



Substance use and sexuality: Comparing sexual identity and attraction using a multilevel multivariate model

Megan Davies^{a,*}, Graham Moon^b, Nathaniel M. Lewis^b

^a Department of Environmental Science, Aarhus University, Frederiksborgvej 299, 4000 Roskilde, Denmark

^b Department of Geography and Environment, University of Southampton, Building 44, Southampton SO17 1BJ, United Kingdom

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ABSTRACT

Previous research has found that sexual minority individuals are more likely than heterosexual individuals to engage in substance use behaviours such as the consumption of illicit drugs, heavy drinking and tobacco smoking. This study innovates by comparing the association of different measures of sexuality with substance use behaviours and exploring whether this association varies by place. We exploit multivariate multilevel models with sexual attraction and sexual identity as exposure measures and Great Britain Local Authorities (LA) as places. This study compares multivariate models for men and women, comparing measures of sexuality using sexual attraction and sexual identity to look simultaneously at cannabis use, current smoking and alcohol use, and variance across LAs. Sexual attraction was a stronger predictor of engaging in substance use behaviours compared to sexual identity for men and women, and LGB women experienced greater odds of engaging in all substance use behaviours than LGB men. After controlling for relevant covariates, there was residual LA level variation only for women cannabis users, although it was not significant. These findings highlight the importance of using different measures of sexuality, and that LGB women are more vulnerable to engaging in risky health behaviours. LGB women in particular may require sexuality-specific interventions, support and policies in LAs with greater cannabis use.

1. Introduction

Research has consistently demonstrated that lesbian, gay and bisexual (LGB) individuals face greater health inequalities compared to heterosexual individuals, and are more likely to engage in health-damaging substance use including smoking, cannabis consumption and risky alcohol use (Peacock et al., 2018). Inequalities in substance use behaviours have received significant attention in recent research, with reviews of the literature showing that LGB individuals have been found to have a higher reported lifetime substance misuse of alcohol and illicit drugs, and higher rates of smoking tobacco than heterosexual individuals (Blosnich et al., 2013; Davies et al., 2018; Goldbach et al., 2014; Lee et al., 2009; Ritchwood et al., 2015).

Research has found higher smoking rates in lesbian and bisexual women than in heterosexual women, suggesting unique factors associated with certain LGB groups might drive smoking behaviour, and reinforces the importance of looking within subgroups rather than LGB as a whole group (Davies et al., 2020; Emory et al., 2016; Shahab et al., 2017). Similarly, research on hazardous alcohol use has found higher

odds for LGB women compared to heterosexual women, attributed to greater incidences of anxiety and depression, whereby alcohol and other substances might be used as a coping mechanism, particularly in response to stigma (Roxburgh et al., 2016). Cannabis use in bisexual women has also been suggested to be associated with the degree of involvement of the lesbian, gay, bisexual and trans community, social support available, and depression (Robinson et al., 2016), with research finding that bisexual women were more likely to have poorer mental health and use cannabis than lesbian women in the UK (Colledge et al., 2015). A review by Green and Feinstein (2012) found mixed results in terms of substance use and gender differences across LGB groups, but ultimately suggested that certain demographic characteristics which are protective against substance use in heterosexual populations, including being a woman, are not protective amongst LGB populations for substance use.

Substance use has also been found to be higher in gay and bisexual men compared to heterosexual men, and has similarly been linked to stress arising from stigma and discrimination (Meyer, 2003), though research is more mixed compared to women. Higher smoking

* Corresponding author.

E-mail address: m.davies@envs.au.dk (M. Davies).

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prevalence has been found in gay and bisexual men compared to heterosexual men (Davies et al., 2020), though research looking at sexual attraction rather than identity found smoking and other tobacco use amongst those reporting attraction to both sexes a less clear pattern for men than for women (Wheldon et al., 2018). Findings on alcohol use are also inconsistent, as some have reported higher hazardous alcohol use in gay and bisexual men, whilst other research has found when socio-economic status was included in the model, this effect was then muted (Shahab et al., 2017). Many of the studies on illicit substance use in men who have sex with men have been associated with ‘chemsex’, whereby individuals take drugs to enhance sexual activity, rather than examining cannabis use on its own unrelated to sexual activity (Barrett et al., 2019; Maxwell et al., 2019; Weatherburn et al., 2017).

Previous research on sexuality has focused mainly on using sexual identity to represent sexuality, without considering the possible impact of different measures. Whilst sexuality surveys have considered the use of sexual behaviour as an indicator for sexuality (Aicken et al., 2011), the use of sexual identity represents much of the work linking sexuality and health outcomes, with sexual attraction much less represented than identity and behaviour (Blosnich et al., 2013; Geary et al., 2018). The use of sexual identity as a measure is often associated with ensuring equal opportunities or equality monitoring purposes for surveys or organisations to represent minority groups and increase inclusion, rather than for the purpose of analysis of sexuality measures (Geary et al., 2018). Using sexual attraction may capture a population that may not wish to attach an identity to themselves, as some individuals might not identify as LGB, or be questioning their identity, but report same-sex attraction. Whilst sexual behaviour is a useful and important part of measuring sexuality as a whole, it is more beneficial when looking at sexual behaviour specific issues, such as modelling sexually transmitted infection risk. Sexual behaviour is a more sensitive topic, and therefore individuals might not feel comfortable reporting their behaviour which could lead to biases. Behaviour is also only useful for those that are or have been sexually active, and therefore excludes those who are not engaging in sexual activity.

The association between substance use behaviour and sexuality is, of course, confounded by other factors such as education level and socio-economic status. In Great Britain (GB), some research has found that socio-economic status can sometimes confound the association of sexual identity on substance use behaviours, whilst other studies have found the effect of sexuality is still observed when including social class (Davies et al., 2019; Shahab et al., 2017). Other individual determinants of substance use behaviours in LGB populations include poor mental health and wellbeing, particularly minority stress related to increased stigma (Fallin et al., 2015; Kerr et al., 2014; Meyer, 2003). Individuals with poorer mental wellbeing might be at risk for depression and anxiety, whereby substance use and maladaptive behaviours might be used as a coping mechanism to decrease stress. Cannabis use itself in bisexual women has been associated with depressive symptoms yet not associated with anxiety, suggesting that cannabis might have alleviated anxiety symptoms but exacerbated depressive ones (Robinson et al., 2016). Thus, mental health and substance use may be a mutually reinforcing cycle in LGB populations.

In addition, controlling for geographical clustering is also necessary, as the role of place has been established in engaging in substance use behaviours (Pearce et al., 2009). The influence of contextual factors in GB has particularly been under-explored in LGB populations. In the United States, studies have shown that states with more restrictive same-sex legislations such as marriage bans had higher prevalence rates of substance use disorders than states with more progressive legislations (Hatzenbuehler, 2010). Higher prevalence rates of cannabis use in LGB youths compared to heterosexual individuals has been found particularly in neighbourhoods with lesbian, gay, bisexual and transgender hate crimes reported (Duncan et al., 2014). A study looking at cannabis use in young people living with HIV found that area level variables predicted daily cannabis use for bisexual males only compared to other sexual

orientation groups (Bruce et al., 2015). These findings suggest that the impact of contextual effects and neighbourhoods can vary between groups, and needs to be considered alongside other individual factors.

