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Latent Class Analysis of Sexual Behaviours and Attitudes to Sexually Transmitted Infections Among Gay and Bisexual Men Using PrEP

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Abstract

Gay and bisexual men (GBM) who use pre-exposure prophylaxis (PrEP) are at increased risk of sexually transmitted infections (STIs) compared to those who don't use PrEP. Since the implementation of PrEP in Australia, it is possible that attitudes towards STIs have shifted in line with changes in risk and transmission dynamics in the context of increased screening. As the extent to which GBM utilise STI prevention strategies likely depends on their attitudes towards STIs and STI prevention, the aims of this study were to use latent class analysis (LCA) to classify GBM using PrEP on the basis of their attitudes towards STIs and reported risk behaviours, and examine how these categorisations relate to risk of STI acquisition. 1225 GBM who were previously enrolled in a PrEP implementation study (The PrEPX Study) completed a survey focused on sexual behaviours and attitudes towards STIs 1 year post-study follow-up. Data on chlamydia, gonorrhoea and syphilis testing and positivity were available through a sentinel network of participating study clinics. Using LCA, participants were allocated into four classes; Class 1, "Some concern and lowest risk"; Class 2, "Low concern and lower risk"; Class 3, " High concern and higher risk"; and Class 4, "Low concern and highest risk". The majority (78%) of participants were classified into Class 3 or Class 4, two groups which were distinguished by highly disparate attitudes towards STIs but with a similar proportion of participants diagnosed with a bacterial STI in the last 12 months (48% and 57%, respectively). Findings suggest that attitudes towards STIs among GBM using PrEP in Australia vary considerably, and this will likely influence their receptivity to different STI prevention strategies.

Keywords Pre-exposure prophylaxis · Sexually transmitted infections · Gay and bisexual men · Sexual behaviour · Latent class analysis

Introduction

In Australia, gay and bisexual men (GBM) are overrepresented in diagnoses of sexually transmitted infections (STIs), including gonorrhoea, chlamydia and syphilis [1]. Decades-long trends of increasing STI incidence among Australian GBM [1, 2] have coincided with steady declines in consistent condom use [3], and in recent years this decline has accelerated in association with the rapid uptake of HIV pre-exposure prophylaxis, PrEP [4]. Between June 2016 and April 2018, more than 20,000 Australian GBM accessed PrEP through implementation studies [5, 6]. Since the closure of these PrEP studies following PrEP becoming available through government subsidy on Australia's pharmaceutical benefits scheme (PBS) in April 2018 [7], more than 37,000 individuals have accessed PrEP via the PBS [8]. A previous analysis of a large cohort of GBM accessing PrEP

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via the PrEPX Study in Victoria, Australia found that STI incidence increased by 21% following PrEP initiation among those starting PrEP for the first time, and was high during PrEP use. Findings also highlighted that a relatively small proportion of PrEP users, among whom repeat infections were common, carried most of the burden of STI diagnoses [9].

The extent to which GBM utilise STI prevention strategies, and their preferences for different strategies, likely depends on their behaviour and perceived level of STI risk, as well as their attitudes towards STIs and STI prevention in general. Previous qualitative research has highlighted a degree of anxiety towards STIs among some GBM, with reports of experiencing stigma associated with STI infection common [10]. Research exploring attitudes towards STIs and STI prevention among Australian GBM found that, while most GBM were not overly concerned with being diagnosed with STIs, some reported feelings of shame, embarrassment and annoyance towards STIs [11]. A more recent study found that while the majority of participants described STIs as easy to manage and a natural part of sexual health, some still considered STIs a serious health issue, including having concerns around antimicrobial resistance [12]. These findings suggest that GBM are not homogenous in their attitudes towards and perceptions of STIs. GBM who use PrEP are at increased risk of STIs compared to those who don't use PrEP [13–15], and since the implementation of PrEP it is possible that attitudes towards STIs have shifted in line with changes in risk and transmission networks and the frequency with which STIs are acquired, diagnosed, and treated in the context of more frequent testing when attending clinics for PrEP prescribing.

Characterising and identifying people at various levels of risk for acquiring STIs can help inform targeted prevention or the development of screening and testing guidelines. Latent class analysis (LCA) is a statistical method commonly used to identify subgroups of individuals based on specific response patterns across multiple variables. LCA has been widely applied to data collected from GBM to identify GBM suitable for PrEP [16] and understand perceived barriers to PrEP uptake [17]; identify GBM at increased risk for STIs [18]; describe and categorise attitudes and perceptions towards biomedical HIV prevention [19] and the utilisation of different combination HIV prevention strategies [20]; identify behaviours associated with HIV risk [21]; and to explore associations between sexualised drug use behaviour and STI risk [22].

To our knowledge, no published research has utilised LCA to classify GBM according to their attitudes towards STIs and sexual behaviours, and explore associations with corresponding STI risk. Understanding how attitudes towards STIs vary among GBM using PrEP, and their potential influence on prevention strategies and behaviours, will help in the development and implementation of appropriately targeted interventions to reduce STI transmission. The aims of this study were to classify GBM who use PrEP on the basis of their attitudes towards STIs and their reported risk behaviours, and examine how these categorisations relate to risk of acquiring an STI.

Methods

Data were drawn from the Pre-exposure Prophylaxis Expanded (PrEPX) Study, a multisite, open-label PrEP implementation study. The PrEPX Study has been described in detail elsewhere [5, 9]. The PrEPX study enrolled participants from three Australian states, with enrolments commencing in July 2016 in Victoria, May 2017 in South Australia and in September 2017 in Tasmania. Participants were dispensed PrEP every 3 months until study closure (1st April 2018 in Victoria and 30th June 2018 in South Australia and Tasmania). PrEPX participants completed a clinician-guided survey at enrolment and were scheduled to return to study clinics every 3 months to receive a prescription for PrEP and undergo comprehensive STI screening.

