents of households and individuals in non-institutional group quarters. Citizens with no fixed address, military personnel on active duty and individuals living in institutional group quarters (e.g., jails, nursing homes, mental institutions, long-term care hospitals) are not included (Medley et al., 2016). The NSDUH is therefore described as being representative for both, at least 97% of the total US population and for each of the 50 US states and the District of Columbia (Lofquist et al., 2012). Weighted interview response

rates for 2015-2017 were between 67% and 70% and 2010 decennial census population estimates were used to calculate analytical and sampling weights. Weights are provided with the datasets to address non-response. Respondents are awarded a $30 cash incentive after completion of the interview (Quality, 2018a, 2018b, 2018c).

Research Ethics

The NSDUH is a publicly available dataset. Thus, this study was not considered as human subjects research under the federal Common Rule, 45 CFR Part 46.

Study Design

A cross-sectional study design was used to assess the association between (a) substance use of SM adults in the US and (b) social inequalities. Data from three consecutive years (2015-2017) was combined to identify differences in substance use between SM and their heterosexual counterparts.

The NSDUH includes questions on sexual identity in interviews conducted with respondents 18 or older. Sexual identity was ascertained through the completion of the question “Which one of the following do you consider yourself to be?”. Response choices were “heterosexual, that is, straight”, “lesbian or gay”, “bisexual” or “don’t know”. Participants who did not respond to the sexual identity question or answered with “don’t know” were excluded from the sample (n= 2,277). Hence, a total cohort of 126,463 was included in this study, including 8,241 SM.

Substance use outcomes of interest were past-month binge drinking, past-year cocaine use, crack cocaine use, heroin use, methamphetamine use, OxyContin misuse and lifetime use of chemsex drugs. A new variable was created to measure the lifetime use of any of the four sexual drugs included in the survey (ecstasy, ketamine, GHB and amyl nitrite). Additionally, a new variable was created to capture individuals with any past-year use of aforementioned substances other than binge drinking. Past-month binge drinking was coded as positive when respondents reported at least one day during the past month of ‘drinking five or more drinks on the same occasion for males or four or more drinks on the same occasion for females’ (Quality, 2018a, 2018b, 2018c). OxyContin misuse was defined as using OxyContin in any way not directed by a doctor (e.g., use without a prescription of one's own medication; use in greater amounts, more often, or longer than told) (Quality, 2018a, 2018b, 2018c). As policy changes regarding medical and recreational use of cannabis have been implemented since the

early 2000s in several US states, cannabis use was not included in this study.
Covariables of interest were gender, age, ethnicity, education, population density at home, self-rated health, health insurance, unmet need for mental health services, annual income, government assistance and socioeconomic vulnerability. Gender was coded binarily as man or woman. Age was reported as a categorical variable with age groups 18-25, 26-34, 35-49, and 50 years or older. Ethnicity was recoded to include the categories White, African American, Native American, Asian or Pacific Islander, Hispanic, and Other. Education was coded as a variable with three categories: elementary (seventh grade or less), secondary (eighth till twelfth grade), or tertiary (higher than twelfth grade) education. Population density at home of respondents was coded as small, large, or non-metropolitan area based on 2013 Rural-Urban Continuum Codes (Quality, 2018c; Service, 2016). Health was described on a self-rated five-point scale as poor, fair, good, very good, or excellent. Health insurance was coded as private, Medicare, Medicaid, Tricare & Veterans' Affairs (VA), or uninsured. Unmet need for mental health treatment was defined as 'perceived need for mental health treatment or counselling in the past twelve months that was not received' and coded as a dichotomous variable (Quality, 2018c). Answers were based on the question "During the past twelve months, was there any time when you needed mental health treatment or counselling for yourself but didn't get it?". Total annual household income was coded as a categorical variable with four categories: less than $20,000, between $20,000 and $49,999, between $50,000 and $74,999, and more than $75,000. A dichotomous variable was analysed to find out about recipients of government assistance. Additionally, a variable indicating socioeconomic vulnerability was created based on research by Yang et al. (Yang et al., 2018). The index variable measures vulnerability on Yang & Roman-Urrestarazu's four-point-scale, using several indicators of social as well as health disparities to aggregate data and subsequently report a single numerical result for every respondent. In this revised version of the index that only include socioeconomic variables (Neicun et al., 2020), points were given for each of the following components: uninsured or insured on Medicaid, government assistance recipient, annual household income less than $20,000, unemployment. The maximum score awarded for vulnerability was four points, with zero points indicating the least vulnerable group.

Statistical analysis

Analyses were performed using STATA 14.2 (StataCorp, College Station, TX, USA). The correlation matrix heatmap was created using R 3.6.0 (The R Foundation for Statistical Computing). Pearson's Chi-squared test and Fisher's exact test were applied to analyse

differences in substance use between sexual identity groups, and to analyse covariables of interest. Weighted prevalence estimates of sociodemographic covariables were calculated for sexual identity groups, stratified by gender. In addition, weighted prevalence estimates for substance use outcomes were estimated, stratified by sexual identity, gender and age. Lastly, prevalence of past-year substance use and past-month binge drinking was calculated for individuals expressing an unmet need for mental health treatment to further explore these associations and potential disparities between sexual identity groups.

Multivariable logistic regression models were implemented to quantify disparities in substance use between SM and heterosexuals. Sexual majority groups were employed as baseline groups for all logistic regressions if not otherwise specified. Unadjusted as well as adjusted odds ratios and corresponding 95% confidence intervals were reported for past-month binge drinking and past-year use of each of the substances as well as any past-year substance use. In a second step, multivariable logistic regression models were implemented, calculating the effect of sociodemographic covariables on any past-year substance use and past-month binge alcohol consumption. Lastly, multivariable logistic regression models were used to assess the association between socioeconomic vulnerability and substance use.

Role of the funding source

No specific funding was received for the conduct of this study. Thus, there has been no interference with study design, data collection, analysis, interpretation, or writing of the report.

Results

The data analysis was conducted with a total of 126,463 individuals, including 8,241 (6.5%) participants identifying as SM. Women were more likely to identify as SM than men ($p < 0.001$) and also significantly more likely to identify as bisexual than lesbian (S2 Table).

Socioeconomic, demographic, and health determinants differed significantly between sexual identity groups. Detailed results are shown in Table 1.

Table 1. Sociodemographic characteristics of 2015-2017 NSDUH participants by gender and sexual identity.

	Man			Woman			
	Heterosexual (N=56,184)	**Gay (N=1,410)**	**Bisexual (N=1,221)**	**Heterosexual (N=62,038)**	**Lesbian (N=1,321)**	**Bisexual (N=4,289)**	**p-value****
Age (years)							
18-25	14.4 (14.0, 14.8)	19.0 (17.0, 21.1)	29.9 (26.8, 33.2)	12.4 (12.1, 12.8)	20.9 (18.5, 23.5)	41.5 (39.5, 43.6)	<0.001
26-34	16.1 (15.7, 16.4)	22.1 (18.5, 26.2)	20.7 (17.9, 23.8)	14.8 (14.5, 15.2)	20.6 (17.6, 24.1)	28.5 (26.6, 30.4)	
35-49	25.3 (24.8, 25.9)	21.4 (19.1, 23.9)	19.5 (16.7, 22.6)	24.6 (24.0, 25.1)	23.0 (20.5, 25.6)	19.8 (17.9, 21.9)	
50 or older	44.3 (43.4, 45.1)	37.5 (33.4, 41.9)	29.9 (24.7, 35.6)	48.2 (47.4, 49.0)	35.5 (30.7, 40.6)	10.2 (8.2, 12.6)	
Ethnicity							
White	65.3 (64.6, 66.1)	62 (58.1, 65.8)	59.1 (55.3, 62.9)	64.7 (63.9, 65.5)	63.8 (59.9, 67.6)	61.3 (59.4, 63.3)	<0.001
African American	11.0 (10.7, 11.4)	11.7 (9.8, 13.8)	10.3 (8.0, 13.0)	12.4 (11.9, 13.0)	15.7 (13.0, 18.8)	14.1 (12.7, 15.7)	
Native American	0.5 (0.5, 0.6)	0.5 (0.3, 0.8)	0.7 (0.3, 1.8)	0.5 (0.5, 0.6)	0.5 (0.3, 0.9)	0.7 (0.5, 1.0)	
Asian or Pacific Islander	5.5 (5.2, 5.9)	5.7 (3.7, 8.7)	7.5 (4.8, 11.6)	5.7 (5.3, 6.0)	3.4 (2.0, 5.6)	4.1 (3.1, 5.4)	
Hispanic	16.0 (15.4, 16.6)	18.1 (14.9, 21.8)	20.2 (16.9, 24.0)	15.1 (14.5, 15.7)	14.3 (11.7, 17.4)	15.7 (14.2, 17.3)	
Other	1.6 (1.4, 1.7)	2.0 (1.4, 2.8)	2.1 (1.4, 3.1)	1.6 (1.5, 1.8)	2.3 (1.5, 3.6)	4.0 (3.4, 4.8)	
Education							
Elementary School	1.1 (1.0, 1.3)	1.2 (0.5, 2.7)	0.7 (0.3, 2.0)	1.2 (1.0, 1.4)	1.9 (0.8, 4.7)	0.9 (0.6, 1.3)	<0.001
Middle School	2.9 (2.6, 3.1)	0.7 (0.3, 1.8)	1.8 (0.8, 3.8)	2.5 (2.2, 2.7)	1.3 (0.5, 3.6)	1.6 (1.0, 2.4)	
High School	36.5 (35.9, 37.2)	22.2 (19.5, 25.1)	35.5 (31.0, 40.3)	31.7 (31.1, 32.3)	26.7 (22.8, 31.1)	37.4 (35.4, 39.4)	
College or Higher	59.5 (58.7, 60.2)	75.9 (72.8, 78.7)	62 (57.0, 66.7)	64.7 (64.0, 65.3)	70.1 (66.1, 73.8)	60.1 (58.3, 62.0)	
Population density							
Large metro area	55.6 (54.8, 56.5)	69.7 (66.4, 72.8)	61.5 (57.3, 65.4)	55.3 (54.6, 56.0)	57.1 (52.9, 61.1)	57.9 (55.9, 59.9)	<0.001
Small metro area	30.0 (29.2, 30.9)	22.6 (19.7, 25.7)	27.7 (24.2, 31.6)	30.1 (29.5, 30.8)	31.0 (27.1, 35.1)	30.4 (28.8, 32.0)	
Non-metro area	14.4 (13.8, 14.9)	7.8 (6.2, 9.7)	10.8 (8.9, 13.1)	14.6 (13.9, 15.2)	12.0 (8.9, 15.9)	11.7 (10.2, 13.4)	
Self-rated health							
Excellent	21.0 (20.4, 21.7)	26.2 (23.0, 29.7)	17.6 (13.7, 22.2)	21.7 (21.1, 22.2)	19.1 (15.8, 22.8)	15.9 (14.3, 17.6)	<0.001
Very Good	35.9	36.1	36.6	36.0	36.1	36.0	