Whilst some research has established the link between smoking, alcohol use and cannabis use, showing that engaging in one substance use behaviour predicts increased use of another (Gubner et al., 2016; Patton et al., 2005; Subbaraman and Kerr, 2015), studies have mainly examined the association between sexuality and substance use behaviours in separate models. Examining the outcomes within the same multivariate model can give better information about how sexuality is implicated in substance use behaviour outcomes by controlling for each other. In this model, we use a multilevel approach, whereby within-individual outcomes are treated as level one units nested within individuals at level two (Goldstein, 2011). This model structure can also be extended by adding a third level to account for variability of area level effects. Modelling the outcomes separately can result in ignoring the possible correlation between the outcomes (Browne et al., 2019; Rasbash et al., 2019). This multilevel multivariate approach allows us to understand the influence of an exposure variable on the outcomes simultaneously, and standard errors are more accurate for independent variables than if the outcomes were modelled in isolation (Mohan et al., 2011; Snijders and Bosker, 1999).

Based on the gaps in current research in substance use behaviours and sexuality, this paper aims to (1) examine the associations between sexuality and substance use behaviour, which throughout this paper refers to the use of tobacco, alcohol and cannabis, whilst controlling for known determinants, (2) compare if substituting sexual attraction for sexual identity impacts on effectiveness at predicting substance use behaviour for men and women, and (3) examine how these associations vary geographically after taking into account compositional factors.

2. Methods

2.1. Data

We used data from the 2012 wave of the National Survey of Sexual Attitudes and Lifestyle (NATSAL), the most recent available, which collects data on sexuality in adults in GB. The survey was administered to households, and a random individual aged between 16-74 was selected from each household and asked a range of questions about sexual behaviours and lifestyle, as well as demographic variables (Erens et al., 2014). We were granted access to NATSAL data with attached Local Authority (LA) geocodes. LAs consist of different councils, boroughs and metropolitan districts across the UK, and administer local services including many aspects of health promotion. There are 368 LAs across England, Scotland and Wales. We excluded cases with less than 10 individuals in a LA, which left 347 LAs in this dataset. Missing data were handled using listwise deletion.

2.2. Measures

2.2.1. Dependent variables

Three binary variables were used as outcomes in this analysis. The first was smoking status, whereby individuals indicated they were light smokers, heavy smokers, ex-smokers or non-smokers. We recoded light smokers and heavy smokers to a single smoker category, and ex-smokers were combined with non-smokers to estimate only those who were current smokers. Smoking was collapsed to a binary variable due to software limitations that do not allow for multilevel, multivariate multinomial models. The second outcome was alcohol use, which was a derived variable about weekly units of alcohol, collapsed into a binary variable which measured if respondents regularly drink over the weekly recommended limit, with the answers being ‘yes’ or ‘no’. When the data were collected, the alcohol weekly recommended limit for men was 21 units and 14 for women. The third outcome variable was about cannabis use, with the question asking, ‘have you ever used cannabis?’, with the

answers being ‘yes’ or ‘no’.

2.2.2. *Exposures: sexual identity and attraction*

Sexuality was measured using two variables. The first asked, ‘which of the following best describes how you think of yourself?’, measuring individual’s self-reported sexual identity. The options included ‘gay or lesbian’, ‘bisexual’, ‘heterosexual’ or ‘other’, the latter of which was excluded from this analysis due to a small number of respondents in this category. Sexual attraction was measured by asking ‘who are you attracted to?’, with options being ‘only opposite sex’, ‘mostly same sex and at least once opposite sex’, ‘equal sexes’, ‘mostly opposite sex and at least once same sex’, and ‘only same sex’. We collapsed the categories ‘mostly same sex and sometimes opposite sex’ and ‘same sex only’ to create a ‘mostly or only same sex’ category, as the numbers within these for respondents were too small to model and would lead to biased estimates.

2.2.3. *Demographic covariates*

In NATSAL, age was categorised into 5 categories with 10-year intervals. Based on previous research that highlights differences within sexual orientation groups, we stratified our data based on sex (in NATSAL sex/gender was treated as singular and binary, referring to male-man/female-woman) to have separate models for men and women (Davies et al., 2018; Shahab et al., 2017).

2.2.4. *Socioeconomic covariates*

Education was measured by asking for the individual’s highest education level, which we collapsed into two categories: ‘post 16 qualifications’ for those with qualifications higher than GCSE, such as A level, degree level, higher or equivalents. ‘No post 16 qualifications’ was categorised as those whose highest qualification was GCSE level, or equivalent, lower or no qualifications. Individual social class status was derived using the National Statistics Socio-Economic Classification, whereby occupation is used as an indicator. Five categories were initially used: ‘professional occupation’, ‘intermediate occupation’, ‘routine workers’, ‘other’ and ‘non-classifiable’. Due to small numbers in some categories and to avoid over-parameterisation of the model, we combined ‘professional’ and ‘intermediate’ into one category which was used as the referent category, and excluded ‘non-classifiable’.

2.2.5. *Mental health covariate*

We included a binary variable that was created based on mental wellbeing scores from the Patient Health Questionnaire-2 (PHQ2), whereby scores above 3 were indicated as screening positive for depression (Arroll et al., 2010).

2.3. *Statistical analysis*

Data were prepared using SPSS version 24. We undertook multivariate multilevel modelling using MLwiN version 3.03 software to analyse the impact of sexuality on three different substance use behaviours. Models were estimated using 1st order marginal quasi likelihood (MQL) estimation, followed by 2nd order predictive quasi likelihood (PQL) estimation. This method is recommended as MQL estimation can lead to biased results, and so PQL provides better estimates (Rasbash et al., 2009). Logit scores were then transformed into odds ratios (OR). This is a single dataset multivariate model, whereby a set of dummy variables are created to indicate which response variable is present for the outcomes (Rasbash et al., 2019). The outcomes are therefore treated as level one, which are then nested in individuals at level two. We have then added third level to account for clustering across LAs. The model for this can be expressed as;

$$\text{logit}(p_{1jk}) = \beta_{0k}x_{0ijk} + \beta_3\text{sexuality} + \beta_6\text{age} + \beta_9\text{ethnicity} + \beta_{12}\text{depression} + \beta_{15}\text{education} + \beta_{18}\text{social class}$$

$$\beta_{0k} = \beta_0 + v_{0k}$$

$$\text{logit}(p_{2jk}) = \beta_{1k}x_{1ijk} + \beta_4\text{sexuality} + \beta_7\text{age} + \beta_{10}\text{ethnicity} + \beta_{13}\text{depression} + \beta_{16}\text{education} + \beta_{19}\text{social class}$$

$$\beta_{1k} = \beta_1 + v_{1k}$$

$$\text{logit}(p_{3jk}) = \beta_{2k}x_{2ijk} + \beta_5\text{sexuality} + \beta_8\text{age} + \beta_{11}\text{ethnicity} + \beta_{14}\text{depression} + \beta_{17}\text{education} + \beta_{20}\text{social class}$$

$$\beta_{2k} = \beta_2 + v_{2k}$$

$$\begin{bmatrix} v_{0k} \\ v_{1k} \\ v_{2k} \end{bmatrix} \sim N(0, \Omega_v) : \Omega_v = \begin{bmatrix} \sigma_{v0}^2 & & \\ \sigma_{v01} & \sigma_{v1}^2 & \\ \sigma_{v02} & \sigma_{v12} & \sigma_{v2}^2 \end{bmatrix}$$

Where *logit* is the log odds for ever having used cannabis (p_1), being a current smoker (p_2) and regularly going over the weekly limit of alcohol (p_3), respectively. β_{0k} , β_{1k} , β_{2k} , are the random intercept terms for each outcome varying at LA level (k). The coefficients from β_3 onwards are the predictor variables that are added as coefficients to each outcome. Sexuality refers to either sexual identity or sexual attraction. σ_{v0}^2 , σ_{v1}^2 , σ_{v2}^2 are the random effects at the LA level and the remainder of the random effects matrix indicates covariances.