A total of 5113 participants were enrolled in the PrEPX study across Victoria (n = 4275), South Australia (n = 656) and Tasmania (n = 182). All PrEPX participants were invited to complete an online survey in March 2019, approximately 1 year after PrEPX study visits ceased. In total, 1469 participants (28.9% of all participants) completed the follow-up survey, of which 1458 (99.3%) identified as non-heterosexual men (gay, bisexual or 'other' sexuality). For this analysis, we included the 1225 (84.0%) participants who reported they were still using PrEP at the time of 1-year follow-up survey completion. Included participants completed the survey between 19th March and 20th June 2019.

Enrollment and follow-up survey data were collected and managed using REDCap electronic data capture tools hosted at the Burnet Institute [23]. The online follow-up survey asked a range of behavioural, demographic, and attitudinal questions derived from a previous sexual health survey of young people [24]. Participants were asked about condom use, partner numbers, sexual positioning, frequency of drug use before or during sex including alcohol, methamphetamine, GHB, ecstasy, amyl/poppers, marijuana, speed and cocaine, whether participants had ever injected drugs and frequency of injecting drug use. Participants were also asked about how often they had discussed STI testing with partners before having sex (never, some of the time, about half of the time, most of the time, always).

Participants also answered eight items on attitudes towards STIs on a 5-point Likert scale. The questions and available responses are below:

1. I worry about getting an STI
2. Getting an STI is something I think about often
3. Getting an STI could seriously affect my health
4. Getting an STI is no big deal
5. I feel I am unlikely to get an STI
6. I can't picture myself getting an STI

1-Strongly disagree, 2-Disagree, 3-Neither Agree nor Disagree, 4-Agree, 5-Strongly Agree.

7. How important is it to you that you avoid STIs?
8. How important is it to you that you avoid passing on STIs to your sexual partners?

1-Very unimportant, 2-Somewhat unimportant, 3-Neither important or unimportant, 4-Somewhat important, 5-Very important.

Statistical Analyses

To explore potential for responder bias in the post-study follow-up survey, we compared baseline characteristics from enrolment surveys between those who completed the follow-up survey and were included in this analysis and those who did not using two-sided test of proportions for dichotomous variables and t-test for continuous variables.

Variables Considered for LCA

Variables included in the LCA included participant age in years (continuous), condom use with casual partners, number of casual partners (categorised into 0, 1–5, 6–10, 11–20, 21–50, > 50; to achieve an approximate even distribution of responses), reporting a regular sex partner (yes/no), sexual position during sex (insertive only, receptive only, both insertive and receptive), chemsex drug use defined as the use of methamphetamine or GHB (with or without other drugs) [25–27] during or before sex (yes/no), discussing STI testing with casual partners and the eight STI attitudinal items dichotomised into agree ('strongly agree' or 'somewhat agree') or not ('neither agree nor disagree', 'somewhat disagree' or 'strongly disagree'). Attitudinal items were included as dichotomous variables to both improve model fit and aid in interpretability; proportion in agreement with each attitude was deemed meaningful in assessing differences in attitudes across classes. Recall period for behavioural variables was last 6 months.

Latent Class Model

We assessed model fit based on models with between two and eight classes, and used Akaike information criterion (AIC), Bayesian information criterion (BIC), and model entropy [28], as well as interpretability, to assess the ideal number of classes. The minimum allowed class size was restricted to 5% of the sample. In order to ensure that maximum likelihood estimation converged on a global and not a local maximum, for each model under consideration, we reran the model 100 times with random starting points. For each draw of random starting points, each individual was randomly allocated to a class and an expectation maximization (EM) algorithm was used to select the starting class values which resulted in the highest log likelihood value after 100 EM iterations. We assumed convergence on a global maximum likelihood if at least 40% of solutions yielded the maximum value of the likelihood function [29]. Individuals were allocated to the class in which they had the highest posterior probability of class membership and average class probability was calculated for each class.

Once the ideal number of classes based on model fit and entropy was determined, we assessed whether the assumption of conditional independence was met in the final model by exploring correlation between included variables within classes. We conducted a conditional analysis by calculating Pearson's correlation coefficient for all variables within each class, with a correlation of 0.5 or greater within one or more classes indicating violation of the assumption of independence. During this process, we observed a high correlation between attitudinal items 7 (How important is it to you that you avoid STIs?) and 8 (How important is it to you that you avoid passing on STIs to your sexual partners?) within three classes. As such, item 8 was removed and the process of running the series of models with 2–8 classes was repeated. We also assessed each class qualitatively to see if any classes were similar across multiple variables. In most model permutations, the mean age of participants was very similar across each class (each within 2 years of the cohort mean), so age was removed from the model.

We report LCA results as class prevalence rates for each classification variable, i.e. distribution of responses across individuals in their respective allocated class. All statistical analyses were conducted in Stata version 15 (StataCorp) and latent class models were run using the gsem command [30].

STI Positivity

Participants who enrolled in the PrEPX study were monitored for STIs using linked data extracted from study clinics which were also participating in the Australian Collaboration for Coordinated Enhanced Sentinel Surveillance of Sexually Transmissible Infections and Blood Borne Viruses (ACCESS) [31]. ACCESS uses specialised data extraction software installed behind patient management software at participating sexual health and general practice clinics to extract de-identified patient data [32]. For the purposes of the PrEPX study, participants consented to having their STI

testing data extracted via ACCESS and linked to their study data.

To explore how LCA classes related to risk of acquiring an STI, we calculated the proportion of participants with an available STI test result who tested positive for chlamydia, gonorrhoea and newly identified infectious [primary, secondary or early latent (< 2 years)] syphilis within each class. Test positivity was determined for any clinic visit in the 12-month period prior to date of survey completion and at their last clinic visit prior to completing the survey. To explore potential for selection bias associated with presenting for STI testing at ACCESS clinics, we compared characteristics between those with and without STI testing data available. Log-binomial regression was used to calculate prevalence ratios between each class of having a positive STI result within the past 12 for each STI outcome.