	(35.4, 36.5)	(32.7, 39.7)	(31.8, 41.6)	(35.5, 36.6)	(31.7, 40.8)	(33.5, 38.5)	
Good	29.6 (29.1, 30.1)	26.6 (23.1, 30.5)	30.9 (27.2, 35.0)	28.2 (27.5, 28.9)	28.7 (24.7, 33.1)	30.7 (29.0, 32.4)	
Fair	10.8 (10.3, 11.4)	9.0 (7.1, 11.3)	12.6 (10.3, 15.4)	11.2 (10.8, 11.7)	13.2 (10.6, 16.3)	14.8 (13.6, 16.1)	
Poor	2.5 (2.4, 2.7)	2.0 (0.9, 4.7)	2.3 (1.2, 4.2)	2.9 (2.6, 3.1)	2.9 (1.6, 5.1)	2.7 (2.0, 3.6)	
Health insurer							
Private	67.6 (66.9, 68.3)	66.9 (62.7, 70.7)	57.7 (53.0, 62.2)	67.3 (66.8, 67.9)	60.9 (55.8, 65.9)	51.9 (49.7, 54.0)	<0.001
Medicare	8.4 (7.9, 8.9)	7.8 (5.7, 10.7)	10.1 (6.9, 14.5)	9.7 (9.3, 10.2)	9.6 (6.3, 14.2)	3.0 (2.3, 3.9)	
Medicaid	8.0 (7.7, 8.3)	9.6 (7.6, 12.0)	15.0 (11.7, 19.2)	11.5 (11.1, 11.8)	13.6 (11.2, 16.4)	27.1 (25.1, 29.2)	
Tricare or VA*	2.2 (2.0, 2.4)	1.3 (0.5, 3.1)	1.4 (0.9, 2.3)	1.5 (1.4, 1.7)	1.3 (0.7, 2.4)	2.1 (1.5, 2.8)	
Other	2.3 (2.2, 2.5)	3.7 (2.4, 5.7)	2.0 (1.2, 3.3)	2.1 (2.0, 2.3)	3.2 (1.9, 5.3)	2.9 (2.3, 3.6)	
Uninsured	11.5 (11.0, 11.9)	10.8 (8.9, 13.0)	13.8 (11.3, 16.8)	7.8 (7.5, 8.1)	11.4 (9.3, 13.9)	13.1 (11.8, 14.5)	
Total household income							
Less than $20,000	14.4 (13.9, 15.0)	17.2 (14.5, 20.4)	24.2 (20.3, 28.5)	18.3 (17.7, 18.9)	24.7 (20.9, 28.9)	28.1 (26.3, 30.0)	<0.001
$20,000 - $49,999	28.8 (28.2, 29.4)	28.2 (24.6, 32.2)	33.2 (29.4, 37.2)	30.4 (29.8, 31.0)	29.3 (25.9, 32.9)	34.4 (32.6, 36.3)	
$50,000 - $74,999	16.3 (15.8, 16.8)	18.6 (15.0, 22.8)	15.5 (12.5, 19.2)	16.2 (15.7, 16.6)	14.7 (11.5, 18.5)	13.6 (12.3, 15.0)	
$75,000 or more	40.4 (39.6, 41.3)	35.9 (31.5, 40.7)	27.1 (23.5, 31.1)	35.1 (34.4, 35.9)	31.4 (28.0, 35.0)	23.9 (22.0, 25.8)	
Receives government assistance							
	15.7 (15.2, 16.3)	17.2 (14.1, 20.8)	20.5 (17.1, 24.3)	20.2 (19.7, 20.8)	27.5 (23.4, 32.0)	34.5 (32.4, 36.7)	<0.001
Past-year perceived unmet need for mental health treatment							
	3.0 (2.8, 3.2)	10.8 (8.7, 13.2)	11.4 (9.0, 14.2)	5.9 (5.6, 6.2)	13.2 (11.1, 15.5)	24.1 (22.4, 26.0)	<0.001

Binary and categorical covariables displayed as percentage proportions (weighted, in %) of the group including 95% confidence intervals.

* VA: Veterans' Affairs.

**p-value for independence calculated from Chi-squared test.

Across all groups, the highest levels of substance use was observed for past-month binge drinking (21.2% - 38.7%). Significant differences in substance use prevalence were observed between sexual identity groups (Table 2). SM were more likely than heterosexuals to report binge drinking, with bisexual women exhibiting the highest prevalence at 38.7%. Gay men were most likely to report past-year cocaine use (7.4%). However, cocaine prevalence of use

was higher for all SM groups when compared to their heterosexual peers. The same pattern was observed for past-year use of any substance. SM were more likely to report crack cocaine use and OxyContin misuse than their heterosexual counterparts. The highest prevalence of crack use was observed among bisexual men (1.3%), while bisexual women showed the highest prevalence rate for OxyContin misuse (2.1%). Methamphetamine use appeared to be more common among men as compared to women, with gay men showing the highest prevalence rate (2.7%). The use of chemsex drugs was also more common among SM, with gay men and bisexual women exhibiting the highest prevalence rates (45.3% and 24.8% respectively).

Table 2. Substance use prevalence for 2015-2017 NSDUH participants by gender and sexual identity.

	Man			Woman			
	Heterosexual (N=56,184)	**Gay (N=1,410)**	**Bisexual (N=1,221)**	**Heterosexual (N=62,038)**	**Lesbian (N=1,321)**	**Bisexual (N=4,289)**	**p-value***
Past-month binge alcohol consumption	31.8 (31.2, 32.4)	37.4 (33.9, 41.0)	33.0 (29.3, 36.9)	21.2 (20.8, 21.7)	30.1 (27.0, 33.4)	38.7 (36.5, 41.0)	<0.001
Past-year cocaine use	2.7 (2.5, 2.9)	7.4 (5.6, 9.8)	5.8 (4.1, 8.2)	1.2 (1.1, 1.3)	2.8 (2.0, 4.1)	6.7 (5.7, 7.8)	<0.001
Past-year crack use	0.5 (0.4, 0.6)	0.8 (0.4, 1.6)	1.3 (0.6, 2.6)	0.2 (0.1, 0.2)	0.3 (0.1, 0.7)	0.7 (0.4, 1.1)	<0.001
Past-year heroin use	0.5 (0.4, 0.6)	0.5 (0.3, 1.1)	1.0 (0.4, 2.6)	0.2 (0.2, 0.2)	0.1 (0.0, 0.5)	1.2 (0.9, 1.7)	<0.001
Past-year methamphetamine use	0.8 (0.7, 0.9)	2.7 (1.7, 4.2)	1.9 (1.0, 3.6)	0.4 (0.3, 0.4)	0.3 (0.1, 0.7)	1.8 (1.4, 2.3)	<0.001
Past-year OxyContin misuse	0.8 (0.7, 0.9)	1.9 (1.0, 3.4)	1.5 (0.8, 2.9)	0.3 (0.3, 0.4)	1.4 (0.7, 2.8)	2.1 (1.6, 2.7)	<0.001
Any past-year substance use	3.8 (3.6, 4.1)	10.5 (8.3, 13.2)	8.6 (6.7, 11.0)	1.8 (1.7, 1.9)	4.5 (3.2, 6.2)	9.4 (8.4, 10.6)	<0.001
Any lifetime chemsex drugs use	11.0 (10.5, 11.5)	45.3 (40.8, 49.9)	22.2 (18.9, 26.0)	6.7 (6.5, 7.0)	18.9 (15.4, 23.0)	24.8 (23.1, 26.5)	<0.001

Substance use displayed as percentage proportions (weighted, in %) of the group including 95% confidence intervals.

*p-value for independence calculated from Chi-squared test.

Significant differences between sexual identity groups were also shown when stratifying substance use by age (S3 Table). Notable differences between groups were observed for all substance use outcomes at all ages ($p < 0.01$) except for past-year heroin use for participants 50 years and older ($p = 0.05$). However, group sizes might have been too small (41 respondents reporting past-year use) to calculate a significant difference for this subgroup. In general, substance use prevalence decreased for sexual majority individuals with age. This

decrease was less pronounced or not present when looking at SM.

Table 3 presents aOR for substance use disparities between sexual identity groups. The adjusted analyses suggested that SM were more likely to report any substance use relative to heterosexual peers, especially gay men (aOR = 2.38, 95% CI = [1.81, 3.14]) and bisexual women (aOR = 2.13, 95% CI = [1.75, 2.59]). Compared to heterosexual individuals, SM were also significantly more likely to have already used chemsex drugs throughout their lifespan, particularly gay men (aOR = 6.45, 95% CI = [5.09, 8.18]) and lesbians (aOR = 2.70, 95% CI = 2.02, 3.60). Gay men were significantly more likely to have experienced at least one occasion of binge drinking in the past month (aOR = 1.21, 95% CI = [1.03, 1.41]). They were also significantly more likely to report past-year cocaine use (aOR = 2.19, 95% CI = [1.58, 3.04]), methamphetamine use (aOR = 3.76, 95% CI = [2.25, 6.28]), and OxyContin misuse (aOR = 1.86, 95% CI = [0.95, 3.68]) relative to heterosexual peers. Increased odds for bisexual men were observed for past-year crack (aOR = 1.97, 95% CI = 0.87, 4.46) and heroin use (aOR = 1.09, 95% CI = [0.41, 2.89]). Additionally, bisexual women had significantly elevated odds relative to heterosexual peers for all examined substance use outcomes. Fewer significant disparities were reported for lesbian women compared to heterosexual peers, yet increased odds for past-month binge drinking (aOR = 1.35, 95% CI = [1.16, 1.57]) and past-year cocaine use (aOR = 1.53, 95% CI = [1.04, 2.25]) were observed. Lesbian women were also the most likely to misuse OxyContin (aOR = 2.89, 95% CI = 1.40, 5.98).