Using a multilevel multivariate model has many advantages when testing for the effect of predictor variables on different outcomes. Firstly, multivariate models are used when theory suggests that the outcomes are likely to be correlated to a certain extent. By using multilevel modelling, this allows us to test the outcomes together and infer the relationship between the outcomes, at both the individual and LA level. Secondly, only by looking at the outcomes together can we look at the association between the effects of common independent variables. This study looks at sexuality measures and other potential confounding variables simultaneously, whilst other studies have looked at the effects separately. Using multivariate multilevel modelling also allows us to estimate correct standard errors and the residual variance at the LA level to determine the effect of environmental factors that may be muted using single level models (Mohan et al., 2011; Subramanian et al., 2005). We examined the patterning in the residuals for each outcome using the supergroup for the 2011 Area classifications for LAs, which has 8 supergroups (Office for National Statistics, 2015).

3. **Results**

3.1. *Differences in substance use behaviours by sexuality for men and women*

Table 1 shows the number and percentage of individuals who report being current smokers, regularly go over the weekly limit for alcohol, and have ever tried cannabis. The prevalence of engaging in substance use behaviours was lower for men and women attracted to the opposite sex only, compared to the other sexual attraction groups. Lower prevalence was also seen in heterosexual men and women compared to gay or lesbian and bisexual individuals. A chi-square test confirmed that the association between sexuality and each substance use behaviour was significant ($p < .001$).

3.2. *Multivariate model results*

Tables 2 and 3 show the unadjusted ORs for cannabis use, smoking and alcohol use stratified by sex, with different models for sexual attraction and sexual identity. The constant logit scores suggest that, for both men and women, the likelihood of ever having used cannabis,

Table 1

Sample size and percentages of substance use behaviours by sexuality measure for men and women.

	Ever used cannabis				Current smoker				Alcohol use			
	Men		Women		Men		Women		Men		Women	
	n	%	n	%	n	%	n	%	n	%	n	%
Sexual attraction												
Opposite sex only	2121	39	1731	24	1649	29	1957	26	483	8	753	10
Mostly opposite sex at least once same sex	145	54	557	62	87	32	343	38	38	14	165	18
Equal sexes	17	38	46	41	15	30	46	39	8	16	18	15
Mostly or only same sex	74	54	50	47	59	41	39	35	18	13	23	21
Sexual identity												
Heterosexual	2258	39	2257	27	1729	29	2287	27	525	9	902	11
Bisexual	35	53	80	52	33	49	68	43	9	13	33	21
Gay/lesbian	60	51	43	47	47	39	34	37	16	13	21	23

Unadjusted odds ratios for sexual attraction for men and women.

	Ever used cannabis		Current smoker		Alcohol use	
	Men	Women	Men	Women	Men	Women
Constant	-0.46	-1.17	-0.92	-1.06	-2.40	-2.22
logit (SE)	(0.03)	(0.03)	(0.03)	(0.03)	(0.05)	(0.04)
Sexual attraction (ref opposite sex only)						
Mostly opposite sex, at least once same sex	1.92	5.27	1.14	1.74	1.73	1.98
Equal sexes	0.99	2.33	0.99	1.99	2.13	1.71
Mostly same sex	1.77	2.97	1.68	1.58	1.49	2.47

Bold text indicates confident intervals that do not span 1, significant at p<.05.

being a current smoker, and frequently going over the alcohol limit is lower for those attracted to the opposite sex only and for identifying heterosexuals. Men attracted to mostly the opposite sex but at least once same sex were more likely to use cannabis and go over the weekly recommended alcohol limit than those attracted to the opposite sex only. Being attracted to mostly same sex was associated with being a current smoker for men. All three sexual attraction groups predicted cannabis use, being a current smoker and going over the weekly alcohol limit for women. Identifying as gay predicted being a current smoker and previous cannabis use for men. Sexual identity did not predict alcohol use for men. Identifying as lesbian predicted cannabis use and alcohol use for women and identifying as bisexual predicted being a current smoker for both men and women.

3.3. Adjusted models

We adjusted the models for our two exposure measures to test the impact of sexuality on substance use behaviours after controlling for theoretically justified covariates, shown in Tables 4 and 5. Covariate

Table 3

Unadjusted odds ratios for sexual identity for men and women.

	Ever used cannabis		Current smoker		Alcohol use	
	Men	Women	Men	Women	Men	Women
Constant logit (SE)	-0.45 (0.03)	-0.97 (0.03)	-0.92 (0.03)	-1.00 (0.03)	-2.36 (0.05)	-2.13 (0.04)
Sexual identity (ref heterosexual)						
Bisexual	1.76 (1.07, 2.90)	2.95 (2.13, 4.09)	2.49 (1.52, 4.09)	2.01 (1.44, 2.79)	1.71 (0.83, 3.51)	2.18 (1.46, 3.26)
Gay/lesbian	1.59 (1.10, 2.30)	2.45 (1.61, 3.73)	1.51 (1.04, 2.21)	1.51 (0.98, 2.33)	1.51 (0.86, 2.64)	2.46 (1.50, 4.04)

Bold text indicates confident intervals that do not span 1, significant at p<.05

adjustment challenged suggestions that being attracted to mostly the same sex was associated with cannabis use among men, and that being attracted to mostly the same sex was associated with smoking among women. Conversely, covariate adjustment strengthened suggestions of an association between being attracted to mostly the same sex and identifying as gay for smoking among men.

3.3.1. Sexual attraction

Ever having tried cannabis use for men was associated with increased odds for those mostly attracted to the opposite sex and at least once same sex [OR 1.90] than those attracted to the opposite sex only. Being equally attracted to the opposite and same sex, and being attracted to mostly same sex was not significantly associated with cannabis use for men. Women mostly attracted to the opposite sex were more likely to have ever tried cannabis [OR 4.17], those equally attracted to the same and opposite sex were more likely [OR 1.80], and those attracted to mostly or only same sex were more likely [OR 2.32] than those attracted to the opposite sex only.

Smoking was not associated for men with being attracted to mostly the opposite sex and at least once same sex or being equally attracted to both the opposite and same sex. Being attracted to mostly same sex was associated with being a current smoker compared to the opposite sex only [OR 1.73]. For women, being attracted to mostly the opposite sex and at least once same sex was associated with current smoking [OR 1.70], as was being equally attracted to both sexes [OR 1.75] compared to being attracted to the opposite sex only. Being attracted to mostly or only same sex was not significantly associated with being a current smoker.

Frequently going over the weekly limit for alcohol for men was associated with being most often attracted to the opposite sex but at least once same sex [OR 1.60]. Being equally attracted to both sexes, and mostly same sex, were not significant. For women, being most often attracted to the opposite sex but at least once same sex was associated with increased likelihood of frequently going over the weekly limit of alcohol [OR 1.79], as did being attracted to mostly or only same sex [OR 2.16]. Being equally attracted to both the opposite and same sex was not significant for women.

3.3.2. Sexual identity

Men who identified as bisexual were more likely than heterosexuals to have ever tried cannabis [OR 1.87], but gay men were not

Table 4
Odds ratios fully adjusted model for men and women for cannabis use, current smoking and alcohol use by sexual attraction.