Results

Participant Characteristics and Survey Responses

Among the 1225 participants included in analyses, the mean age was 42.1 years and 94% identified as gay. Responses to behavioural questions in the follow-up survey are shown in Table 1. The distributions of participant responses to the eight STI attitudinal questions are shown in Table 2.

Based on enrolment survey responses, compared to PrEPX participants not included in the analysis, those included were older at enrolment (mean age, 39.7 years compared to 35.0 years; $P < 0.001$), less likely to have reported methamphetamine use in the 3 months prior to PrEPX study enrolment (9.1% compared to 12.4%; $P = 0.001$), more likely to have used PrEP prior to enrolment (30.7% compared to 22.1%; $P < 0.001$), and less likely to be report injecting drug use at enrolment (3.1% compared to 4.9%; $P = 0.009$). There was no difference between those included and not included in analyses on other enrolment survey responses, including reporting condomless receptive anal sex with a casual partner, reporting an STI diagnosis prior to enrolment, or reporting more than one episode of insertive condomless anal sex with a casual partner, in the 3 months prior to enrolment.

Latent Class Model

In addition to removing participant age from consideration in the LCA (see "Methods" section), item 8 (How important is it to you that you avoid passing on STIs to your sexual partners?) was removed due to high correlation with item 7 (How important is it to you that you avoid STIs?) within three classes (Pearson's correlation coefficient = 0.59, 0.64, and 0.69). Item 7 was retained over item 8 as it was deemed more relevant to the participant's attitudes towards avoiding STIs. In the final model specification, entropy was greatest in a model with three classes (0.74), AIC was lowest in a model with eight classes (22,284.7) and BIC was lowest a model with four classes (22,944.8, Table 3). As entropy was 0.62 in the 4-class model and decreased substantially with increasing classes thereafter, a model with four classes was selected and inspected for interpretability and conditional independence. Response patterns across classes were deemed reasonable and classes made interpretative sense in relation to distinguishing common attitudes across classes. The model satisfied the assumption of conditional independence (no correlation between variables within a class of greater than 0.5) and so a model with four classes was chosen for the final model. In the final model, the average posterior probabilities for class membership were 99% for Class 1, 81% for Class 2, 89% for Class 3 and 89% for Class 4 (Table 4).

Table 4 shows the distribution of variables included in the LCA across participants according to their allocated class. The latent class model revealed two smaller classes, Class 1 (9% of participants) and Class 2 (13%), and two larger classes, Class 3 (44%), Class 4 (35%). The four classes exhibited varying combinations of behaviors and perceived risk and concerns regarding STIs.

Class 1: 'Some concern and lowest risk'

GBM classified as belonging in Class 1 were most likely to report having a regular partner and the majority reported no casual partners in the past 6 months. Despite fewer reporting casual partners, GBM in Class 1 reported some concerns about STIs, indicating moderate levels of agreement for the item 'I worry about STIs' and the vast majority agreeing that 'STIs could seriously affect my health'.

Class 2: 'Low concern and lower risk'

GBM in Class 2 reported fewer casual partners than Classes 3 and 4, reported the highest proportion of insertive sex only with casual partners and the lowest level of chemsex drug use, but the proportion reporting never using condoms with casual partners was similar to Class 4. While some GBM in Class 2 still agreed they 'worry about STIs' and a large majority agreed that 'getting an STI could seriously affect their health' and wanted to avoid STIs, they had the lowest agreement with the item 'getting an STI is something I think about often'.

Class 3: 'High concern and higher risk'

Almost all of the GBM in Class 3 reported they 'worry about getting an STI', and GBM in Class 3 had the highest agreement with 'getting an STI is something I think about often'

Table 1 Participant characteristics and behaviours at time of follow-up survey

	n (N = 1225)	(%)
Age, years (mean, SD)	42.1 (11.1)	
Sexual identity		
Gay	1153	94.1
Bisexual	64	5.2
Other	8	0.7
Ever injected drugs		
No	1111	90.7
Yes	108	8.8
Prefer not to answer	6	0.5
Has regular partner	595	48.6
Number of casual partners in the last 6 months		
0	115	9.39
1–5	301	24.6
6–10	233	19.0
11–20	258	21.1
21–50	233	19.0
More than 50	85	6.9
Condom use with casual partners in the last 6 months[a]		
Never	437	39.4
Some of the time	451	40.6
About half the time	97	8.7
Most of the time	77	6.9
All of the time	33	3.0
No response	15	1.4
Drug use before or during sex in the last 6 months		
Methamphetamine	196	16.0
GHB	162	13.2
Alcohol	930	75.9
Ecstasy	209	17.1
Popper/amyl	878	71.7
Marijuana	274	22.4
Cocaine	185	15.1
Ketamine	101	8.2
Speed	56	4.6
Sexual positioning with casual partners in the last 6 months[a]		
Insertive/'top' only	220	19.8
Receptive/'bottom' only	169	15.2
Both insertive and receptive	708	63.8
No response	13	1.2
In the last 6 months, how often did you discuss STI testing with a casual partner?		
Never	296	24.2
Some of the time	439	35.8
About half of the time	151	12.3
Most of the time	215	17.6
Always	124	10.1

[a]Among those who reported a casual partner in the last 6 months (n = 1110)