Table 3. Unadjusted and adjusted odds ratio estimates of sexual identity disparities in substance outcomes among 2015-2017 NSDUH participants.

Man									Woman								
Heterosexual	Gay				Bisexual				Heterosexual	Lesbian				Bisexual			
OR	OR	95% CI	aOR	95% CI	OR	95% CI	aOR	95% CI	OR	OR	95% CI	aOR	95% CI	OR	95% CI	aOR	95% CI
Past-month binge drinking																	
1	1.28	(1.09, 1.49)	**1.21**	(1.03, 1.41)	1.06	(0.88, 1.26)	0.94	(0.80, 1.10)	1	1.60	(1.37, 1.87)	**1.35**	(1.16, 1.57)	2.34	(2.12, 2.60)	**1.49**	(1.34, 1.65)
Past-year cocaine use																	
1	2.91	(2.16, 3.91)	**2.19**	(1.58, 3.04)	2.23	(1.53, 3.26)	**1.31**	(0.90, 1.92)	1	2.44	(1.68, 3.54)	**1.53**	(1.04, 2.25)	5.95	(4.90, 7.22)	**2.15**	(1.70, 2.71)
Past-year crack use																	
1	1.64	(0.78, 3.44)	**1.45**	(0.69, 3.05)	2.68	(1.24, 5.82)	**1.97**	(0.87, 4.46)	1	1.40	(0.47, 4.14)	0.92	(0.29, 2.88)	3.69	(2.21, 6.17)	**1.84**	(1.04,3.28)
Past-year heroin use																	
1	1.12	(0.55, 2.29)	0.90	(0.44, 1.84)	2.11	(0.80, 5.51)	**1.09**	(0.41, 2.89)	1	0.65	(0.18, 2.37)	0.35	(0.10, 1.29)	6.40	(4.28, 9.55)	**1.97**	(1.34, 2.89)
Past-year methamphetamine use																	
1	3.61	(2.22, 5.88)	**3.76**	(2.25, 6.28)	2.56	(1.33, 4.92)	**1.51**	(0.78, 2.90)	1	0.82	(0.38, 1.80)	0.46	(0.21, 1.03)	4.74	(3.37, 6.67)	**1.54**	(1.08, 2.19)
Past-year OxyContin use																	
1	2.47	(1.27, 4.79)	**1.86**	(0.95, 3.68)	2.01	(1.02, 3.98)	**1.14**	(0.58, 2.23)	1	4.40	(2.25, 8.60)	**2.89**	(1.40, 5.98)	6.37	(4.52, 8.99)	**2.43**	(1.66, 3.56)
Any past-year substance use																	
1	2.92	(2.26, 3.77)	**2.38**	(1.81, 3.14)	2.35	(1.77, 3.12)	**1.42**	(1.07, 1.88)	1	2.60	(1.86, 3.63)	**1.66**	(1.17, 2.36)	5.81	(4.95, 6.82)	**2.13**	(1.75, 2.59)
Any lifetime chemsex drugs use																	
1	6.70	(5.47, 8.21)	**6.45**	(5.09, 8.18)	2.32	(1.90, 2.83)	1.85	(1.50, 2.29)	1	3.23	(2.51, 4.17)	**2.70**	(2.02, 3.60)	4.56	(4.10, 5.07)	**2.63**	(2.30, 2.99)

Reference groups are same-gender heterosexual participants.

Bold red numbers indicate adjusted odds ratio (aOR) estimates that are significant at the 0.05 level.

Adjusted regression models included: age, ethnicity, level of education, population density at home, self-rated health, insurance type, income level, government assistance status, unmet need for mental health.

Odds ratio (OR) estimates are weighted to account for NSDUH survey design.

Fig 1 shows the prevalence of any past-year substance use by sexual identity for individuals reporting an unmet need for mental health treatment. Among those with a perceived unmet need, men were significantly more likely than women to report substance use within the past year ($p < 0.001$). Within the group of men, gay men were most likely and heterosexual men least likely to report past-year substance use (21.9% and 15.0% respectively), with the difference being statistically significant ($p = 0.04$). Among women, bisexual women reported the highest substance use (13.7%), with heterosexual women showing the lowest level of substance use (7.9%). Men were also more likely than women to have use chemsex drugs at some point in their life ($p < 0.001$), with gay and bisexual men showing the highest prevalence of use (52% and 34% respectively) (S4 Figure).

Fig 1. Prevalence of any past-year substance use among 2015-2017 NSDUH participants disclosing a perceived unmet need for mental health treatment, by sexual identity.

Differences in prevalence were not as pronounced when looking at past-month binge drinking of individuals with unmet need for mental health treatment (Fig 2). Prevalence was highest among bisexual women (43.8%). However, heterosexual men, lesbian women, and gay men all showed a prevalence above 42%. Heterosexual women were least likely to report any past-month binge drinking (36.4%). Significant differences between men and women could be observed ($p < 0.001$) but prevalence within male and female groups was only significantly different for female sexual identity groups ($p < 0.001$).

Fig 2. Prevalence of past-month binge drinking among 2015-2017 NSDUH participants disclosing a perceived unmet need for mental health treatment, by sexual identity.

Multivariable logistic regression analyses were performed to examine effects of covariables on any past-year substance use (Fig 3) and past-month binge drinking (Fig 4). Detailed results can be found in S5 Table.

Fig 3. Coefficient plot of effects of sociodemographic factors on any past-year substance use among 2015-2017 NSDUH participants.

Women had significantly lower odds of any past-year substance use (aOR = 0.42, 95% CI = [0.39, 0.46]). Older age groups exhibited decreased odds of substance use when compared to

18 to 25-year-olds, with participants being 50 years or older showing the lowest odds (aOR = 0.20, 95% CI = [0.17, 0.24]). Looking at ethnic minorities, significantly reduced odds were observed for African American (aOR = 0.51, 95% CI = [0.42, 0.61]), Asian or Pacific Islander (aOR = 0.29, 95% CI = [0.22, 0.39]), and Hispanic participants (aOR = 0.55, 95% CI = [0.47, 0.65]) when compared to White respondents. However, Native Americans had notably higher odds than their White counterparts (aOR = 1.39, 95% CI = [1.04, 0.86]). The odds of substance use decreased with increasing levels of population density. The poorer respondents rated their health, the higher the odds of substance use, with odds of 2.24 for participants describing their health as poor (aOR = 2.24, 95% CI = [1.69, 2.97]). When compared to privately insured respondents, decreased odds were shown for people on Medicare schemes (aOR = 0.71, 95% CI = [0.54, 0.93]) while participants on Tricare or VA, other insurance schemes, or uninsured participants exhibited higher odds. Those having a household income of more than $20,000 had significantly decreased odds for past-year substance use while participants receiving government assistance (aOR = 1.38, 95% CI = [1.24, 1.53]) and participants expressing an unmet need for mental health treatment (aOR = 2.73, 95% CI = [2.46, 3.04]) showed significantly higher odds.

As shown in Fig 4, substance use patterns were different for past-month binge drinking. Again, women showed significantly lower odds (aOR = 0.60, 95% CI = [0.58, 0.62]). The link between age and binge alcohol use was not as prominent. Decreased odds were only shown for participants 35 years or older. Lower odds were also observed for all ethnic minority groups when compared to White respondents. Results were significant at the 0.05 level except for Native Americans. The higher the educational level, the higher the odds for past-month binge drinking, going up to 1.77 for participants with a college degree (aOR = 1.77, 95% CI = [1.43, 2.19]). As for substance use, participants living in small metropolitan areas showed lower odds for binge drinking. In contrast, when looking at self-rated health, slightly increased odds for binge drinking were shown for respondents rating their health as very good (aOR = 1.11, 95% CI = [1.06, 1.17]) or good (aOR = 1.09, 95% CI = [1.03, 1.16]) relative to those with poor self-rated health. When compared to privately insured respondents, increased odds of binge drinking were shown for those uninsured (aOR = 1.08, 95% CI = [1.02, 1.14]) while participants on Medicare and Medicaid exhibited lower odds. Significant differences were also observed for different household incomes, with those making up to $74,999 having lower odds than those having a total income of $75,000 or more. No difference in odds was shown for government assistance while participants disclosing an

unmet need for mental health treatment had significantly higher odds for binge drinking than their peers not disclosing such need (aOR = 1.30, 95% CI = [1.22, 1.38]).

Fig 4. Coefficient plot of effects of sociodemographic factors on past-month binge drinking among 2015-2017 NSDUH participants.

The variation of vulnerability between sexual identity groups is shown in Fig 5. SM individuals experienced significantly higher vulnerability than their sexual majority counterparts ($p < 0.001$). Also, vulnerability was significantly higher among women ($p < 0.001$).

Fig 5. Mean vulnerability index score among adult 2015-2017 NSDUH participants by sexual identity.

Higher vulnerability scores were associated with elevated odds of cocaine, crack, heroin, and methamphetamine use, and OxyContin misuse (Table 4). This was particularly pronounced for crack and heroin use, where those with a vulnerability score of 1 showed respective aOR of 4.52 (95% CI = [2.85, 7.15]) and 3.36 (95% CI = [2.41, 4.68]) while those with a vulnerability score of 4 exhibited aOR of 29.71 (95% CI = [12.63, 69.90]) and 28.66 (95% CI = [16.29, 50.42]) respectively. Conversely, vulnerability scores of 2 and 3 were associated with decreased odds for past-month binge drinking.