	Ever used cannabis		Current smoker		Alcohol use	
	Men	Women	Men	Women	Men	Women
Constant logit (SE)	0.16 (0.07)	-0.38 (0.07)	-1.37 (0.08)	-1.44 (0.08)	-2.71 (0.14)	-1.75 (0.09)
Sexual attraction (ref opposite sex only)						
Mostly opposite sex, at least once same sex	1.90 (1.45, 2.50)	4.17 (3.58, 4.87)	1.23 (0.93, 1.62)	1.70 (1.46, 1.99)	1.60 (1.11, 2.32)	1.79 (1.47, 2.17)
Equal sexes	0.91 (0.47, 1.79)	1.80 (1.21, 2.68)	0.91 (0.45, 1.84)	1.75 (1.16, 2.63)	2.16 (0.92, 5.05)	1.64 (0.98, 2.77)
Mostly or only same sex	1.35 (0.94, 1.93)	2.32 (1.55, 3.48)	1.73 (1.21, 2.48)	1.48 (0.97, 2.25)	1.35 (0.80, 2.29)	2.16 (1.34, 3.48)
Age (ref 16–25)						
25-34	1.22 (1.04, 1.43)	0.94 (0.81, 1.06)	1.19 (1.01, 1.41)	0.96 (0.83, 1.10)	1.50 (1.11, 2.02)	0.76 (0.63, 0.92)
35-44	0.89 (0.74, 1.07)	0.74 (0.62, 0.87)	0.80 (0.65, 0.98)	0.68 (0.57, 0.81)	1.45 (1.03, 2.06)	0.73 (0.58, 0.93)
45-54	0.48 (0.39, 0.58)	0.39 (0.33, 0.48)	0.82 (0.67, 1.00)	0.68 (0.57, 0.81)	2.16 (1.57, 2.97)	1.00 (0.79, 1.25)
55-64	0.22 (0.18, 0.27)	0.22 (0.17, 0.27)	0.46 (0.37, 0.58)	0.44 (0.36, 0.53)	2.15 (1.56, 2.96)	0.67 (0.51, 0.87)
65+	0.07 (0.05, 0.12)	0.07 (0.05, 0.10)	0.41 (0.32, 0.52)	0.34 (0.27, 0.42)	1.79 (1.26, 2.53)	0.55 (0.40, 0.75)
Ethnicity (ref white)						
Black/ Black British	0.40 (0.28, 0.57)	0.34 (0.23, 0.48)	0.56 (0.38, 0.83)	0.37 (0.26, 0.53)	0.18 (0.06, 0.57)	0.11 (0.04, 0.30)
Asian/Asian British	0.25 (0.19, 0.34)	0.17 (0.11, 0.25)	0.88 (0.66, 1.17)	0.19 (0.12, 0.28)	0.17 (0.07, 0.43)	0.13 (0.06, 0.30)
Mixed/Chinese/other	1.00 (0.73, 1.37)	0.69 (0.52, 0.91)	1.30 (0.94, 1.81)	1.02 (0.78, 1.34)	0.31 (0.12, 0.76)	0.59 (0.38, 0.92)
Social class group (ref professional/ intermediate)						
Routine	0.97 (0.84, 1.12)	0.85 (0.72, 1.01)	1.67 (1.45, 1.93)	1.59 (1.37, 1.84)	0.97 (0.76, 1.23)	1.16 (0.94, 1.43)
Other	0.66 (0.54, 0.79)	0.64 (0.55, 0.75)	1.04 (0.86, 1.25)	1.00 (0.87, 1.15)	0.80 (0.58, 1.10)	0.71 (0.57, 0.88)
Education (ref post 16 qualifications)						
No post 16 qualifications	0.78 (0.69, 0.88)	0.76 (0.69, 0.85)	2.10 (1.84, 2.39)	2.68 (2.39, 3.00)	0.98 (0.81, 1.19)	0.84 (0.73, 0.98)
Depression (ref no)						
Yes	1.68 (1.40, 2.02)	1.33 (1.13, 1.55)	1.77 (1.49, 2.13)	1.74 (1.51, 2.01)	1.27 (0.96, 1.68)	0.96 (0.78, 1.20)
Unexplained LA level variance (standard error)	0.033 (0.021)	0.066 (0.022)	0.030 (0.022)	0.034 (0.018)	0.075 (0.055)	0.054 (0.033)

Bold text indicates confident intervals that do not span 1, significant at $p < .05$.

significantly more likely. For women, identifying as a lesbian was associated with increased odds of ever having tried cannabis [OR 1.92], as was identifying as bisexual [OR 2.14] compared to heterosexuals.

Increased odds of being a current smoker was associated with identifying as gay [OR 1.57] and identifying as bisexual for men [OR 2.42] compared to heterosexuals. For women, identifying as bisexual was associated with increased odds of being a smoker [OR 1.55], whereas identifying as lesbian was not significant.

For men, identifying as gay or bisexual was not significantly associated with frequently going over the weekly limit of alcohol compared to heterosexual men. For women, identifying as lesbian [OR 2.16] or bisexual [OR 2.00] was associated with increased odds of frequently going over the weekly alcohol limit.

3.3.3. Covariates

Associations with covariates were as expected. Older individuals had decreased odds of ever having tried cannabis, except for 25-34 year old men, and the same pattern was seen for current smoking. Increasing age was associated with an increase in likelihood of frequently going over the weekly limit for alcohol for men, but a decrease in likelihood for women. Compared to white individuals, other ethnicities were associated with decreased odds of cannabis use, smoking and alcohol use for men and women, though not all were significant. Routine occupation was only significantly associated with increased likelihood of smoking for men and women, and those in other professions were less likely to have ever tried cannabis only. Having no post-16 qualifications was

associated with a decreased likelihood of cannabis use for men and women, alcohol use only for women, and an increased likelihood of smoking for men and women. Screening positive for depression was associated with increased odds of ever having tried cannabis and being a current smoker for both men and women. No significant results were associated with alcohol use for either men or women.

3.3.4. Unexplained local authority level variance

The variance at LA level was significant only for cannabis consumption among women, and this variation is evident for both sexual attraction and sexual identity, with an estimated 7% and 9% residual variance, respectively.

3.4. Analysis of residuals

Using the calculated residual variance and 95% confidence intervals from the adjusted models, we examined the LA level residuals for cannabis use for women, in the sexual identity and attraction exposure groups.

Fig. 1 shows the residuals for sexual attraction and sexual identity for women who have ever used cannabis, by LA type. The LA type most clearly associated with positive residuals with cannabis use is London Cosmopolitan, which also had the greatest variation between the residuals for sexual attraction exposure group and that for sexual identity. It is possible that women attracted to other women and living in this LA type are more likely to have been cannabis users than the model

Table 5
Odds ratios fully adjusted model for men and women for cannabis use, current smoking and alcohol use by sexual identity.