Table 2 Participant responses to attitudinal questions in follow-up survey

	Strongly disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Strongly agree
	n (%)	n (%)	n (%)	n (%)	n (%)
Getting an STI could seriously affect my health	47 (3.8)	117 (9.6)	157 (12.8)	518 (42.3)	386 (31.5)
Getting an STI is no big deal	244 (19.9)	338 (27.6)	225 (18.4)	338 (27.6)	80 (6.5)
I feel I am unlikely to get an STI	236 (19.3)	478 (39)	319 (26)	145 (11.8)	47 (3.8)
I can't picture myself getting an STI	481 (39.3)	420 (34.3)	206 (16.8)	82 (6.7)	36 (2.9)
I worry about getting an STI	91 (7.4)	186 (15.2)	260 (21.2)	490 (40)	198 (16.2)
Getting an STI is something I think about often	135 (11)	272 (22.2)	340 (27.8)	344 (28.1)	134 (10.9)
	Very unimportant	Somewhat unimportant	Neither important or unimportant	Somewhat important	Very important
How important is it to you that you avoid STIs?	38 (3.1)	57 (4.7)	99 (8.1)	537 (43.8)	494 (40.3)
How important is it to you that you avoid passing on STIs to your partners?	49 (4)	18 (1.5)	30 (2.5)	294 (24)	834 (68.1)

Table 3 Model goodness of fit measures for models with two to eight classes

Classes	AIC	BIC	Entropy
2	23,272.3	23,512.6	0.68
3	22,643.8	23,001.6	0.74
4	**22,510.4**	**22,944.8**	**0.62**
5	22,420.6	22,967.5	0.46
6	22,345.7	23,005.0	0.28
7	22,317.5	23,073.9	0.26
8	22,284.7	23,158.6	0.39

Final model selection indicated in bold

and 'avoiding STIs is somewhat or very important'. A high proportion also agreed with the statement 'STIs could seriously affect my health'. GBM in Class 3 had more partners than those in Class 2, but fewer than in Class 4, and a moderate level of condom use. GBM in Class 3 were most likely to report discussing STIs with their casual partners most or all of the time in the past 6 months (35.4%).

Class 4: 'Low concern and highest risk'

GBM classified as belonging to Class 4 were least likely to agree they 'worry about STIs' or that they were concerned about avoiding STIs. GBM in Class 4 also reported the lowest agreement rate for the items; 'getting an STI could seriously affect my health', 'I feel I am unlikely to get an STI', and 'I can't picture myself getting an STI'. GBM in Class 4 reported higher numbers of casual partners than those in Classes 1–3, the lowest level of condom use, and more commonly reported both insertive and receptive sex with casual partners and chemsex drug use. GBM in Class 4 were least likely to report discussing STIs with their casual partners most or all of the time in the past 6 months (15.1%).

STI Positivity

A total of 957 participants (78% of those in the latent class model) were linked to a test result for chlamydia, gonorrhoea or syphilis at an ACCESS clinic in the 12 months prior to completing the survey (Table 5). Of these, 45.8% had at least one positive syphilis, chlamydia or gonorrhea result in this period. The proportion of those with a test result who had any positive STI diagnosis in the 12 months prior to survey completion was 18.8% in Class 1, 24.1% in Class 2, 48.2% in Class 3 and 56.7% in Class 4 (Fig. 1). At their most recent STI test (occurring a median of 53 days prior to survey completion), positivity for any STI was 2.4% in Class 1, 3.6% in Class 2, 14.8% in Class 3 and 23.0% in Class 4 (Fig. 2).

There was a significant difference in the prevalence of any STI in the past 12 months between each of the classes, except for between Classes 2 and 1 (PR = 1.28 [95% CI = 0.74–2.22]). The greatest difference in prevalence of any STI in the past 12 months was between Classes 4 and 1 (PR = 3.01 [95% CI = 1.92–4.73]). Between the two higher-risk classes (Classes 3 and 4), prevalence of any STI in the past 12 months was greater in Class 4 (PR = 1.18 [95% CI = 1.02–1.36]), with the largest relative

Table 4 Distribution of characteristics, behaviours and responses to attitudinal survey items according to class membership

	Class 1 N (%)	Class 2 N (%)	Class 3 N (%)	Class 4 N (%)
Total	114 (9.3)	158 (12.9)	537 (43.8)	416 (34.0)
Mean age (years)[a]	41.4	43.0	42.4	41.5
Number of casual partners in last 6 months				
0	107 (93.9)	0 (0)	3 (0.6)	5 (1.2)
1–5	5 (4.4)	108 (68.4)	159 (29.6)	29 (7)
6–10	2 (1.8)	41 (26)	122 (22.7)	68 (16.4)
11–20	0 (0)	5 (3.2)	131 (24.4)	122 (29.3)
21–50	0 (0)	2 (1.3)	100 (18.6)	131 (31.5)
> 50	0 (0)	2 (1.3)	22 (4.1)	61 (14.7)
Mean casual partner number in last 6 months[a]	0.1	8.9	17.9	32.8
Median casual partner number in last 6 months[a]	0.0	4.0	10.0	20.0
Condom use with casual partners in last 6 months				
No casual partners/no response	107 (93.9)	12 (7.6)	6 (1.1)	5 (1.2)
Always	5 (4.4)	7 (4.4)	21 (3.9)	0 (0)
Most of the time	0 (0)	10 (6.3)	59 (11)	8 (1.9)
About half the time	0 (0)	24 (15.2)	60 (11.2)	13 (3.1)
Some of the time	0 (0)	32 (20.3)	234 (43.6)	185 (44.5)
Never	2 (1.8)	73 (46.2)	157 (29.2)	205 (49.3)
Ever injected drugs	5 (4.5)	1 (0.6)	39 (7.3)	63 (15.2)
Chemsex drugs[b] before or during sex in the last 6 months	15 (13.2)	3 (1.9)	101 (18.8)	124 (29.8)
Has regular partner	79 (69.3)	69 (43.7)	267 (49.7)	180 (43.3)
Sexual position				
No casual partners/no response	108 (94.7)	10 (6.3)	5 (0.9)	5 (1.2)
Insertive only	0 (0)	67 (42.4)	105 (19.6)	48 (11.5)
Receptive only	2 (1.8)	31 (19.6)	99 (18.4)	37 (8.9)
Both insertive and receptive	4 (3.5)	50 (31.6)	328 (61.1)	326 (78.4)
I worry about getting an STI				
n (Agree or strongly agree)	57 (50.0)	58 (36.7)	522 (97.2)	51 (12.3)
Getting an STI is something I think about often				
n (Agree or strongly agree)	36 (31.6)	10 (6.3)	393 (73.2)	39 (9.4)
Getting an STI could seriously affect my health				
n (Agree or strongly agree)	99 (86.8)	131 (82.9)	461 (85.9)	213 (51.2)
Getting an STI is no big deal				
n (Agree or strongly agree)	26 (22.8)	40 (25.3)	112 (20.9)	240 (57.7)
I feel I am unlikely to get an STI				
n (Agree or strongly agree)	38 (33.3)	60 (38.0)	58 (10.8)	36 (8.7)
I can't picture myself getting an STI				
n (Agree or strongly agree)	23 (20.2)	32 (20.3)	49 (9.1)	14 (3.4)
How important is it to you that you avoid STIs?				
n (Important or very important)	107 (93.9)	140 (88.6)	518 (96.5)	266 (63.9)
In the last 6 months, how often did you discuss STI testing with a partner?				
n (Most of the time or all the time)	33 (29.0)	53 (33.5)	190 (35.4)	63 (15.1)