Table 4. Prevalence and adjusted odds ratio estimates (including 95% confidence intervals) of vulnerability associated with substance use among adult 2015-2017 NSDUH participants.

Vulnerability

0 (N = 71,379)		1 (N = 28,316)		2 (N = 16,109)		3 (N = 9,052)		4 (N = 1,607)		0		1		2		3		4	
%	95% CI	%	95% CI	%	95% CI	%	95% CI	%	95% CI	aOR	95% CI	aOR	95% CI	aOR	95% CI	aOR	95% CI	aOR	95% CI
Past-month binge alcohol																			
26.4	(25.8, 27.0)	28.6	(27.8, 29.4)	25.8	(24.9, 26.8)	27.2	(25.9, 28.5)	33.1	(29.3, 37.2)	1		0.98	(0.93, 1.04)	0.84	(0.80, 0.88)	0.86	(0.80, 0.93)	**1.05**	(0.86, 1.27)
Past-year cocaine use																			
1.4	(1.3, 1.5)	3.1	(2.8, 3.4)	3.4	(3.1, 3.7)	4.0	(3.5, 4.7)	5.5	(3.9, 7.7)	1		**1.76**	(1.55, 2.00)	**2.02**	(1.78, 2.29)	**2.40**	(1.93, 2.98)	**2.88**	(1.95, 4.23)
Past-year crack use																			
0.1	(0.1, 0.1)	0.4	(0.3, 0.5)	0.9	(0.8, 1.1)	1.7	(1.3, 2.1)	2.6	(1.4, 4.9)	1		**4.52**	(2.85, 7.15)	**10.54**	(7.42, 14.97)	**18.34**	(12.09, 27.82)	**29.71**	(12.63, 69.90)
Past-year heroin use																			
0.1	(0.1, 0.1)	0.4	(0.3, 0.5)	1.0	(0.8, 1.2)	1.5	(1.2, 1.9)	3.2	(2.0, 5.0)	1		**3.36**	(2.41, 4.68)	**8.86**	(6.68, 11.75)	**14.15**	(9.73, 20.57)	**28.66**	(16.29, 50.42)
Past-year methamphetamine use																			
0.2	(0.2, 0.3)	0.7	(0.6, 0.9)	1.8	(1.5, 2.1)	2.5	(2.0, 3.1)	3.5	(2.5, 5.0)	1		**3.14**	(2.25, 4.36)	**8.22**	(5.89, 11.48)	**11.57**	(7.98, 16.77)	**16.86**	(10.26, 27.72)
Past-year OxyContin use																			
0.4	(0.3, 0.4)	0.9	(0.7, 1.0)	0.9	(0.8, 1.2)	1.5	(1.2, 1.8)	1.8	(1.1, 2.8)	1		**2.05**	(1.64, 2.56)	**2.28**	(1.70, 3.06)	**3.55**	(2.65, 4.74)	**3.95**	(2.44, 6.41)
Any past-year substance use																			
1.9	(1.8, 2.0)	4.2	(3.9, 4.6)	5.5	(5.1, 6.0)	7.2	(6.5, 8.0)	9.5	(7.6, 11.7)	1		**1.95**	(1.73, 2.21)	**2.76**	(2.40, 3.16)	**3.65**	(3.04, 4.39)	**4.48**	(3.41, 5.87)
Any lifetime chemsex drug use																			
8.7	(8.4, 9.0)	11.1	(10.6, 11.7)	11.5	(10.9, 12.2)	12.6	(11.5, 13.9)	12.2	(10.1, 14.7)	1		**1.31**	(1.22, 1.39)	**1.40**	(1.30, 1.51)	**1.52**	(1.35, 1.71)	**1.41**	(1.12, 1.78)

Reference groups are participants with a vulnerability score of 0.

Bold red numbers indicate adjusted odds ratio (aOR) estimates that are significant at the 0.05 level.

Adjusted regression models included: sex, sexual identity, age, population density at home, unmet need for mental health.

Odds ratio (OR) estimates are weighted to account for NSDUH survey design.

As shown in Fig 6, an upward trend for all analysed substances associated with increasing vulnerability was shown among heterosexual individuals. Binge-drinking prevalence increases with highest levels of vulnerability for both heterosexual individuals and SM. For SM, substance use prevalence seemed to remarkably increase more with increasing vulnerability scores relative to heterosexual peers. Highest prevalence of cocaine and heroin use was shown for gay and lesbian respondents of highest vulnerability, while use of heroin, methamphetamine, and OxyContin was less prevalent among those populations. Cocaine and crack use were less prevalent among bisexual men of highest vulnerability, while the use of methamphetamine and OxyContin was most prevalent among more vulnerable bisexual women. However, a clear link between an increase in vulnerability and an increase in substance use was not established.

Fig 6. Patterns in prevalence of substance use among adult 2015-2017 NSDUH participants by sexual identity and vulnerability.

Discussion

Results from this study support previous research highlighting higher rates of substance use as well as mental health issues among SM. Although a clear association was observed for SM status and higher past-year substance use, outcomes varied significantly between different SM subgroups due to specific factors potentially mediating the relationship between SM status and substance use. Stigma, discrimination and violence experienced by sexual minorities throughout their lifespan are stressors that contribute to higher levels of substance use and mental distress (Hatzenbuehler, 2016; Lowry et al., 2017). Furthermore, heterogeneity was amplified by sociodemographic, economic, and health covariables shown to have a notable influence on substance use patterns of both, SM and heterosexual adults.

Among men, individuals that identified themselves as homosexual (gay) showed higher prevalence rates for all substances (particularly for binge drinking, methamphetamine and cocaine use), while bisexual men presented a marked preference for crack and methamphetamine use. Among women, lesbian and bisexual individuals showed higher levels of cocaine use and OxyContin misuse relative to heterosexual women, while bisexual women also showed a notably higher prevalence of binge drinking and methamphetamine use. These findings are consistent with previous studies, notably with regard to the higher odds for opioid misuse observed among SM women (Duncan et al., 2019; Schuler et al., 2019). Higher levels of opioid misuse among SM women have particular public health implications due to the risk

of poisoning and fatal overdose it involves, as well as the structural barriers to access harm reduction services for women (Medina-Perucha et al., 2019; Shirley-Beavan et al., 2020). While binge alcohol consumption has traditionally been more frequent in men, our results confirm that problematic alcohol use is becoming more common among women. According to evidence, binge alcohol consumption is strongly related to sexual activity which increases the risk of STIs. Moreover, self-medication to treat undesirable effects of excessive alcohol in-take seems to be common among women (Martinotti et al., 2017); this may be supported by the highest rates of OxyContin misuse observed among women SM from our study.

Our findings also highlight higher prevalence of chemsex drugs use (ecstasy, ketamine, GHB and amyl nitrite) among gay men and bisexual women. As polydrug use may seems to be normative in chemsex contexts, according to previous research (Melendez-Torres et al., 2018), patterns of drugs use that include higher levels of (poly) substance use among SM may also involve long-term negative mental health outcomes such as drug-induced psychiatric problems (particularly psychosis). The surge of this phenomena highlights the need for specific preventive and treatment strategies and has important public health implications in terms of early differential diagnosis and choice of clinical interventions (Martinotti et al., 2020).

Overall, higher levels of unmet mental health need were observed among women compared to men, and also among heterosexual individuals irrespective of their gender. In this regard, the notably higher rates of unmet mental need observed among homosexual women (lesbian and bisexual) are of particular concern. Mental distress may be partly explained by the internalisation of traditional social conceptions of women's role in society and the difficulties for homosexual women to legitimate their sexual identity in such context. Moreover, people that identify themselves as bisexual may also experience stigma as they encounter the binary model of sexual orientation, according to which bisexuality is seen as an interstitial abnormal sexual identity (Feinstein and Dyar, 2017; Mereish et al., 2017). Women are also more exposed to discrimination and economic disadvantage, which negatively affect their ability to access health services. In addition, there is a lack of integrated gender-specific health and drug services, which also deter women from accessing health care (European Monitoring Centre for Drugs and Drug Addiction, 2017; Shirley-Beavan et al., 2020). Finally, we observed higher levels of socioeconomic vulnerability among SM, particularly among women. It was also observed that substance use increases with socioeconomic vulnerability, especially among SM, with patterns of drug use differing according to sexual identity groups.

The significance of addressing this heterogeneity has been previously described by other studies focussing on substance use and mental health outcomes (Salway et al., 2019; Schuler et al., 2018). Our findings emphasise the importance of examining different SM groups separately, rather than treating them as one minority group. Moreover, different patterns of drug use in sexual settings require specific approaches to prevention, as they involve different forms and degrees of exposure to risk (Santoro et al., 2020). This has to be considered when designing prevention as well as treatment strategies. Currently available approaches seem insufficient for SM individuals, because they do not forcibly focus on decreasing the effect of stigma and discrimination, which may prevent SM individuals from seeking help. Insufficient access to drug services may lead SM individuals not only to higher prevalence of substance use and related disorders, but also to more mental health problems (Urbanoski et al., 2008; Wang et al., 2007). Of particular interest is the situation of SM men - especially gay men – whose higher levels of lifetime chemsex drugs use may implicate an increase in risky sexual behaviour leading to higher rates of STD (Bourne and Weatherburn, 2017; Hakim, 2019; Stardust et al., 2018). Approaches specifically tailored to SM subgroups that include sexual health and LGBTQ counselling along with gender-sensitive drug services may be needed to effectively address the problems of increased substance use among these populations. Furthermore, new ways of identifying those at risk and of increasing treatment access and adherence may be necessary for reducing health disparities in the long-term. However, research is still limited (particularly regarding lesbian/bisexual women) and the little evidence available could not show large benefits for SM-specific treatment strategies (Green and Feinstein, 2012). Our study adds to the evidence base around vulnerability to substance use and highlights the distinct disparities experienced by SM individuals. In particular, this paper worked out that higher substance use among SM cannot be pinned down to minority stress or social inequalities alone. It is rather an interaction of both psychological and socioeconomic determinants as well as other contributing factors that makes SM more susceptible to substance use problems.