	Ever used cannabis		Current smoker		Alcohol use	
	Men	Women	Men	Women	Men	Women
Constant logit (SE)	0.20					
(0.07)	-0.17 (0.07)					
(0.09)	-1.37 (0.08)					
Sexual identity (ref heterosexual)						
Bisexual	1.87 (1.10, 3.18)	2.14 (1.52, 2.99)	2.42 (1.45, 4.06)	1.55 (1.10, 2.19)	1.69 (0.82, 3.52)	2.00 (1.34, 3.01)
Gay/lesbian	1.16 (0.79, 1.71)	1.92 (1.24, 2.98)	1.57 (1.05, 2.32)	1.53 (0.97, 2.41)	1.33 (0.76, 2.34)	2.16 (1.31, 3.56)
Age (ref 16–25)						
25–34	1.23 (1.05, 1.44)	0.95 (0.83, 1.09)	1.21 (1.02, 1.43)	0.96 (0.83, 1.10)	1.51 (1.12, 2.04)	0.76 (0.63, 0.92)
35–44	0.89 (0.74, 1.07)	0.73 (0.62, 0.86)	0.80 (0.65, 0.98)	0.67 (0.56, 0.80)	1.45 (1.02, 2.05)	0.73 (0.57, 0.93)
45–54	0.48 (0.40, 0.58)	0.38 (0.32, 0.46)	0.81 (0.66, 1.00)	0.66 (0.56, 0.79)	2.15 (1.56, 2.96)	0.97 (0.77, 1.21)
55–64	0.22 (0.18, 0.28)	0.20 (0.16, 0.25)	0.46 (0.37, 0.58)	0.42 (0.35, 0.51)	2.15 (1.56, 2.96)	0.64 (0.49, 0.83)
65+	0.07 (0.05, 0.10)	0.06 (0.04, 0.09)	0.41 (0.32, 0.52)	0.32 (0.26, 0.40)	1.77 (1.25, 2.50)	0.52 (0.38, 0.71)
Ethnicity (ref white)						
Black/ Black British	0.39 (0.27, 0.55)	0.32 (0.22, 0.46)	0.55 (0.37, 0.82)	0.37 (0.26, 0.52)	0.18 (0.05, 0.56)	0.11 (0.04, 0.30)
Asian/Asian British	0.25 (0.18, 0.34)	0.16 (0.11, 0.24)	0.86 (0.65, 1.15)	0.18 (0.12, 0.27)	0.13 (0.05, 0.37)	0.12 (0.05, 0.28)
Mixed/Chinese/other	0.99 (0.72, 1.35)	0.69 (0.52, 0.91)	0.69 (0.52, 0.91)	1.02 (0.78, 1.34)	0.31 (0.12, 0.76)	0.60 (0.39, 0.94)
Social class group (ref professional/intermediate)						
Routine	0.97 (0.84, 1.12)	0.86 (0.73, 1.01)	1.67 (1.44, 1.92)	1.58 (1.36, 1.83)	0.96 (0.76, 1.22)	1.17 (0.95, 1.44)
Other	0.67 (0.55, 0.80)	0.64 (0.54, 0.74)	1.04 (0.87, 1.26)	0.99 (0.86, 1.14)	0.81 (0.59, 1.11)	0.71 (0.57, 0.88)
Education (ref post 16 qualifications)						
No post 16 qualifications	0.77 (0.68, 0.87)	0.72 (0.65, 0.80)	2.08 (1.83, 2.37)	2.59 (2.32, 2.90)	0.96 (0.79, 1.17)	0.82 (0.71, 0.95)
Depression (ref no)						
Yes	1.67 (1.39, 2.00)	1.39 (1.19, 1.62)	1.77 (1.48, 2.11)	1.78 (1.54, 2.06)	1.29 (0.97, 1.71)	0.99 (0.80, 1.23)
Unexplained LA level Variance (standard error)	0.034 (0.022)	0.086 (0.024)	0.031 (0.022)	0.036 (0.018)	0.073 (0.055)	0.050 (0.032)

Bold text indicates confident intervals that do not span 1, significant at $p < .05$

suggests. To a much lesser extent, this also applies to women attracted to women in the LA types Affluent England and Countryside Living. Conversely, the model is most likely to overestimate the likelihood of cannabis use among women attracted to other women in Industrial Legacy LAs. In the case of sexual identity, there is a generally even spread of residuals around zero, with great model under-estimation occurring in Cosmopolitan Living LAs and, paradoxically, LGB women in London Cosmopolitan LAs tending to be less likely to be cannabis consumers than suggested by the model. This latter finding suggests the possibility that there are place-specific consequences at the LA level that flow from the use of different measures of sexuality. Overall, however, all LA types overlap zero, have both positive and negative LA residual variation, and there is no systematic association between model performance and LA types. Further examination of LA level covariances showed no clear patterning to substance use behaviours once individual factors taken into account.

4. Discussion

This study is the first to look at substance use behaviours simultaneously whilst comparing sexual attraction and sexual identity as exposure groups stratified by sex. Using different measures for sexuality may capture otherwise hidden populations that have a high risk of substance use. Examining the outcomes together also gives better and more accurate estimates of how the same covariates predict each outcome (Mohan et al., 2011). Whilst some studies have started to look

at sexual attraction as a sexuality measure and acknowledge the need to include it when examining inequalities (Geary et al., 2018; Kuyper and Bos, 2016), our study extends current findings by also comparing sexuality measures. We also extend previous research by using multi-level modelling to adjust for possible higher-level influences on substance use overall and examine if there are differences in substance use across LAs for men and women.

Our findings substantiate previous studies that suggest LGB women use substances at higher rates than their heterosexual counterparts, which was observed in both the sexual attraction and sexual identity model (Fish et al., 2019; Shahab et al., 2017; Watson et al., 2018b). Whilst the initial prevalence rates showed a higher percentage of some substance use in different sexuality categories for men, these descriptive statistics did not control for other factors. Previous research has attributed the inequalities in rates of alcohol use and smoking between LGB male and female youths to a decrease in bullying for LGB males and increased support, but less so for LGB females (Watson et al., 2018a). Our study also suggests that bisexual individuals, or those attracted to both sexes, might be more at risk for maladaptive behaviours in both men and women (Shahab et al., 2017), which may be due to stigma and less inclusive attitudes that stem from both heterosexual and gay and lesbian communities (Homma et al., 2016).

We found that the sexual attraction model appears to show slightly higher odds for some substance use behaviour than sexual identity and appears to capture more differences between groups than sexual identity alone. For women, bisexuality predicted substance use behaviour across

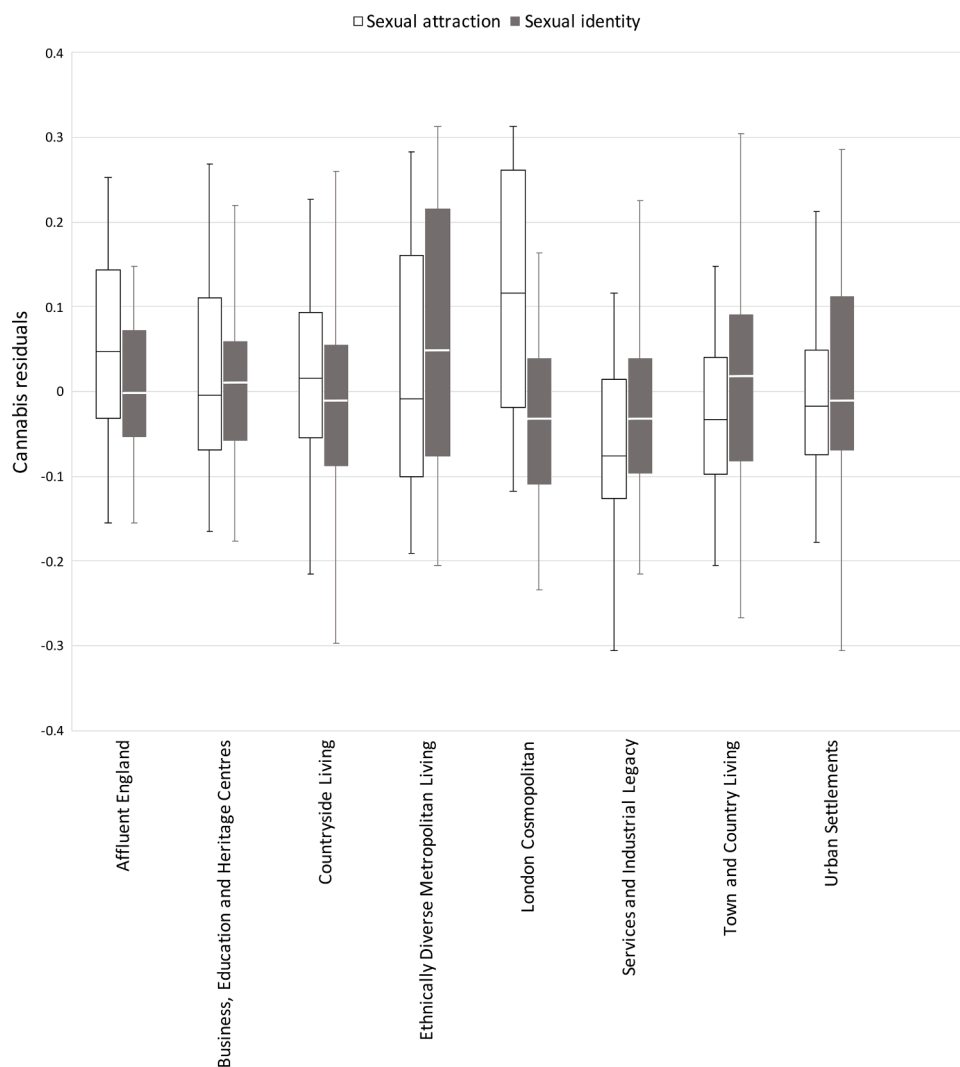


Fig. 1. Residuals by LA type for women in sexual attraction and sexual identity groups.