[a]Indicates variables that were not included in the latent class model, but which are reported here for each class

[b]Defined as use of either methamphetamine or GHB

Table 5 Proportion of participants with a linked test result in ACCESS within 12 months prior to survey completion and proportion positive by class membership

	Class 1	Class 2	Class 3	Class 4	Total
n in class (% of total sample)	114 (9.3)	158 (12.9)	537 (43.8)	416 (34.0)	1,225 (100)
Number with test present in ACCESS in last 12 months (% of class)					
Any STI test (gonorrhoea, syphilis or chlamydia)	85 (74.6)	112 (70.9)	425 (79.1)	335 (80.5)	957 (78.1)
Gonorrhoea or chlamydia test	85 (74.6)	111 (70.3)	424 (79.0)	334 (80.3)	954 (77.9)
Gonorrhoea test	85 (74.6)	111 (70.3)	424 (79.0)	334 (80.3)	954 (77.9)
Chlamydia test	85 (74.6)	111 (70.3)	424 (7.09)	334 (80.3)	954 (77.9)
Rectal NG or CT test	83 (72.8)	108 (68.4)	421 (78.4)	332 (79.8)	944 (77.1)
Urethral NG or CT test	85 (74.6)	111 (70.3)	422 (78.6)	333 (80.0)	951 (77.6)
Pharyngeal NG or CT test	85 (74.6)	111 (70.3)	422 (78.6)	334 (80.3)	952 (77.7)
Syphilis	81 (71.1)	100 (63.3)	401 (74.7)	321 (77.2)	903 (73.7)
Any positive result in the last 12 months (% of tested)					
Any STI (gonorrhoea, syphilis or chlamydia)	16 (18.8)	27 (24.1)	205 (48.2)	190 (56.7)	438 (45.8)
Gonorrhoea or chlamydia	16 (18.8)	26 (23.4)	197 (46.5)	180 (53.9)	416 (43.6)
Gonorrhoea	6 (7.1)	11 (9.9)	113 (26.7)	98 (29.3)	227 (23.8)
Chlamydia	12 (14.1)	16 (14.4)	142 (33.5)	133 (39.8)	303 (31.8)
Rectal (NG or CT)	14 (16.9)	17 (15.7)	136 (32.3)	138 (41.6)	305 (32.3)
Urethral (NG or CT)	8 (9.4)	13 (11.7)	80 (19.0)	68 (20.4)	169 (17.8)
Pharyngeal (NG or CT)	5 (5.9)	9 (8.1)	81 (19.2)	76 (22.8)	171 (18.0)
Syphilis	2 (2.5)	3 (3.0)	33 (8.2)	38 (11.8)	76 (8.4)
Positive result at the most recent test within 12 months (% of tested)					
Any STI (gonorrhoea, syphilis or chlamydia)	2 (2.4)	4 (3.6)	63 (14.8)	77 (23.0)	146 (15.3)
Gonorrhoea or chlamydia	1 (1.2)	3 (2.7)	58 (13.7)	67 (20.1)	128 (13.4)
Gonorrhoea	0 (0)	2 (1.8)	25 (5.9)	27 (8.1)	54 (5.7)
Chlamydia	1 (1.2)	2 (1.8)	37 (8.7)	44 (13.2)	84 (8.8)
Rectal (NG or CT)	1 (1.2)	3 (2.8)	43 (10.2)	46 (13.9)	93 (9.9)
Urethral (NG or CT)	2 (2.4)	1 (0.9)	22 (5.2)	24 (7.2)	49 (5.2)
Pharyngeal (NG or CT)	1 (1.2)	1 (0.9)	18 (4.3)	19 (5.7)	39 (4.1)
Syphilis	1 (1.2)	1 (1.0)	6 (1.5)	16 (5.0)	24 (2.7)