Limitations

Certain limitations have to be considered when interpreting our results. NSDUH data relies solely on self-reported substance use and therefore on the memory and truthfulness of respondents. Hence, some over- and underreporting may have impacted the results of this analysis and differential misclassification may have been introduced (self-reporting bias). This is even more likely considering the topics covered in the survey which are almost

exclusively behavioural aspects and health conditions associated with stigmatization (Yu and Tse, 2012). Additionally, non-differential misclassification bias may have been introduced due to the collection of information on past behaviours (e.g., past-year substance use, past-month binge drinking). This recall bias may affect the accuracy of prevalence estimates in our sample and eventually lead to an underestimation of substance use. SM status was assessed using a single survey question asking about sexual identity. Since sexual orientation is a three-dimensional construct (behaviour, identity, attraction), some individuals identifying as SM as gender non-conforming people may have been missed, resulting in potential underreporting of SM prevalence and inaccuracy in substance use estimates. Lastly, the survey represents a cross-sectional study design and thus, does not allow for an assessment of temporal relationships and causality.

All eligible 2015-2017 NSDUH respondents were included in our primary analyses, resulting in a sample representing 98.2% of adult interviewees. Due to previously applied imputation methods, no data was missing on any of the substance use outcome variables. Less than 0.1% of participants did not respond to questions about self-rated health and unmet need for mental health treatment respectively. Thus, no additional assessment of respondents with missing data for those variables was conducted. However, 1.8% of interviewees did not disclose their sexual identity and were therefore excluded. Performed sensitivity analyses revealed significant differences between participants with missing data on sexual identity and those included in our study for most covariables and some substance use outcomes. Yet, the proportion of dropped observations was small (< 5%).

As pointed out by Schuler et al. (Schuler et al., 2018), important risk as well as protective factors which may differ between SM and heterosexual individuals were not assessed by the NSDUH (discrimination, sexual assault, extent of social support, HIV-related loss etc.). Hence, unmeasured (residual) confounding has to be considered when interpreting the results of this study.

Conclusions

This study provided information with public health implications for case identification as well as identification of potential intervention targets unique to SM individuals. Public Health professionals should be aware of specific sociocultural factors related to substance use among SM and act culturally-competently, especially when addressing barriers to mental health and substance use treatment (Green and Feinstein, 2012). However, not all determinants associated with substance use and SM populations could be depicted in this paper. The

influence of factors like affiliation with SM culture, level of outness, discrimination, or HIV status - raised by other studies - was beyond the scope of this study. Therefore, results have to be interpreted with due diligence. Critical gaps in the literature concerning the association between SM, sociodemographic factors, and substance use remain. This leads to a lack of information not only on which health policies are needed, but also on how they can be implemented effectively. As previous scientific evidence has already suggested, further research is needed to explore relationship between psychosocial motivations and type of drug used (Melendez-Torres et al., 2018). Researchers need to make their work more inclusive of SM populations to present more sufficient evidence on factors related to substance use among SM and respective prevention strategies. Moreover, it would be useful to explore the prevalence of mental health conditions such as psychological distress, depression and PTSD among different sexual identity groups (men and women). An interesting topic for future research in the field of substance use may be to explore patterns of use along with its socioeconomic and mental health correlates among SM women (lesbian and bisexual)(Schecke et al., 2019). Finally, a better understanding of the specific needs of sexual minority groups - particularly of lesbian and bisexual women - in terms of healthcare and social support, as well as an increased awareness of the structural barriers those populations face (i.e., stigma, discrimination and criminalisation of substance use) in accessing health services are crucial to improve public health responses and health outcomes. This should be accompanied by health education on specific substance-related risks for users, training on sexual minority needs for healthcare professionals and public advocacy of sexual minorities' human rights.

Authors' contributions and conflict of interest statements

Bastian Rosner: study design, general methodology, data collection and analysis, figures, data interpretation, writing, literature search

Jessica Neicun: study design, general methodology, data collection and analysis, figures, data interpretation, writing, literature search

Justin C. Yang: data analysis, figures, editing and review

Andres Roman-Urrestarazu: supervision, study design, editing and review

We declare no competing interests.

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Supporting information

S1 Table. Weighted substance use prevalence among adult 2015-2017 NSDUH participants by sexual identity and age group.

S2 Table. Unadjusted and adjusted odds ratio estimates of effects of sociodemographic factors on any past-year substance use and past-month binge drinking among adult 2015-2017 NSDUH participants.

S1 File. Research in context. Literature review of available evidence before our study.

S1 Table. Weighted prevalence of sexual identity per year (in %) with 95% confidence intervals.

		2015 N=43,561	2016 N=42,625	2017 N=42,554
Man	Heterosexual	46.6 (45.9, 47.4)	46.7 (46.0, 47.3)	46.4 (45.8, 47.1)
	Gay	1.0 (0.9, 1.2)	1.1 (0.9, 1.2)	1.1 (0.9, 1.3)
	Bisexual	0.7 (0.6, 0.9)	0.7 (0.6, 0.8)	0.9 (0.8, 1.0)
Woman	Heterosexual	48.9 (48.2, 49.7)	48.9 (48.3, 49.5)	48.5 (47.9, 49.1)
	Lesbian	0.8 (0.7, 1.0)	0.8 (0.7, 0.9)	0.9 (0.8, 1.0)
	Bisexual	1.9 (1.7, 2.0)	1.8 (1.7, 2.0)	2.2 (2.0, 2.3)

S1 Table. Weighted substance use prevalence among adult 2015-2017 NSDUH participants by sexual identity and age group.

	Men			Women			
	Heterosexual (N=56,184)	**Gay (N=1,410)**	**Bisexual (N=1,221)**	**Heterosexual (N=62,038)**	**Lesbian (N=1,321)**	**Bisexual (N=4,289)**	**p-value***
Past-month binge drinking							
18-25	40.1 (39.1, 41.2)	42.1 (38.1, 46.3)	32.3 (27.9, 37.0)	35.9 (34.9, 37.0)	44.9 (39.2, 50.8)	41.4 (39.5, 43.4)	<0.001
26-34	44.5 (43.3, 45.7)	50.4 (44.7, 56.2)	44.7 (36.4, 53.3)	30.3 (29.3, 31.4)	44.6 (36.9, 52.6)	41.4 (37.9, 45.1)	<0.001
35-49	35.2 (34.2, 36.3)	41.9 (34.3, 49.9)	37.3 (28.5, 46.9)	23.9 (23.0, 24.7)	29.8 (23.8, 36.6)	37.4 (31.4, 43.8)	<0.001
50 or older	22.6 (21.6, 23.5)	24.7 (18.5, 32.1)	22.9 (16.0, 31.5)	13.3 (12.6, 14.0)	13.1 (8.9, 18.9)	22.9 (15.5, 32.4)	<0.001
Past-year cocaine use							
18-25	6.4 (5.8, 7.0)	13.0 (9.5, 17.5)	8.6 (5.6, 13.0)	4.0 (3.6, 4.4)	7.0 (4.8, 9.9)	8.8 (7.3, 10.4)	<0.001
26-34	5.1 (4.6, 5.7)	12.6 (8.9, 17.6)	6.6 (3.7, 11.5)	2.3 (1.9, 2.7)	4.4 (1.9, 10.0)	5.9 (4.3, 8.1)	<0.001
35-49	2.1 (1.8, 2.5)	6.6 (3.6, 11.7)	4.7 (1.9, 11.5)	0.7 (0.5, 0.9)	0.9 (0.3, 3.1)	4.8 (3.1, 7.4)	<0.001
50 or older	1.0 (0.8, 1.2)	2.1 (0.6, 6.6)	3.2 (1.2, 8.3)	0.4 (0.3, 0.5)	0.8 (0.1, 5.2)	4.0 (1.2, 12.4)	<0.001
Past-year crack use							
18-25	0.3 (0.2, 0.4)	0.6 (0.2, 2.1)	0.6 (0.2, 1.9)	0.2 (0.1, 0.3)	0.4 (0.1, 2.2)	0.6 (0.3, 1.4)	<0.05
26-34	0.5 (0.4, 0.7)	0.4 (0.1, 3.3)	1.9 (0.5, 6.6)	0.2 (0.1, 0.3)	0.5 (0.1, 3.7)	0.7 (0.3, 1.4)	<0.001
35-49	0.5 (0.4, 0.7)	0.8 (0.2, 3.0)	0.0	0.2 (0.1, 0.3)	0.2 (0.1, 0.9)	0.8 (0.2, 2.4)	<0.001
50 or older	0.5 (0.3, 0.7)	1.0 (0.3, 3.9)	2.3 (0.8, 6.5)	0.2 (0.1, 0.3)	0.0 (0.0, 0.4)	0.8 (0.1, 5.7)	<0.001
Past-year heroin use							
18-25	0.7 (0.6, 0.8)	1.8 (0.8, 4.2)	0.6 (0.1, 2.5)	0.4 (0.3, 0.5)	0.4 (0.1, 2.1)	1.3 (0.8, 2.2)	<0.001
26-34	1.2 (1.0, 1.5)	0.2 (0.1, 0.9)	2.2 (0.7, 6.7)	0.4 (0.3, 0.6)	0.2 (0.0, 1.3)	1.8 (1.1, 2.9)	<0.001
35-49	0.5 (0.4, 0.6)	0.7 (0.2, 3.0)	0.0	0.2 (0.1, 0.2)	0.0	0.8 (0.4, 1.8)	<0.001
50 or older	0.2 (0.1, 0.3)	0.0	1.3 (0.2, 9.1)	0.1 (0.0, 0.2)	0.0	0.0	0.05
Past-year methamphetamine use							
18-25	1.0 (0.8, 1.2)	1.7 (0.9, 3.0)	1.9 (0.7, 5.1)	0.7 (0.5, 0.8)	0.8 (0.3, 2.2)	1.9 (1.3, 2.8)	<0.001
26-34	1.2 (0.9, 1.5)	2.8 (1.4, 5.4)	2.1 (0.8, 5.5)	0.7 (0.5, 0.9)	0.4 (0.1, 1.9)	1.7 (0.9, 3.3)	<0.001
35-49	1.0 (0.8, 1.2)	6.5 (3.2, 12.7)	2.1 (0.6, 6.6)	0.4 (0.3, 0.6)	0.3 (0.0, 1.5)	2.4 (1.4, 3.9)	<0.001
50 or older	0.4 (0.3, 0.6)	1.1 (0.3, 4.3)	1.8 (0.4, 7.7)	0.2 (0.1, 0.3)	0.0	0.2 (0.0, 1.3)	<0.001
Past-year OxyContin use							
18-25	1.6 (1.4, 1.8)	3.2 (1.5, 6.7)	1.1 (0.3, 3.9)	0.7 (0.5, 0.8)	2.7 (1.4, 5.0)	2.3 (1.6, 3.3)	<0.001
26-34	1.3 (1.1, 1.5)	1.2 (0.3, 4.2)	1.7 (0.6, 4.6)	0.7 (0.5, 0.9)	1.2 (0.3, 4.4)	2.0 (1.1, 3.6)	<0.001
35-49	0.8 (0.6, 1.0)	3.0 (1.1, 7.6)	1.1 (0.2, 5.0)	0.3 (0.2, 0.4)	1.4 (0.4, 4.8)	2.4 (1.3, 4.3)	<0.001