all three outcomes, although there were differences in odds across the level of same sex attraction. For example, being mostly attracted to the opposite sex but at least once same sex predicted substance use more than being attracted to equal sexes. In men, the findings were mostly similar across the two models with few differences, though alcohol use was not significant for LGB men in the identity model. This might suggest that on the spectrum of same sex attraction and bisexuality, and particularly for women, the increased vulnerability and potential stigma could lead to engaging in more maladaptive behaviours than those attracted to mostly the same sex or identifying as lesbian. Examining same sex attraction in addition to sexual identity might uncover categories of individuals not captured within the LGB group. Using only sexual identity may be missing some individuals who might not identify as LGB but may be vulnerable to engaging in substance use behaviours. These individuals could be uncertain about their identity, as previous studies have shown questioning individuals have greater barriers to healthcare and increased anxiety than LGB and heterosexual individuals (Birkett et al., 2009; MacApagal et al., 2016).

Whilst other studies have demonstrated the link between sexuality and substance behaviours (Davies et al., 2019; Robinson et al., 2016; Shahab et al., 2017), our findings highlight the importance of looking within LGB groups, and also across sexuality measures. This extends previous research that has looked at smoking behaviours amongst non-heterosexual individuals and even those examining trends amongst sexual attraction by looking at multiple substance use outcomes (Emory

et al., 2016; Wheldon et al., 2018). Research on substance use behaviours in LGB populations has largely been carried out in a North American context, and studies in GB have been limited and focussed mainly on sexual identity as a measure of sexuality (Geary et al., 2018; Semlyen et al., 2016; Shahab et al., 2017). This is largely due to access, or lack thereof, to health and social surveys with appropriate sexuality data (Uhrig, 2015). Using both sexual attraction and sexual identity has merit in sexuality research, but incorporating measures beyond sexual identity may give more insight into sub-categories of sexuality and substance use and include more individuals at risk.

Adjusting for socio-economic factors affected some of the results for men and women, particularly women reporting equal same sex attraction for alcohol use, and men reporting mostly same sex attraction or identifying as gay and cannabis use. Other research in GB has found that when controlling for socio-economic status, the effect of identifying as gay for men disappeared for risky alcohol use, but not for women (Shahab et al., 2017). This might suggest a more complex link between alcohol use for LGB women, and cannabis use for LGB men. As depressive symptoms were positively associated with ever having tried cannabis, this might also imply that for men, inequalities persist for bisexual individuals or those attracted to both sexes due to stigma and greater levels of minority stress (Baams et al., 2015). In the United States, whilst support for bisexual and gay men is better than for LGB women (Watson et al., 2019, 2018a), it is unclear if support in GB is equal between sexual minority groups for men.

Looking at outcomes simultaneously using multilevel multivariate modelling has several advantages, and allowed us to infer the relationship between each outcome at LA level when controlling for individual level covariates (Subramanian et al., 2005). We found that there was some unobserved residual variance for cannabis use for women, but not for other outcomes, and not for men across all outcomes. When we examined the residuals for cannabis use in women, we found that LAs did not differ significantly from the overall average. We also looked at LA type, and found that there was some variation between exposure groups, particularly in the case of London Cosmopolitan type areas, with sexual attraction having higher positive residuals than sexual identity. This corroborates previous research, albeit in gay men, finding that gay enclaves, which are found mainly in cities and particularly London Cosmopolitan areas with a concentration of LGB nightlife spaces, have been found to facilitate cannabis use (Carpiano et al., 2011). Whilst other research looking at smoking behaviours found the impact of community level risk factors in the UK to be smaller than individual level risk factors (Adachi-Mejia et al., 2012), we found that community risk factors might be more important for cannabis use, and particularly for women.

5. Limitations and policy implications

Despite our novel findings, our study is not without limitations. Firstly, using predictors for sexuality is difficult with secondary health surveys, as the groups are often unbalanced, and thus it is difficult to examine particular trends without over-parameterising the model. Numbers of sexual minority individuals are often small in survey data and rely on self-reporting. The NATSAL sample size of sexual minority individuals estimates are slightly higher than current UK estimates of LGB individuals, which were roughly 2% in 2017 compared to 2.8% in NATSAL wave 3 (Office for National Statistics, 2019a), though individual categories are still small. Whilst using more robust analysis techniques, such as MCMC, to account for small numbers would have been preferential, limitations in current MLwiN software restrict which estimation methods can be used. Secondly, the data in this survey were captured before changes in guidelines for alcohol use for men, which are now in line with guidelines for women at 14 units per week. Therefore, male drinking habits in this study are based on outdated guidelines, and the odds may actually be greater now. Thirdly, the inclusion of sex as a binary variable and a lack of variables asking about individuals' gender did not allow for examining substance use amongst non-cis or non-binary individuals. Fourthly, substance use behaviours were self-reported and not objective measures, and again could under-represent true figures of smoking, cannabis use and alcohol intake, particularly where individuals might be less inclined to report taking illicit drugs and other stigmatised health behaviours. Finally, cannabis use in this study was reported as having ever used, whereas smoking and alcohol use were current behaviours. This reflects data that was available and suitable for analysis in this study, but ever using cannabis may not be current and is likely to be a higher prevalence.

Future research could extend our findings by looking at other health behaviours such as diet and exercise, and other drugs explored in the context of sexual activity. Previous studies have also found that LGB individuals engage in earlier initiation of substance use behaviours than their heterosexual counterparts (Talley et al., 2019), and the role of mental health in LGB individuals and substance use behaviours has been well established (Davies et al., 2019; Watson et al., 2019). Looking at the interaction of these known determinants and sexuality was beyond the remit of this paper and would have risked over-parameterisation of the models. Future studies could, however, look at these interactions comparing sexuality measures. With recent policy calls for reducing smoking in England and Wales (Department of Health, 2017), and current research highlighting the negative health consequences of binge drinking (Kuntsche et al., 2017), policies should take into account different groups that are more vulnerable and consider sexuality specific

interventions. Our results sustain calls for nationally standard policies to reduce substance use behaviours for men and women, with a greater focus on social determinants of health, including sexuality but also social class, education and the co-morbidity of mental health. There is, however, still a need for LAs to assist specific populations that are unequally affected, such as LAs with a greater sexual minority population.