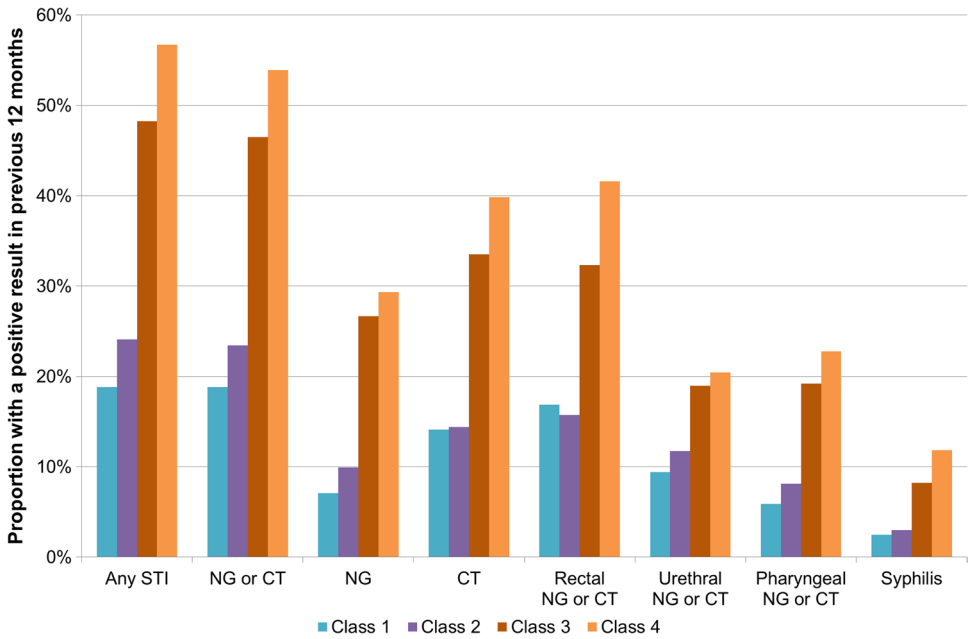

Fig. 1 Proportion of participants in each class with a positive test result within 12 months prior to survey completion

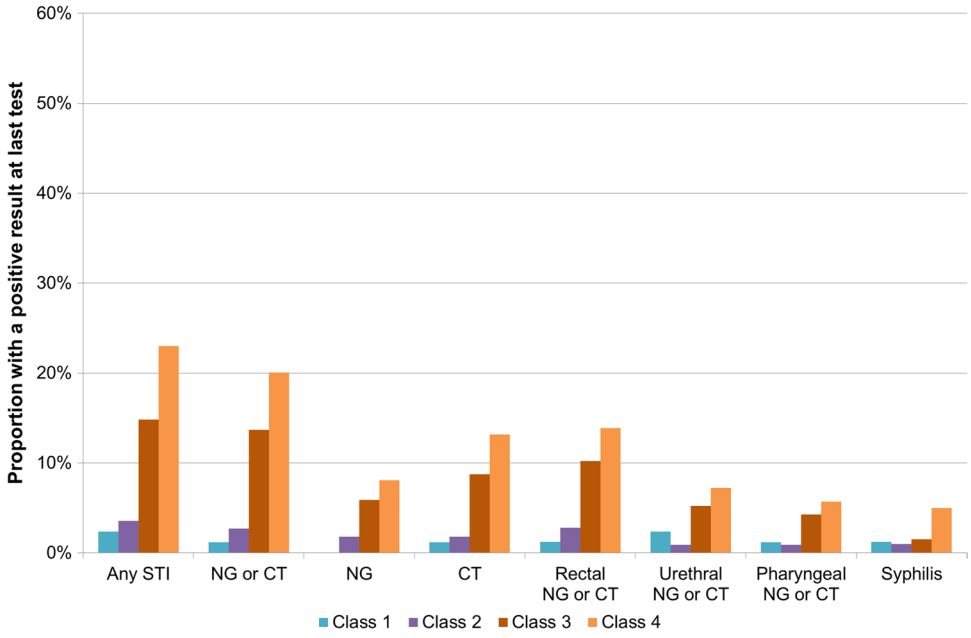

Fig. 2 Proportion of participants in each class with a positive test result at the most recent visit prior to survey completion

increase between Classes 4 and 3 observed for rectal infections (PR = 1.29 [95% CI = 1.07–1.56], Table 6).

Discussion

In this cohort of Australian GBM previously enrolled in a PrEP implementation study and who were still using PrEP 1 year post-study closure, we observed highly heterogeneous attitudes towards STIs and levels of sexual risk behaviours. Using LCA, we described four distinct groups of PrEP users exhibiting characteristic differences in behaviours, attitudes and risk related to STIs. Classes 1 and 2 were comprised mostly of GBM with no or very few casual partners, respectively. The majority (78%) of the cohort were classified into Classes 3 and 4, two groups that were distinguished by disparate attitudes towards STIs but had similarly high patterns of risk and STI diagnosis rates when compared to the others in the cohort. While GBM in Class 4 reported low concern about being diagnosed with an STI, GBM in Class 3 worried about STIs and considered STIs to be a serious health issue.

Approximately half of GBM allocated to Class 3 (high concern, higher risk) and Class 4 (low concern, highest risk) were diagnosed with an STI in the 12 months prior to completion of the follow-up survey. Given this relatively high incidence of STIs, GBM from both classes would benefit from additional STI prevention strategies. However, the receptiveness and motivation of each class to take up different interventions will likely vary considerably. When considering Class 4, there is an apparent degree of conflicting attitudes towards STIs; many (51%) acknowledge that getting an STI could seriously affect their health and that it is important to avoid STIs (64%), however few worried about getting an STI (12%), despite high rates of STI diagnoses detected in the previous 12 months. This may translate to a recognition that, while their current behaviour does put them at risk of the potential harms of STIs, the cost of reducing that harm (e.g. having fewer sexual partners) is greater than the perceived derived benefit (i.e. having fewer STIs). GBM in Class 4 may therefore be most receptive to strategies with minimal imposition on their sexual practices, such as rapid point-of-care testing or home testing, STI prophylaxis [33, 34], or, in the future, STI vaccines [35]. In contrast, GBM in Class 3, who worry about STIs yet still have high rates of STI diagnosis, may be more willing to adopt prevention strategies involving behavioural change if they can see that the direct benefit would be less STIs.