50 or older	0.3 (0.2, 0.5)	1.0 (0.1, 6.9)	2.2 (0.7, 6.5)	0.1 (0.1, 0.2)	0.8 (0.1, 5.8)	0.4 (0.0, 2.6)	<0.001
Past-year use of any substance							
18-25	7.8 (7.2, 8.5)	15.2 (11.7, 19.7)	10.7 (7.1, 15.8)	4.8 (4.4, 5.3)	9.8 (7.3, 13.1)	11.3 (9.8, 12.9)	<0.001
26-34	7.1 (6.5, 7.7)	15.1 (11.0, 20.4)	9.7 (6.3, 14.8)	3.4 (3.0, 3.9)	6.0 (3.0, 11.7)	9.1 (6.8, 12.1)	<0.001
35-49	3.5 (3.1, 3.9)	13.4 (9.0, 19.6)	7.9 (4.1, 14.8)	1.4 (1.2, 1.6)	2.5 (1.0, 6.3)	8.6 (6.1, 11.8)	<0.001
50 or older	1.6 (1.4, 1.9)	3.6 (1.4, 8.9)	6.2 (3.0, 12.0)	0.7 (0.5, 0.8)	1.6 (0.4, 6.2)	4.5 (1.6, 12.3)	<0.001
Lifetime use of any chemsex drug							
18-25	13.8 (13.0, 14.7)	31.6 (27.0, 36.5)	18.1 (14.3, 22.7)	10.1 (9.6, 10.7)	18.9 (15.2, 23.3)	20.2 (18.2, 22.4)	<0.001
26-34	19.3 (18.2, 20.3)	45.3 (38.6, 52.2)	25.8 (20.5, 31.9)	13.0 (12.3, 13.8)	29.7 (23.3, 36.9)	30.6 (27.5, 33.9)	<0.001
35-49	13.3 (12.5, 14.2)	51.2 (43.1, 59.4)	27.0 (19.8, 37.7)	9.1 (8.5, 9.7)	12.9 (8.6, 18.9)	29.2 (25.0, 33.8)	<0.001
50 or older	5.8 (5.2, 6.4)	48.8 (38.7, 59.0)	20.9 (14.0, 29.9)	2.7 (2.4, 3.1)	16.6 (10.5, 25.1)	18.4 (11.0, 29.1)	<0.001

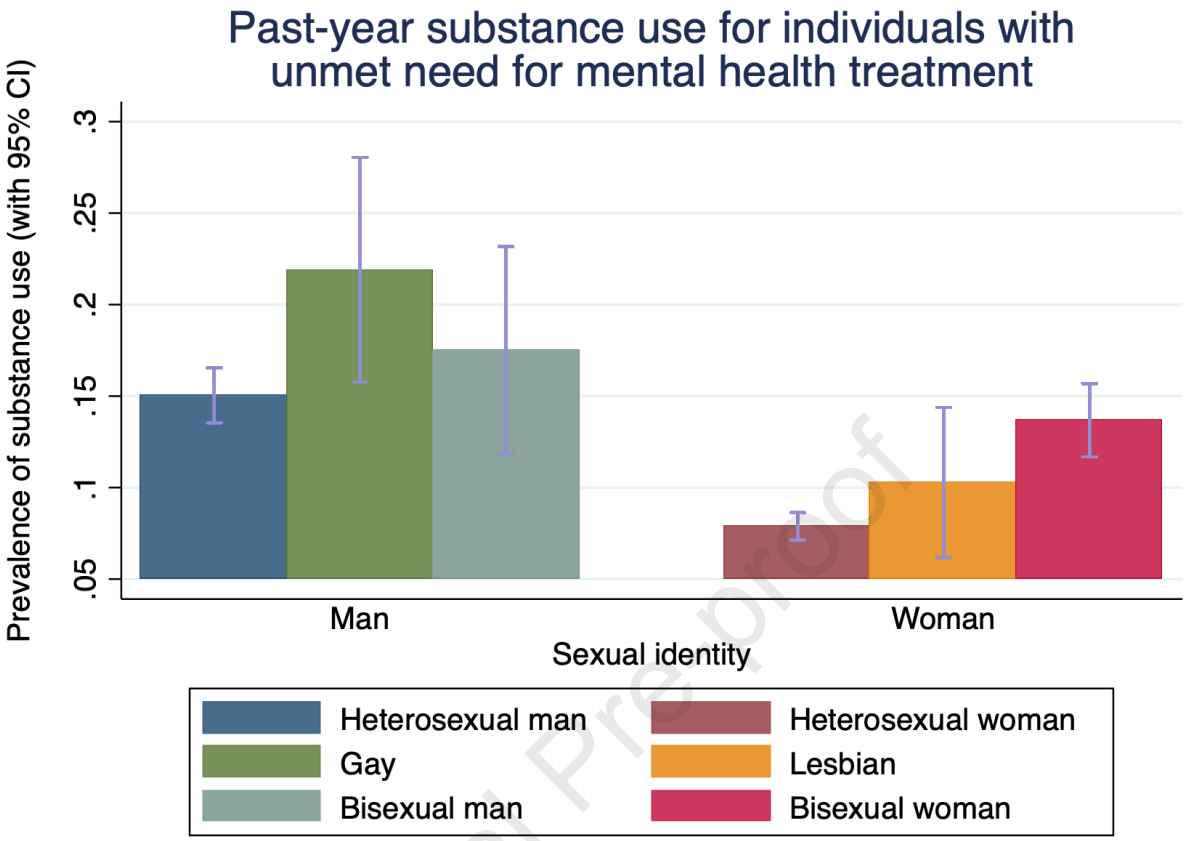
Age displayed in years.
Substance use displayed as percentage proportions of the group (in % including 95% confidence intervals).
*p-value for independence calculated from Chi-squared test or Fishers exact test where cell counts <5.

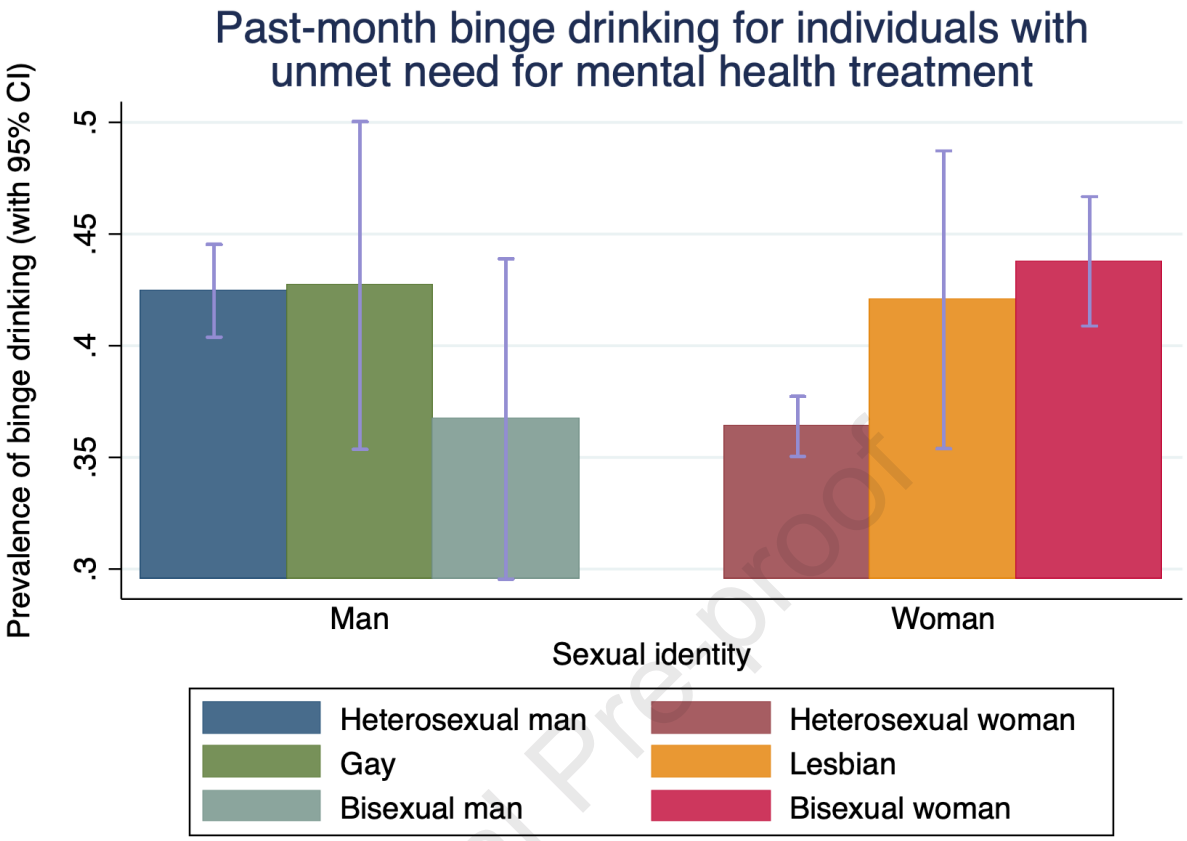
S2 Table. Unadjusted and adjusted odds ratio estimates of effects of sociodemographic factors on any past-year substance use and past-month binge drinking among adult 2015-2017 NSDUH participants.