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Declaration of Competing Interest

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

References

- Adachi-Mejia, A.M., Carlos, H.A., Berke, E.M., Tanski, S.E., Sargent, J.D., 2012. A comparison of individual versus community influences on youth smoking behaviours: A cross-sectional observational study. *BMJ Open* 2, 1–10. <https://doi.org/10.1136/bmjopen-2011-000767>.
- Aicken, C.R.H., Nardone, A., Mercer, C.H., 2011. Alcohol misuse, sexual risk behaviour and adverse sexual health outcomes: Evidence from Britain's national probability sexual behaviour surveys. *J. Public Health* 33, 262–271. <https://doi.org/10.1093/pubmed/fdq056> (Bangkok).
- Arroll, B., Goodyear-Smith, F., Crengle, S., Gunn, J., Kerse, N., Fishman, T., Falloon, K., Hatcher, S., 2010. Validation of PHQ-2 and PHQ-9 to screen for major depression in the primary care population. *Ann. Fam. Med.* 8, 348–353. <https://doi.org/10.1370/afm.1139>.
- Baams, L., Grossman, A.H., Russell, S.T., 2015. Minority stress and mechanisms of risk for depression and suicidal ideation among lesbian, gay, and bisexual youth. *Dev. Psychol.* 51, 688–696. <https://doi.org/10.1037/a0038994>.
- Barrett, P., O'Donnell, K., Fitzgerald, M., Schmidt, A.J., Hickson, F., Quinlan, M., Keogh, P., O'Connor, L., McCartney, D., Igoe, D., 2019. Drug use among men who have sex with men in Ireland: prevalence and associated factors from a national online survey. *Int. J. Drug Policy* 64, 5–12. <https://doi.org/10.1016/j.drugpo.2018.11.011>.
- Birkett, M., Espelage, D.L., Koenig, B., 2009. LGB and questioning students in schools: the moderating effects of homophobic bullying and school climate on negative outcomes. *J. Youth Adolesc.* 38, 989–1000. <https://doi.org/10.1016/j.jphysbeh.2017.03.040>.
- Blosnich, J., Lee, J.G.L., Horn, K., 2013. A systematic review of the aetiology of tobacco disparities for sexual minorities. *Tob. Control* 22, 66–73. <https://doi.org/10.4324/9781315865485>.
- Browne, W.J., Browne, W.J., Charlton, C., Rasbash, J., Browne, W.J., Charlton, C., Kelly, M., Pillingier, R., 2019. MCMC estimation in MLwiN v3.03 [WWW Document]. URL <http://www.bristol.ac.uk/cmm/media/software/mlwin/downloads/manuals/3-03/mcmc-web.pdf> (accessed 2.12.17).
- Bruce, D., Kahana, S.Y., Bauermeister, J.A., Nichols, S.L., Hightow-Weidman, L.B., Heinze, J.E., Shea, J., Fernández, M.I., 2015. Neighborhood-level and individual-level correlates of cannabis use among young persons living with HIV/AIDS. *Drug Alcohol Depend.* 151, 173–180. <https://doi.org/10.1016/j.drugalcdep.2015.03.017>.
- Carpiano, R.M., Kelly, B.C., Easterbrook, A., Parsons, J.T., 2011. Community and drug use among gay men: the role of neighborhoods and networks. *J. Health Soc. Behav.* 52, 74–90. <https://doi.org/10.1177/0022146510395026>.
- Colledge, L., Hickson, F., Reid, D., Weatherburn, P., 2015. Poorer mental health in UK bisexual women than lesbians: evidence from the UK 2007 Stonewall Women's Health Survey. *J. Public Heal.* (United Kingdom) 37, 427–437. <https://doi.org/10.1093/pubmed/fdu105>.
- Davies, M., Lewis, N.M., Moon, G., 2019. Differential pathways into smoking among sexual orientation and social class groups in England: a structural equation model. *Drug Alcohol Depend.* 201. <https://doi.org/10.1016/j.drugalcdep.2019.04.012>.
- Davies, M., Lewis, N.M., Moon, G., 2018. Sexuality, space, gender, and health: Renewing geographical approaches to well-being in lesbian, gay, bisexual, transgender, and queer populations. *Geogr. Compass* 12. <https://doi.org/10.1111/gec3.12369>.
- Davies, M., Moon, G., Lewis, N.M., 2020. Trends in smoking prevalence over time and space: a comparison between sexual minority and heterosexual populations. *Heal. Place* 65 (102421). <https://doi.org/10.1016/j.healthplace.2020.102421>.
- Department of Health, 2017. Towards a smokefree generation: a tobacco control plan for England [WWW Document]. URL https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/630217/Towards_a_Smoke_free_Generation_-_A_Tobacco_Control_Plan_for_England_2017-2022_2_.pdf (accessed 8.1.17).
- Duncan, D.T., Hatzenbuehler, M.L., Johnson, R.M., 2014. Neighborhood-level LGBT hate crimes and current illicit drug use among sexual minority youth. *Drug Alcohol Depend.* 135, 65–70. <https://doi.org/10.1021/nn300902w.Release>.