Classes 3 and 4 also reported different levels of drug use. Compared to those in Class 3, those in Class 4 were more likely to have ever injected drugs (15% vs. 7%), and more likely to have engaged in chemsex in the last 6 months (30% vs. 19%). As the sexual behaviours that participants were asked about revolved mostly around condom use, partner number and sexual positioning, we were unable to explore the frequency of more specific sexual practices associated with increased STI risk across classes, including participation in group sex or sex at sex-on-premises venues. While GBM in Class 4 had the highest positivity across each STI outcome, the greatest relative increase in past-12-month positivity compared to Class 3 was observed for rectal infections (29% higher) and syphilis (43% higher), indicating that Class 4 may be more likely to engage in high-risk receptive anal sex (e.g. condomless receptive sex in group sex

Table 6 Prevalence ratios for STI diagnosis in the past 12 months between classes

	Class 2 compared to Class 1		Class 3 compared to Class 1		Class 4 compared to Class 1		Class 3 compared to Class 2		Class 4 compared to Class 2		Class 4 compared to Class 3	
	PR (95% CI)	P	PR (95% CI)	P	PR (95% CI)	P	PR (95% CI)	P	PR (95% CI)	P	PR (95% CI)	P
Any STI (gonorrhoea, syphilis or chlamydia)	1.28 (0.74–2.22)	0.378	2.56 (1.63–4.03)	< 0.001	3.01 (1.92–4.73)	< 0.001	2.00 (1.42–2.82)	< 0.001	2.35 (1.67–3.31)	< 0.001	1.18 (1.03–1.35)	0.019
Gonorrhoea or chlamydia	1.24 (0.71–2.17)	0.440	2.43 (1.54–3.83)	< 0.001	2.86 (1.82–4.50)	< 0.001	1.95 (1.37–2.78)	< 0.001	2.30 (1.62–3.27)	< 0.001	1.18 (1.02–1.36)	0.025
Gonorrhoea	1.15 (0.54–2.43)	0.717	2.29 (1.25–4.18)	0.007	2.37 (1.29–4.34)	0.005	1.99 (1.21–3.27)	0.007	2.06 (1.25–3.40)	0.005	1.04 (0.82–1.31)	0.769
Chlamydia	1.12 (0.59–2.14)	0.733	2.33 (1.39–3.90)	0.001	2.76 (1.65–4.62)	< 0.001	2.08 (1.35–3.19)	0.001	2.47 (1.61–3.78)	< 0.001	1.19 (0.99–1.42)	0.063
Rectal (NG or CT)	0.93 (0.49–1.78)	0.826	1.95 (1.18–3.21)	0.009	2.51 (1.53–4.12)	< 0.001	2.09 (1.32–3.31)	0.002	2.70 (1.71–4.26)	< 0.001	1.29 (1.07–1.56)	0.008
Urethral (NG or CT)	1.24 (0.54–2.87)	0.607	2.00 (1.01–3.99)	0.048	2.16 (1.08–4.32)	0.029	1.61 (0.93–2.79)	0.088	1.74 (1.00–3.02)	0.050	1.08 (0.81–1.44)	0.607
Pharyngeal (NG or CT)	1.38 (0.48–3.96)	0.551	3.25 (1.36–7.77)	0.008	3.87 (1.62–9.26)	0.002	2.36 (1.22–4.54)	0.010	2.81 (1.46–5.41)	0.002	1.19 (0.90–1.57)	0.218
Syphilis	1.22 (0.21–7.10)	0.829	3.33 (0.82–13.61)	0.094	4.79 (1.18–19.46)	0.028	2.74 (0.86–8.76)	0.089	3.95 (1.24–12.51)	0.020	1.44 (0.92–2.24)	0.107

PR prevalence ratio

setting). Taken together, these data suggest that respondents in Class 4 may benefit from comprehensive harm reduction strategies that address both STI risk and risks arising from substance use.

Our analysis also revealed a level of anxiety towards STIs among some PrEP users. In particular, Class 3 was characterised by high levels of concern around STIs, with 73% saying they think about STIs often, in contrast with only 9% in Class 4 participants. Novel prevention strategies that reduce risk of STI acquisition risk, such as doxycycline pre- or post-exposure prophylaxis [33, 34], may be beneficial in reducing and improving both mental and physical wellbeing among some PrEP users at heightened risk of STIs. Research has shown that PrEP has been associated with large reductions in HIV-related anxiety among Australian GBM [36]. However, in the case of doxycycline prophylaxis, the potential benefit of reduced anxiety would need to be balanced against the theoretical potential harms caused by long term antibiotic use. A further distinction between Classes 3 and 4 was the frequency at which they reported discussing STI testing with their partners; 35% of Class 3 said they discussed STI testing most or all of the time, compared to only 15% of Class 4. However, overall more than three-quarters of PrEP users in our analysis reported discussing STI testing with partners at least some of the time. PrEP users who express comfort in discussing STI testing with casual partners may be good candidates for partner-centred prevention strategies, such as partner notification technologies, as well as for approaches relying on community diffusion of health promotion messages.

Biobehavioural data collected annually among GBM in Melbourne show that consistent condom use with casual partners has declined from 41% in 2016 to 22% in 2020 [37]. In our cohort of PrEP users, less than 3% of participants reported consistent condom use with casual partners in the past 6 months. Compared to GBM in Classes 4 and 2, GBM in Class 3 had a higher level of overall condom use with casual partners, with only 29% reporting never using condoms, compared to 49% in Class 4 and 46% in Class 2. Although condom use was higher among GBM in Class 3 than in Class 2, STI positivity was higher in Class 3 compared to Class 2. In contrast, GBM in Class 2 reported fewer casual partners in the past 6 months (median, 4) than those in Class 3 (median, 10). These findings reflect a previous survival analysis among the PrEPX cohort in which greater number of casual partners was independently associated with greater STI risk, whereas decreased condom use was not [9]. It is evident that selective use of condoms with casual partners is common among some GBM, with approximately half of those in Class 3 reporting using condoms some or about half of the time. Whilst acknowledging the potential complexity of health promotion messaging associated with this

finding, it is an issue worth addressing. Without diminishing the message of the importance of condom use overall, it is important to understand how to communicate that there are circumstances when condom use likely provides the greatest benefit and protection against STI risk—such as with a new partner or in a group sex setting.