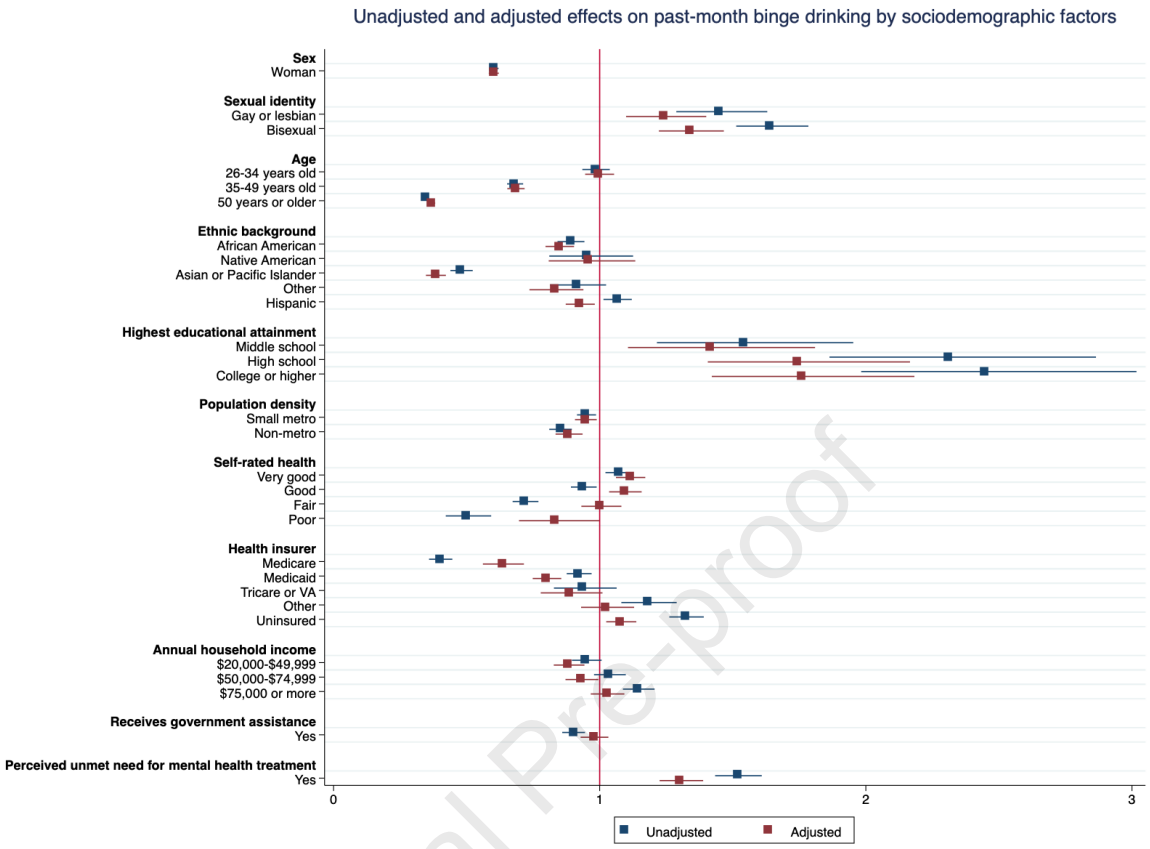
	Any past-year substance use				Past-month binge alcohol consumption			
N = 126,463	**OR**	**95% CI**	**aOR**	**95% CI**	**OR**	**95% CI**	**aOR**	**95% CI**
Gender								
Man	1		1		1		1	
Woman	0.50	(0.46, 0.54)	**0.42**	(0.39, 0.46)	0.60	(0.58, 0.62)	**0.60**	(0.58, 0.62)
Sexual identity								
Heterosexual	1		1		1		1	
Gay or lesbian	2.98	(2.38, 3.73)	**2.11**	(1.66, 2.67)	1.45	(1.29, 1.63)	**1.24**	(1.10, 1.40)
Bisexual	3.54	(3.11, 4.03)	**1.89**	(1.65, 2.17)	1.64	(1.51, 1.78)	**1.34**	(1.22, 1.47
Age								
18-25 years old	1		1		1		1	
26-34 years old	0.79	(0.73, 0.86)	**0.82**	(0.76, 0.90)	0.97	(0.92, 1.03)	1.00	(0.95, 1.06)
35-49 years old	0.36	(0.33, 0.40)	**0.42**	(0.37, 0.47)	0.68	(0.65, 0.71)	**0.69**	(0.66, 0.72)
50 years or older	0.16	(0.14, 0.18)	**0.20**	(0.17, 0.24)	0.35	(0.33, 0.36)	**0.37**	(0.35, 0.38)
Ethnicity								
White	1		1		1		1	
African American	0.78	(0.68, 0.90)	**0.51**	(0.42, 0.61)	0.89	(0.84, 0.94)	**0.85**	(0.80, 0.90)
Native American	2.05	(1.59, 2.64)	**1.39**	(1.04, 1.86)	0.93	(0.79, 1.09)	0.96	(0.81, 1.13)
Asian or Pacific Islander	0.34	(0.26, 0.43)	**0.29**	(0.22, 0.39)	0.45	(0.41, 0.49)	**0.38**	(0.35, 0.42)
Hispanic	0.91	(0.81, 1.02)	**0.55**	(0.47, 0.65)	1.05	(1.00, 1.10)	**0.93**	(0.88, 0.98)
Other	1.64	(1.30, 2.07)	1.01	(0.79, 1.30)	0.93	(0.83, 1.04)	**0.83**	(0.73, 0.94)
Education								
Elementary school	1		1		1		1	
Middle school	1.89	(0.81, 4.44)	1.62	(0.64, 4.11)	1.57	(1.25, 1.98)	**1.41**	(1.11, 1.81)
High school	3.11	(1.39, 6.95)	2.05	(0.84, 4.98)	2.41	(1.96, 2.96)	**1.75**	(1.41, 2.17)
College or higher	2.46	(1.11, 5.46)	2.21	(0.91, 5.37)	2.57	(2.10, 3.14)	**1.77**	(1.43, 2.19)
Population density								
Large metro	1		1		1		1	
Small metro	0.94	(0.82, 1.07)	**0.81**	(0.70, 0.92)	0.96	(0.92, 0.99)	**0.95**	(0.91, 0.99)
Non-metro	0.90	(0.76, 0.95)	**0.70**	(0.62, 0.80)	0.86	(0.82, 0.91)	**0.88**	(0.83, 0.94)
Self-rated health								
Excellent	1		1		1		1	

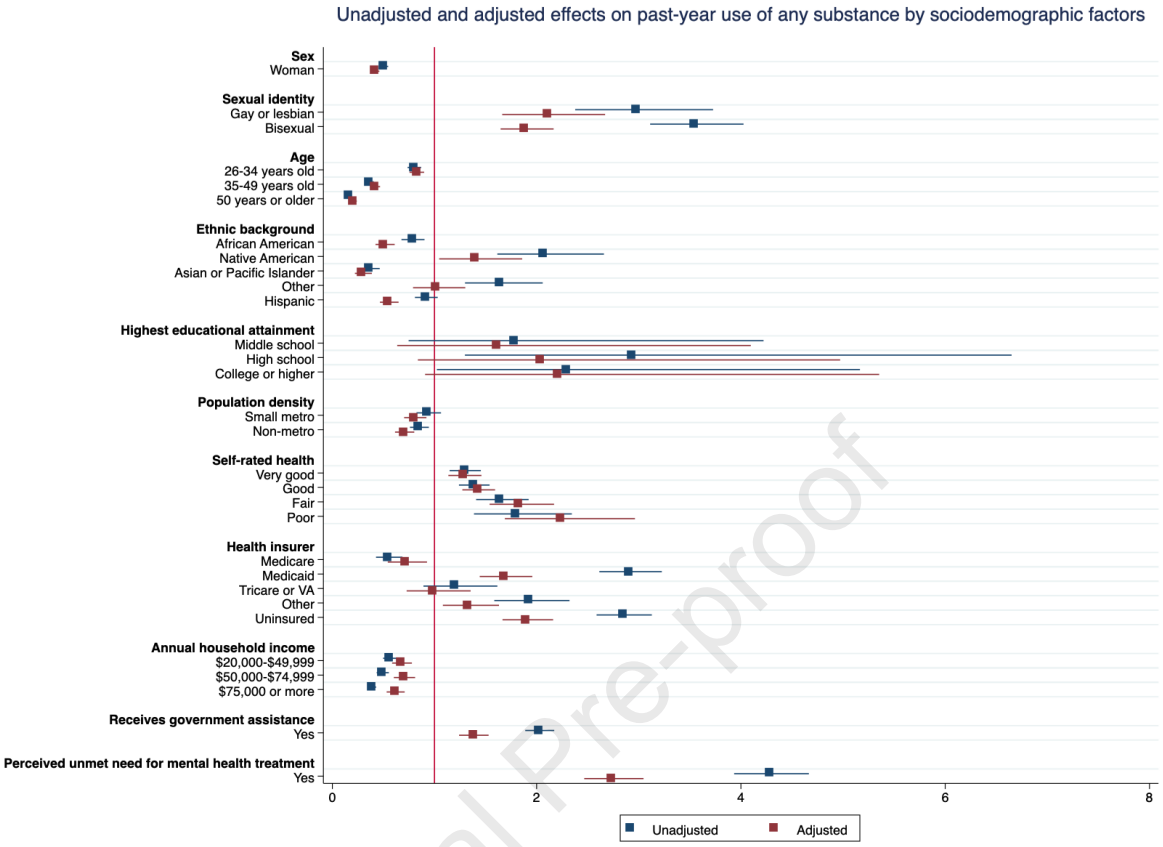
Very good	1.30	(1.15, 1.47)	**1.29**	(1.14, 1.46)	1.08	(1.03, 1.13)	**1.11**	(1.06, 1.17)
Good	1.39	(1.25, 1.55)	**1.43**	(1.28, 1.59)	0.94	(0.89, 0.99)	**1.09**	(1.03, 1.16)
Fair	1.63	(1.40, 1.91)	**1.83**	(1.54, 2.18)	0.72	(0.67, 0.77)	1.00	(0.93, 1.08)
Poor	1.78	(1.37, 2.31)	**2.24**	(1.69, 2.97)	0.50	(0.42, 0.59)	0.83	(0.70, 1.00)
Health insurer								
Private	1		1		1		1	
Medicare	0.53	(0.42, 0.68)	**0.71**	(0.54, 0.93)	0.40	(0.36, 0.45)	**0.64**	(0.56, 0.72)
Medicaid	2.87	(2.59, 3.17)	**1.68**	(1.44, 1.95)	0.91	(0.87, 0.96)	**0.80**	(0.75, 0.85)
Tricare or VA	1.21	(0.90, 1.62)	0.99	(0.73, 1.35)	0.95	(0.84, 1.07)	0.89	(0.78, 1.01)
Other	1.94	(1.59, 2.38)	**1.33**	(1.08, 1.63)	1.18	(1.08, 1.28)	1.02	(0.93, 1.13)
Uninsured	2.82	(2.56, 3.10)	**1.90**	(1.67, 2.16)	1.31	(1.25, 1.37)	**1.08**	(1.02, 1.14)
Total household income								
Less than $20,000	1		1		1		1	
$20,000-$49,999	0.56	(0.50, 0.64)	**0.67**	(0.58, 0.78)	0.96	(0.90, 1.01)	**0.88**	(0.83, 0.94)
$50,000-$74,999	0.49	(0.43, 0.56)	**0.70**	(0.60, 0.81)	1.04	(0.99, 1.11)	**0.93**	(0.87, 0.99)
$75,000 or more	0.39	(0.35, 0.43)	**0.61**	(0.53, 0.71)	1.16	(1.10, 1.22)	1.03	(0.96, 1.09)
Receives government assistance								
Yes	2.01	(1.88, 2.16)	**1.38**	(1.24, 1.53)	0.90	(0.86, 0.94)	0.98	(0.93, 1.03)
Past-year perceived unmet need for mental health treatment								
Yes	430	(3.95, 4.68)	**2.73**	(2.46, 3.04)	1.53	(1.44, 1.62)	**1.30**	(1.22, 1.38)