- Emory, K., Kim, Y., Buchting, F., Vera, L., Huang, J., Emery, S.L., 2016. Intragroup variance in lesbian, gay, and bisexual tobacco use behaviors: evidence that subgroups matter, notably bisexual women. *Nicotine Tob. Res.* 18, 1494–1501. <https://doi.org/10.1093/ntr/ntv208>.
- Erens, B., Phelps, A., Clifton, S., Mercer, C.H., Tanton, C., Hussey, D., Sonnenberg, P., Maccowall, W., Field, N., Datta, J., Mitchell, K., Copas, A.J., Wellings, K., Johnson, A.M., 2014. Methodology of the third british national survey of sexual attitudes and lifestyles (Natsal-3). *Sex. Transm. Infect.* 90, 84–89. <https://doi.org/10.1136/sextrans-2013-051359>.
- Fallin, A., Goodin, A., Lee, Y.O., Bennett, K., 2015. Smoking characteristics among lesbian, gay, and bisexual adults. *Prev. Med. (Baltim.)* 74, 123–130. <https://doi.org/10.1016/j.ypmed.2014.11.026>.
- Fish, J.N., Watson, R.J., Gahagan, J., Porta, C.M., Beaulieu-Prévost, D., Russell, S.T., 2019. Smoking behaviours among heterosexual and sexual minority youth? Findings from 15 years of provincially representative data. *Drug Alcohol Rev.* 38, 101–110. <https://doi.org/10.1111/dar.12880>.
- Geary, R.S., Tanton, C., Erens, B., Clifton, S., Prah, P., Wellings, K., Mitchell, K.R., Datta, J., Gravningen, K., Fuller, E., Johnson, A.M., Sonnenberg, P., Mercer, C.H., 2018. Sexual identity, attraction and behaviour in Britain: the implications of using different dimensions of sexual orientation to estimate the size of sexual minority populations and inform public health interventions. *PLoS One* 13, 1–16. <https://doi.org/10.1371/journal.pone.0189607>.
- Goldbach, J.T., Tanner-Smith, E.E., Bagwell, M., Dunlap, S., 2014. Minority stress and substance use in sexual minority adolescents: a meta-analysis. *Prev. Sci.* 15, 350–363. <https://doi.org/10.1007/s1121-013-0393-7>.
- Goldstein, H., 2011. *Multilevel Statistical Models*, 4th ed. John Wiley & Sons, New York. <https://doi.org/10.4135/9781446251119.n61>.
- Green, K.E., Feinstein, B.A., 2012. Substance use in lesbian, gay, and bisexual populations: an update on empirical research and implications for treatment. *Psychol. Addict. Behav.* 26, 265–278. <https://doi.org/10.1037/a0025424>.
- Gubner, N.R., Delucchi, K.L., Ramo, D.E., 2016. Associations between binge drinking frequency and tobacco use among young adults. *Addict. Behav.* 60, 191–196. <https://doi.org/10.1016/j.addbeh.2016.04.019>.
- Hatzenbuehler, M.L., 2010. Social factors as determinants of mental health disparities in LGB populations: implications for public policy. *Soc. Issues Policy Rev.* 4, 31–62. <https://doi.org/10.1111/j.1751-2409.2010.01017.x>.
- Homma, Y., Saewyc, E., Zumbo, B.D., 2016. Is it getting better? An analytical method to test trends in health disparities, with tobacco use among sexual minority vs. heterosexual youth as an example. *Int. J. Equity Health* 15, 1–8. <https://doi.org/10.1186/s12939-016-0371-3>.
- Kerr, D.L., Ding, K., Chaya, J., 2014. Substance use of lesbian, gay, bisexual and heterosexual college students. *Am. J. Health Behav.* 38, 951–962. <https://doi.org/10.5993/AJHB.38.6.17>.
- Kuntsche, E., Kuntsche, S., Thrul, J., Gmel, G., 2017. Binge drinking: health impact, prevalence, correlates and interventions. *Psychol. Heal.* 32, 976–1017. <https://doi.org/10.1080/08870446.2017.1325889>.
- Kuyper, L., Bos, H., 2016. Mostly heterosexual and lesbian/gay young adults: differences in mental health and substance use and the role of minority stress. *J. Sex Res.* 53, 731–741. <https://doi.org/10.1080/00224499.2015.1071310>.
- Lee, J.G.L., Griffin, G.K., Melvin, C.L., 2009. Tobacco use among sexual minorities in the USA, 1987 to May 2007: a systematic review. *Tob. Control* 18, 275–282. <https://doi.org/10.1136/tc.2008.028241>.
- MacApagal, K., Bhatia, R., Greene, G.J., 2016. Differences in healthcare access, use, and experiences within a community sample of racially diverse lesbian, gay, bisexual, transgender, and questioning emerging adults. *LGBT Heal* 3, 434–442. <https://doi.org/10.1089/lgbt.2015.0124>.
- Maxwell, S., Shahmanesh, M., Gafos, M., 2019. Chemsex behaviours among men who have sex with men: a systematic review of the literature. *Int. J. Drug Policy* 63, 74–89. <https://doi.org/10.1016/j.drugpo.2018.11.014>.
- Meyer, I.H., 2003. Prejudice, social stress, and mental health in lesbian, gay, and bisexual populations: conceptual issues and research evidence. *Psychol. Bull.* 129, 674–697. <https://doi.org/10.1037/0033-2909.129.5.674>.
- Mohan, J., Twigg, L., Taylor, J., 2011. Mind the double gap: using multivariate multilevel modelling to investigate public perceptions of crime trends. *Br. J. Criminol.* 51, 1035–1053. <https://doi.org/10.1093/bjc/azr041>.
- Office for National Statistics, 2019. *Sexual orientation, UK: 2017* [WWW Document]. URL <https://www.ons.gov.uk/peoplepopulationandcommunity/culturalidentity/sexuality/bulletins/sexualidentityuk/2017> (accessed 8.9.19).
- Office for National Statistics, 2015. *Methodology note for the 2011 area classification for output areas* [WWW Document]. URL <https://www.ons.gov.uk/methodology/geography/geographicalproducts/areaclassifications/2011areaclassifications/methodologyandvariables> (accessed 8.3.19).
- Patton, G.C., Coffey, C., Carlin, J.B., Sawyer, S.M., Lynskey, M., 2005. Reverse gateways? Frequent cannabis use as a predictor of tobacco initiation and nicotine dependence. *Addiction* 100, 1518–1525. <https://doi.org/10.1111/j.1360-0443.2005.01220.x>.
- Peacock, A., Leung, J., Larney, S., Colledge, S., Hickman, M., Rehm, J., Giovino, G.A., West, R., Hall, W., Griffiths, P., Ali, R., Gowing, L., Marsden, J., Ferrari, A.J., Grebely, J., Farrell, M., Degenhardt, L., 2018. Global statistics on alcohol, tobacco and illicit drug use: 2017 status report. *Addiction* 113, 1905–1926. <https://doi.org/10.1111/add.14234>.
- Pearce, J., Hiscock, R., Moon, G., Barnett, R., 2009. The neighbourhood effects of geographical access to tobacco retailers on individual smoking behaviour. *J. Epidemiol. Community Health* 63, 69–77. <https://doi.org/10.1136/jech.2007.070656>.
- Rasbash, J., Steele, F., Browne, W.J., Goldstein, H., 2019. *A user's guide to MLwiN v3.03. Centre for Multilevel Modelling. University of Bristol*.
- Rasbash, J., Steele, F., Browne, W.J., Goldstein, H., 2009. *A User's Guide to MLwiN, Version 2.10*.
- Ritchwood, T.D., Ford, H., DeCoster, J., Lochman, J.E., Sutton, M., 2015. Risky sexual behavior and substance use among adolescents: a meta-analysis. *Child. Youth Serv. Rev.* 52, 74–88. <https://doi.org/10.1016/j.childyouth.2015.03.005>.
- Robinson, M., Sanches, M., MacLeod, M.A., 2016. Prevalence and mental health correlates of illegal cannabis use among bisexual women. *J. Bisex.* 16, 181–202. <https://doi.org/10.1080/15299716.2016.1147402>.
- Roxburgh, A., Lea, T., de Wit, J., Degenhardt, L., 2016. Sexual identity and prevalence of alcohol and other drug use among Australians in the general population. *Int. J. Drug Policy* 28, 76–82. <https://doi.org/10.1016/j.drugpo.2015.11.005>.
- Semlyen, J., King, M., Varney, J., Hagger-Johnson, G., 2016. Sexual orientation and symptoms of common mental disorder or low wellbeing: combined meta-analysis of 12 UK population health surveys. *BMC Psychiatry* 16. <https://doi.org/10.1186/s12888-016-0767-z> <https://doi.org/https://doi.org/>
- Shahab, L., Brown, J., Hagger-Johnson, G., Michie, S., Semlyen, J., West, R., Meads, C., 2017. Sexual orientation identity and tobacco and hazardous alcohol use: findings from a cross-sectional English population survey. *BMJ Open* 7, e015058. <https://doi.org/10.1136/bmjopen-2016-015058>.
- Snijders, T.A.B., Bosker, R.J., 1999. *Multilevel analysis: an introduction to basic and advanced multilevel modeling*, 1st Edition. Sage, Thousand Oaks, CA.
- Subbaraman, M.S., Kerr, W.C., 2015. Simultaneous versus concurrent use of alcohol and cannabis in the national alcohol survey. *Alcohol. Clin. Exp. Res.* 39, 872–879. <https://doi.org/10.1111/acer.12698>.
- Subramanian, S.V., Kim, D., Kawachi, I., 2005. Covariation in the socioeconomic determinants of self rated health and happiness: a multivariate multilevel analysis of individuals and communities in the USA. *J. Epidemiol. Community Health* 59, 664–669. <https://doi.org/10.1136/jech.2004.025742>.
- 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, 1073–1086. <https://doi.org/10.1007/s10508-018-1275-7>.
- Uhrig, N.S.C., 2015. Sexual orientation and poverty in the UK: a review and top-line findings from the UK household longitudinal study. *J. Res. Gen. Stud.* 5, 23–72.
- Watson, R.J., Goodenow, C., Porta, C., Adjei, J., Saewyc, E., 2018a. Substance use among sexual minorities: has it actually gotten better? *Subst. Use Misuse* 53, 1221–1228. <https://doi.org/10.1080/10826084.2017.1400563>.
- Watson, R.J., Grossman, A.H., Russell, S.T., 2019. Sources of social support and mental health among LGB youth. *Youth Soc* 51, 30–48. <https://doi.org/10.1177/0044118X16660110>.
- Watson, R.J., Lewis, N.M., Fish, J.N., Goodenow, C., 2018b. Sexual minority youth continue to smoke cigarettes earlier and more often than heterosexuals: findings from population-based data. *Drug Alcohol Depend.* 184, 64–70. <https://doi.org/10.1016/j.drugalcdep.2017.11.025>.
- Weatherburn, P., Hickson, F., Reid, D., Torres-Rueda, S., Bourne, A., 2017. Motivations and values associated with combining sex and illicit drugs ('chemsex') among gay men in South London: findings from a qualitative study. *Sex. Transm. Infect.* 93, 153–154.
- 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 Heal* 5, 33–44. <https://doi.org/10.1089/lgbt.2017.0175>.