Our findings that certain subgroups of GBM are at increased risk of STIs are consistent with previous research utilising LCA [16, 18]. However, while previous work has shown associations between certain characteristics and behaviours among groups of GBM and increased STI risk, this is the first LCA to our knowledge which incorporates both behaviours and attitudes towards STIs as class indicators. We believe that in the context of PrEP users, individuals' behaviours are so closely intertwined with their attitudes towards STIs, that neither can truly be said to be causing the other. Rather, behaviours and attitudes are likely driven by a single construct which we aimed to model as latent class membership. This is also the first LCA to be undertaken specifically among GBM who have been using PrEP for a considerable length of time. Attitudes among GBM may change in the context of increasing PrEP use, including through the normalisation of frequent testing and increasing STI incidence. The way in which PrEP users utilise particular STI prevention strategies will likely depend on their attitudes towards STIs. Successful targeting of strategies may need to rely not only on behavioural indicators and previous STI risk, but also on individuals' attitudes and motivation to utilise different strategies. Our findings suggest that tools used to screen patients for STI risk could be guided not only behavioural risk factors, but also by items on patients' attitudes towards STIs. Future research should aim to identify and refine which attitudinal questions are most indicative of STI risk in this population. Engaging in conversation to better understand patients' attitudes around STIs may help clinicians recommend interventions most likely to be adopted by the patient.

Limitations

There are several limitations to our analysis. First, only one quarter of participants in the PrEPX Study responded to the survey 1 year after study completion. Sensitivity analysis of characteristics of those who responded and those who did not revealed that respondents were older and less likely to report injecting drug use and methamphetamine use at enrolment. However, there was no difference in the HIV-related sexual risk criteria between groups. Second, some key behavioural variables which have been shown to be strong indicators of STI risk among GBM using PrEP, such as participation in group sex [9], were not included in the survey. Further analysis of specific sexual practices associated with STI risk among this cohort may be warranted. Third, only 78% of those included in the LCA had available STI testing data from the ACCESS surveillance system. However, missing testing data is likely due to some participants accessing their PrEP, and therefore being tested, outside of the ACCESS clinical network, rather than not being tested for STIs; all participants were still using PrEP at the time of the survey completion and 98% of participants reported being tested for STIs at their most recent PrEP clinic visit prior to survey completion. It is unlikely that attending a different clinic for STI testing is greatly influenced by STI risk. Fourth, we were only able to look at associations between class membership and risk of bacterial STIs, and not viral STIs. As the attitudinal questions included in the survey did not explicitly mention bacterial STIs, we were not able to discern any differences in attitudes towards curable bacterial STIs compared to non-curable STIs, such as human papillomavirus or herpes simplex virus. Concern towards contracting life-long viral STIs may have influenced some participants' responses. Finally, this analysis was restricted to GBM currently using PrEP and may not be generalisable to GBM not using PrEP or GBM in general. However, the issues explored in this work are particularly relevant to STI control in the era of PrEP, given rapid uptake of PrEP among Australian GBM has coincided with declines in condom use and increases in STI incidence.

Conclusions

GBM using PrEP in Australia are a priority population for bacterial STIs, however, our study shows that their beliefs and attitudes towards STIs vary considerably and this will likely influence their receptivity to different STI prevention strategies. We found that PrEP users with the highest risk of STIs reported the highest rates of injecting drug use and chemsex, suggesting that this group of PrEP users would benefit from harm reduction strategies that address both STI risk and risks resulting from drug use. A multifaceted and targeted public health response which considers and monitors how different interventions are received and adopted by PrEP users will be required to curtail the high incidence of STIs among this population.

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Author Contributions MWT lead the data analysis and manuscript preparation. MWT, EJW and MAS conceived the analysis. EJW, KR, JA and DM designed the follow-up survey. JA curated the data. EJW was the principal investigator of the PrEPX study. All authors contributed to data interpretation and have contributed to the intellectual content and preparation of the manuscript.

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Declarations

Conflict of interest MWT received speaker's fees from Gilead Sciences. DM received grants from Alfred Health. VJC has received speaker's fees and conference assistance from Gilead Sciences and advisory board fees from ViiV Healthcare. EJW reports receipt of grants from the Victorian, Tasmanian and the South Australian governments for PrEPX; other from Gilead Sciences compensation to her institution for chairing a nursing education session and for attending an advisory board meeting, and uncompensated attendance for attending 2 Gilead meetings regarding listing of Truvada on the Australian pharmaceutical benefits scheme); grants from, Gilead Science and Merck Sharp and Dohme outside the submitted work; and financial support from, Gilead Sciences, Abbott Laboratories, Janssen-Cilag, Boehringer Ingelheim, ViiV Healthcare, and Merck Sharp and Dohme. MH received grants from the Australian Department of Health, Gilead Sciences, Abbvie and Bristol Myers-Squibb. JA received grants from the Australian Government's Department of Health. MS received a research fellowship from the National Health and Medical Research Council, and investigator-initiated grants from Gilead Sciences and Bristol-Myers-Squibb. All other authors declare no potential conflicts of interest.

Ethical Approval The PrEPX study was approved by the Alfred Health Human Research and Ethics Committee (HREC100/16) and registered on the Australian New Zealand Clinical Trials Registry (ACTRN12616001215415). Ethics approval for the ACCESS Project in Victoria was provided by the Alfred Hospital Human Research Ethics Committee (Project 248/17), as well as several specialised committees for key populations, including ACON, Thorne Harbour Health, and the Aboriginal Health and Medical Research Council.

Informed Consent Informed consent was obtained from all individuals in the PrEPX study.

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