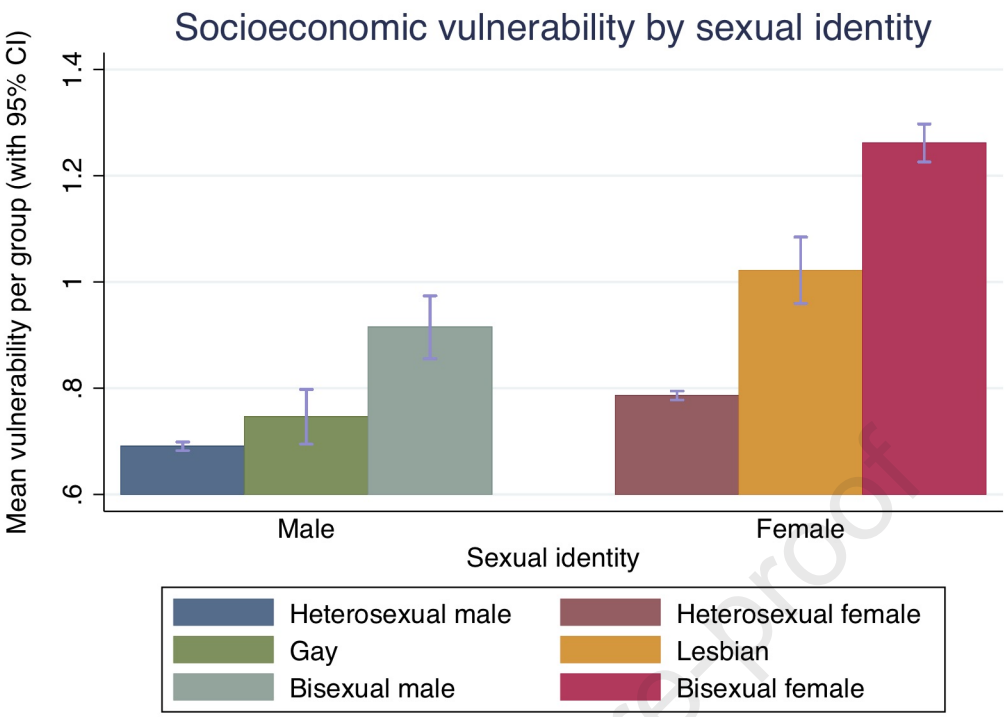
Bold red numbers indicate adjusted odds ratio (aOR) estimates that are significant at the 0.05 level.
Adjusted regression models included: sex, sexual identity, age, ethnicity, level of education, population density at home, self-rated health, insurance type, income level, government assistance status, unmet need for mental health.
Odds ratio (OR) estimates are weighted to account for NSDUH survey design.

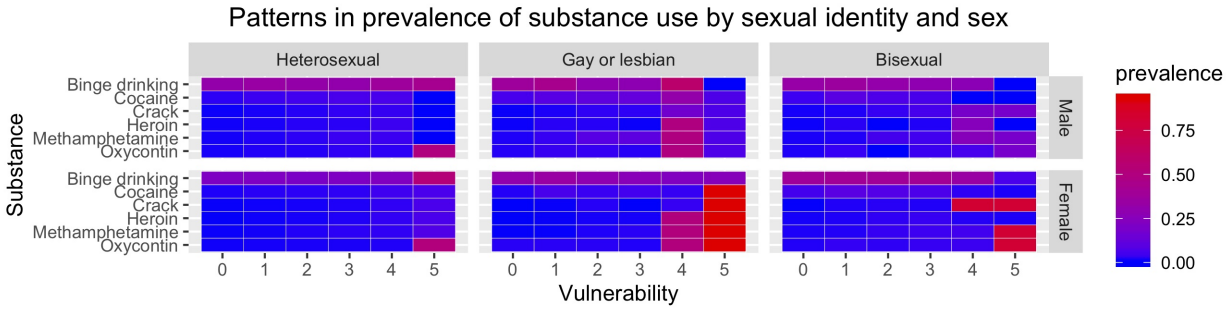


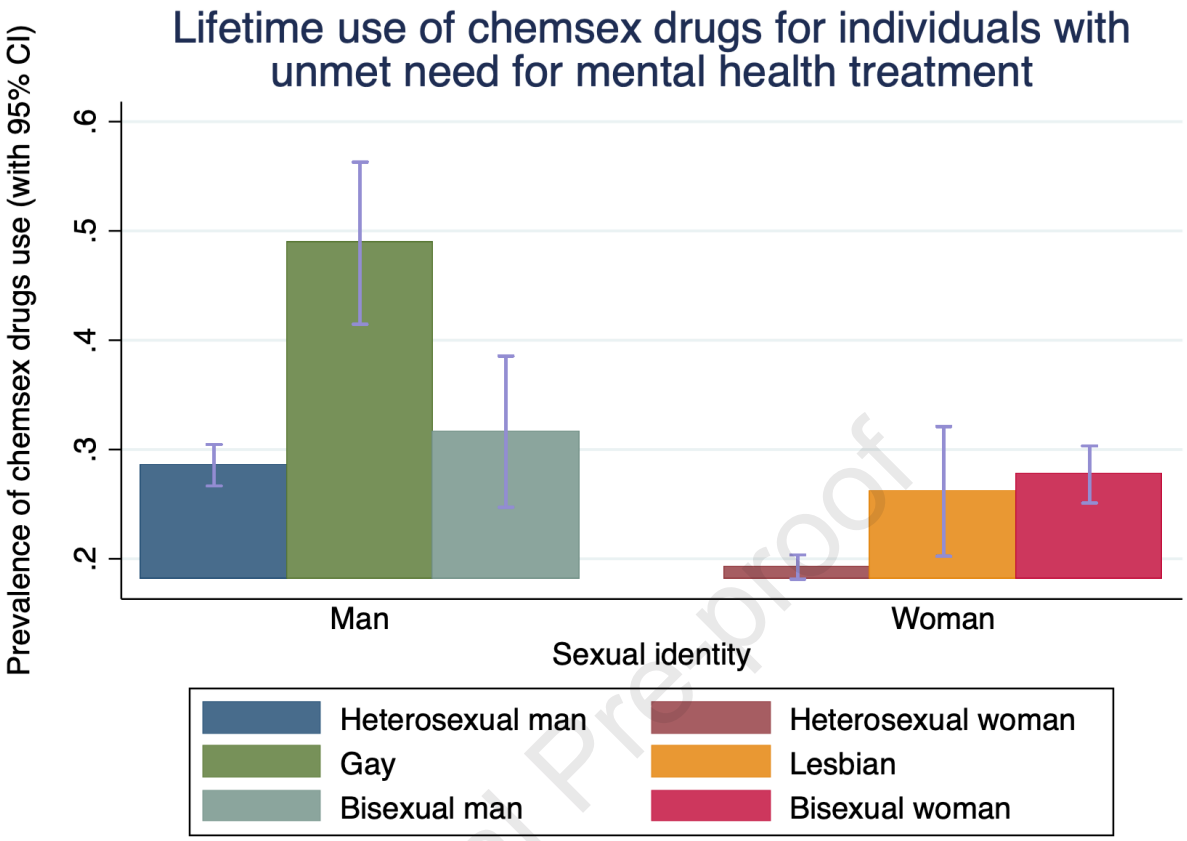












Conflict of interest statement

Bastian Rosner:
Declares no conflict of interest.

Jessica Neicun:
Declares no conflict of interest.

Justin Christopher Yang:
Declares no conflict of interest.

Andres Roman-Urrestarazu:
Declares no conflict of interest.